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HABITAT DESTRUCTION IN THE WORLD'S WATERS

Progress report by the Global International Waters Assessment

INTRODUCTION

1. In accordance with the Memorandum of Cooperation and joint work programme betwe Secretariat of the Convention on Biological Diversity and the Coordination Office of the G International Waters Assessment (GIWA), a report on habitat destruction in the world's waters cor by GIWA is being circulated herewith for the information of participants in the eighth meeting Subsidiary Body on Scientific, Technical and Technological Advice. This document is of relevance to the programmes of work on marine and coastal biological diversity and biological di of inland water ecosystems.

2. The report is being circulated in the language and form in which it was received by the Sec of the Convention on Biological Diversity.

* UNEP/CBD/SBSTTA/8/1.

I. BACKGROUND

1. This information document was prepared for the SBSTTA 8 meeting of the Convention on Biol Biodiversity in Montreal, Canada, March 2003. The global overview presented draw from the on GEF assessment of the world's transboundary waters performed by Global International W Assessment, United Nations Environmental Programme, and is thus preliminary in nature. Referenc given when examples are provided from additional sources. Case studies have been provided by and the GIWA co-ordination office, Kalmar, Sweden.

II. HABITAT DESTRUCTION IN THE WORLD'S WATERS

2. Water covers 71% of the earth's surface and constitutes a key component in all ecosystem economic value provided by aquatic ecosystems is estimated at three-quarter of the total value biosphere making these habitats most important to human livelihood and wellbeing (Costanza 1997). The threats to the world's aquatic habitats are mainly linked to physical destruction, and ch in the quality and quantity of water resources as a result of human intervention.

3. Habitat destruction is generally accepted as the principle cause of loss in biodiversity. In light knowledge, the current rate and scale of degradation of aquatic habitats is alarming with implications for global biodiversity. The major threats to aquatic habitats on a global scale c summarized in the following:

- In Europe and Central Asia, eutrophication, overfishing and water abstraction have re in habitat destruction of rivers, lakes, estuaries and semi-enclosed seas.
- In South America, habitats along the Atlantic coast in the vicinity of large metropolitan are threatened by heavy industrialization, tourism developments and release of dor sewage.
- In Africa, habitat destruction hotspots are scattered over the continent. The Lake Vi ecosystem is in a precarious situation as a result of many contributing factors inc eutrophication, invasive species and overfishing. In southern Africa and in the northw part of the continent, rivers and wetlands have been severely impacted by dam construc agriculture and development.
- In Southeast Asia mangrove forests are the most threatened habitats mainly due to ext aquaculture practices.
- Coral reefs in the Pacific and Indian Ocean are deteriorating as a result of destructive f practices and large-scale coral bleaching events caused by increased sea s temperatures.

3. This information document presents the interim results of the ongoing Global International W Assessment (GIWA-UNEP). A global overview of the status of freshwater, coastal and m ecosystems is provided together with three case studies highlighting specific issues and regions world.

A. Global International Waters Assessment (GIWA)

4. Global International Waters Assessment (GIWA) is led by the United Nations Environm Programme (UNEP) and mainly funded by the Global Environment Facility (GEF) with addi support from National Oceanic and Atmospheric Administration (NOAA), the Finnish Departme International Development Co-operation, and the Swedish International Development Co-ope Agency (Sida).

5. The objective of GIWA is to develop a strategic framework for the identification of prioriti remedial and mitigatory actions in international waters. The Global Environment Facility (GEF) a partners can use the results of the assessment as an effective means of developing well targeted, pra proposals for incremental funding. In the case of international waters, there is no global asses comparable with those on climate change, biodiversity and stratospheric ozone. Consequently, often proven difficult to prioritize projects related to international waters, particularly give insufficient understanding of the nature and root causes of environmental problems in this area GIWA assessment encompasses the ecological status of trans-boundary freshwater basins and associated coastal and ocean systems, as well as analyses on the causes of environmental problem potential policy responses.

6. GIWA focuses on five major concerns: Freshwater shortage, Pollution, Habitat and Comm Modification, Unsustainable Exploitation of Fisheries and Other Living Resources, and Global ch To achieve the goals of the project, the world has been divided into 66 sub-regions that are assess regional teams of experts. The impact of each concern is assessed on a four-point scale; no k impact, slight impact, moderate impact, and severe impact. Each scale is associated to predefined c and thus, the GIWA results are comparable on a global scale. In figure 1, the currently reported imp "Habitat and Community Modification" is presented. The map presents the environmental impact Regions not scored on the map have not yet finalized the assessment report. More information GIWA project and methodology used to assess the world's waters can be retrieved http://www.giwa.net.

7. The GIWA project began in 1999 and is projected to be completed in 2004. Currently, most sub-regions have finalized the initial assessment of environmental and socio-economic impacts a moving into causal chain and policy option analysis. The assessment of current environmental im clearly indicates that "Unsustainable exploitation of fisheries" and "Habitat and comm modification" are considered as the most stressing concerns i.e. they have been assessed as sev more sub-regions than any other of the five major concerns.

B. Habitat destruction in relation to other threats to the aquatic environment

8. The current condition of aquatic habitats has been assessed as severe in 16 sub-regions out within the GIWA assessment at this time of the project (figure 1). Within the assessment, Habita Community Modification has been compared with other urgent water related issues. When rankin five environmental concerns, including socio-economic and future concerns, about half of the re have ranked Habitat and Community Modification among their two top priorities. In other regio concern is perceived as secondary in relation to other more stressing regional issues, although h modification may be prevalent. The socio-economic impacts of habitat modification and los generally not rated as severe as the environmental impact, possibly as a consequence of the intric estimating the true value of the services provided. The future prospect regarding the status of a habitats is mixed but more than half of the regions anticipate a further deterioration in the next 20 There is a however, a growing realization that ecosystems are not inexhaustible and preventive me need to be taken. In the GIWA assessment there is a growing concern for increased costs for conser and management of aquatic ecosystems in various parts of the world.

C. Freshwater ecosystems

9. Freshwater ecosystems in rivers, lakes and wetlands make up only 0.01% of the world's water b services provided are invaluable; water for drinking, agriculture, energy production, industry, fish and countless other human uses are supplied by this limited resource. The increasing human popu and demand for water puts an escalating stress on freshwater habitats and functions.

- Construction of dams to provide hydroelectricity, irrigation and drinking water has c major changes of riverflow with associated habitat and biodiversity modification.
- Eutrophication and overfishing is threatening the ecosystem balance in several of the w largest lakes.

- Conversion of wetlands for agriculture has led to the loss of 50% of the world's wetla the last century.

Rivers

10. The construction of dams is the major anthropogenic cause of river flow modification. Accord the GIWA assessment, the impacts of river flow modification is most severe in the Aral Sea regic Yellow and Yangtze rivers in east China, in Sao Francisco River Brazil and in rivers in Souther Western Africa, but measurable impacts can be found in most parts of the world.

11. In Brazil more than 600 dams have been built supplying the country with 90% of its elec (WCD 2000). Dam constructions and subsequent altered stream flow have resulted in changes physical characteristics of the rivers e.g. in turbidity, salinity, depth, velocity and nutrient concentra The altered conditions have in turn led to changes in the floral and faunal abundance and diversity rivers.

12. In Europe, United States, Southern Africa and India, flow modification has resulted in rela stable flows on a yearly basis which has led to an increase in macrophyte abundance. Species wetlands like rushes *(Juncus sp)* now proliferate in weir pools of the controlled rivers. The areas di downstream many dams are in turn subjected to fluctuating water levels and are characterize communities poor in macroinvertebrate species. In some cases dams act as a reproductive barrier ca isolation of species while in the Zambezi (Southern Africa) and Paraná (Brazil) rivers, the fish faur mixed as a result of eliminated barriers (Marshall 1998, Oliveira et al. 2002). Thus, altered gene flo changes in biodiversity are recurrent effects of altered river flow. The changed river flow can also l altered migration routs and destruction of spawning habitats for aquatic organisms. In the Caspia tributaries many spawning sites for the Beluga sturgeon have vanished as a consequence of altered contributing to the diminishing fish stock (Caspian Sea TDA 2002).

