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Indonesian Seas

GIWA Regional assessment 57

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Executive summary

The Indonesian Seas GIWA region 57 contains most of the land and seas of the Republic of Indonesia; some 18 000 islands with 1.9 million km^2 of land area and 6 million km^2 of seas. The region is geologically and topographically diverse, lying at the global centre of tropical marine biodiversity. Because of the highly significant geographic, oceanographic, demographic and biodiversity differences within the region, the Assessment was conducted independently for three sub-systems:

- Sunda (western part of the region);
- Wallacea (central part);
- Sahul (eastern part).

The priority international waters issues and concerns vary markedly among the three sub-systems. Sunda's international waters resources are under most severe environmental and socio-economic pressure. Major concerns for the present include Pollution, Habitat and community modification and Unsustainable exploitation of fish. All of these concerns are already having severe environmental and socio-economic impacts and are expected to deteriorate further over the next 20 years, primarily because of population growth and lack of adherence to and enforcement of regulations. Freshwater shortage is, at present, exerting moderate to severe impacts on the sub-system and is also expected to caused severe environmental and socio-economic impacts in the future. For Wallacea and Sahul, the major concerns are Unsustainable exploitation of fish and Habitat and community modification, with the present moderate to severe environmental and socio-economic impacts expected to stabilise (habitats) and worsen (fish) in the future. There are expected to be complex linkages between global change effects on freshwater shortage and habitat loss, and also between continuing habitat loss and fisheries and increasing pollution and fisheries in all three sub-systems.

The present population of the region is approximately 210 million, with approximately140 million living within 60 km of the coasts. Most people live in Sunda, with 100 million on Jawa alone. Future scenarios suggest an overall human population increase of approximately 1.7% per year to approximately 300 million in 2020. There is expected to be increasing urbanisation and reliance on extractive industries; mining, plantation agriculture, aquaculture, mariculture and industrial fishing. There is already widespread overexploitation and use of inappropriate technologies, raising serious concerns as to even the medium-term (decadal) sustainability of the production systems. There are also likely to be limits to development of other sectors from freshwater shortage, particularly through linkages with habitat loss and global change.

Total pressures are likely to increase moderately to severely over the next 20 years, being driven by the continued population growth, which is expected to cause significant deterioration in environmental and socio-economic aspects of all major concerns. Importantly, rate of deterioration will be contingent upon the success of improved regulation and ongoing and future planned interventions by government and non-government organisations (NGOs).

The causal chain analysis was focused on destructive fishing practices; particularly poison fishing to supply the burgeoning international live fish food trade and ornamental aquarium trade. Destructive fishing, and poison fishing in particular, is an increasing problem of great future concern that already impacts all three sub-systems, both in terms of fish and habitat loss. It has major transboundary implications, both in terms of target species population dynamics and replenishment, and in terms of the driving forces of international market demand. The most significant root causes are the interactions among market trends (notably the insatiable international demand for seafood) and poverty among coastal people, driven by rapid population growth. Population growth is exacerbating the lack of employment and poverty, which are placing greater pressure on fisheries. Lack of enforcement of laws governing destructive fishing, abetted through corruption within

enforcement agencies and government, allows the illegal practices to flourish. Indonesia is party to most of the key international treaties and conventions, and the relevant government departments have proposed policies or legislation in relation to these obligations. However, only modest progress has been made to date in their effective implementation and the resolution of related problems.

Most laws and regulations are not well accepted and the effectiveness of implementation of national laws at provincial and local levels varies markedly. There is insufficient capacity for effective alleviation, in part related to currency depreciation, shifts in government spending and recent political instability. Despite a recent trend towards decentralisation in governance, there remains insufficient capacity for effective stewardship and control of the renewable resources. Key government departments, including the enforcement agencies, are hampered by a lack of qualified and experienced staff, and also by funding shortfalls and cutbacks.

Economics and market trends drive the unsustainable use of resources and also influence corruption and the illegal practices. Addressing the combined synergistic negative impacts of population growth, political instability and widespread poverty among coastal populations is at the core of developing successful policy options and implementing successful interventions, along with concurrent efforts to address international demands.

At present, policy options and legislation are neither sufficiently well developed nor integrated to facilitate implementation of the most urgent remedial measures. Recommended policy options for Indonesian Seas, from the broad-scale to the fine-scale, include:

- Improved integration of local, provincial and national laws and regulations in order to maximise effectiveness of the legislative instruments to control destructive fishing at local and national levels, and to better encompass all sectors and meet obligations under international conventions and treaties.
- Improved surveillance, enforcement and effective policing of laws to reduce illegal fishing practices, including development and effective implementation of export quotas, catch and fish size limits.
- Continued and expanded community education programmes;
- Improved incomes for fishermen through generation of ecologically viable alternative or additional incomes (e.g. well planned and ecologically-sustainable mariculture).
- Development of alternative legal supply lines for live fish, particularly through mariculture, with increased supply of such maricultured species to supplement dwindling catches of wild stocks.
- Expanded research and development to 'close' the reproductive cycles of the key mariculture species in captivity, with opportunities for increased regional collaboration.
- Major expansion and improved integration of the marine protected area (MPA) network, with improved management, including major focus on community co-management, particularly in relation to fisheries, with increased development of 'no-take' zones, and protection of spawning aggregation sites.

National surveillance strategies, with participation from all levels of government, NGOs and local communities may be the best way of bridging the gaps between formulation, legislation and enforcement of regulations. There are many national, regional and international "players" actively pursuing sustainable development initiatives, and best use of this developing network should be made during future policy implementation. Government – donor projects such as the Coral Reef Rehabilitation and Management Project (COREMAP) and Marine and Coastal Resources Management Project (MCREP), among others, and NGO programmes such as the Wallacea Bioregion (World Wildlife Fund), Komodo National Park Management Plan and others provide useful models for future improvements in fish and habitat protection.

In this regard, there has been recent convergence in views among scientists and resource managers on the crucial importance of MPAs and MPA network strategies as tools for sustainable fisheries management and resource protection. An integrated network of well-designed and well-managed MPAs should form the core of fisheries management and marine conservation strategies. The development of a functional, integrated network of MPAs is an extremely urgent priority and there is an immediate need for the establishment of substantial no-take zones, with the development of policy and legal frameworks that facilitate the process.

Two major foci for action are apparent:

- The urgent need for effective management of the existing MPA network.
- Careful planning and continued support for expansion of the network in terms of integration, particularly of cluster and transboundary protected areas with neighbouring nations in relation to the increasing effects of global change.

Successful implementation will primarily require a high degree of local intervention and community-based support, including application and local enforcement of 'no-take' replenishment areas in MPAs and protection of fish spawning aggregation sites, and also reliable stock assessment and monitoring. These need to be founded in an improved

understanding of the population biology of the target species and issues of ecological scale and connectivity in relation to replenishment, including:

- Catch volumes and Catch Per Unit Effort (CPUE).
- Traditional knowledge (e.g. locations of spawning aggregation sites of major commercial species), for development of protection measures.
- Natural changes in diversity, distribution and abundance of major commercial species, in relation to seasonality effects, predator-prey relationships, recruitment fluctuations.

Concurrently, policies addressing the international demand aspects of the fishery, both for food and aquarium fishes, need to be implemented. A useful model is provided by the Marine Aquarium Council (MAC). The Indonesian Ministry of Marine Affairs and Fisheries signed a Memorandum of Understanding (MoU) with the MAC in July 2003, formalising the strong government support for the MAC's work in developing fishery sustainability in Indonesia. With effective management, the aquarium industry can support long-term conservation and sustainable use of coral reefs in regions where other options for generating revenue are limited (UNEP-World Conservation Monitoring Centre Director Mark Collins). Thus, the recent MoU between the Government of Indonesia and the MAC regarding the collection and export of ornamental aquarium fish can provide a useful model for the live food fish industry.

The Indonesian Seas region lies at the centre of the world's marine biodiversity, support rapidly growing, generally poor, coastal populations and have rapidly deteriorating riverine, coastal and marine ecosystems, with continued degradation and possible collapse of many international waters resources. The policy options recommended herein affect much of society, and place major responsibilities on government, NGOs, educational institutions and the private sector. The challenge of gathering the cooperation necessary for the sustainable development of this critical region is great, but not insurmountable. More appropriate allocation of local funds with continuing international assistance will be required in the short-term. In particular, development and population policies require urgent review if growth over the next several decades is to be managed effectively and the present rapid rate of increase of impacts is to be curbed. In recognition of the central importance of Indonesian Seas in terms of global biodiversity, and the severe threat posed by the complex interaction of factors identified herein, the Task team suggests that Indonesian Seas be afforded the highest priority by the Global International Waters Assessment.

Abbreviations and acronyms

ADB	Asian Development Bank
AIG	Alternative Income Generation
ASEAN	Association of South East Asian Nations
BAPEDAL	Environmental Impact Management Agency
BAPPEDA	Regional Planning Boards
BOD	Biological Oxygen Demand
CBD	Convention on Conservation on Biological Diversity
CI	Conservation International
CITES	Convention on International Trade in Endangered Species
COREMAP	Coral Reef Rehabilitation and Management Project
CPUE	Catch Per Unit Effort
CRIF	Central Research Institute for Fisheries
CSIRO	Commonwealth Scientific & Industrial Research Organisation
DGWRD	Directorate General of Water Resources Development
EEZ	Exclusive Economic Zone
ENSO	El Niño Southern Oscillation
GCRMN	Global Coral Reef Monitoring Network
GNP	Gross National Product
GOI	Government of Indonesia
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management Program
IUCN	World Conservation Union
IUUF	Illegal, Unreported, and Unregulated Fisheries
KNP	Komodo National Park
LIPI	Indonesian Institute of Science
LME	Large Marine Ecosystem
MAC	Marine Aquarium Council
MAREMAP	Marine Resources Evaluation, Management and Planning Project
MARPOL	International Convention on the Protection of Pollution from Ships
MCREP	Marine and Coastal Resources Management Project
MoU	Memorandum of Understanding
MPA	Marine Protected Area
MREP	Marine Resources Evaluation and Planning Project
MSY	Maximum Sustainable Yield
NGO	Non Governmental Organisation
PEMSEA	Partnership in Environmental Management for the Seas of East Asia
PKA	Directorate General for Forestry Protection and Nature Conservation
PROKASIH	Program Kali Bersih (Clean River Programme)
SARS	Severe Acute Respiratory Syndrome
SPM	Suspended Particulate Matter
SST	Sea Surface Temperature
TNC	The Nature Conservancy
ULCC	Ultra Large Crude Carriers
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization
WRI	World Resources Institute
WWF	World Wildlife Fund

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Regional definition

This section describes the boundaries and the main physical and socio-economic characteristics of the region in order to define the area considered in the regional GIWA assessment and to provide sufficient background information to establish the context within which the assessment was conducted.

