XVI-52 North Brazil Shelf: LME #17

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The North Brazil Shelf LME extends along northeastern South America from the boundary with the Caribbean Sea to the Parnaíba River estuary in Brazil (Ekau & Knoppers 2003). It has a surface area of about 1.1 million km^2, of which 1.69% is protected, and contains 0.01% of the world's coral reefs and 0.06% of the world's sea mounts (Sea Around Us 2007). The hydrodynamics of this region is dominated by the North Brazilian Current, which is an extension of the South Equatorial Current and its prolongation, the Guyana Current. Shelf topography and external sources of material, particularly the Amazon River with its average discharge of 180,000 m^{3}s^{-1} (Nittrouer & DeMaster 1987), exert a significant influence on the LME. This is complemented by discharge from other rivers such as Tocantins, Maroni, Corantyne, and Essequibo. A wide continental shelf, macrotides and upwellings along the shelf edge are some other features of this LME. Book chapters and reports pertaining to the LME include Bakun (1993), Ekau & Knoppers (2003), UNEP (2004a, 2004b).

I. Productivity

The North Brazil Shelf LME is considered a Class I, highly productive ecosystem (>300 gCm^{-2}yr^{-1}), with the Amazon River and its extensive plume being the main source of nutrients. Primary production is limited by low light penetration in turbid waters influenced by the Amazon, while it is nutrient-limited in the clearer offshore waters (Smith & DeMaster 1996). Primary productivity on the continental shelf has been found to be greatest in the transition zone between these two types of waters, occasionally exceeding 8 gCm^{-2}day^{-1} (Smith & DeMaster 1996). In addition to high production, the food webs in this LME are moderately diverse. Brazil's coral fauna is notable for having low species diversity, yet a high degree of endemism.

Oceanic Fronts (Belkin *et al.* 2009) (Figure XVI-52.1): Major fronts within this LME are associated with outflow from the Amazon River and, to a lesser extent, that of the Orinoco River. The Amazon plume initially turns northwestward and flows along the Brazil coast as the North Brazil Current. Off the Guyana coast, between 5°N and 7°N, the North Brazil Current retroflects and flows eastward. This retroflection develops seasonally and produces anticyclonic rings of warm, low-salinity water that propagate northwestward toward Barbados, the Lesser Antilles Islands and eventually the Caribbean Sea. The second major source of fresh water is the Orinoco River plume. Most thermal fronts are associated with salinity fronts related to freshwater lenses and plumes originated at the Amazon and Orinoco estuaries. Such fronts are relatively shallow, sometimes just a few meters deep. Nonetheless, these fronts are important to many species whose ecology is related to the upper mixed layer. Fresh lenses generated by the Amazon and Orinoco outflows persist for months, largely owing to the sharp density contrasts across TS-fronts that form their boundaries (in case of fresh, warm tropical lenses, the temperature and salinity contributions to the density differential reinforce each other).

North Brazil Shelf LME SST (Belkin 2009)(Figure XVI-52.2):
Linear SST trend since 1957: 0.22°C.
Linear SST trend since 1982: 0.60°C.

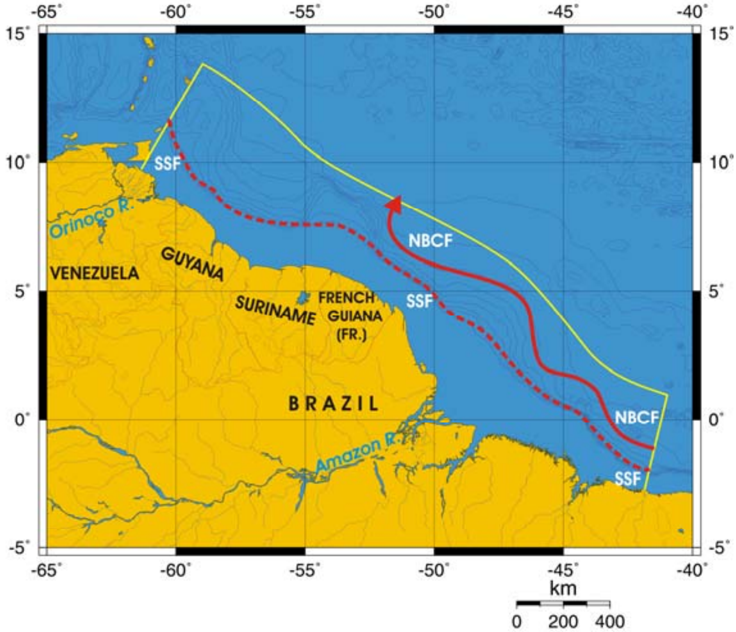

Figure XVI-52.1. Fronts of the North Brazil Shelf LME. Acronyms: NBCF, North Brazil Current Front. SSF, Shelf Slope Front (most probable location. Yellow line, LME boundary. After Belkin *et al.* (2009).