13. Construction of dams has not only impacted aquatic habitats but also the living condition for p near impoundments. The construction of the Akosombo dam on the Volta River in Ghana is linked increase in the incidence of water-related diseases such as bilharzia, malaria and onchocerciasis blindness). Since the construction of the dam, bilharzia has increased from 2 to 32%, malaria from 99% and onchocerciasis is now prevailing among 75-90% of the population in local communities (Boakye 2001).

Lakes

14. Lakes hold almost 90% of the liquid surface freshwater and are critical "storage tank freshwater. The littoral zone acts as a filter where degradation of terrestrial wastes improves quality, a most important feature since lake water makes up a large proportion of drinking water in countries. Due to the isolation between most lakes they frequently harbor a high number of en species i.e. species that exists nowhere else in the world. Lake Tanganyika, in the African Rift V has for example more than 600 endemic fish species, an invaluable resource from a global biodiv perspective. The vast majority of lakes are located within national boundaries and unless affect transboundary discharge they are not included in the GIWA assessment. Seven out of the world's l lakes (by surface) do however cross international borders and many of them are in a deteriorating st

15. Inland fish catches account for about 12% of the global fisheries and in many landlocked cou freshwater fish consumption makes up a high proportion of total protein intake. Overfishi combination with habitat destruction has led to a decreasing trend in inland capture in foremost Eu North America and Australia (World Resources 2000-2001). In the Caspian Sea, landings of the fa Beluga sturgeon have decreased from 30.000 tons in 1985 to 5.700 tons in 1995 (Caspian Sea 2001). In addition to the loss of spawning grounds due to altered river flow, overfishing and wides poaching of sturgeons have contributed to the declining stock.

16. In Lake Victoria pollution from domestic, industrial and agricultural activities have increas nutrient levels leading to algal blooms, oxygen depletion and subsequent periodic fish kills. The a

conditions paved the way for invading species i.e. the Nile perch and the water hyacinth, that severely affected the Lake Victoria ecosystem with entailing socio-economic problems information provided in appended case-study) (Scheren et al. 2000, Lung'ayia et al. 2001).

17. The collapse of the Aral Sea ecosystem is a deterrent example of human intervention. In the most of the water from the two major tributaries was diverted for irrigational purposes. Today, the surface of the Aral Sea has been reduced by 50%, the volume with 70% and the level has dropp meters. As a result of increasing salt concentration in the Lake, most of the fish stocks have died o the fisheries industry collapsed already in the 1980s. Destruction and desertification of coastal and areas expands over tens of thousands hectares. Due to improper irrigational practices, rive groundwater have become increasingly saline resulting in critical health conditions for populations delta regions that have been deprived of adequate drinking water (Glazovsky 1995).

Wetlands

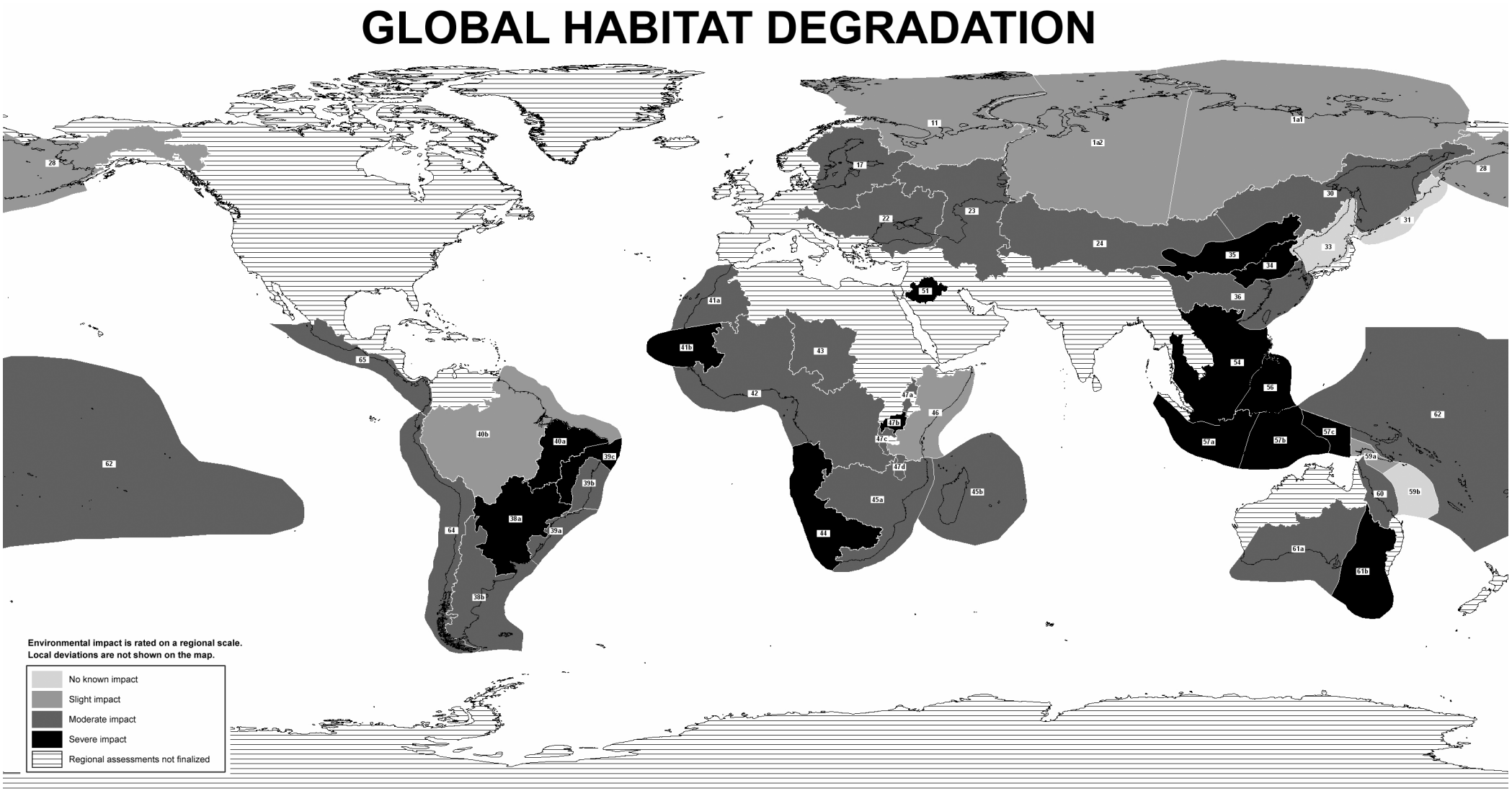
18. Freshwater wetlands are present in all parts of the world and the major ecotypes are fens, swamps and floodplains. 1/. The global extent of natural freshwater wetlands is calculated at 550 million ha. The formation, function and characteristics of wetlands are dependent on the regime resulting in a wide variety of ecotypes with high biological biodiversity (Bakan & Büyüky 2000). Freshwater wetlands are estimated to provide a number of direct human services and in ecosystem services at a value of 10% of the total value of the biosphere (derived from Costanza 1997). Increased demand for agricultural land associated with population growth is the most signi cause of wetland loss while river flow regulation and pollution have had a negative impact o function of many wetlands (Bergkamp & Orlando 1999).

19. It is estimated that 50% of the freshwater wetlands that existed in the beginning of the 20th c have been lost worldwide. Most of the wetland loss occurred in the northern countries during the f years of this century while tropical and sub-tropical wetlands have been increasingly lost since the (Spiers 1999).

20. The general threat to wetlands in developing countries is conversion for agricultural purpos Sub-Saharan Africa 40% of the land is used for agricultural activities (World bank 2002a). Irri agriculture covers less than five percent of the total arable land in Sub-Saharan Africa and consequence there is a heavy reliance on natural wetlands for cropping and pasture in these arid are Central Africa, 352.000 ha of floodplains and valley bottoms are used for agricultural activities (W Bank 2002, FAO AQUASTAT). The environmental impact of wetland conversion and exploitati agricultural activities is generally not transboundary unless agricultural practices are heavily laden pesticides and fertilizers. This is the case in East Asia and the Pacific Islands where fertilizer u double the world average (World Bank 2002b). The socio-economic implications of agric activities in wetland areas are mainly localized while the resulting biodiversity concerns are global.