Boundaries of the region

The Indonesian Seas regional boundaries encompass most of the approximately 18 000 islands and territory of the Republic of Indonesia, being bounded on its western and northern extent by the adjacent GIWA regions of Bay of Bengal (GIWA region 53), South China Sea (GIWA

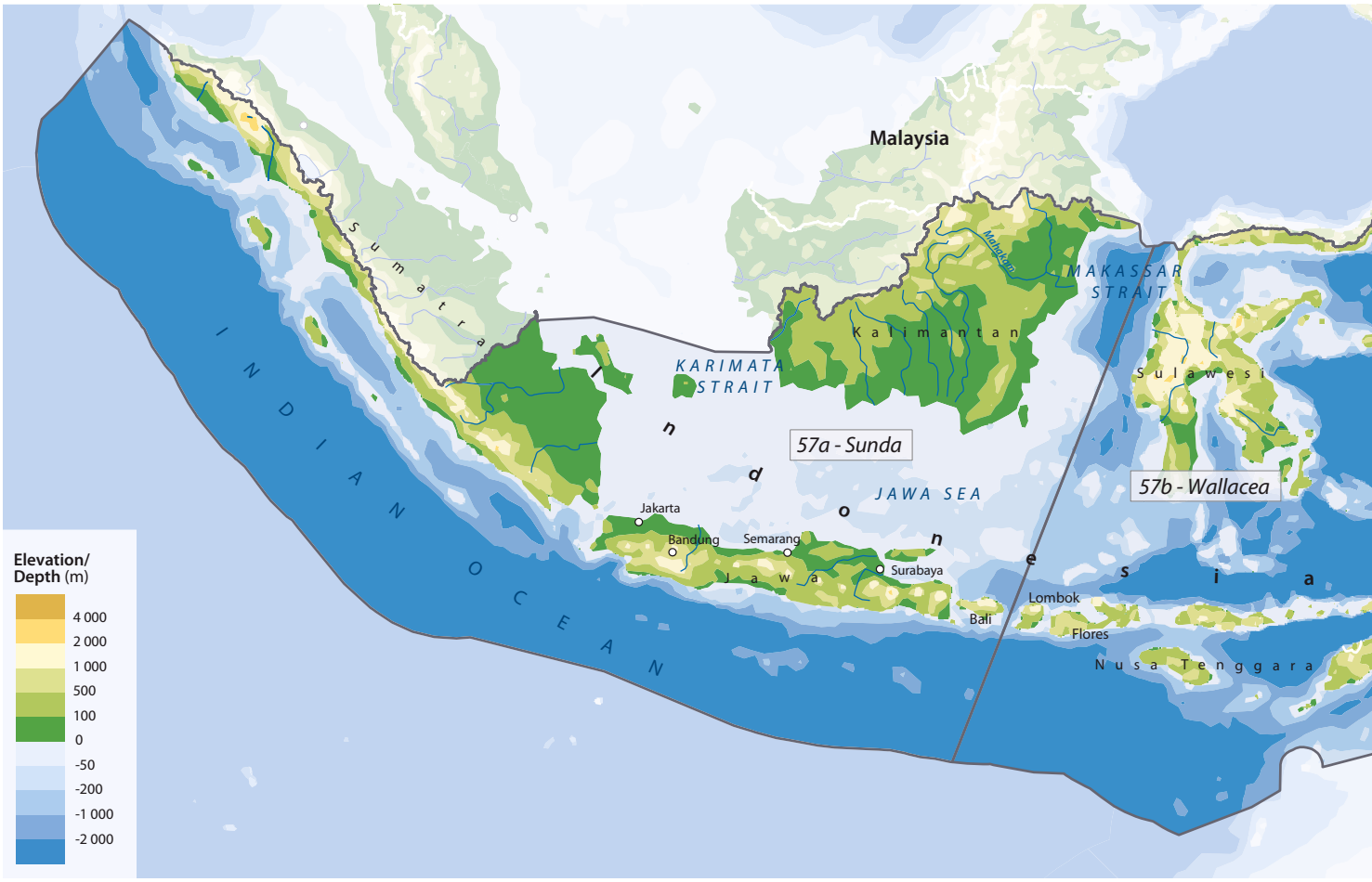

Figure 1 Boundaries of the Indonesian Seas region.

region 54) and Sulu-Celebes (Sulawesi) Sea (GIWA region 56); on its southern extent by the North Australian Shelf (GIWA region 58); and northeastern extent by Pacific Islands (GIWA region 62). The region is composed of many smaller seas of diverse character; including the Jawa Sea, Bali Sea, Flores Sea, Sawu Sea, Timor Sea, Banda Sea, Seram Sea, Maluku Sea, Halmahera Sea and Arafura Sea, and the Makassar Strait.

At its eastern extent, the regional boundary was extended to encompass all of Irian Jaya (Papua), Kepulauan Aru and Kepulauan Tanimbar, following the 200 m depth contour on the northern coast of Irian in the north and across the Arafura Sea on the Indonesia/Australia territorial boundary to the Irian Jaya/Papua New Guinea territorial boundary in the south (Figure 1).

On its western extent, the boundary include the southwestern portion of Sumatra, its catchments, and islands of Kepulauan Mentawi and Nias. The region boundary includes all of southern and eastern Sumatra, following the central dividing range of Sumatra from Aceh in the north to Jambi in the central highlands, then northwards to the coast.

The boundary continues from the north coast of Sumatra in Jambi Province across the Karimata Strait to include the southeastern area of Sumatra and Pulau Bangka and Belitung to the South-West Kalimantan border, then north along the provincial border to include all of South Kalimantan and parts of East Kalimantan, notably the Mahakam River catchment.

On its northwestern extent, the boundary continuing east across Makassar Strait and includes most of Sulawesi. The northern boundary includes the islands of Halmahera and Morotai, and follows the 200 m depth contour eastwards along the north coast of Irian to the Irian Jaya/Papua New Guinea (PNG) territorial border. The southern boundary extends from the Irian Jaya/PNG territorial border across the Arafura Sea following the Indonesia/Australia territorial boundary, to the south of the main island chain, including the Jawa Trench in the Indian Ocean, to the northwestern tip of Sumatra (Aceh). The region also includes the small independent state of East Timor.

Exclusions of Indonesia's territory from the region include the northeastern and central parts of Kalimantan facing the Malacca Strait as well as the western part of Kalimantan (including Indonesian West Kalimantan, Malaysian Sarawak and Sabah and Brunei). The north coast of Sulawesi, parts of East Kalimantan and the south of the Jawa Trench, Christmas Island and Cocos-Keeling Island (Australia) are also excluded.

International waters, in the sense of the GIWA definition, include the entire coastal and marine area; as this is a potential source or recipients of transboundary impacts, primarily from shipping, fisheries, pollution, introduction of alien species, riverine discharges, and law and order issues.

Given the major differences that exist in geomorphology, oceanography, bathymetry, climate, biodiversity, patterns of human demography, use and impact and transboundary issues within Indonesian Seas, the region was assessed as three sub-systems:

- Sunda (western part of the region);
- Wallacea (central part);
- Sahul (eastern part).

Boundaries of the sub-systems

The Sunda sub-system includes all the western islands and waters that are developed on the Sunda Shelf from the northern tip of Sumatra, southeast along the central range then northeast to include East Kalimantan, and southwards to Jawa and Bali in the east. The sub-system also includes the Indian Ocean waters of the Jawa Trench to

the south of Sumatra/Bali. The boundary between Sunda and Wallacea passes through Makassar Strait and Lombok Strait to the east of Bali.

Wallacea includes the central islands and waters of the region, extending eastwards from the Makassar and Lombok Straits to encompass Sulawesi, Lombok, Sumbawa, Flores, Sumba and the smaller islands of Nusa Tenggara, Ambon, Ceram, Buru and the other Maluku Islands, Halmahera and Morotai and the Kai, Aru and Tanimbar Islands in the east. The eastern boundary of Wallacea follows the border of the Sahul Shelf. Wallacea encompasses the area of transition of Asiatic and Australasian biodiversity initially noted by A.R. Wallace in the mid-1800s ('Wallace Line'), and after which the sub-system is named. Boundaries of the Wallacea sub-system are also in close congruence with those of the WWF Wallacea Bioregion (see below).

Sahul includes Irian Jaya and the Rajah Ampat Islands of Pulau Waigeo and others, Pulau Misool and Kepulauan Schouten. The sub-system includes the major central mountain range of Pegunungan Maoke and major river systems of Mamberamo-Tariku-Van Daatan-Taritatu on the north coast and Digul and Pulau Vriendschaps on the south coast.

Physical characteristics

The Indonesian Seas region contains most of the land and seas of the Republic of Indonesia, which is the world's largest archipelagic nation, with some 18 000 islands. The region is 6 million km^2 of which 1.43 million km^2 is land. The major islands in the region are Sumatra, Jawa, Nusa Tenggara, Kalimantan, Sulawesi, Maluku and Irian Jaya (Papua). Most of the major islands have a mountain range running for much of their length. The mountains are mostly of volcanic origin and in some cases remain active. The elevations of the islands range from 0 to 5 030 m above sea level.

Geologically, the Indonesian Seas region lies at the confluence of three tectonic plates: the Eurasian Plate, the Indo-Australian Plate and the Pacific Plate. The Island of Kalimantan (Borneo), the third largest island on Earth, lies on the Asian continental (Sunda) shelf, is physically stable and has been joined by a land bridge to the Asian mainland during Pleistocene and earlier periods of glaciation (Daws & Fujita 1999). Similarly, Papua lies on the relatively geologically stable Sahul Shelf, and the larger Island of Irian (New Guinea) has been joined to Australia during glacial falls in sea level. Sumatra and Jawa lie on the southeastern edge of the Sunda Shelf, and with many of Indonesia's islands are subject to tectonic instability and volcanic activity (with numerous active volcanoes and earthquake occurrences). In total, Indonesia has some 129 volcanoes, 15 of which are considered critical and likely to explode, with three to five eruptions annually. Thus, most of Indonesian Seas are in a geologically active region.

Climate

The Indonesian archipelago stands between the Pacific and Indian Oceans and is heavily influenced by annual and inter-annual variations in surface temperature due to a reversing monsoonal system. The region lies within the sub-equatorial and equatorial zones (from latitudes 4° N to 10° S), and mostly lies under the influence of the seasonal monsoon winds. There are two seasons, the dry season and the wet season. The dry season lasts from March to August and the wet season from September to March with the heaviest rainfall usually from November to February. Annual rainfall in excess of 1 000 mm occurs in many of the western and eastern areas and annual minimum temperatures are usually more than 20°C other than in the highlands. Rainfall in the region is highest on the upland areas, notably of central Kalimantan (Borneo), central Sumatra, Jawa and Papua. Some places receive more than 3 000 mm of rain annually. By contrast, parts of the lowlands, coastal areas and other areas in rain-shadows receive far less rain (less than 1 000 mm/year), and may experience severe water shortages. Examples include some of the islands of Nusa Tenggara, to the east of Bali and Lombok. The temperature ranges from 21 to 33°C, but at higher altitudes the climate is cooler. Humidity is mostly between 60 and 80% (FAO AQUASTAT 2003).

A recently discovered climate feature, the Indian Ocean Dipole (IOD), is linked with fluctuations in sea surface temperature (SST) within the region. For example, in 1997, anomalously cool SSTs occurred in the eastern Indian Ocean, affecting parts of the region, both in terms of environmental and socio-economic impacts (Abram et al. 2003).