The North Brazil Shelf's thermal history over the last 50 years started with a long-term cooling that culminated in the all-time minimum of 27.3°C in 1976, followed by warming until present. Using the year of 1976 as a true breakpoint, a linear trend would yield a 0.9°C increase over 30 years, which would place the North Brazil Shelf among moderate-to-fast warming LMEs. The North Brazil Shelf thermal history differs from the adjacent South Brazil Shelf. This can be explained by the decoupling of their oceanic circulation. Indeed, the North Brazil Shelf is strongly affected by the North Equatorial Current and Amazon Outflow, whereas the South Brazil Shelf is principally affected by sporadic inflows of Subantarctic waters from the south and also by offshore oceanic inflows from the east.

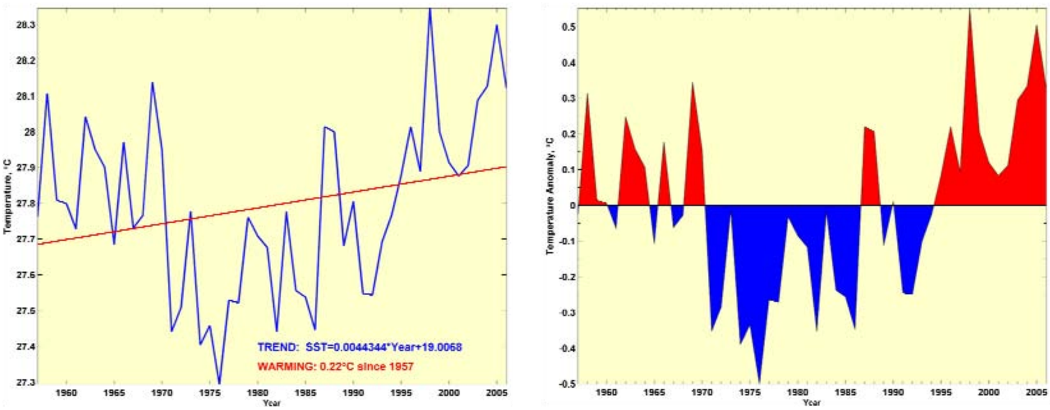

Figure XVI-51.2. North Brazil Shelf LME annual mean SST (left) and SST anomalies (right), 1957-2006, based on Hadley climatology. After Belkin (2009).

North Brazil Shelf LME Chlorophyll and Primary Productivity: The North Brazil Shelf LME is a Class I, highly productive ecosystem (>300 $gCm^{-2}yr^{-1}$)(Figure XVI-51.3).

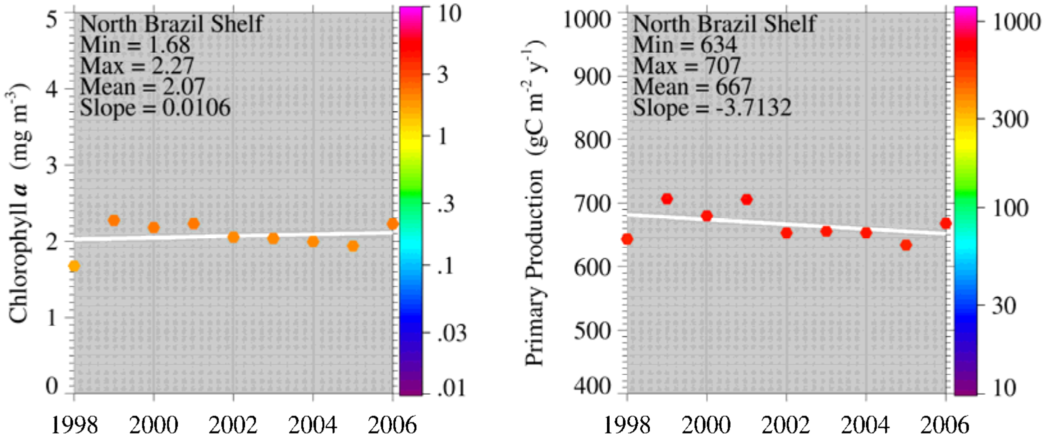

Figure XVI-51.3. North Brazil Shelf LME trends in chlorophyll *a* (left) and primary productivity (right), 1998-2006, from satellite ocean colour imagery. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume.