1/ The definition of wetlands varies considerably depending on source. According to the classification of the Ramsar Convention of Wetlands, 20 inland wetlands are identified including rivers and lakes. For the purpose of this presentation, broad definitions have been applied to provide a summarized glob overview.

Figure 1. Environmental impact of Habitat and Community Modification. Interim results of the GIWA assessment, February 2003.



D. Coastal ecosystems

21. Almost 40 percent of the world's population lives within 100 km of a coastline. Costal ecosy provide a number of essential services including shoreline protection and water quality improv spawning grounds, fisheries resources, and habitat and food for migratory and resident an Population growth and conversion for development, agriculture and fisheries puts an increasing pr on the coastal ecosystems.

- Estuaries are threatened worldwide by coastal development, eutrophication, non-n pollutants, deforestation and water abstraction.
- Mangrove forests are estimated to have occupied 75% of the tropical and sub-tropical c areas but anthropogenic pressure have reduced the coverage by half.
- Coral reefs are suffering from deteriorating conditions due to destructive fishing me land-based pollution and increases in seasurface temperatures.

Estuaries

22. Estuaries denominate enclosed bodies of water at the mouth of rivers where freshwater fron drainage mixes with saline seawater. Due to the continually changing cycle of salinity, water temperature and constant supply of detritus and dissolved nutrients, the diversity is restricted and li to species that can tolerate the varying conditions. Estuaries provide a structurally complex habit offers refuges in the form of macrophyte beds and serve as important nursery grounds. Alth covering a small fraction of the earth surface (<1%) estuaries are estimated to provide a number of human services and indirect ecosystem services at a value of 12% of the total value of the bios (Costanza et al. 1997). Estuarine areas are often densely populated and major threats include development, eutrophication, non-nutrient pollutants and water abstractions.

23. Eutrophication, mainly induced by run-off and riverine inflow from agricultural landscape altered the habitat structure in many of the world's estuaries. The littoral zone in estuaries is ger dominated by seagrasses and brown macroalgae but as a consequence of nutrient enrichment the g of phytoplankton and opportunistic macroalgae is stimulated. The increased biomass results in decr light penetration and extinction of seagrasses in deeper areas. If the increased biomass reaches where the oxygen demand during degradation exceeds oxygen availability, hypoxic events be prevalent. This in turn results in extinction of seagrasses in shallow areas as well as in the de benthic feeders such as mussels. This pattern is common for many European and North Ame estuaries (Flindt et al. 1999).

24. In tropical estuaries the major threat is the increased transport of mud and sediment as consec of riverbank erosion brought on by deforestation and intense rainfall. The increased transportati sediments results in reduced light penetration, destruction of spawning grounds and may lead to r closing of the estuary. Decreased sediment load on the other hand, results in coastal erosion sin shoreline lost by weathering is no longer replaced. Flow modification and dam construction alo river course have reduced the sediment load and caused a severe retreat of the coastline in e.g. e and delta areas of the Nile, Rhône, Volta and São Fransisco river.

25. In Southern Africa land use changes and excessive freshwater abstractions have had the negative impact on estuarine systems (Whitfield 1997). 15% of the estuaries along the South A coast have been assessed to be in poor condition with dwindling fish stocks as one measurable effec

26. In the estuaries of the Bohai, Yellow and East China Sea, costal development is the major ca estuarine degradation. Disappearance of species and shortening of the food chain are some consequences reported in the GIWA assessment.

Mangroves

27. Mangrove communities are largely restricted to the tropics between 30°N and 30°S, with exter to the north in Bermuda and Japan and to the south in Australia and New Zealand. They are only a grow on shores that are sheltered from wave actions and are particularly well developed in estuarir deltaic areas but they may also extend some distance upstream along the banks of rivers. Southeas harbors 48% of the global mangrove area while Latin America/Caribbean and Africa account for and 23% respectively. Mangrove forests are providing important ecosystem services by their abi protect the coastline against erosion and serve as breeding, spawning, and nursing grounds for marine species (Dahdouh-Guebas 2002). In tropical areas 80 to 90% of marine organisms are belie spend some part of their life cycle in the mangrove system (Nickerson 1999, Adeel & Pomeroy 2 For humans, mangroves constitute an economic important resource having lead to its direct abu activities such as overharvesting for timber and fuel-wood, reclamation for aquaculture and salt construction. Indirect negative impact mainly stems from mining, pollution, tourism developmer freshwater diversions (Kairo et al. 2001, Dahdouh-Guebas 2002). The mangrove forests are estima have occupied 75% of the tropical and sub-tropical coastal areas but anthropogenic pressure reduced the coverage by half and the current rate of destruction is on average 2-8% annually (Kairo 2001).

28. A major threat to mangrove forests is the conversion of mangroves to areas of aquaculture acti It is estimated that 1-1.5 million ha of coastal lowlands (out of which 14-43% were mangrove areas been converted into shrimp farms mainly in China, Thailand, India, Indonesia, Philippines, Mal Ecuador, Mexico, Honduras, Panama and Nicaragua (Paez-Osuna 2001). In El Salvador the effe mangrove deforestation is highly visible. The mangrove cover has decreased by half since 1964 has caused a decline in associated reptile, bird and mammal populations (Abuodha & Kairo 200 addition to the physical destruction, the effluents from aquaculture are damaging. Shrimp effluer high in suspended solids, nutrients and organic matter altering the environmental variables for a organisms and thus affecting biodiversity (Paez-Osuna 2001). Although aquaculture contributes to term economic profits, the destruction of mangroves yields long-term economic backlashes. estimated that each hectare of mangrove generates 1.0-11.8 tones of fisheries catch per y developing countries with a market value of 900-12.400 US$ (Dahdouh-Guebas 2002). Aquacultur not have direct transboundary implications but by reducing reproductive sites for aquatic organisr activity will inevitably affect population structure on a wider scale.

29. Mangrove harvesting for export, building material and charcoal production has long be important economic activity in East Africa. The physical destruction of mangroves for timber prod has the same negative consequences for associated flora and fauna as shrimp aquaculture. Alt management steps have been taken in e.g. Kenya, illegal cutting and allocation of mangrove la private developers constitutes a major problem to sustainable utilization of the resource (Abuod Kairo 2001). In order to preserve the mangrove habitat there have been attempts at replanting trees has proven difficult to restore the ecosystem functions lost, even if the forest is successfully reestab (Kairo et al. 2001, Sheppard 2001).

Coral reefs

30. Coral reefs are tropical shallow water ecosystems largely restricted to seas between the latitu 30°N and 30°S and they occur in around 110 countries. They are most abundant in shallow well fl marine environments characterized by clear, warm, low nutrient water of oceanic salinity and saturated with calcium carbonate. Coral reefs are highly productive and diverse ecosystems wi estimated diversity of 800 species of corals and 4000 associated fish (Dahdouh-Guebas 2002) resources derived from coral reefs supply millions of people in the tropics with food and their mo value is disproportionately large; coral reefs constitute 0.2% of the world's aquatic ecosystems bu been estimated to contribute 1.8% to the total value of the biosphere (Costanza et al. 1997). The anthropogenic threats to coral reefs are coastal development, land-based pollution, overfishing destructive fishing methods (Souter & Linden 2000).

31. World wide it is estimated that 36% of the coral reefs are in danger from overexploitation r due to destructive fishing practices. Blast, cyanide and other destructive activities have physically a many coral reefs, while overfishing causes changes in species composition. It is estimated that th resulting from destructive fishing practices on Indonesian reefs is somewhere around 0.1-1.2 m US$/km² of reef over a 25 year period. Blast fishing is most widespread in Southeast Asia and alo East African coast. The explosives dropped onto coral reefs in order to concuss or kill the fish are l damaging to the brittle corals and once the complex structure of the coral reefs are demolished mu its attractiveness to associated fauna is lost. Cyanide fishing is effective in providing live fis aquarium and food markets and Indonesia is currently the largest exporter of live fish covering 5(the world market. The cyanide poison kills the corals instantly at large concentrations but it also a fitness at lower concentrations by impeding the photosynthesis of symbiotic algae (zooxanth (Souter & Linden 2000). The fishing activities on coral reefs are most often local in nature transboundary effects. Depending on the currents, reefs can be either sources or sinks concerning larvae dispersal. Some reefs are very efficient in supplying others with recruits and if these ree targeted fishing grounds the consequences can be widespread.