River basins and water resources

The region includes the drainage basins of streams and rivers of most of Indonesia, some 5 590 rivers in all, and including the major river systems of the larger islands of Jawa, Irian, Sumatra and Kalimantan. The regional boundary was extended to include the major Mahakam River and catchment of East Kalimantan, flowing into the Makassar Strait. The Mahakam River drains almost one third of East Kalimantan, with a discharge of 1 500 m^3/sec, a suspended sediment load of 80 mg/l, a sediment yield of up to 10 million tonnes annually, producing a plume for some 400 km to the southeast of the delta into Makassar Strait (Dutrieux 1991). South Kalimantan has many smaller rivers and streams, including the Negara, Medawai, Sampit, Pembuang, Arut and Lamandau rivers. Major rivers of southeast Sumatra include the Seputih,

Tulangbawang, Musi, Kamering, Rawas and Hari rivers. On Jawa, major rivers include the Japat, Sadane, Tarujm, Kali Mas, Manuk, Serang, Solo and Brantas rivers flowing into the Jawa Sea on the north coast. In Papua, the major rivers include Digul and Vriendschaps.

There are also numerous smaller rivers and streams flowing from the mountainous interiors of most of the islands in the region. Although water resources are abundant, the seasonal and spatial variation in the rainfall pattern and lack of adequate storage create competition and conflicts among users. Most of the lakes in Indonesia are volcanic in origin. Lake Toba, Sumatra, is the largest volcanic lake in the world, with an average surface area of 1 100 km^2 and an average volume of 1 258 km^3 (FAO AQUaSTAT 2003).

Oceanography

The Indonesian Seas Large Marine Ecosystem (LME) has an area of 400 000 km^2 and extends from east to west across a distance of 5 000 km (LME 2003). The LME has strong tidal currents and the pattern of surface currents varies during the southeast and northwest monsoon. It also experiences annual and interannual variations in surface temperature. The warm ocean and its links to the atmosphere create the El Niño Southern Oscillation (ENSO) phenomenon. The influence of El Niño, La Niña and the Australian and Asian monsoons contribute to the unique climate conditions in this region, of major relevance to global climate and the subject of continuing climatological research.

The region has complex bathymetry, the western area lying on the Sunda Shelf, the central area forming a transition zone composed in part by the deep basins of the Flores and Banda Seas and the eastern area lying on the Sahul Shelf. Coastal waters of the Sunda Shelf, the Jawa Sea and the Sahul Shelf are shallow (<200 m depth) and influenced by both marine and terrestrial inputs. By contrast, the Banda Sea has depths greater than 4 500 m, the Flores Sea is deeper than 5 000 m and the Jawa Trench exceeds 6 500 m in depth. Most of these seas can be characterised as marginal seas, being enclosed by island landmasses, and with oceanic input from the Pacific and Indian Oceans in the Indonesian Through-flow. The Through-flow, the exchange of ocean water between the Pacific and Indian Oceans, is thought to be influenced by, and may influence in turn, ENSO.

The Indonesian Through-flow exports warm, relatively fresh (low salinity) thermocline water from the North Pacific, providing a major freshwater source for the Indian Ocean. Strong ocean mixing influences sea surface temperature and nutrient concentrations (LME 2003). This influx of Pacific oceanic waters moves into the area from the Sulawesi Sea via the Makassar Strait and through corridors between Sulawesi, Halmahera, Morotai and Papua and focused through the Lombok Strait (Bali-Lombok) and corridors around Timor. There is a general north-south through-flow, but with some (mostly sub-surface) flow in the opposite direction. Additionally, reversing seasonal surface currents driven by the monsoon winds bring waters from the South China Sea into and out of the Jawa Sea along the north coasts of Sumatra and Jawa and southern coast of Kalimantan. The Jawa coastal current flows eastwards to the south of Jawa/Sumatra. Local current patterns form complex eddies and counter-currents around most islands, and in places reach speeds of more than 5 knots.

The southern coastlines from Sumatra to Timor and northern coastlines of Halmahera, Morotai and Papua are under the influence of long period ocean swell that can exceed 5 m in height from the Indian and Pacific Oceans, generated by tropical-temperate storms, many of which are thousands of kilometres away. More localised severe waves (tsunamis) can be generated by tectonic activity, such as that which devastated southern Sumatra and northern Jawa following the Krakatau volcanic cataclysm of August 1883. By contrast, within the marginal seas of the Indonesian Archipelago, ocean swells are generally less than 2 m high and generated by local weather patterns and the trade winds of the monsoons, and sea conditions are often calm and referred to as "the doldrums".

Coastal and marine ecosystems

Mangroves and seagrasses

Most of the region's protected coastlines were originally fringed by mangrove forests and seagrass beds. Mangroves, with some 47 species known from Indonesian Seas, have an area estimated at between 2.49 million ha (Tomascik et al. 1997) and 4.25 million ha (Wilkinson 1994). Most mangroves are located in Papua (estimated at 29 000 km^2), Sumatra (4 170 km^2), Kalimantan (2 750 km^2) and Jawa (343 km^2) (Priyono & Sumiono 1997). This represents over two thirds of the area of mangroves in South East Asia. Seagrass beds are even more extensive (30 000 km^2 according to Tomascik et al. 1997) with 13 species developed in varied habitats from intertidal mudflats to shallow sandy beaches to coral reef flats. However, extensive cutting for timber, conversion for aquaculture and other forms of coastal development and extensive siltation/sedimentation have caused major fragmentation and reduction in the area of these habitats (see Assessment, Habitat and community modification).

Coral reefs

With a total estimated area of between 50 000 and 90 000 km^2, Indonesia's coral reefs comprise more than 10% of the global total (Spalding et al. 2001). By contrast, an earlier official estimate for the area

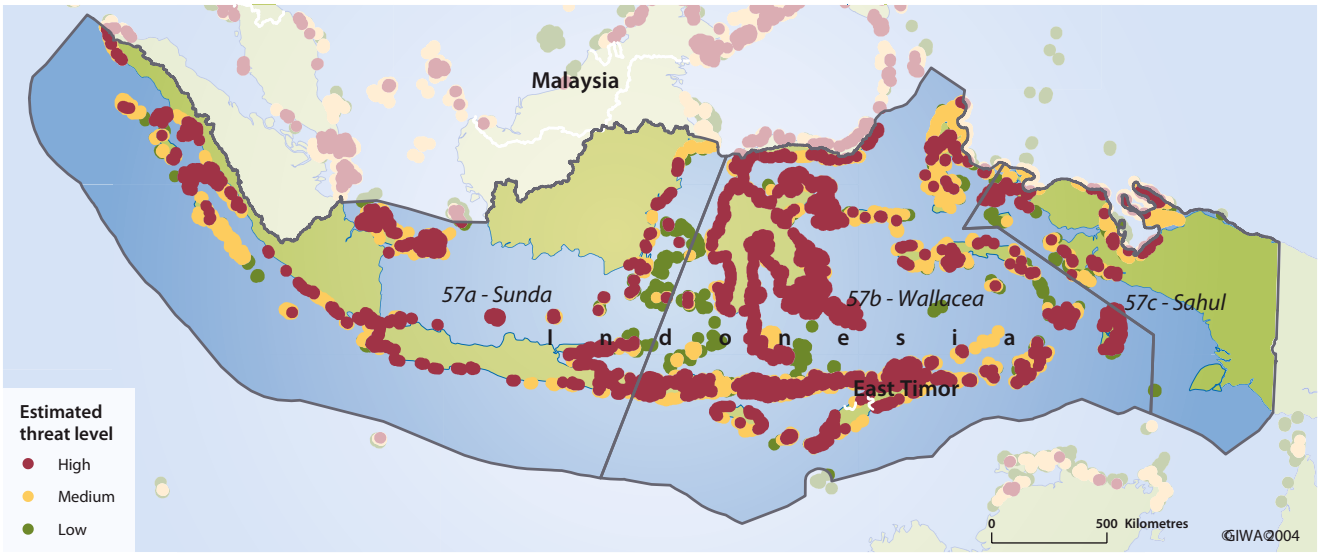

Figure 2 Reefs at risk in the Indonesian Seas region.
(Source: Burke et al. 2002)

of coral reefs is just 7 500 km^2 (KLH 1992). However, another re-estimate by Tomascik et al. (1997), based on a longer figure for total coastline, is 85 707 km^2 which represents about 14% of the world total (Hopley & Suharsono 2000). As with the coastal habitats, reefs of the region have been damaged through destructive fishing, sedimentation and other forms of human use. Many of the region's reefs (~ 80%) are at extremely high risk of further damage from human activities (e.g. Bryant et. al. 1998, Burke et al. 2002) (Figure 2).

The coast under the immediate influence of the major river systems (e.g. Mahakam and Berau rivers, East Kalimantan) is mostly devoid of fringing coral reefs, although small fringing and patch reefs are present in some places. Fringing reefs are very well developed away from the major river estuaries and fringe much of the coastlines of the approximately 18 000 islands of the Archipelago. Some of the most widespread fringing reefs in Indonesia are in the turbid waters of the Aru Islands, which consist of six main islands and 79 smaller islands separated by long narrow channels (Tomascik et al. 1997, Hopley & Suharsono 2000). Offshore, series of large platform reefs and atolls are developed; the most famous being the Taka Bone Rate Atoll reefs of the Flores Sea. All major reef types; fringing, patch-platform (including barrier) and atolls, occur. Offshore in eastern Kalimantan, the better water quality has allowed the development of barrier reef systems.

The longest barrier reef in Indonesia, the Great Sunda Barrier Reef, runs inside the 200 m isobath at the margin of the Sunda shelf, some 60 km offshore, and has a length of 630 km. Smaller barrier reefs occur north of the Mahakam Delta. The Berau system is immediately north of the Berau Delta, in places only 10 km offshore, and has a length of 25 km. Parts of the Mangkalihat Peninsula are also bordered by a barrier reef. The most unique barrier system in Indonesia is the Banggai Barrier Reef running 175 km along the southern margins of the Banggai Islands. Part of this barrier consists of lagoonal 'faro' reefs very similar to those of the Maldives. North of the Mangkalihat Peninsula are three major reefs which Tomascik et al. (1997) term atolls, although Hopley and Suharsono (2000) consider that they are more likely to be large lagoonal shelf reefs rather than fulfilling the strict geological criteria for oceanic atolls with volcanic foundations. Similarly, Tomascik et al. (1997) describe 27 atolls in the waters around Sulawesi. Tomascik et al. (1997) and Hopley and Suharsono (2000) provide detailed analysis of the reef types and their distribution. Moosa et al. (2002) provide a recent overview of the status of research into Indonesia's coral reefs.

Because of their rich biodiversity, diverse geo-morphology and great importance in providing sustenance for local human populations, the coral reef areas around much of Indonesia are recognised as being of exceptional conservation value. These include the patch reef complexes of northern Jawa, fringing reefs of Bali, fringing, patch and atoll reefs of Sulawesi (e.g. Taka Bone Rate, Tukang Besi Islands, Bay of Tomini, Bunaken), Nusa Tenggara, the Banda Sea and northern Papua (notably Rajah Ampat Islands and Teluk Cendarawasa).

Halimeda bioherms

A closely related habitat which requires similar management and conservation approaches to coral reefs is the major area of *Halimeda* algal bioherms, notably at the southern end of the Makassar Strait

(Phipps & Roberts 1988, Hopley & Suharsono 2000). Associated with the Kalukalukuang Bank in particular, these algal 'reefs' also occur around the margin of the Sunda Shelf towards Kalimantan. Here algal growth is favoured over reef growth as nutrient rich deep Pacific water floods southwards through the Makassar Strait and upwells around the banks and shelf margin (Hopley & Suharsono 2000).

For further information and a detailed and informative description of the oceanography, biology and ecology of Indonesian Seas, see Tomascik et al. (1997).