II. Fish and Fisheries

The multispecies and multigear fisheries of the North Brazil Shelf LME are targeted by both national and foreign fleets (FAO 2005 and see below). Major exploited groups include a variety of groundfish such as weakfish (*Cynoscion* sp.*)*, whitemouth croaker or corvina (*Micropogonias furnieri*) and sea catfish (*Arius* sp.). The shrimp resources, such as southern brown shrimp (*Penaeus subtilis*)*,* pink spotted shrimp (*P. brasiliensis*), southern pink shrimp (*P. notialis)*, southern white shrimp (*P. schmitti*) as well as the smaller seabob (*Xiphopenaeus kroyeri*) support one of the most important shrimp fisheries in the world. Tuna is also exploited, and although its catch weight is relatively small, its value is significant. Total reported landings in this LME underwent a steady increase from 1950 to just over 290,000 tonnes in 2004 (Figure XVI-52.4) and the value of the reported landings reached US$532 million (in 2000 US dollars) in 2004 (Figure XVI-52.5).

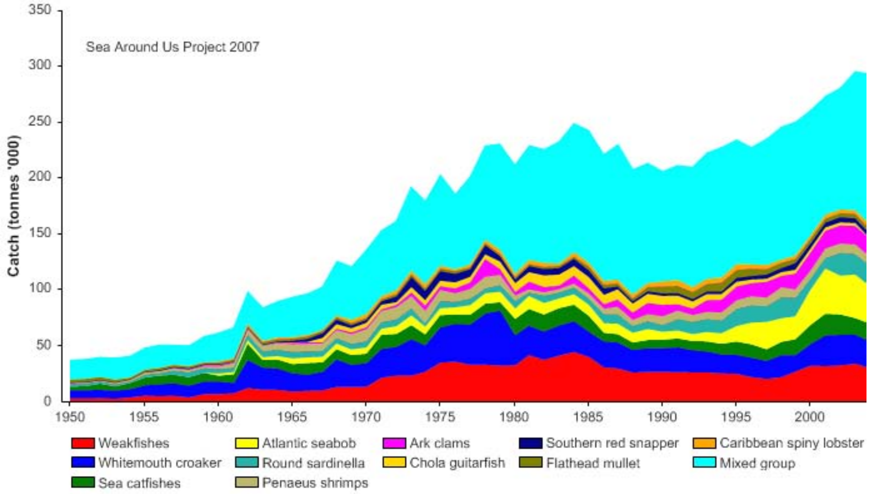

Figure XVI-52.4. Total reported landings in the North Brazil Shelf LME by species (Sea Around Us 2007).

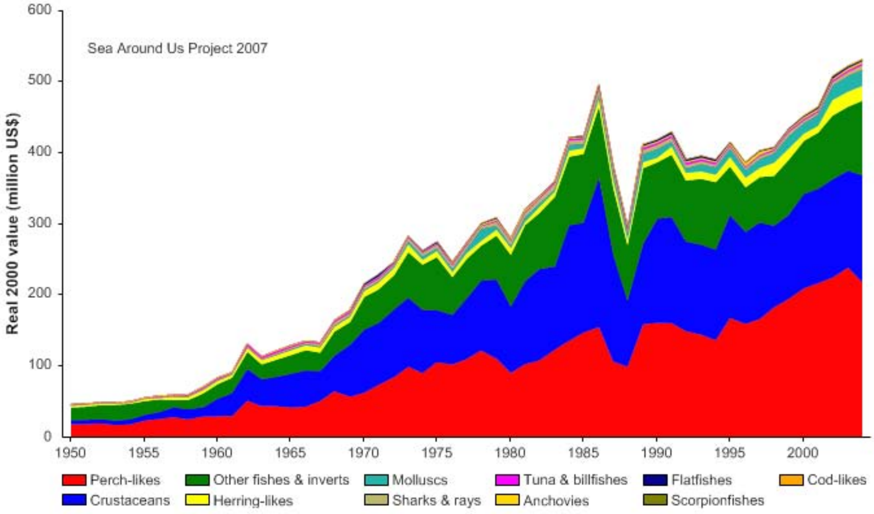

Figure XVI-52.5. Value of reported landings in the North Brazil Shelf LME by commercial groups (Sea Around Us 2007).

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings in this LME is low, currently at 3% of the observed primary production (Figure XVI-52.6). Brazil has the largest share of the ecological footprint in this LME, followed by Venezuela and Guyana.