32. Eutrophication poses an increasingly negative impact on coral reefs. Phytoplankton bloom algal growth covering the corals results in light limitation and promote the spread of coral diseases result of eutrophication the reefs flats outside urban centers in Brazil show high levels of macr cover, 77% compared to 41% in less populated areas (Costa et al. 2000).

33. The condition of coral reefs has been put in additional jeopardy from threats of natural origin l Niño. After the El Niño event in 1997-98, 50-95% of the reefs in the Indian Ocean were bleache consequence of increased water temperatures and most seriously affected were the reefs of mainlan Africa, Socotra, Comoros, Mayotte, Seychelles and the islands of South Asia (Souter et al. Wilkinson 2002).

E. Marine ecosystems

34. Marine pelagic waters embrace the largest ecosystems on earth. The vast volume was long ass to cleanse whatever was discharged and the fisheries resources were considered inexhaustible. T overexploitation of fisheries is a global concern with consequent ecosystem changes far more drasti ever conceived.

- Overexploitation of fisheries has resulted in the collapse of fish stocks in many regions world.
- Eutrophication of semi-enclosed seas has altered the composition of both benthic and p communities.
- Invasion of exotic species is an increasing concern that has knocked out important fish s in e.g. the Black Sea and thereby altered the ecosystem balance.

Pelagic waters

35. The most productive part of the pelagic ecosystem is the upper water mass where light pene and primary production takes place, constituting the basis for the whole aquatic food web. The p ecosystem is highly structured by natural forces like currents, light, temperature and ambient nu concentration. Anthropogenic sources such as pollution, freshwater withdrawal and overexploitatio however, significantly alter the structure and stability of the pelagial. Most issues concerning the pe are of transboundary nature as a result of the interconnectedness of oceanic water masses.

36. Overexploitation of fisheries is rated as a severe problem in 33 of the 47 regions assessed within the GIWA project and overfishing has large implications for the pelagic ecosystem. Overexp fisheries causing the depletion or severe reduction in a trophic level results in disrupted food chain cascading implications for the stability of stocks and ecosystems (Murawski 2000).

37. Atlantic cod fisheries on the East Coast of Canada suffered a collapse in fish stocks in the 1990s. To rebuild the stocks, the entire fishery was closed. While overfishing is generally conside be the single most contributing factor to the collapse, the fishing ban did not generate the exp recovery of stocks. In some areas there have been signs of recruitment and modest catches ar permitted, but in other areas the decline continues (Rose et al. 2000). Overfishing of cod in the Balt has resulted in changes in the offshore fish community; the trophic composition is no longer cont by cod predation but instead of planktivorous fish such as sprat and herring. The increased abunda planktivorous fish in turn contributes to a decreasing cod stock since they prey upon cod eggs and (HELCOM 2001). The reduced coverage of *Fucus vesiculosos* (bladder wrack) in the Baltic has suggested to be a cascading effect of the decline in cod stocks. Juvenile cod spend extended peri *Fucus* belts where they feed upon the crustacean *Idotea baltica*. The crustaceans that live in the se beds consume the plants at high rates when predation pressure is relived. Thus, the reduced num juvenile cods is suspected to have caused a population increase of the crustaceans which th undisturbed have had the chance to devour the *Fucus* plants (Engkvist et al. 2000). The full eff overfishing on the ecosystem structure is still unknown but is certain to reveal as more and more ar the world are exploiting the fisheries resources to and above sustainable limits.

38. In general, eutrophication is most evident in estuaries and small to moderate sized lakes. heavily nutrient polluted waters enter open waterbodies with little exchange or mixing of v eutrophication may however become prevalent in large sea areas. This is the case in semi-enclosed of the Black Sea and Baltic Sea which share many traits with eutrofied lakes and estuaries concerned regions are densely populated, high in agricultural activities and in some cases provide insufficient sewage treatment facilities. The Danube River, flowing through 17 European cou brings large amounts of inorganic nutrients to the Black Sea. As a consequence, the phytopla community has undergone compositional changes and algal blooms have intensified over th decades (Bakan & Büyükyüngör 2000). An area of 30.000 – 40.000 km² annually becomes hy resulting in mass mortality of the zoobenthic community (Black Sea TDA 1997).

39. It appears that a stressed waterbody (e.g. exposed to eutrophication and overfishing) is susceptible to invasive species than a waterbody in ecological balance. In the early 1990s, the Bla was invaded by a comb jellyfish (*Mnemiopsis leidy)*, presumably introduced by ballast water fr Atlantic coast of North America. The introduction was followed by a tremendous population explos the jellyfish and the high abundance of this predator, that consumes fish larvae and eggs, led to collapse of the Black Sea anchovy stock. The anchovy is, despite its low economical value, impor the coastal population in especially Turkey where it contributes considerably to the protein intak jellyfish invasion of the Black Sea has now abated owing to the invasion of another comb jel (*Beroe sp)* that exerts a high predation pressure on *Mnemiopsis* (Bakan & Büyükyüngör 2000).

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Annex I

CASE STUDY: ENVIRONMENTAL AND SOCIO-ECONOMIC IMPLICATIONS OF ECOSYSTEM DEGRADATION IN LAKE VICTORIA

1. Lake Victoria is bordered by Uganda, Tanzania and Kenya that control 45, 49 and 6% respectiv the lake. By surface, it is the third largest lake in the world but the shallow mean depth of 40 m makes the volume of water the lowest among the African Rift Valley Lakes (Hughes 1992). The balance is dominated by evaporation and rainfall with minor contributions from river inflow and ou The relatively low volume of water and long flushing time (138 years) has a negative impact o Lake's capacity to handle discharged pollutants (Lynch 1997, Lindenschmidt et al. 1998, Ntiba 200

2. The Lake Victoria ecosystem has undergone major degradation since the 1960s. Human infl through eutrophication and extensive trawling have interacted to disrupt the food web and thereby the way for two invading species; the Nile perch that rapidly increased during the 1970s, and the hyacinth that infested the Lake during the late 1980s. The invasive species rapidly became dom members of the Lakes biological community, further aggravated the environmental conditions, an ensued by socio-economic problems. The large expanses of water hyacinth caused oxygen deplet shallow areas of the Lake, affecting the recruitment of fish that depend on these habitats for prolife The conglomerating mats also obstructed economic activities like hydroelectric power generation operations, fishing and navigation. The Nile perch on the other hand, has boosted the econon increasing the fish landings but reduced the native stock of planktivorous fish and thereby cau further increase in phytoplankton abundance. In addition, the Nile perch fisheries has raised s problems as the local fisheries transformed to an activity closely integrated with the global economy

Environmental impacts of ecosystem degradation

3. The catchment area is approximately three times the size of the Lake and supports a population million people with an annual population growth of 3-6%. The majority of the population (70 engaged in agriculture and the landuse practice is dominated by farming and livestock keeping. C and tea plantations in the catchment area support a significant part of the nations' agricultural ex Land based activities are major contributors to the current condition of Lake Victoria. Nu enrichment in particular has altered the physical conditions and resulted in characteristics that are t for eutrophied waters. Since the 1960s a number of changes have been observed including (i) a fou decrease in water transparency, (ii) reduced oxygen concentrations, (iii) increased nitrogen levels, 4-5 fold increase in algal biomass, (v) doubled phytoplankton production, (vi) the seasonal success a diverse phytoplankton community has been replaced by a dominance of cyanobacteria, (vi composition of aquatic invertebrates has shifted, (viii) the benthic community has become domina species that can tolerate low oxygen levels such as midgets (*chironomidae*) and the fresh water *Caridina nilotica* (Ogutu-Ohwayo et al. 1997, Lungayia et al. 2001).