Biodiversity

With the adjacent regions of Sulu-Celebes (Sulawesi) Sea and South China Sea, the region lies within the global centre of biodiversity for marine species (Table 1), supporting for example more than 500 species of reef-building corals, 2 500 species of marine fishes, 47 species of mangroves and 13 species of seagrasses (Veron 1995, Chou 1997, Tomascik et al. 1997, Veron 2000, Spalding et al. 2001). The exceptional biodiversity of marine flora and fauna is a result of its geographical and geologic history. The vast archipelago is a "melting pot of a number of biogeographic provinces" (Tomascik et al 1997), and includes seven of the eight first order biogeographic divisions of East Asian Seas (Hayden et al. 1984, Bleakley & Wells 1995). Indonesian Seas also include the deepest seas of South East Asia, and the pelagic realm is an important habitat, supporting high biodiversity of large and small migratory marine life, including a wide variety of cetaceans. The cetaceans, including the Blue whale (*Balaenoptera musculus*, considered endangered by the World Conservation Union IUCN) and the vulnerable Fin whale (*B. physalus*) and Humpback whale (*Megaptera novaeangliae*), and other migratory species, frequently use the marine corridors of the archipelago in migrations, particularly the deep seas of Maluku and the straits at Flores and Lombok (Kahn & Pet 2003, Kahn pers. comm.).

Table 1 Diversity of selected groups of marine organisms in Indonesia.

Major group	Group forms	Range recorded*	Species
Plants	Green algae	1	196
	Brown algae	1	134
	Red algae	1	452
	Seagrasses	1	13
	Mangrove	1	38
Corals	Scleractinians	2	350
	Soft corals	1	210
	Gorgonians	1	350
Sponges	Desmospongia	1	850
	Gastropoda	2	1 500
Mollusca	Bivalvia	1	1 000
Crustacea	Stomatopoda	1	102
	Brachyura	1	1 400
Echinoderms	Crinoidea	2	91
	Asteroidea	2	87
	Ophiuroidea	2	142
	Echinoidea	2	284
	Holothuroidea	2	141
Fishes	Marine fishes	1	2 140
Reptiles	Sea turtles	1	6
	Crocodiles	1	ND
Birds	Marine birds	2	148
Mammals	Whales & dolphins	1	29
	Dugong	2	1

Note: 1 = Specifically Indonesia; 2 = Indonesia and adjacent waters. ND = No Data.*
(Source: Hopley & Suharsono 2000, Moosa 1999, amended from Soegiarto & Polunin 1981)

Marine species considered by the World Conservation Union (IUCN) as vulnerable, threatened or endangered that occur in Indonesian Seas include dugongs, turtles, whales and dolphins (29 species) (Moosa 1999). Under various Indonesian Government decrees, some 25 species, including the Dugong (*Dugong dugon*), six species of sea turtle, 12 species of mollusc and six species of whales are listed for protection (Cheung et al. 2002).

The distribution of dugongs is fairly widespread, from sheltered to highly wave-exposed coasts (e.g. South Bali) although mostly occurring in low numbers as a result of hunting and accidental catch (Cheung et al. 2002). The major populations occur in western Cenderawasih in Papua and Kepulauan Aru in the Arafura Sea (Husar 1978). More than 140 turtle nesting sites are known (Salm & Halim 1984, Soehartono 1994), although the degree of usage by large nesting populations remains unclear, and it is thought to be declining because of widespread habitat destruction, targeted and accidental capture and other disturbances (Cheung et al. 2002).

Biodiversity and endemism is particularly high on the Island of Sulawesi (Wallacea sub-system), formed from three different land masses (Daws & Fujita 1999). On neighbouring Kalimantan (Sunda sub-system), there are some 10 000 species of flowering plants, 222 mammals, including primates (e.g. orang-utan), 420 birds, 166 snakes, 7 100 amphibians and 390 freshwater fishes (with 1 400 freshwater fish species for Indonesia as a whole). A.R Wallace first described in the 1880s the major faunal discontinuity between Asia and Australasian that divides the archipelago into two major faunal realms, subsequently named "Wallace's LineSocio-economic characteristics.

Socio-economic characterstics

Indonesia has a population of some 200 million people, which is comprised predominantly by peoples of Indo-Malay and Melanesian origin (Irian). Peoples of other ethnic origins are also present, some forming ancestral tribal groups, particularly in Kalimantan (Borneo), Sumatra and adjacent islands (e.g. Nias and Kepulauan Mentawi), others of more recent arrival (e.g. Chinese and Indian traders). Within these broad ethnic groups, there are substantial cultural differences and various forms of religious belief, principally Islam, but with areas of Christianity (notably Ambon, North Sulawesi and parts of Kalimantan), Hinduism (notably Bali) and Buddhism (parts of Jawa and Bali). There has been broad acceptance of different religious viewpoints in the past, and Indonesia's guiding principle is 'Unity through Diversity'. However, racial, cultural and religious tensions have been building in recent times, concomitant with the economic difficulties of the late 1990s. For example, parts of Sumatra, Jawa, East Kalimantan and the Moluccas (Ambon) have experienced civil instability and clashes between different religious and political groups. The recent independence of East Timor created civil unrest and armed clashes requiring the intervention of an UN-led international peacekeeping force. Secessionist movements, groups seeking autonomy or semi-autonomy, are also active in Northern Sumatra (Aceh area) and Irian.

Population

In 1996, the total population in Indonesia was about 198 million inhabitants (63.6% rural), with a growth rate of 1.7% (FAO AQUASTAT 2003). By 2000, this had grown to more than 206 million, and by 2001 to 209 million (World Bank 2003).

More recent estimates suggest a total population of 230 million in Indonesia as a whole, with most (200 million) residing in the GIWA region Indonesian Seas, and some 140 million living within 60 km of the coast (UN 2002). In 1996, the average population density was 105 inhabitants per km^2, increasing to 112 per km^2 by 1998 (FAO AQUASTAT 2003). The population is unevenly distributed with about 60% living on the Island of Jawa, which has an average population density of over 800 inhabitants per km^2, among the highest population density of any island on Earth. Another 20% of the population live on the Island of Sumatra, with a population density of 77 inhabitants per km^2. Kalimantan supports another 10 million, with a density of less than 17 inhabitants per km^2. By contrast, some of the smaller islands of Nusa Tenggara are sparsely populated, in part because of water shortages, while to the east, the comparatively large area of Papua supports less than 10 million people, almost entirely of Melanesian ancestry. Of the three sub-systems, approximately 150 million live in Sunda, some 35 million in Wallacea and less than 10 million in Sahul (Figure 3).

The population is distributed in the larger urban settlements and throughout thousands of villages spread along the coast, across the lowlands and into the highlands, usually concentrated on the watercourses. The larger urban centres include Jakarta (>10 million), Surabaya eastern Jawa (>4 million), Bandung Jawa (2.5 million), Semarang Jawa (2 million), Makassar Sulawesi (4 million), Denpasar Bali (1 million), Mataram Lombok(0.5 million), Palu (300 000), Kupang Timor (300 000), Ambon city Ambon (300 000) and Jayapura Papua (300 000). With very few exceptions the major cities, towns and villages are all developed on rivers, with concomitant water-related issues of use and pollution. The rivers passing through the major cities and adjacent

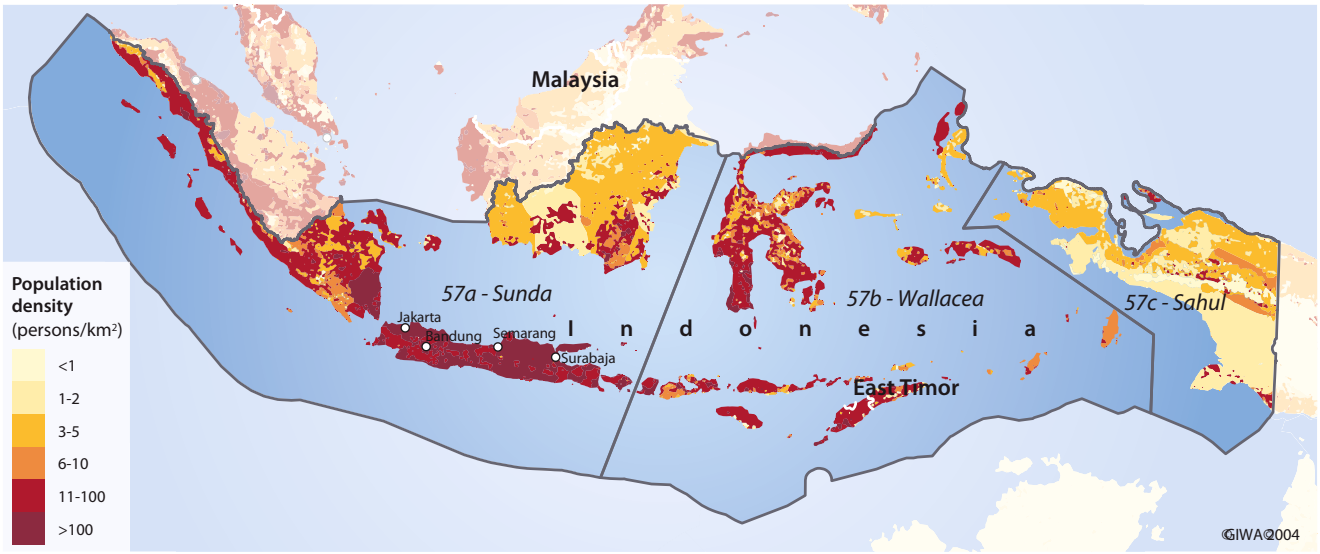

Figure 3 Population density in the Indonesian Seas region.
(Source: ORNL 2003)

coastal waters are in most cases badly polluted by sewage, heavy metals and other industrial and agricultural waste products.

Some areas are also experiencing substantial immigration of the order of 4% annually through a transmigration project developed to ease population pressures in Jawa. It is predicted that the population of the region will reach 300 million by 2020 and double to 400 million by 2035 (UN 2002). Levels of literacy have been relatively stable over the past decade, at greater than 85%.

Economic activities

Indonesian Seas support a wide range of economic activities, from subsistence agriculture and artisanal fisheries to high technology industries (Table 2). The region has various forms of traditional land-ownership customs and systems of natural resource use. Economic development and a tremendous growth in population have taken place in this coastal country. The climatic fluctuations within the Asian-Australian monsoon region have important implications for the society and the economy. Indonesian waters play a major role, providing food resources for millions of people, as well as a mode of transportation and area of exploration and production of minerals and natural gas. The coastline areas are sites for industrial and other economic activities. Ports of importance are Ujung Pandang (Makassar), Kalianget, Surabaya, Jakarta, Arjuna, Cirebon, Tegal and Semarang. Tourism is an important economic activity.

Gross National Product (GNP) in 1997-1998 was estimated at 130.6 billion USD, with a negative annual growth rate of -16.7%, and international rank of 30th. Per capita GNP was 640 USD, with a negative growth of -18% and international rank of 198th (World Bank 2003).

Overall effects of globalisation in the region are not well understood, but may be exacerbated over the next few years by the unstable global situation. Large gaps remain in reliable socio-economic data at the scale of the sub-systems. This is in part because of government restrictions on data access, and in part because of the lack of accurate census information from the widespread human populations.

Table 2 Socio-economic indicators for Indonesia.