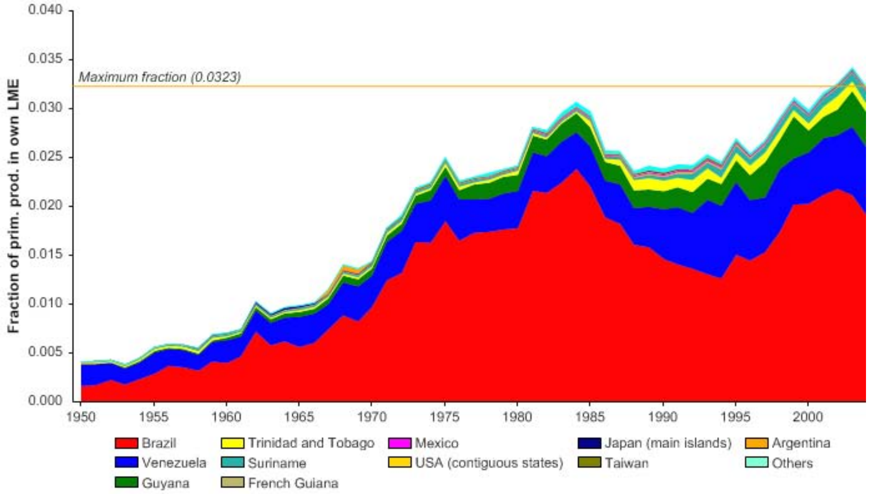

Figure XVI-52.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the North Brazil shelf LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

From the mid 1980s, the mean trophic level of the reported landings (i.e., the MTI; Pauly & Watson 2005) has undergone a steady decline (Figure XVI-52.7, top), a trend indicative of a 'fishing down' of the food webs (Pauly *et al.* 1998) in the LME, while the flatness of the FiB over the same period (Figure XVI-52.7, bottom) implies that the increase in the reported landings has not compensated for the decline in the mean trophic level. A detailed study of ecosystems in the region by Freire (2005) has found similar trends using local catch data.

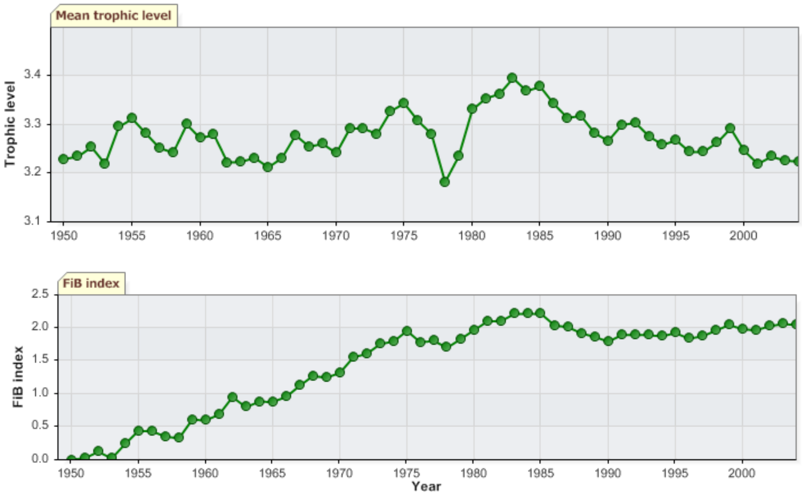

Figure XVI-52.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the North Brazil Shelf LME (Sea Around Us 2007).

The Stock-Catch Status Plots indicate that over 60% of commercially exploited stocks in the LME are either overexploited or have collapsed (Figure XVI-52.8, top). However, 70% of the reported landings come from fully exploited stocks (Figure XVI-52.8, bottom).

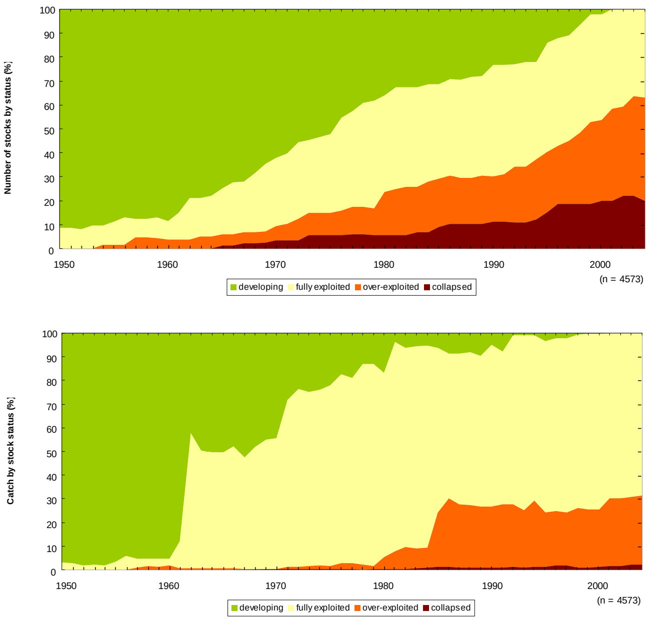

Figure XVI-52.8. Stock-Catch Status Plots for the North Brazil Shelf LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number 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).