4. The nutrients enriching Lake Victoria's water stem from agriculture, domestic source atmospheric deposition. In the near shore areas eutrophication is primarily a result of point source domestic sewage and industries. For the Lake ecosystem as a whole, atmospheric deposition media rainfall is considered the main enriching source. The nutrients stem primarily from combustion pro i.e. wood and charcoal fires for household purposes and burning of vegetated areas for conversio agricultural land (Ogutu-Ohwayo et al. 1997, Scheren et al. 2000, Lung'ayia et al. 2001).

5. The shores of Lake Victoria are swampy and dominated by dense papyrus vegetation. The fri wetlands play an important role in nutrient retention and its high complexity provide habitat for organisms (Kassenga 1997, Bugenyi 2001). Reclamation of coastal wetlands for agriculture the aggravates eutrophication and impedes reproduction of valuable species. Deforestation is another that contributes to eutrophication. The stripping of trees along riverbanks has resulted in erosion further increases the nutrient loading and amount of suspended solids brought to the Lake (LVFO Bugenyi 2001).

6. The disturbances caused by eutrophication facilitated the invasion of the water hyacinth (*Eichi crassipes*) in 1989. The species is native of South America but has spread to many parts of the wo entered Lake Victoria through the river Kagera and rapidly became abundant in bays and inshore sh waters in Uganda and Kenya. The hyacinth forms dense floating conglomerations that effectively the sea surface. The plant reproduces fast and a single individual can produce 140 million daughter every year covering 140 hectares (Matagi 2001, Ogutu-Ohwayo et al. 1997). The major implicati the hyacinth mats for the Lake's biota have been reduced light penetration and oxygen depletion c by decomposing plant material. This in turn has led to loss of spawning grounds and deteric foraging conditions (Lung'ayai et al. 2001, Albright et al. 2001).

7. Fisheries is the main earner of export revenues in the region contributing 600 million US$ anr and provide the direct and indirect employment of 3 million people (Kassenga 1997, Ntiba Fisheries have always been an important source of food and income for local communities in the Victoria area. Until the beginning of the 20th century the fishery was of subsistence character b introduction of more efficient gear and improved infrastructure rapidly led to an increased pressu the fish stocks. Already in 1928 a fishery survey showed that some species were being over- (Oguto-Ohwayo 2001). The most revolutionary change in fishing practice was, however, the introd of commercial trawling activities in the beginning of the 1970s. Trawling led to a sharp decline biomass of native fish species and paved the way for the population explosion of the Nile perch *niloticus*). The Nile perch was introduced to the Lake already in the 1950s but remained at relative numbers until the late 1970s. The onset of commercial trawling activities and reduction of nati stocks seems to have given the opportunity for the Nile perch to proliferate. The haplochromine largest group of cichlids in the Lake, comprised up to 80% of the fish biomass until the early 198 the proportion is now the reverse with Nile perch making up 80% of the biomass (Lynch 1997 haplochromines occupied virtually all levels of the food web from phytoplanktivores to pisc maintaining an efficient flow of organic matter through the system. This flow was disrupted as th perch consume phytoplanktivorous fish in large quantities. This resulted in a further increa phytoplankton biomass and decrease in the light penetration of the Lake - a condition that is advantageous for the perch than for cichlids (Ogutu-Ohwayo et al. 1997, Okeyo-Owuor 1999). combined result of negative impacts, the biodiversity of the Lake has been severely reduced. C estimated 300+ haplochromines endemic to Lake Victoria two thirds have disappeared or are threa by extinction.

Socioeconomic implications of the water hyacinth infestation

8. The water hyacinth infestation of Lake Victoria water's during the 1990s caused many unw socio-economic effects. In Uganda negative impacts of the dense hyacinth mats included (i) ph interference with commercial transportation of people and goods; (ii) physical interference with acc urban and rural water supply and added costs for purification of water with high concentratio suspended organic matter; (iii) obstruction of water intake at the Kiira falls hydro-electric power s resulting in interruptions in power generation; (iv) provision of habitats for unwanted organism bilharzia-carrying snails, mosquitoes and snakes; (v) and physical interference with fishing opera especially in bays where fish are brought ashore to piers and landing beaches. There have been att at estimating the cost of hyacinth interference with some Lake activities and the largest costs associated with maintaining a clear passage to Port Bell, Kampala, amounting to 3-5 million US$ (Albright et al. 2001, Kateregga in prep.).

9. Programs aimed at controlling the spread of the water hyacinth started during the early 199(were primarily directed at manual removal of the water hyacinth. With the hyacinth weighing 400tons/ha manual removal efforts were limited in success. Chemical and biological means of contr the plant was tested in the mid 1990s and an environmental impact analysis concluded that mech and biological control was to prefer (Albright et al. 2001). Biological control of the water hya involved the introduction of two weevils that has proven successfully in controlling the hya (Howard & Harley 1998). In 1997 the Lake Victoria Environmental Management Program (LV

began to support the water hyacinth control program and after a peak in hyacinth abundance in 19 when coverage was 20.000 ha, the affected area has decreased. In Tanzania the coverage of hyacinths was reduced by 99% in eleven months after the release of weevils and in Uganda and the decrease was 55% and 81% respectively during a three-year period. The reduction coincided rapidly increasing population of weevils but also with the El Niño rains of late 1997 and early 199 therefore difficult to conclude whether the weevils or the rains had most effect in reducing the hyacinth cover, but presumably they both contributed (Albright et al. 2001). Even if reduced, the hyacinth has not vanished from Lake Victoria and there are still "outbreaks" of hyacinths m prolonged monitoring and control measures essential in order to keep the species in check.

10. The socio-economic consequences of the water hyacinth invasion have been overwhelr negative. There are, however, a few examples of positive effects. The floating hyacinth ma Murchison bay, Uganda, have for instance contributed to lowering the nutrient levels and th decreased the cost for water treatment. A positive benefit to local communities has been the use water hyacinth in furniture and handicraft production (Fuggle 2002, Kateregga in prep.).

Socioeconomic implications of the Nile perch fisheries

11. The Nile perch has undergone an interesting turn in Lake Victoria. It was introduced in the and successfully out competed the native endemic species of the Lake, then become an important to the fisheries, and is now itself in danger of overexploitation.

12. As a result of the introduction of the perch, the fisheries catch increased from 150 000 tones 1980s to 500 000 in the early 1990s with Nile perch accounting for 65% of the catch. As a consec of the increased landings the associated processing industry flourished and there are more th licensed fish processing factories in the Lake Victoria region (Mbuga 1998). During the 1990s hov the catch has decreased and the average size of the Nile perch has declined considerably indic unsustainable exploitation. In 1994 a ban on commercial trawling and beach seines and nets with size below five inches was imposed. Trawling has since continued despite the ban as enforcemer proven difficult. The large amount of money involved in the business has led to corruption and thre personal security of enforcing personnel (Medard 1998).

13. Although the Nile perch has contributed to economic benefits, services and infrastru development at fish landing sites, it has also transformed local fisheries to an activity closely inte with the global economy and thereby deprived rural people of their livelihood (Okeyo-Owuor 1999 changes in fishing modes from traditional to trawling activities have caused loss and redistribution opportunities. Traditional fishing activities created employment in rural areas while job opportuni relation to trawling are centralized and fewer. Women have been particularly hit as they engag selling and preparing fish that is now transported to processing plants. Fishing is an important occu in the rural areas since alternatives are few and more than 60% of the fishermen in some village higher education further restricting their choice of livelihood. The wages in the trawl-industry are u much higher than in artisan fishery but only a few fishermen benefit compared to the traditional f boats that provided sustained incomes for many fishermen (Medard 1998, Abila, 1998).

14. Despite the large quantities of fish harvested in the Lake, much of the fish is exported and supply is often limited. A survey conducted in 1997 revealed that almost all mature Nile perch lanc Lake Victoria ended up in factories for processing and export. Only juvenile Nile perch, low qualit and trimmings remain for local consumption. Even when fish is plentiful the local households c have the purchasing power to compete with factories, hence food security is a stressing issue in the areas around the Lake (Abila 1998).