Socio-economic indicator	1997	2000	2001
Population	198 200 000	206 300 000	209 000 000
Illiteracy (%)	15.1	13.2	12.7
GDP (billion USD)	215.7	152.2	145.3
GDP Growth	4.7	4.9	3.3
Value of GDP added in Agriculture (%)	16.1	17	16.4
Value of GDP added in Industry (%)	44.3	47	46.5
Value of GDP added in Services (%)	39.6	35.9	37.1
Value of GDP added in Exports (%)	27.9	42.4	41.1
Value of GDP added in Imports (%)	28.1	31.7	32.6

(Source: World Bank 2003)

Agriculture

The agriculture sector provides employment for 49% of the population. In 1995, the total cultivated area was estimated to be 35 579 000 ha. Of the cultivated area, 13 836 000 ha were under permanent crops such as rubber, coconut, coffee, cocoa and palm oil (Figure 4). Annual crops such as rice, maize, soybean, sugar cane and tobacco were grown on 21 743 000 ha. Farm-holdings in Indonesia are relatively small: 34% are less than 0.25 ha and a further 25% are between 0.25 and 0.5 ha. In total, value added to GDP from agriculture in Indonesia averaged approximately 16-17% from 1997 to 2001 (World Bank 2003).

Figure 4 Locals processing copra, Anambas & Natuna Archipelago, Indonesia.
(Photo: J.L.N. Sivasothi, Reefbase)

Fishing

Subsistence farming and fishing are the major activities of large numbers of people outside the main urban centres. Most of the approximately 6 000 regional coastal communities are directly dependent on the sea as their primary source of both food and income (Dahuri & Dutton 2000), with some 16.5 million fishermen. Domestic agricultural and artisanal fisheries production (15.5 kg per person per year) are very important, with increased fisheries production required to meet the increase in domestic demand from the growing population (Talaue-McManus 2000). During the 1980s and 1990s, there were major increases in aquaculture (notably *Tilapia* in lakes and inland waters) and mariculture (shrimps) in coastal ponds, to supply both domestic and international consumption, concomitant with major expansion in reef fisheries to supply the live fish trade to Hong Kong, China and Japan.

At present, mariculture is largely dependent on wild stocks, although hatcheries are being developed. The estimated contribution of the fisheries sector to the national GDP is about 2%. However, a significant proportion of total catch is illegal and unreported.

Live reef fish export operations have increased since the 1980s. This has caused the loss of large numbers (thousands of tonnes) of demersal coral reef fishes from many reefs in Indonesia - even in remote areas. Poison fishers mostly use two forms of cyanide (sodium and potassium cyanide) but there have been recent shifts toward locally produced and inexpensive vegetable poisons (Johannes & Riepen 1995). Collecting of ornamental reef fishes and other organisms for the global aquarium market is also widespread and is expanding in the region. It has already caused serious damage to reefs in some areas, through use of destructive techniques of poison fishing and/or coral breakage.

Forestry

Forestry is a major industry, particularly in Kalimantan, Sumatra and Papua, and less so in many other areas, where much of the harvestable forests has already been exploited. Much of the land area of the region was originally covered by diverse tropical forest. However, as noted above, substantial deforestation of dipterocarps and other commercial timber species has taken place since the colonial era and continuing logging is further reducing the original forest cover. Fertile lowlands and hill areas have been extensively developed for rice production, as paddy fields and upland terraces. Lowland areas and river flood plains also support mixed agriculture. In total, Indonesia has 1 million km^2 of forests remaining, and an annual deforestation rate of 1.2% (World Bank 2003).

Oil and mining

Oil production, mostly offshore in the Jawa Sea, supplies the large domestic market and also provides export earnings. Indonesia is one of the world's major oil producers, with 1.36 million barrels per day in 1997 from 8 535 wells and much if this is from Sunda (Edinger & Browne In press in Hopley & Suharsono 2000). Another major producing area is off the coast of East Kalimantan, particularly the Mahakam Delta. Bontang Bay in south Kalimantan is a major producer of liquified natural gas. Mining for gold, copper, zinc and other minerals, notably in Papua and Sulawesi, is another major export earner.

Shipping

The northern Jawa Sea and Makassar Strait/Lombok Strait form part of major oil tanker routes (the Main route and ULCC route respectively) between Japan and the greater Pacific Ocean and the Indian Ocean and west Asia-Europe. Minor routes pass between Jawa and Sumatra and through the Jawa Sea to the east via the Arafura Sea. These shipping routes all have associated risks of collisions and spills (Etkin 1997, MPP/EAS 1998).

Secondary industries

These include natural resource processing and light manufacturing, and are also of growing importance, particularly in the major urban centres of north Jawa. Service industries, including tourism, were expanding during the 1990s and make a substantial contribution to GDP, contributing between 37-40% of GDP from 1997-2001. Tourism, centred on Bali but with expansion during the 1980s and early to mid-1990s throughout much of western and central Indonesia, has increased annually. However, the Asian financial crisis and growing civil unrest, combined with the recent upsurge in international terrorism and concern over epidemic diseases (e.g. Severe Acute Respiratory Syndrome, SARS), have caused a recent major decline in international tourism. This is expected to be exacerbated over the next few years by the unstable global situation.

Exports

The major export earners include commercial exploitation of natural resources; particularly mining (Papua, Kalimantan, Sulawesi, Sumatra, Jawa Sea), forestry (mostly in Sumatra, Kalimantan, Papua), pelagic and demersal reef fisheries, aquaculture and mariculture, oil palm and other forms of plantation agriculture. Crop production and livestock contribute approximately 18% of GDP (World Bank 2003).

In 1992, exports yielded Indonesia a profit of more than 1 billion USD, accounting for about 2% of the global total. Imports at the time accounted for some 60 million USD, less than 1% of the global total (Talaue-McManus 2000). In the mid-1990s, GDP for Indonesia as a whole was estimated at 160 billion USD, with a growth rate of approximately 79 million USD per year in 1995-1996, prior to the economic crisis of the late 1990s. Output and consumption varies in relation to the degree of industrialisation. In 1995/1996, the percentage GDP industry growth rate was about 38% per year, compared with the agriculture growth rate of 13% per year, with a per capita GNP of about 1 000 USD per year (Talaue-McManus 2000). GDP and economic growth have been declining over the past several years (Table 2).

Overall effects of globalisation in the region are not well understood, but may be exacerbated over the next few years by the unstable global situation. Large gaps remain in reliable socio-economic data at the scale of the sub-systems. This is in part because of government restrictions on data access, and in part because of the lack of accurate census information from the widespread human populations.

Governance

The Republic of Indonesia gained independence in 1948 and has been governed since then from the capital city of Jakarta on Jawa. Indonesia is a constitutional democracy, with the President elected for five year terms. Indonesia has a three tiered system of government, with national (central), provincial and district levels. In addition, there are two further levels, sub-district level and village level, which are not considered autonomous because they do not have a local house of representatives. The provincial district, sub-district and village levels are coordinated by the Ministry for Home Affairs (Hopley & Suharsono 2000).

Indonesia has undergone extensive political reform since 1997 and currently pursues a policy of decentralisation and regional autonomy. There is a growing trend for decentralisation of political and administrative activity, and after Jakarta much of the political life is focused in the provinces, cities, towns and villages. For administrative purposes Indonesia is divided into 26 provinces. Overall planning and implementation of government policies follow five year terms or 'Repelita' with Repelita VI covering the period 1994-999 and Repelita VII from 2000-2004. These Repelita are in turn within a larger 25 year development period 'Pembangunan Jangka Panjang I' (PJP I), the first phase of long-term development (FAO AQUASTAT 2003).

Indonesia has sovereign rights to the 12 nautical mile limit and has also declared a 200 nautical mile Exclusive Economic Zone (EEZ). Several different schemes and doctrines with different geographic, political and legislative relevance are considered in relation to Indonesia's area and waters including internal, archipelagic, territorial (12 mile limit), Exclusive Economic Zone (200 nautical mile limit), High Seas, continental shelf, internal seas and seabed, and Contiguous zone.

The Indonesian Government has declared its commitment to sustainable development in the oceans by ratifying a number of conventions and formulating programmes and projects that aim to defend and conserve the environment. Indonesia has gazetted 331 terrestrial protected areas covering some 19 253 000 ha and representing some 10% of total land area of 1.9 million km^2. Indonesia also has 102 gazetted marine protected areas (MPAs) e.g. Laut Banda, Bunaken and Taluk Cendraw, five biosphere reserves (1 329 000 ha), three World Heritage sites (2 845 000 ha) and two wetlands of international importance (243 000 ha). Thus, Indonesia has many legally designated protected areas including coastal and marine habitats and has a target of developing a network of MPAs encompassing some 30 million ha. In total, there are estimates of between 34 and 50 protected areas in the region containing coral reefs (Hopley & Suharsono 2000, Spalding et al. 2001), with a total area estimated at 4.6 million ha. The effectiveness of many MPAs is limited at present by insufficient resources for management and enforcement of regulations. Many of the protected areas are not well managed, despite ongoing efforts, and the ecosystems that sustain this rich biodiversity are under severe threat in much of the region (e.g. Chia & Kirkman 2000).

However, several large government initiatives and smaller community-based management programmes are helping to protect coastal and marine habitats. Several such projects have been implemented by the Indonesian Government since the 1990s, including the Marine and Coastal Resources Management Project (MCREP) and the Coral Reef Rehabilitation and Management Project (COREMAP) (see also Annex III). MCREP, a large coastal and marine management project focused on 15 of Indonesia's provinces, has been operational since the early 1990s and is now in its second phase. COREMAP has also been operational since the mid-1990s, the initial phase documenting reef resources and management capacities of reefs in 10 provinces, while latter phases are focusing on developing ecologically sustainable management, under international funding from the World Bank and Asian Development Bank. Other projects are being coordinated by various NGOs including Worldwide Fund for Nature (WWF), The Nature Conservancy (TNC) and Conservation International.

International treaties and conventions

With its neighbouring nations, Indonesia forms part of the Association of South East Asian Nations (ASEAN), with strong multi-lateral links at political and trade levels. As noted above, Indonesia is signatory to several international conventions and has enacted various national laws and regulations that are relevant to water-related issues in the region, including:

- United Nations Convention on the Law of the Sea (UNCLOS);
- International Convention on the Protection of Pollution from Ships (MARPOL);
- United Nations Convention on Conservation on Biological Diversity (CBD);
- Convention on International Trade in Endangered Species (CITES);
- Ramsar Wetlands Convention;
- United Nations Framework Convention on Climate Change (UNFCCC);
- World Heritage Convention.

The relevant government departments have proposed policies or legislation in relation to obligations under the various international conventions. However, it is apparent that, despite the international ratifications of the conventions, there has been only modest progress to date in their effective implementation and the resolution of related

problems. This has been attributed to the lack of action by different government departments in addressing their obligations under the conventions. A recently developed "Environmental Strategy for the Seas of East Asia" provides many pertinent recommendations and solutions to these problems (Chua pers. comm.).

Recently, Indonesia has taken steps at the community (local), provincial and national levels, including implementation of legislation, to provide a modern framework for sustainable resource management. Indonesia's Constitution provides the legal basis for development of legislature relevant to use and management of water resources. The Constitution is expected to undergo major review in the near future.

Legislative instruments and integration

At international and national levels, a raft of legislation addressing resource management and protection has been developed. However, there are inefficiencies related to the transfer and application of international and national legislation at provincial and local levels, with large inter-provincial and local differences in efficiency and success of such application.