Detailed analysis of the fisheries in this LME confirms this diagnosis of severe overexploitation. There is evidence that some of the fisheries may be fully exploited or overexploited in relation to MSY, particularly some of the groundfish stocks. Where assessments have been undertaken, there are clear signs of overexploitation of the southern red snapper (*Lutjanus purpureus*) resource (UNEP unpubl), with declining catch rates and a decrease in the size of this species (Charuau *et al*. 2001, Charuau & Medley 2001). Recent trends in catch per unit effort and other analyses indicate that the corvina is now overexploited in some areas, with the low stock levels of this species being commensurate with exploitation levels beyond the MSY level (Alió *et al*. 2000, Alió 2001). Similarly, lane snappers (*L. synagris*), bangamary (*Macrodon ancylodon*) and sharks are also showing signs of overexploitation (Alio 2001, Ehrhardt & Shepard 2001a). Moreover, a decrease in the average size of some groundfish species has raised sustainability issues (Booth *et al*. 2001, Chin-A-Lin & IJspol 2001). The increasing capture of small individuals is potentially compromising recruitment to the spawning stock (Souza 2001). For instance, in Brazil, immature southern red snappers comprise over 60% of the catch of this species (Charuau *et al*. 2001). Trawl and Chinese seines harvest bangamary at ages far below the age at maturity (Ehrhardt & Shepherd 2001a).

In general, all the shrimp species in the region are subjected to increasing trends in fishing mortality (Ehrhardt 2001) and the fishery is generally overcapitalised (Chin-A-Lin & M. IJspol 2001). Stocks of brown and pink spotted shrimp may be close to being fully exploited (Charuau & Medley 2001, Ehrhardt 2001, Ehrhardt & Shepherd 2001b, Negreiros Aragão *et al*. 2001), with the latter being overexploited in some areas (Ehrhardt & Shepherd 2001b). There has been a general downward trend in the abundance of brown and pink shrimps, particularly during the late 1980s and throughout the 1990s. The trends in fishing mortality were not high enough to have created the very conspicuous decline in abundance, which implies that environmental factors (seasonal river run-off and rainfall) may be more significant than fishing in determining recruitment in these species.

Excessive bycatch and discards and destructive fishing practices are severe, and are of concern throughout the LME. The shrimp bycatch issue is well known in the region, where the bycatch/shrimp ratios are typically between 5 and 15:1 (Villegas & Dragovich 1984, Marcano *et al*. 1995). Many commercial species, predominantly young individuals, comprise the bycatch, most of which is discarded dead at sea. Several species have practically disappeared from the bycatch, indicating a dramatic shrinking of their populations, notably in the case of sharks (Charlier 2001). The operation of trawlers in shallow areas also causes extensive physical damage to benthic habitats and their communities (Charlier 2001). The use of explosives and poisons on the reefs (bleach for capturing octopus) and mangroves (toxic chemicals to capture crabs), capture of immature individuals through diving as well as the use of nets to catch lobsters, which drag sediments, animals and calcareous algae from the sea floor, have also been reported in this region (UNEP 2004a).

III. Pollution and Ecosystem Health

Pollution: Overall, pollution was found to be moderate, but severe in localised hotspots near urban areas. Most of the pollution is concentrated in densely populated and industrialised coastal basins, and not widespread across the region. Water quality in the coastal areas is threatened by human activities that give rise to contamination from sewage and other organic material, agrochemicals, industrial effluents, solid wastes and suspended solids (EPA/GEF/UNDP 1999).

Effluents from industries are released, sometimes untreated, into the water bodies. Contamination by mercury as well as by chemical agricultural wastes is the main source of chemical pollution in the Amazon Basin (UNEP 2004b). Gold is exploited in all the countries of the region and mercury from gold mining operations is dispersed into the air. It is assumed that the largest part ends up in rivers, transforms into methyl-mercury and other chemical compounds and concentrates along the food chain. Mercury contamination could, on the longer-term, become a hazard for the coastal marine ecosystem and for human health, if suitable measures to limit its use are not implemented. There is also the potential risk of pollution from oil extraction, both in the coastal plain and the sea.