15. Other social implications associated to fisheries are conflicts and modified social structures. have been a number of conflicts between local fishermen and trawl operators as a consequen violation of local fishing rules (e.g. protected fish breeding sites) and wrecked fishing gear. In the c locally owned trawl boats and local crew, fishing practices are less frowned upon and cause less co

The influx of migrants (temporary traders, hawkers, adventurers and service providers) in conjunct trawling activities and the increased economic activity has changed the social structure of many f villages. (Abila 1998, Medard, 1998, Mbuga 1998).

Management of Lake Victoria

16. In 1994 the Lake Victoria Environmental Management Project (LVEMP) was initiated by the riparian countries Kenya, Tanzania and Uganda. The project was funded in 1997 by a credit fro International Development Association (IDA) and a grant from the Global Environment Facility through the World Bank. The project is aimed at "rehabilitation of the Lake ecosystem for the ben the people who live in the catchment area, the national economies of which they are a part, and the community". The project consists of several components including fisheries management, water hy control, waste management, wetlands management and capacity building. Achievements up to include among others the reduction of the water hyacinth coverage through biological control prog accomplishment of fishing pressure surveys, and the initiation of management and protection stra for habitats that reflect the biodiversity of the Lake before the onset of eutrophication and invasion Nile perch.

17. The implementation of the project is done through relevant national institutions and gover departments and is coordinated by National Secretariats for LVEMP. A regional Secretariat has established in Dar es Salaam, Tanzania, that is responsible for ensuring uniformity in approach to p implementation and coordination of all regional meetings and activities. The project was initially f to 2002 but additional funds have now been granted from the World Bank. The project, that had implementation problems, is now rated as Highly Satisfactory (World Bank 2001).

18. The three riparian states have ratified the international conventions; the Ramsar Conventi Wetlands of International Importance, the Convention for International Trade in Endangered Spec Wild Fauna and Flora (CITES), and the Convention on Biological Diversity (CBD). They a implementing National Environmental Action plans and have policies and plans for manageme wetlands. Collaboration on fisheries management of Lake Victoria is concerted through the Lake V Fisheries Organization (LVFO) that was established in 1994.

Final remark

19. The multitude of impacts exerted on Lake Victoria has by some been termed "a giant biol experiment". This "experiment" has not only resulted in altered conditions for residing organism also for the riparian population relying on the Lake for food, transport and recreation.

20. With the concerted effort of national, regional and international initiatives, considerable progre been made in incorporating environmental and biodiversity concerns into the management of Victoria during the last decade. Significant improvement of the ecosystem must however, be face long-term goal. Socio-economic aspects put limits on some of the most obvious actions that improve the environmental condition of the Lake. The Nile perch has unquestionably contributed reduction in abundance and biodiversity of native species and a sharp reduction of the perch woul improving their stocks. Due to the high economic value of the Nile perch this option is, hov currently not a conceivable approach to improve the state of the Lake. The environmental and economic causes and consequences of the degradation of Lake Victoria are highly interlinked dema an integrated approach in finding viable solutions for the future.

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Annex II.

CORAL REEFS: THEIR VALUE, THREATS AND OPTIONS FOR A SUSTAINABLE FU

1. Coral reefs are one of the most diverse and productive of all marine ecosystems suppo approximately 4000 species of fish and 800 species of coral (Paulay, 1997). In fact, only one of t phyla that exist on Earth does not occur on coral reefs and 15 occur nowhere else (Norse, 1993). flourish in warm, well lit tropical waters that are virtually devoid of nutrients (Hatcher, 1988; H Guldberg, 1999) making them unique among marine ecosystems.

2. Coral reefs provide a diverse array of fish, molluscs, crustaceans, turtles and algae that are cons by humans and, in many tropical developing nations are the primary source of dietary protein. Cora provide between 10% and 12% of the harvest of finned fish from tropical countries and up to 2 developing nations (Jameson et al. 1995; Gomez, 1997) and the fish catches from shallow coastal v in Asia alone are estimated to support 1 billion people (Lindén, 1990). Their high productivit prompted The World Conservation Strategy (IUCN/UNEP/WWF) to recognise coral reefs as one essential global life support systems necessary for food production, health and other aspects of h survival and sustainable development (UNEP/IUCN, 1988).

3. In addition to the food security offered by coral reefs, much of the economic benefits of ree derived from tourism, particularly in many small island nations. In Seychelles, tourism is the largest foreign exchange earner (UNEP/IUCN, 1988) and contributes 45% of the GNP of Mal (Cesar, 1999) and up to 50% of the GNP of some Caribbean countries.

4. Further, because many of the world's coral reefs are situated along continental margins and su small islands, they perform an important role in protecting the shoreline from erosion by oceanic and tropical storms (Wilkinson & Buddemeier, 1994). The protection offered by coral reefs pe productive mangrove and wetland habitats to flourish in sheltered area and provide essential nu areas for juvenile fish, many of which inhabit coral reefs as adults (Jameson et al. 1995). In ad accretion of white, coral sand along coastlines protected by coral reefs is a significant attract thousands of tourists annually.

5. Finally, because many inhabitants of coral reefs produce bioactive substances for their own d against predators and competitors (Fearon & Cameron, 1998) and the environment (Shick et al. they are coming under increasing scrutiny from pharmaceutical and biotechnology companies. In half of all cancer research is concentrating on active compounds derived from marine organisms (Fe 1996) and the calcium carbonate skeletons of corals are already being used for human bone (Birkeland, 1997).

Threats to Coral Reefs

6. Approximately 3 billion people live in urban areas all over the world and about 60% of these towns and cities located less than 50 miles form the coast. Moreover, 2/3 of the population of devel nations live along the coast. This close proximity of coastal waters to many poor people mean resources extracted from these waters are often the primary source of food and the continued hea coral reefs is essential for their food security. Yet, despite the aesthetic and commercial value world's coral reefs, they are undoubtedly one of the most overutilised and threatened coastal ecosy Bourgeoning human populations, urbanisation and the general migration of people to coastal areas the recent past is placing immense pressure on these habitats and, as a consequence, many coral re being degraded at an unprecedented rate.

Coastal Development

7. The limited space in coastal areas means that development often occurs at the expense of c habitats. The use of land fill to provide sites for housing, industry, recreational facilities and other

works threatens coastal habitats through increased turbidity and sedimentation resulting from soil washed from development sites and onto nearby reefs (Nowlis et al. 1997). In addition, the constr of hotels and accommodation facilities along the foreshore adjacent to coral reefs increases the num people living in these areas and subsequently the amount of waste that is produced. Often waste pro by these developments is discharged directly into inshore lagoons without any treatment and, consequence, coral reefs situated close to these tourist developments often suffer from eutrophi (Jameson et al. 1995). Further, coastal development, especially in small island nations where terr resources are scarce, has promoted the practise of coral mining for the purposes of cement manufa which destroys significant areas of reef (Cesar et al. 1997).

Overfishing and the use of destructive fishing techniques

8. Fishing for food and livelihood is a ubiquitous activity undertaken by humans in coastal habit over the world (Jennings & Polunin, 1996). The dependence of people living within coastal commu coupled with diminishing resources are driving fishers into using more destructive and indiscrir methods of fishing, such as dynamite, cyanide, muro-ami and kayakas techniques, in order to secur and a living for themselves and their families (McManus, 1997).

9. Blast fishing uses explosive charges dropped into the water to concuss and kill fish that are simply picked up by fishers. This form of fishing is highly destructive and widespread, especia south-east Asia (Cesar et al. 1997) and along the east coast of Africa (Johnstone et al. 1998). Int blast fishing can rapidly reduce a once flourishing ecosystem to a pile of rubble (Jennings & Po 1996) causing a considerable reduction in the fisheries productivity of those reefs (Jennings & Po 1996) and will require many years to recover. Fishers that use this destructive method usually l urban areas and lack traditional ties to fishing grounds or they are simply desperate to meet imm requirements for food or income (Jennings & Polunin, 1996).