Some national and provincial laws relevant to different sectors such as fisheries, mining, forestry and environmental protection, are not fully integrated, and have legislation that does not refer specifically to particular sectoral or environmental systems, causing uncertainty in application of legislative instruments. This has provided 'loop-holes' for exploitation and caused confusion over which laws have priority, which departments or agencies hold responsibilities for management, and the rights of stakeholders and interest groups. Some government departments are hampered by a lack of qualified and experienced staff, and also by funding shortfalls and cutbacks. There is also a lack of awareness and acceptance of some laws among local populations, and insufficient capacity for dissemination of information and enforcement of regulations and quotas. Thus, the lack of understanding and adherence to laws and regulations among local communities is compounded by insufficient communication of information and the lack of surveillance and enforcement, which provides complex management challenges.

These difficulties notwithstanding, there have been major advances since the 1980s in regional capacity for development of policy and legislation based in sound science. This has relevance to international waters assessment and monitoring and implementation of measures to promote sustainable development and conservation. For example, a critical mass of regional expertise now resides in government, inter-governmental agencies, academic institutions and NGOs, including:

- Directorate for Marine and Coastal Degradation Control, Environmental Impact Management Agency (Bappedal);
- Conservation and Marine National Parks, Ministry of Marine Affairs and Fisheries;
- The State Ministry for Environment;
- Directorate General of Forest Protection and Nature Conservation, under the Ministry of Forest and Crop Estates;
- Research and Development Centre for Oceanology (Pusat Perelitian dan Pengembangan Oseanologi, LIPI), Indonesian Institute of Science;
- Universities throughout Indonesia;
- United Nations - UNEP (Regional Seas and Regional Organization for Asia and Pacific);
- IOC Sub-Commission for teh Western Pacific (IOC-WESTPAC);
- GEF/UNDP/IMO Regional Programme on Partnerships in Environmental Management for the Seas of East Asia (PEMSEA);
- World Wide Fund for Nature (WWF);
- The World Conservation Union (IUCN);
- The Nature Conservancy (TNC);
- Conservation International (CI).

Legal and institutional framework regulating biodiversity and the environment

(also see Annexes III-V)

The Ministry of Environment is the key national body for coordinating sustainable development, with the National Clearing House on Biodiversity and a National Coordinating Body on Biodiversity being established to supervise and plan activities relating to the conservation and sustainable use of biodiversity. The Ministry of Forestry, specifically its Directorate General for Forestry Protection and Nature Conservation (formerly PHPA now PKA) and the Ministry of Agriculture also play important roles in coastal environmental matters (Cheung et al. 2002).

The Ministry of Marine Affairs and Fisheries may in future prove to be most relevant for coastal and marine environmental issues. There are two Directorates within the PKA, one dealing with Nature Conservation and one with National Parks and Recreation Forest. The Directorate for Nature Conservation provides overall planning of the terrestrial and marine protected areas network, drafting of conservation legislation and the proposal, establishment and management of protected areas. The Directorate of National Parks and Recreation Forest oversees the development of the national parks programme. The regional planning boards (BAPPEDA) work with the provincial offices of PKA. In 1990, the "Conservation of Living Natural Resources and their Ecosystem Act" became the chief legislative tool for the management of protected areas. Based on this Act, the various MPAs fall under four categories corresponding with IUCN classifications (see Cheung et al. 2002 for details).

Other government departments and agencies concerned with marine conservation and protected areas include the Ministry of State for Population and Environment, through the Environmental Impact Management Agency (BAPEDAL), the Department of Agriculture's Directorate of Fisheries, the Department of Communications' Directorate of Marine Communications and the Indonesian Institute of Science (LIPI). The Bappedal coordinates coastal zone management and assesses development projects through the Analysis of Environmental Impacts (Amdal), while LIPI's Research and Development Centre for Oceanology provides scientific advice to other agencies (Cheung et al. 2002).

Legal and institutional framework regulating the water sector

The 1945 Constitution declared national water and land resources to be controlled by the State and that they should be utilised in an equitable manner for the benefit of the people. The responsibilities for the development and management of water resources and irrigation schemes are specified in laws, presidential instructions and government regulations. The most important are:

- Presidential Instruction No. 1 (1969), on the management of irrigation water and maintenance of irrigation networks.
- Law on water resources development No. 11 (1974).
- Government regulations on:
    - Beneficiaries contribution for maintenance cost of water resources facilities No. 6 (1981);
    - Water management No. 6 (1982) ;
    - Irrigation, No. 23 (1982);
    - Rivers (1991);
    - Swamps (1991).
- Decree of the Minister of Mining and Energy concerning underground water resources management (1983).

Numerous institutions are presently involved in water resources management. Their tasks and responsibilities are clearly stated in national legislation:

- The Ministry of Public Works, with its Directorate General of Water Resources Development, is responsible for planning, design, construction, equipment, operation and maintenance (O&M), and guidance in water resources development.
- The Ministry of Forestry is responsible for catchment area development.
- The Ministry of Environment is responsible for environmental quality development and management.
- The Environmental Impact Management Agency is responsible for environmental impact control.

Assessment

This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 3. Detailed scoring information is provided in Annex II of this report.

Table 3 Scoring table for Sunda, Wallacea and Sahul sub-systems.

	Sunda						Wallacea						Sahul					
	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	3* ↗	3 ↗	3 ↘	3 ↘	**2.8**	2	2* ↗	3 ↗	2 →	2 →	**2.4**	3	1* ↗	1 ↗	1 →	1 →	**1.0**	4
Modification of stream flow	2						2						2					
Pollution of existing supplies	3						2						1					
Changes in the water table	3						3						1					
Pollution	3* ↗	3 ↗	3 →	3 ↗	**3.0**	1	1* ↗	3 ↘	2 →	1 →	**1.8**	4	1* ↗	1 ↗	1 →	1 →	**1.3**	3
Microbiological pollution	3						1						1					
Eutrophication	2						1						0					
Chemical	3						1						1					
Suspended solids	3						2						1					
Solid wastes	3						2						1					
Thermal	1						0						0					
Radionuclides	0						0						0					
Spills	1						2						1					
Habitat and community modification	3* ↗	3 ↗	2 ↗	3 ↗	**2.8**	3	3* →	3 →	2 ↘	3 →	**2.6**	1	2* ↘	1 ↗	1 →	1 ↘	**1.3**	2
Loss of ecosystems	3						2						1					
Modification of ecosystems	3						3						2					
Unsustainable exploitation of fish	3* ↗	3 ↗	2 ↘	3 →	**2.6**	4	3* ↗	3 ↗	1 →	3 →	**2.3**	2	2* ↗	2 ↗	1 ↗	3 ↗	**2.1**	1
Overexploitation	3						3						3					
Excessive by-catch and discards	3						3						3					
Destructive fishing practices	3						3						3					
Decreased viability of stock	3						1						0					
Impact on biological and genetic diversity	3						1						1					
Global change	1* ↗	1 →	0 ↗	1 ↗	**1.1**	5	1* ↗	0 ↗	0 ↗	0 ↗	**0.9**	5	1* ↗	0 ↗	0 ↗	1 →	**0.9**	5
Changes in hydrological cycle	2						2						2					
Sea level change	1						1						0					
Increased UV-B radiation	0						0						0					
Changes in ocean CO_2 source/sink function	0						0						0					
Sea surface temperature	2						2						1					

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter)

IMPACT 0 No known impacts · IMPACT 1 Slight impacts · IMPACT 2 Moderate impacts · IMPACT 3 Severe impacts

The arrow indicates the likely direction of future changes.

↗ Increased impact · → No changes · ↘ Decreased impact

* This value represents an average weighted score of the environmental issues associated to the concern. ** This value represents the overall score including environmental, socio-economic and likely future impacts. *** Priority refers to the ranking of GIWA concerns.

International waters in the sense of this analysis include all coastal and marine waters in the Indonesian Seas region. These waters are all potential sources or recipients of transboundary impacts, primarily from shipping, fisheries, riverine discharges, and the transport of pollutants via ocean currents. Several of East Kalimantan's rivers rise in the mountainous interior of Kalimantan, including Malaysian Sabah, and cross the international boundary into Indonesia. Conversely, pollution and other impacts arising in the Indonesian Seas may be transported to the waters of adjacent nations. Of particular concern in this regard are detrimental effects on the population viability of target marine species, the planktonic larvae of which may be dispersed in the Indonesian Through-flow and other currents into international waters, replenishing populations further a field.

A wide range of coastal and near-shore ecosystems exist in Indonesia with three; coral reefs, mangroves and seagrass beds, having particularly significant transboundary importance (Hopley pers. comm.). Each has an international importance because of its biodiversity. Additionally, each provides an important habitat and breeding ground for many fish species (which also reach their maximum biodiversity in Indonesian waters) including pelagic species (for example, see Jeyaseelan 1998). All these environments are also visited by other wide-ranging marine species including turtles and marine mammals. Continental shelf environments may also be highly complex, and have considerable transboundary importance. Ecosystems include deepwater coral communities and algal (mainly Halimeda sp.) banks for which Indonesia is well known (Phipps & Roberts 1988, Roberts et al. 1987, Sydow 1996 in Hopley & Suharsono 2000).

Another important transboundary consideration is the distribution and exploitation of offshore oil and gas, with significant oil and gas fields in the Jawa Sea, off the Mahakam Delta and at Bontang Bay in Kalimantan. There are also extensive oil and gas reserves in the Timor Sea, although these are partly outside the boundaries of this GIWA region. The 1989 Timor Gap Treaty with Australia and the more recent 1997 Perth Treaty have not fully settled all political issues related to resource development of this area of shelf and the more recent independence of East Timor has created further uncertainties (Sitepu 1999 in Hopley & Suharsono 2000, Herriman & Tsamenyi 1999) (also see GIWA regional assessment 58 North Australian Shelf).

A final important transboundary implication for international waters is the major role played by Indonesian Seas as a heat engine for global climate and their pivotal role (with nearby areas) in ENSO events, both of which hold particular significance for global climate change.

The results presented herein are supported wherever possible by published data. However, for many of the issues and concerns raised in this analysis, few if any publications exist, and of those, many are of a confidential nature, either by government or 'commercial in confidence' and thus were unavailable for inclusion in this report. Furthermore, large gaps in information remain, particularly at the sub-system level (Statistik Indonesia 1996), and thus the scores presented herein are the consensus view of the Task team, derived during three workshops and subsequent discussions.

Freshwater shortage

In Indonesia in 1990, water withdrawals were 69.2 km^3 for agriculture, 4.7 km^3 for domestic and municipal water supply and 0.38 km^3 for industrial use. As the nation has started to implement development programmes in order to meet the sharply increasing needs for irrigation, safe drinking water, industrial water, energy, and other uses, the demand on water resources has increased rapidly. It is estimated that from 1990 to 2020 the demand will increase by about 220%. More than 50% of all irrigation water is consumed in Jawa. By 2002, overall consumption of freshwater in Indonesia was even more strongly dominated by the agricultural sector, which uses some 98% of water resources. Potable water supplied by the regional Drinking Water Company provides water for some 20% of the more than 200 million Indonesians (UN 2002).