Agricultural development is concentrated along the coast and includes intensive cultivation of sugarcane, bananas and other crops. This involves the application of large quantities of fertilisers and pesticides, which eventually end up in the coastal environment. Sugarcane plantations along the coast are also suspected to contribute persistent organic contaminants, which are widely used in pest control, to the coastal habitats (UNEP 2004b).

As a result of the coastal hydrodynamics in this LME, the potential for transboundary pollution impacts is significant. River outflow is deflected towards the northwest and influences the coastal environment in an area situated west of each estuary. It has been estimated that 40-50% of the annual Amazon run-off transits along the Guyana coast (Nittrouer & DeMaster 1987). In fact, Amazon waters can be detected as far away as the island of Barbados (Borstad 1982). As a result, most of the coastal area of the Brazil-Guianas region has been described as an ‘attenuated delta of the Amazon’ (Rine & Ginsburg 1985). This implies that contaminants in river effluents, particularly those of the Amazon, could be transported across national boundaries and EEZs.

Habitat and community modification: Human activities have led to severe habitat modification in this LME. Mangroves, which dominate a major part of the shoreline, have been seriously depleted in some areas, for example, in Guyana, where mangrove swamps have been drained and replaced by a complex coastal protection system (EPA 2005. Likewise, on the Brazilian coast, the original mangrove area has been significantly reduced by cutting for charcoal production and timber, evaporation ponds for salt and drained and filled for agricultural, industrial or residential uses and development of tourist facilities (Marques *et al*. 2004). In Brazil, erosion also threatens coastal habitats and some coastal lagoons have been cut off from the sea.

In the past, the coral reefs were mined for construction material. Currently, they are exposed to increased sedimentation due to poor land use practices and coastal erosion, chemical pollution from domestic sewage and agricultural pesticides, overfishing, tourism and development of oil and gas terminals (Maida & Ferreira 1997). Additionally, there has been some coral bleaching associated with climate variation (Charlier 2001).

Trawlers often operate without restriction in the shallower areas of the shelf, over ecologically sensitive areas inhabited by early life stages of shrimp. The environmental impact of such activities is likely to be high, considering the intensity of shrimp trawling operations in these areas (Ehrhardt & Shepherd 2001b). Evidence from other regions suggests that precautionary measures should be undertaken in environmentally sensitive areas of the continental shelf (Ehrhardt & Shepherd 2001b). Trawlers also catch significant quantities of finfish as bycatch, of which dumping at sea is still a widespread practice in the region (FAO 2005). This is especially damaging to the stocks when the bycatch includes a significant portion of juvenile fish. In Suriname, small-scale fishers have reported the incidence of ‘dead waters’, in shallow areas, following fishing activity by trawlers (Charlier 2001). These dead waters were scattered with dead fish in larger amounts than could have been discarded by the trawlers. Vast areas were devoid of live fish, as they had apparently died or moved out of the area. Such mortality could be the result of local oxygen depletion, caused by the re-suspension of anoxic sediment combined with the presence of organic matter dumped from the vessels.

Growth of the local human population and pressures associated with urban and industrial development will continue to threaten the health of the LME. The problems are, however, potentially reversible, considering that there is a greater public and governmental awareness about environmental issues and several measures at national and regional levels are being taken to address some of these problem.

IV. Socioeconomic Conditions

Brazil (states of Amapá, Pará, Maranhão), French Guiana, Guyana, Suriname and the southeastern part of Venezuela border this LME. A high percentage of the total population consists of indigenous communities. Human uses of the coastal zone include subsistence agriculture, fisheries, exploitation of clay and sand and limited ecotourism. Marine fisheries constitute an important economic sector in the region, providing foreign exchange earnings, employment and animal protein. A significant portion of the region's population depends upon fishing for its survival and is unable to substitute other sources of animal protein for fish protein (UNEP 2004b). In Guyana, the fishery sector is of critical importance to the economy and to social well-being. The economic contribution of Guyana's fisheries has grown dramatically in recent years, contributing about 6% to GDP and employing about 10,000 persons (FAO 2005). Furthermore, fish protein is the major source of animal protein in Guyana, with per capita consumption of about 60 kg in 1996, more than four times the world average (FAO 2005). In general, unsustainable overexploitation of living resources as well as environmental degradation may result in threats to the food security of fishers and loss of employment, as well as loss of foreign exchange to the countries of this LME. Because of shrinking resources and degradation of habitats, a number of development projects have been implemented to support local communities.