10. Cyanide fishing began in the 1960s in the Philippines as a result of the increasing mark aquarium fish. Since then, 1 million kg of sodium cyanide have been squirted or dumped onto the re the Philippines alone (Bryant et al. 1998). Unfortunately, this practise has spread both geographical in the range of species targeted and, despite being illegal, is prevalent throughout the south-east region. In addition cyanide fishing is now targeting larger predatory fish such as groupers (Serra and the famed Napoleon Wrasse (*Cheilinus undulatus*) for the live food fish trade (Cesar et al. Indonesia is currently the largest exporter of live fish supplying approximately 50% of the world m which is worth approximately $200 million USD per year (Cesar et al. 1997). Species such *undulatus*, when exported alive to restaurants in Hong Kong and other Asian cities that support si Chinese populations, can fetch prices between $60 and $180 USD per kilogram (Cesar et al. While significant gains can be made in the short-term, in the long-term, cyanide fishing will co national economy dearly. For example, the cost of cynaide fishing to Indonesia has been estimated million dollars over the next 25 years, mostly though lost tourism revenues, while over the same pe susatainably managed hook and line fishery will yeild a profit of $322 million USD (Cesar et al. In addition, cyanide fishing, despite being more selective than other destructive fishing techniqu more insidious because the more remote areas that generally escape land based threats such as poll sedimentation and coastal development are the prime targets for this method of fishing (Bryant 1998).

11. Overfishing causes a change in the size distribution of fish populations, decreases in abundanc shifts in species composition (Roberts, 1995), genetic structure and life history characteristics of target species (Jennings & Polunin, 1996). Furthermore, overfishing can lead to the removal of ke predators which may cause shifts in the community dynamic of coral reefs (Jennings & Polunin, For example, on Kenyan coral reefs overfishing of triggerfish (Balistidae) resulted in a dramatic in in the numbers of the bioeroding sea urchin *Echinometra matthei* which, in turn, lead to increased of reef erosion (McClanahan & Muthiga, 1988).

Land based pollution

12. The close proximity of coastal marine habitats to shore means that they are subject to terr
influences and anthropogenic pressures such as agricultural runoff, development, pollution and re
extraction. In fact, 80% of all marine pollution originates from land-based sources (GESAMP,
The addition of nutrients as untreated effluents from coastal population centres has caused dra
changes on some reefs within these areas (Lundin & Lindén, 1993). The addition of nutrients pro
the growth of algal competitors which may smother the corals and inhibit the settlement of new re
or cause algal blooms that increase the turbidity of the water reducing coral growth. In addition
agricultural practices and deforestation have also lead to decreases in the extent of coral reefs, espe
near river mouths (Bryant et al. 1998). Rainfall washes soil, pesticides and fertilisers from arabl
into rivers and are then transported to coastal waters and dumped on nearby coral reefs. The sedi
smother the corals impeding coral growth and in severe cases killing the coral (Nowlis et al.
Destruction of mangrove habitats at the mouths of these rivers to create space for aquaculture, c
development or simply to supply firewood may exacerbate the problem by reducing their capac
filter excess sediment and nutrients from the water (Jameson et al. 1995).

Bleaching of coral and the significance of increases in global sea temperature

13. Until 1998, the global agenda to conserve coastal habitats had concentrated on preventing
anthropogenic impacts such as inappropriate coastal development, pollution and overfishing. Hov
during 1998, the coral reefs of the world suffered the largest mass coral bleaching event ever witn
Large scale coral bleaching was reported from all tropical regions of the globe (Wilkinson, 1998
subsequent mortality of corals was extensive. In particular, the Indian Ocean was seriously affecte
morality frequently exceeding 75% and sometimes approaching 90% (Linden & Sporong,
Wilkinson et al. 1999).

14. Mass bleaching of hard corals is a sign of stress (Glynn, 1991) and can result either from the l
the symbiotic zooxanthellae that live within the tissues of the coral (Hoegh-Guldberg & Smith, 19
from loss of zooxanthellar pigment (Muller-Parker & D'Elia 1997) or both (Glynn, 1991; Fagoone
1999). While a variety of adverse environmental conditions have been implicated in causing blea
(Hoegh-Guldberg & Smith, 1989; Brown, 1997; Jones & Steven, 1997; Jones et al. 1998),
increases in sea temperature caused by an extreme El Niño event were undoubtedly the primary ca
mass bleaching of coral during 1998.

15. Recent work has determined that when corals and their zooxanthellae are exposed to abnor
high sea temperatures the control mechanisms of photosynthesis malfunction and the zooxanthell
into photosynthetic overdrive which produces oxygen free radicals that are toxic the to corals. Th
order to prevent intoxication the zooxanthellae are expelled (Hoegh-Guldberg, 1999). Onc
zooxanthellae are lost from the tissues of the coral, the tissues become transparent revealing the c
calcium carbonate skeleton giving the coral a white "bleached" appearance. Although a coral t
bleached retains its own tissues and may survive in this condition for weeks or even months, the s
and amino acids produced by the zooxanthellae are essential for its survival and, if the abn
conditions that caused the bleaching do not abate allowing the coral to recruit new zooxanthellae,
die (Glynn, 1991).

16. Prior to 1979, bleaching of coral was known only as a local phenomenon. However, since th
mass bleaching events have occurred and each has coincided with a period of El Niño (Hoegh-Gul
1999). The recent proliferation of mass bleaching events has been caused by the apparently incre
frequency and severity of El Niño events exacerbating rapidly increasing global mean sea tempera
During the last century, the mean global sea temperature has increased by 1°C and the last two de
have been the warmest period ever recorded (Wilkinson et al. 1999). This has brought mea
temperatures close to the upper limit that many corals and their zooxanthellae can tolerate.
consequence, each time a sufficiently strong El Niño event occurs, producing relatively calm w
conditions throughout the tropics which allows solar radiation that would otherwise be dissipa
surface winds, currents and mixing of oceanic waters to be absorbed, the sea temperature rises b

that which can be tolerated by the corals and their zooxanthellae and a mass coral belaching ev witnessed. Once bleached, the likelihood that a coral will is proportional to the length of time for the thermal limit of the coral is exceeded (Brown, 1997; Hoegh-Guldberg, 1999).

17. At present, mass bleaching of corals only occurs if a period of El Niño of sufficient strength pr for long enough to cause significant increases in sea temperature. However, if global sea tempera continue to rise as is predicted by the IPCC (2002), becoming closer to the thermal tolerance lir corals, El Niños of smaller magnitude will be sufficient to cause mass bleaching. Moreover, the the mean sea temperature becomes to the thermal limit of corals the longer will be the period for the tolerances of corals will be exceeded during any El Niño, thus increasing the likelihood of mortality. Eventually, the mean sea temperature will reach a level where normal seasonal increa temperature during summer will be sufficient to cause mass bleaching of corals (Hoegh-Guldberg, Wilkinson et al. 1999). Unless the current trend of rising sea temperatures changes, Hoegh-Gu (1999) forecasts that annual bleaching of corals will begin in south east Asia and the Caribbean a the year 2020, in the northern Great Barrier Reef (GBR) approximately 2040 and in about 2070 southern GBR.

Options for a sustainable future

18. Considering the heavy dependence of millions of people on dwindling coastal resources, ac must be taken to promote the sustainable use of coastal resources to ensure their continued availabi

Implementation of Integrated Coastal Zone Management

19. With the exception of direct overexploitation of resources, most anthropogenic threats to the health of coastal marine habitats originate on land. Subsequently, if sustainable use of coastal resou to be achieved, management strategies must also incorporate land based activities so that pot threats, such as sedimentation resulting from deforestation, coastal development and poor agricu practices, are recognised and dealt with appropriately. During the last decade, the concept of Inte Coastal Zone Management (ICZM) has come to prominence (Linden & Lundin, 1996) offering a facted approach to management of both marine and terrestrial resources. A comprehensive ICZM should consider the wishes of all user groups, such as local people, local and federal governm commercial organisations, non-governmental organisations, conservation lobby groups and scie and promote open dialogue between them. The introduction of ICZM into tropical developing na provides a mechanism by which anthropogenic disturbances to coastal habitats can be mitigate resources used sustainably (McManus, 1997; Wilkinson et al. 1999).