In 1995, Indonesia had 82 large dams with capacities exceeding 15.8 km^3 and an additional 638 reservoirs, 10 770 weirs, 1 017 barrages, 1 192 pumping stations; and 6 792 intakes were used to supply water to an area of 4.6 million ha. Moreover, irrigation from groundwater reportedly covered an area of 44 209 ha (FAO AQUASTAT 2003). Total groundwater resources are estimated at 455 km^3 per year, although most (an estimated 90%) return as base flow to the rivers. The groundwater potential in Indonesia is limited and can meet only part of the urban and rural needs for water supply, while providing irrigation water for very limited areas in the eastern parts of Indonesia (Wallacea and Sahul). In some places, overexploitation of groundwater has led to intrusion of saline water.

Of the more than 500 river basins in the region, many have been extensively modified, primarily through loss of riparian vegetation, major clearing of catchments, with resulting loss of soils as sedimentation into rivers and streams (also see Pollution, suspended solids and Habitat and community modification). All river systems supporting major urban

developments have been seriously polluted by industrial and sewage wastes (FAO AQUASTAT 2003).

Modification of stream flow

Sunda, Wallacea and Sahul

Modification of stream flow was assessed as having severe impacts in the Sunda sub-system and moderate in Wallacea and Sahul. There are however severe local effects in the major urban areas of Jawa (particularly the north coast) (Douglas 1978), and agricultural/forestry areas of Jawa, Sumatra and South and East Kalimantan, where major loss of riparian vegetation and deltaic wetlands has occurred through effects of logging (also see Douglas & Spencer 1985). The high rates of sediment transport in streams and rivers has caused significant changes to stream flow and increases in flood plains and river deltas, some of which are prograding rapidly, notably on north coast of Jawa (e.g. Solo River prograding at more than 70 m per year) (Spalding et al. 2001). In Wallacea, the urban centres and agricultural areas of south Sulawesi, Bali, Lombok, Sumbawa and the many "dry islands" are particularly susceptible to alterations to stream flow. In Sahul, impacts are less widespread, being focused around Jayapura (Irian Jaya) and in areas affected by stream alterations of mining.

Pollution of existing supplies

Sunda

According to the GIWA Experts, pollution of existing supplies is severe in the sub-system, both to surface and groundwater supplies. Most human settlements are concentrated on rivers and streams and chemicals from agriculture, industry, aquaculture and domestic sewage have caused severe and widespread pollution. Municipal and industrial wastewater is discharged virtually untreated into the waterways causing rapid deterioration in the quality of river water (FAO AQUASTAT 2003). Hotspots include the Siburik, Lahat, Japat and Kali Mas rivers, with severe oxygen depletion and fish kills. In these areas, many people are getting water from sources contaminated by human, agricultural and industrial wastes, and surface water does not meet WHO drinking water criteria because of human inputs resulting in water of poor quality.

Wallacea

Pollution of existing supplies in Wallacea has experienced moderate environmental impact, but with highly localised severe damage around Makassar and Ambon, East Nusa Tenggara and Kupang (Timor). According to the GIWA Experts, there have been fish kills from various chemical inputs, notably from agricultural chemicals and increases in nutrient loads from aquaculture activities, with likely increases in other inputs. Some surface water does not meet WHO drinking water criteria.

Sahul

Pollution of existing supplies by mining wastes has caused slight environmental impacts resulting in occasional fish kills. Wastewater is discharged into rivers and streams virtually without any treatment, causing rapid deterioration in the water quiality (FAO AQUASTAT 2003).

Changes in the water table

Sunda and Wallacea

Changes in the water table has caused moderate to severe impact in the sub-systems, where many aquifers are suffering widespread salinisation and pollution, and wells have been deepened due to lowering of water tables (e.g. wells that were originally 20 m deep are 35 m deep in 2001). Hotspots include the north coast of Jawa, particularly the major urban centres of Jakarta, Semarang and Surabaya where increasing populations are placing increasing pressures on groundwater resources.

Overexploitation of groundwater has led to critical problems in for example in Jakarta where the total groundwater abstraction in 1993 was 32.6 million m^3. Groundwater abstraction has caused saline groundwater to reach about 10 km inland from the coastline and led to land subsidence at a rate of 2 to 34 cm per year in east Jakarta.

The supply of groundwater is limited and can meet only part of the urban and rural needs for water, while providing irrigation water for very limited areas in the eastern part of Indonesia. In some places, overexploitation of groundwater has led to critical problems. In Wallacea, the "dry islands" of East Nusa Tenggara are worst affected, where 70% of the groundwater aquifer supply is used, wells have been deepened and there is widespread salinisation. Hotspots include East Nusa Tenggara, Taka Bone Rate, the Togian Islands and Tukang Besi Islands. Wells have been deepened hundreds of km^2 in these areas.

Sahul

Changes in the water table have caused only slight environmental impacts and have been concentrated in the major urban area of Jayapura.

Socio-economic impacts

Sunda and Wallacea

The impacts of freshwater shortage on economic, health and other social and community impacts were considered moderate to severe in the Sunda and Wallacea sub-systems. Major socio-economic impacts are concentrated in Jawa and Sumatra, particularly the larger urban centres. For millions of people there is little access to potable water

either in wells or through piped supply. Even in some areas with reticulated water, there are regular or episodic interruptions to supply.

Freshwater shortage is already a food security concern, and although water resources are abundant, the seasonal and spatial variation in the rainfall pattern and lack of adequate storage create competition and conflicts among users. In Wallacea, freshwater shortage is a food security concern in many of the semi-arid areas, notably of East Nusa Tenggara. Additional economic impacts accrue from costs in supplying irrigation (FAO AQUASTAT 2003).

Socio-economic impacts and threats in large areas of Sunda and Wallacea remain unquantified at the sub-system scale but clearly include loss/interruptions to human drinking water supplies, changes in traditional use, losses of agricultural uses such as crops, livestock, aquaculture and also reacreational use. Impacts also include increased potential for upstream/downstream conflicts or conflicts among urban and squatter groups, increased costs of alternative water supplies, loss of waste assimilative capacity, reduction in future use options as well as human health impacts. Other socio-economic impacts in the sub-systems include reduced agricultural production and reduced availability of fish as food, increased intake treatment costs, increased damage to water-related equipment, increased costs of deepening wells and pumping, damage to infrastructure, and population migration and transboundary implications (see also FAO 1992, FAO/UNDP/UNEP 1994, ESCAP 1995).

Sahul

Socio-economic impacts of feshwater shortage in the Sahul sub-system were considered slight and most of the socio-economic impacts are concentrated in the major urban centre of Jayapura.

Conclusions and future outlook

The environmental and socio-economic impacts of freshwater shortage in the Indonesian Seas region range from slight to severe, with Sunda being worst affected. The environmental and economic impacts are expected to worsen in all three sub-systems in the future, whereas health and other social and community aspects are expected to remain as they are, or show some improvement.

In Sunda, freshwater shortage has caused severe environmental impact, with little access to potable water among poor urban populations in much of the sub-system. The environmental situation is expected to deteriorate further, remaining severe in the future. By contrast, impacts to health and other social and community aspects are expected to be ameliorated through intervention, improving from severe to moderate, although the economic situation is expected to remain severe over the next 20 years. As noted above, major forcing factors include widespread increases in human populations, and the compounding problems of poor water supply and contamination. Despite the best efforts of government and NGOs, a continuing lack of effective enforcement of regulations and little environmental control will contribute to the expected deterioration in economic aspects of freshwater shortage.

Parts of Wallacea have a natural vulnerability to freshwater shortage, being semi-arid. This natural vulnerability is being exacerbated by impacts from the increasing human populations. The environmental situation is expected to deteriorate further, remaining moderate. From the socio-economic perspective, impacts to health and other social and community aspects are expected to remain moderate, being managed through intervention, although the economic situation is expected to deteriorate further and will continue to be severe over the next 20 years. Major forcing factors include the widespread increases in human populations, and the compounding problems of natural, semi-arid conditions, poor water supply and contamination.

In Sahul, freshwater shortage has caused only minor environmental impacts mainly to urban areas and mining sites. The environmental situation is expected to deteriorate but will remain slight. From the socio-economic perspective, impacts to the economy are also expected to deteriorate, while health and other social and community aspects are likely to be little changed.

Remedial interventions

In 1990, just 35% of Indonesia's urban population and 33% of the rural population had access to reliable water supply. It is estimated that between 1990 and 2020, the demand will increase by about 220% (FAO AQUASTAT 2003). The Ministry of Public Works through its Directorate General of Water Resources Development (DGWRD) has identified four main missions in water resources sector programming as part of Repelita VI, namely: (i) maintanance of self-sufficiency in rice production to achieve long-term food security; (ii) provision of water to meet increasing water supply demands; (iii) flood alleviation and river management; and (iv) water resources development, conservation and management (DGWRD 1993a-c, 1995a-b, 1996).

The four missions directed by the DGWRD are being implemented through several major and support programmes. The water resources sector now has two major sub-sectors:

- Water resources development, with three major programmes:
  - Water resources development and conservation;
  - Supply and management of water;
  - Management of rivers, lakes and other water resources.

- Irrigation, with two major programmes:
  - Development and management of irrigation networks;
  - Development and management of swamp areas.

Major forcing factors on freshwater shortage include widespread increases in human populations; with a doubling expected by 2035, which is compounded by problems caused by poor water supply and contamination. Deforestation, which is driven by significant foreign investment in the forestry sector, the use and market for the timbers and other social causes such as Indonesia's transmigration programme, is another major contributor. Deforestation in Indonesia as a whole is estimated at approximately 1.6 million ha annually (UN 2002).

By 2015, water use is predicted to grow by some 7% for irrigation, 7% for domestic needs and 13% for industry (UN 2002). Increasing water consumption, combined with the decreasing quantity and quality of water resources, has already created water scarcity issues. The government aims to mitigate these issues in three ways (also see Jezeph 1992, Soenarno 1995), by:

- Reducing pollution from industries;
- Conserving water resources;
- Rehabilitating the physical conditions of rivers.

Recent legislation on freshwater use include Ministerial Decree No. 20/2001 dealing with the rehabilitation of forest and land as issued by the Ministry of Forestry, Government Regulation No. 82/2001 dealing with Water Quality Management and Water Pollution Control and ratification of the Ramsar Convention through Regulation No. 27/1991 (also see Annexes III-V).

Three government agencies are responsible for research on these and other issues relating to water conservation; the Agency for Assessment and Application of Technology; the Agency for Irrigation Research and Development; and the Ministry of Settlement and Regional Infrastructure. Government partner institutions and collaborating international organisations also include: the Ministry of Energy and Mineral Resources; the Ministry of Foreign Affairs, the World Bank; the Asian Development Bank; and the German Gesellschaft fur Technische Zusammenarbeit.

In developing its water resources further, greater integration among all government departments and agencies is crucially important, in order to ensure that decisions regarding water resources (e.g. increased irrigation and conversion of swampland) are managed to minimise adverse impacts on other aspects of international waters (e.g. habitat loss and modification) (also see Jezeph 1992, Soenarno 1995). Recent attempts to achieve improved management of water resources have focused on enhancing the efficiency of water use, improving the quality of water resources, balancing water source availability and developing an integrated water resource management programme (UN 2002).

Nevertheless, despite the best efforts of government (as outlined above) and NGOs, a continuing lack of effective regulation and little environmental control is expected to contribute to the further deterioration in socio-economic aspects of freshwater shortage. With the sharply increasing needs for irrigation, safe drinking water, industrial water, energy, and other uses, the demand on water resources has increased rapidly.