V. Governance

Fisheries management issues in the countries bordering the North Brazil Shelf LME are complicated because of the variety of gears used, and the multi-species and multinational nature of the groundfish fisheries. This situation is further complicated by the paucity of data pertaining to the biology and productivity of the region's fish stocks and catch and fishing effort. As a consequence, confidence in stocks assessments is low (Booth *et al*. 2001). The countries have ongoing programmes for environmental and natural resource management and coastal zone management and most have established several national marine parks and protected areas.

The countries are parties to several international environmental agreements, for example CBD, UNFCCC, UNCLOS, MARPOL and Ramsar Convention on Wetlands. Brazil, Guyana, Peru, Suriname and Venezuela, along with Bolivia, Colombia, Ecuador and Peru have developed a project for support by GEF: 'Integrated Management of Aquatic Resources in the Amazon' For the Brazilian Amazon River Basin. The project, approved for Work Program Entry in June 2005, recognises the close linkages between integrated water resource management and the protection of marine habitats. The general objective of this project is to strengthen the institutional framework for planning and executing, in a coordinated and coherent manner, activities for the protection and sustainable management of the land and water resources of the Amazon River Basin, based upon the protection and integrated management of transboundary water resources and adaptation to climatic change.

The first phase of the project will involve strategic planning and institutional strengthening, including the development of a TDA of the Basin and preparation of a Framework SAP. Brazil has applied for the GEF biodiversity project 'Strengthening the Effective Conservation and Sustainable use of Mangrove Ecosystems in Brazil through its National System of Conservation Units'. The aim of the project is to develop conservation and sustainable management of mangrove ecosystems in Brazil to conserve globally significant biodiversity and key environmental services and functions important for national development and the well-being of traditional and marginalised coastal communities.

References

Alió, J.J. (2001). Venezuela, Shrimp and Groundfish Fisheries. FAO Fisheries Report 651:115-119.

Alió, J.J., Marcano, L., Soomai, S., Phillips, T., Altuve, D., Alvarez, R., Die, D., and Cochrane, K. (2000). Analysis of industrial trawl and artisanal fisheries of whitemouth croaker (*Micropogonias furnieri*) of Venezuela and Trinidad and Tobago in the Gulf of Paria and Orinoco River Delta. FAO Fisheries Report 628:138-148.

Bakun, A. 1993. The California Current, Benguela Current, and Southwestern Atlantic shelf ecosystems – A Comparative Approach to Identifying Factors Regulating Biomass Yields, p 199-221 in: Sherman, K., Alexander, L.M. and Gold, B.D. (eds), Large Marine Ecosystems – Stress Mitigation, and Sustainability AAAS, Washington D.C., U.S.

Belkin, I.M. (2009) Rapid warming of Large Marine Ecosystems, Progress in Oceanography, in press.

Belkin, I.M., Cornillon, P.C., and Sherman, K. (2009). Fronts in Large Marine Ecosystems. Progress in Oceanography, in press.

Booth, A., Charuau, A., Cochrane, K., Die, D., Hackett, A., Lárez, A., Maison, D., Marcano, L.A., Phillips, T., Soomai, S., Souza, R., Wiggins, S. and IJspol, M. (2001). Regional assessment of the Brazil-Guianas groundfish fisheries. FAO Fisheries Report 651:22-36.

Borstad, G.A. (1982). The influence of the meandering Guiana Current and Amazon River discharge on surface salinity near Barbados. Journal of Marine Research 40:421-434.

Charlier, P. (2001). Review of environmental considerations in management of the Brazil-Guianas shrimp and groundfish fisheries. FAO Fisheries Report 651:37-57.

Charuau, A. and Medley, P. (2001). French Guiana, snapper fishery. FAO Fisheries Report 651:77-80.

Charuau, A., Cochrane, K., Die, D., Lárez, A., Marcano, L.A., Phillips, T., Soomai, S., Souza, R., Wiggins, S. and IJspol, M. (2001). Regional Assessment of red snapper, *Lutjanus purpureus*. FAO Fisheries Report 651:15-21.

Chin-A-Lin, T. and IJspol, M. (2001). Suriname, groundfish and shrimp fisheries. FAO Fisheries Report 651:94-104.

Ehrhardt, N. M. and Shepherd, D. (2001a). Guyana, groundfish fisheries. FAO Fisheries Report 651:85-89.

Ehrhardt, N.M. (2001). Comparative regional stock assessment analysis of the shrimp resources from northern Brazil to Venezuela. FAO Fisheries Report 651:1-14.

Ehrhardt, N.M. and Shepherd, D. (2001b). Guyana, shrimp fisheries. FAO Fisheries Report 651:81-84.