Development of alternative livelihoods

20. Traditionally, many coastal communities in tropical developing countries have been relia coastal habitats for food and economic well being through the conduct of artisanal fishing. Hov burgeoning coastal populations are increasing the pressure on these habitats to continue to supply bounty. Faced with ever diminishing resources, the prospect of economic failure and the lack o alternative source of income, fishers are increasingly turning to destructive fishing practices to ma catch sizes and profitability. The alleviation of this sole dependence on coral reef resources is the achieving sustainable resource use in these regions. Moffat et al. (1998) suggested the only w accomplish this is through community development.

21. The introduction of alternative livelihoods to people traditionally dependent on coastal ha serves to reduce exploitation of these areas in a number of ways. McManus (1997) demonstrate providing an alternative source of income to fishers reduces the fishing pressure on coastal habit making fishing less profitable. This is because in order to go fishing, the fisher forgoes whatever in they would have gained from their alternative source hence increasing the amount of fish needed caught before a profit is returned. Subsequently, when offered a choice, some fishers will stop fish favour of the alternative livelihood thus alleviating some of the pressure on coastal marine reso Furthermore, once families develop the financial capacity to purchase food and other goods they longer dependent on these habitats as their sole source of food.

22. One of the obvious alternative sources of income in coastal areas is tourism. Coral ree particular, are one of the biggest draw cards for tourism and the introduction of tourism to c communities provides a mechanism for economic growth and community development. In adc because tourists are attracted to the natural beauty of many coastal regions, the economic gains ge by tourism will provide incentives to preserve the natural features of these habitats rather than e them. It should be noted however, that, despite the benefits of tourism, its introduction into coastal often brings undesirable factors such as unplanned coastal development and pollution. Therefo introduction of tourism to coastal communities of developing nations should be planned and c managed by all interested parties.

23. Another example of an alternative livelihood is aquaculture exemplified by the seaweed fa undertaken on Zanzibar, Tanzania. The cultivation of seaweed (*Eucheuma spinosum*) was introdu the late 1980's to traditional fishing villages situated inshore of the fringing reef on the east co Zanzibar (Johnstone & Olafsson, 1995). Seaweed, grown in the sheltered lagoon behind this fri reef, is now one of the largest export earners of Zanzibar. This industry provides an alternative to f and an additional source of income for families residing in these coastal communities. Further because sea weed farming is conducted by the women of the villages, they derive this financial b independent of the men which has given them a degree of independence and has also brought g financial security to individual families within these communities.

Capacity development

24. One of the keys to ensuring the sustainable use of resources is having the ability to g appropriate information to make the correct management decisions and then having the capac implement those decisions. Unfortunately many of the nations that are charged with ensuring the health of the world's coastal habitats do not possess sufficient capacity in either of these se Subsequently, increasing the capacity of scientists and managers to gather pertinent inform describing the status of coastal marine resources should be one of the primary objectives of any na programme. The international community can assist with training courses and exchange progra between developed and developing nations to ensure that the nations that possess coral reefs ha capacity to monitor their condition and identify future trends in their health. In addition, assis should be given to scientific development in tropical developing nations. Scientists in these re should have the capacity to recognise and prevent problems arising in their own countries and should have significant input on management decisions.

25. The second facet of capacity development is concerned with implementing and enfo management decisions. Often developing nations have neither the human or financial resources to The low salaries of managers and poor job security of government officials make these people vuln to bribery and political intimidation which exacerbates the problem (Gomez, 1997). Obviousl international community can make financial donations but this is often only an immediate soluti long-term solution is to promote a system of self-regulation in which local user groups monito manage activities conducted in coastal marine habitats. To achieve this form of management it m demonstrated to local user groups why there is a need for management and what the consequen unregulated exploitation are. For this to succeed it is imperative that local user groups are involved the outset in the development and implementation of management strategies. The development o self-regulatory processes negates the need for otherwise expensive government enforcemer circumvents problems associated with corruption.

Appropriately managed Marine Protected Areas (MPAs).

26. The Fourth World Congress on National Parks and Protected Areas called for a minimum of 1 each of the world's biomes to be incorporated into protected areas. The current number of protected in marine environments is well below this recommendation (Kelleher et al. 1995). Jameson et al. suggested the current number of marine protected areas and their dispersed nature are inadequ preserve the biodiversity and fisheries stocks on coral reefs in any part of the world except in Austr Great Barrier Reef Marine Park. These authors recommended that a worldwide system of m

protected areas that includes widely dispersed small reserves and several strategically located reserves encompassing 20% of the world's coral reef should be set up.

27. While there is increasing evidence that marine parks contribute to the diversity of adjacent through the export of larvae and emigration of adults and protection of spawning stock (Polu Roberts, 1993; Gomez, 1997), institutionalising marine parks must be done in the appropriate plac the appropriate reasons and in the appropriate manner. Kelleher et al. (1995), following the guideli out by Kelleher & Kenchington (1992), provide a comprehensive account of "where" and "why" r parks should be set up but in developing nations it is often the "how" that is the most diffic accomplish successfully. Marine parks in these regions often fail because there is lack of public s and willingness of users to follow rules, poor enforcement either through lack of commitment or l financial and technical resources, or through failure to address impacts that originate outside the b of the marine park (Kelleher et al. 1995; McClanahan, 1999). Further, in these countries tradi marine parks that conserve resources through strict regulation of access cannot work because dependence of these communities on these resources for their economic and physical well being cannot ask users to make sacrifices for conservation without providing suitable and viable altern Therefore, biodiversity must be conserved through sustainable use of resources and eff management and the only way to achieve this is to focus on the local people most affected b implementation of the marine park. To ensure the success of marine parks in these regions user g must be incorporated into every stage of the park's development. If a feeling of ownership of the p instilled in the people of the community that depend on the park then they will fell like they ha obligation to see that it is successfully managed. Furthermore, McClanahan (1999) warns that a MP greater chance of success if it is profitable. Indeed, if local communities can see how the setting u marine park can benefit them financially through tourism and continued availability of resource will be more receptive giving the marine park a greater likelihood of success.

Increase monitoring of coral reefs

28. The great majority of the world's reefs occur in remote locations and, as a consequence, condition is unknown (Bryant et al. 1998). Obviously, without appropriate data describing their con and trends in their health making decisions regarding the sustainable use of their resources is dif Therefore increased monitoring of reefs is clearly needed. Wilkinson (1998) demonstrates tha products are yielded from regular monitoring of the state of coral reefs. First, the data that describ status of coral reefs of the world and the establishment of trends in their health and second, the awareness that is generated by the collection of those data. At present, there are several organisa (GCRMN, Reef Check, Aquanaut, Coral Reef Alliance) conducting monitoring of coral reefs. Hov it has only been in the last few years that these organisations have begun to monitor reefs and many reefs remain unsurveyed.

Tighter controls on fishing practices especially those employing destructive techniques

29. Broad-scale testing for cyanide residues in exported and imported fish should be implemente example, a recent coalition has been formed between the government of the Philippines an International Marinelife Alliance that has set up a network of laboratories around the Philippines exported fish for levels of cyanide in their tissues (Bryant et al. 1998). Reef Check (1998) call similar testing of imported fish in target cities for the live fish trade such as Hong Kong and sugg that offending exporters and importers should be punished with sentences that would dissuade the poisons for capturing live fish. In addition, the sale of fish captured using blast fishing techniques s be prohibited. To facilitate such legislation fisheries managers and fish market agents should be tau recognise fish captured using blast fishing techniques and should report fisherman engaging in destructive activities.

Final remark

30. The widespread poverty and overpopulation of the coastal zones is placing an unsustainable b on coastal habitats and the resources they provide. Only through the systematic implementati integrated coastal zone management that involves all user groups and managers alike and focus

poverty alleviation through community and capacity development and issues of public awarenes sustainable use and conservation of coastal marine resources be achieved. Without such action the health and food security of human and coastal populations could be compromised. Furthermor spectre of global warming and rising sea temperatures determines that reef management and conser is no longer the sole responsibility of countries fortunate enough to have coral reefs. Ensurin sustainability of the world's environment is now the responsibility of all nations includin industrialised, first world nations.

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