Ekau, W. and Knoppers, B. A. (2003). A review and redefinition of the Large Marine Ecosystems of Brazil, p 355-372 in: Sherman, K. and Hempel, G. (eds), Large Marine Ecosystems of the World: Trends in Exploitation, Protection and Research. Elsevier Science. Amsterdam, The Netherlands.

EPA (2005). Issues and Importance of Guyana's Coastal Zone. Environmental Protection Agency Guyana. http://www.epaguyana.org/iczm/articles.htm

EPA/GEF/UNDP (1999). Guyana National Biodiversity Action Plan. www.epaguyana.org/ downloads/National-Biodiversity-Action-Plan.pdf

FAO (2005). Fishery Country Profile. The Federative Republic of Brazil. www.fao.org/fi/fcp /en/BRA/profile.htm

Freire, K. (2005). Fishing impacts on marine ecosystems off Brazil, with emphasis on the north-eastern region. PhD thesis, University of British Columbia, 254 p.

Freire, K.M.F. and Pauly, D. (2005). Richness of common names of Brazilian marine fishes and its effect on catch statistics. Journal of Ethnobiology. 25 (2): 279-296.

Maida, M. and Ferreira, B.P. (1997).Coral reefs of Brazil: An overview, p 263-274 in: Proceedings of the 8th International Coral Reef Symposium, Vol. 1.

Marcano, L., Alió, J.J., Altuve, D.E. and Celaya, J. (1995). Venezuelan shrimp fisheries in the Atlantic margin of Guyana. National report of Venezuela. FAO Fisheries Report 526 (Suppl.):1-29.

Marques, M., da Costa, M.F., de O. Mayorga, M.I. and Pinheiro, P.R.C. (2004). Water environments: Anthropogenic pressures and ecosystem changes in the Atlantic drainage basins of Brazil. Ambio (33)1-2:68-77.

Negreiros Aragão, J.A., de Araújo Silva, K.C., Ehrhardt, N.M., Seijo, J.C. and Die, D. (2001). Brazil, Northern Pink Shrimp Fishery. Regional Reviews and National Management Reports – Fourth Workshop on the Assessment and Management of Shrimp and Groundfish Fisheries on the Brazil-Guianas Shelf. FAO Fisheries Report 651.

Nittrouer, C.A. and DeMaster, D.J. (1987). Sedimentary Processes on the Amazon Continental Shelf. Pergamon Press, New York, U.S.

Pauly, D. and Christensen, V. (1995). Primary production required to sustain global fisheries. Nature 374: 255-257.

Pauly, D. and Watson, R. (2005). Background and interpretation of the 'Marine Trophic Index' as a measure of biodiversity. Philosophical Transactions of the Royal Society: Biological Sciences 360: 415-423.

Pauly, D., Christensen, V., Dalsgaard, J., Froese R. and Torres, F.C. Jr. (1998). Fishing down marine food webs. Science 279: 860-863.

Rine, J.M. and Ginsburg, R.N. (1985). Depositional facies of the mudshorefave in Suriname, South America: A mud analogue to sandy, shallow-marine deposits. Journal of Sedimentary Petrology 55(5):633-652.

Sea Around Us (2007). A Global Database on Marine Fisheries and Ecosystems. Fisheries Centre, University British Columbia, Vancouver, Canada. www.seaaroundus.org/lme/SummaryInfo.aspx?LME=17

Smith, W.O. and DeMaster, D.J. (1996). Phytoplankton biomass and productivity in the Amazon River plume: Correlation with seasonal river discharge. Continental Shelf Research 16(3):291-319.

Souza, R. (2001). Brazil, northern red snapper fishery. FAO Fisheries Report 651:3-70.

UNEP (2004a). Marques, M., Knoppers, B., Lanna, A.E., Abdallah, P.R. and Polette, M. Brazil Current, GIWA Regional Assessment 39. University of Kalmar, Kalmar, Sweden. www.giwa.net/publications/r39.phtml

UNEP (2004b). Barthem, R. B., Charvet-Almeida, P., Montag, L. F. A. and Lanna, A.E. Amazon Basin, GIWA Regional Assessment 40b. University of Kalmar, Kalmar, Sweden. www.giwa.net/publications/r40b.phtml

Villegas, L. and Dragovich, A. (1984). The Guianas-Brazil shrimp fishery, its problems and management aspects, p 60-70 in: Gulland, J.A. and Rothschild, B.J. (eds), Penaeid Shrimps - Their Biology and Management. Fishing News Books, Farnham, U.K.