Pollution

Not much is known about the status of the region in regards to pollution. Urban expansion and industrialisation have resulted in water pollution from industrial wastes, sewage problems, and air pollution. Oil spills, slowly degrading toxic wastes from chemical and non-chemical industries, agricultural run-off and the dumping of materials such as metals threaten inland and coastal waters. Toxic materials settle into seafloor sediments where they accumulate as hazards to living organisms that feed on bottom mud. Long-lasting chemicals may enter the food web and contaminate fish and shellfish. There are threats to the reefs and mangroves (LME 2003).

Specific catchment and riverine effects of pollution are in direct relation to (FAO AQUASTAT 2003, Hopley pers. comm.):

- Flow rates and natural sedimentation levels;
- Channel capacity and modification in relation to changing catchment conditions including deforestation, mining and release of tailings, dams and other structures;
- Water quality including nutrients and human health considerations;
- Use and status of groundwater resources including land subsidence (after groundwater pumping) and saltwater intrusion.

Municipal and industrial wastewater is discharged virtually untreated into the waterways causing rapid deterioration of the water quality in the region (FAO AQUASTAT 2003). Industrial forms of water pollution are concentrated in the major urban centres, primarily the large cities of northern Jawa (e.g. Jakarta, Suribaya, Semarang, Bandung), and capital

cities of Sulawesi (Makassar), Sumatra (Medan), and Kalimantan (e.g. Balikpapan). Sewage treatment is superficial at best, with raw and/or primary treated sewage is discharged directly into watercourses from most towns and cities. Agricultural pollution is also widespread, through leaching of fertilisers and pesticides into watercourses, massive loss of soils following land clearing and forestry and increasing aquaculture activities.

Total emissions of organic water pollution have experienced a rapid increase from some 214 tonnes per day in 1980 to more than 537 tonnes per day in 1993. The food sector is the major industrial contributor (59%). Municipal and industrial wastewater is discharged virtually untreated into the waterways causing rapid deterioration in quality of river water (FAO AQUASTAT 2003).

Environmental impacts from thermal pollution in Indonesia are slight to negligible, being notable only in the immediate vicinity of the few power plants where ocean discharge of cooling waters occurs (e.g. north Jawa). For example, hot water discharges from the Botang plant have killed corals on adjacent fringing reefs (Edinger & Browne in press in Hopley & Suharsono 2000). There are no known effects beyond the mixing zone and no significant interference with migration patterns. There are no known environmental impacts from radionuclides, with no nuclear power plants in the region, although there may be some episodic discharge from nuclear powered ships navigating through the area.

Microbiological pollution

Sunda

The environmental impacts of microbiological pollution in Sunda are severe in most of the major urban areas and along major rivers in Jawa and Sumatra, while fisheries in parts of the Jawa Sea have also been affected. Microbiological pollution is a significant problem from inadequate sewage disposal and treatment. There is only rudimentary sewage treatment for much of the sub-system, where most sewage is discharged without treatment or treated only by settlement, and most primary treatment consists of screening, particularly in the urban areas. Most streams and rivers flowing through urban centres (e.g. Jakarta, Surabaya) have highly elevated levels of faecal coliform contamination and there has been a major increase in incidence of bacterial-related gastro-enteric disorders in fisheries product consumers, but no fisheries closures or advisories. Blooms of toxic dinoflagellates (Maclean 1989) have caused paralytic shellfish poisoning and shellfish from most of the Jawa Sea are no longer eaten. By contrast, rural areas of Sumatra and Kalimantan have lower impacts.

Wallacea and Sahul

The environmental impacts of microbiological pollution are slight overall, with moderate impacts localised around Makassar and the other major urban centres (e.g. Denpasar, Bali and Jayapura, Papua). There it is a locally significant problem stemming from inadequate sewage disposal and treatment in virtually all towns and cities. As with Sunda, there is little or no sewage treatment for much of the sub-system. In the urban areas, elevated levels of faecal coliform contamination and incidences of bacterial-related gastro-enteric disorders have occurred in fisheries product consumers, but with no fisheries closures or advisories.

Eutrophication

Sunda

The overall environmental impacts of eutrophication in Sunda are moderate, but with severe impacts locally, particularly in enclosed bays, harbours and lagoons with limited water circulation, and where sewage, agricultural and/or industrial discharges are present. This is most common along the north coast of Jawa, notably in Jakarta Bay and the river deltas. In Jakarta Bay, massive blooms of phytoplankton several metres thick are present for several kilometres offshore, moderating slowly with increasing distance away from Jakarta (Brown 1986). There is some use of fertilisers, particularly in plantation agriculture, although by world standards pesticide and fertiliser use are low.

Iron fertilisation by the Indonesian wildfires resulting from the 1997 Indian Ocean Dipole was considered sufficient to produce an extraordinary red tide causing extensive reef death in the islands off Eastern Sumatra (Abram et al. 2003), highlighting the relation between climate, wildfires and impacts to coastal marine ecosystems.

Wallacea

Eutrophication in Wallacea has only slight environmental impact, concentrated around the major urban centre of Makassar. There have been some episodic fish kills, notably in south Bali and Lombok Strait in December 1997, but these remain anomalies rather than regular or widespread events.

Sahul

There are no known environmental impacts of eutrophication in Sahul at present.

Chemical pollution

Sunda

Chemical pollution has had moderate to severe environmental impact in Sunda at present, being a significant problem in the rivers of north

Jawa and urban areas of Jakarta, Bandung, Semarang, Surabaya and Padang in Sumatra. Water contamination occurs from agricultural pesticides and from manufacturing, metal fabrication, ship repair and agricultural and food processing industries (oil milling, sugar refining and meat and fish processing) and from mining, with contaminant loads concentrated near the discharges. Releases of chemical and other forms of pollution from shipping in harbours are common, as regulations and controls relating to ship-derived pollution are rarely enforced. Pollution on coral reefs has been identified in bio-indicator studies using stomatopod crustaceans (Erdmann & Caldwell 1997).

Wallacea and Sahul

Chemical pollution has had only minor environmental impact at present, being a significant problem only around Makassar, and in Jayapura, and in mining-affected streams and coastal waters, with contaminant loads concentrated near the discharges. For example, the Minahasa mine on North Sulawesi discharges tailings into Buyat Bay just 80 m below sea level. Since it opened in 1996, people living around the bay have complained about mud and dead fish being washed up along the shoreline, empty fishing nets, and skin rashes among people exposed to the seawater. Toxicologist Rizal Rompas of Sam Ratulangi University in Manado, Sulawesi, found heavy-metal contamination in fish and plankton. He blamed the mine discharges and warned that, contrary to the mine operator's claims, toxic tailings were returning to the surface (Pearce 2000). The nickel mine on Gebe Island, Sahul, also loses tailings and ore into coastal waters, producing locally significant impacts (Done et al. 1997).

Suspended solids

There is a well-demonstrated correlation between catchment size and erosion rate and the generally small size of Indonesian catchments automatically produces a high sediment yield (Hopley pers. comm.). This is exacerbated by deforestation which, for Indonesia as a whole, is estimated at approximately 1.6 million ha annually (UN 2002), caused largely by forest concessionaires, forest fires, illegal logging, lack of law enforcement, mining, and transmigration and is driven by market demand. Details of government efforts at ameliorative interventions for deforestation are provided in Remedial interventions section below. Figure 5 shows reefs at risk due to sedimentation in the Indonesian Seas region.

Sunda

Environmental impacts from suspended solids are severe in streams, rivers and coastal waters throughout most of Sunda, particularly in north Jawa and Sumatra, with major increased turbidity over wide areas and changes in biodiversity due to excessive sedimentation. This has mostly resulted from sediment transport in streams and rivers to coastal waters following extensive deforestation in many watersheds, compounded by high rates of erosion, and siltation rates among the highest on Earth (Hodgson & Dixon 1992).

Most large-scale forestry by both national and international commercial operators is focused in Kalimantan and Sumatra. In Borneo overall, more than half the original forest remained in the mid-1990s, although lowland forests are under particular threat from logging, and also from drought and fire (e.g. the 1997 ENSO event) (Kartawinata, pers. comm., Daws & Fujita 1999) (Figure 6). Major ENSO-

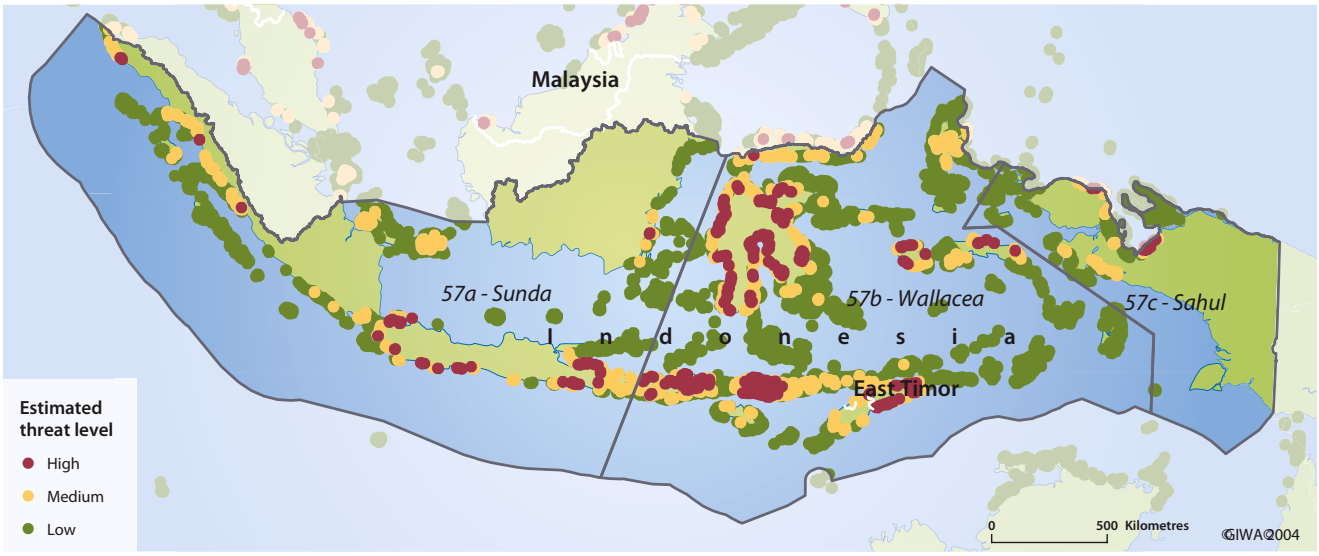

Figure 5 Reefs at risk due to sedimentation.
(Source: Burke et al. 2002)

Figure 6 Deforestation, Jawa, from October 19, 2002.
Islands of forest appear green against the paler landscape. In nearly every patch active fires can be seen (red dots). (Photo: NASA)

related droughts and fires in the 1990s contributed to loss of ground cover, sediment mobilisation and loss.

In Sumatra and Kalimantan, large areas of forest have already been logged and other areas have been assigned for logging, contributing to the severe soil erosion. This is of particular concern given that the timber industry in Indonesia, as well as other areas of South East Asia, has traditionally suffered from mismanagement and corruption, although there have been recent improvements. Nonetheless, implementation of "best-practice" forestry management (Ascher 1993), such as the retention of buffer zones along watercourses, is rarely enforced and violations are common. Large-scale sediment mobilisation from unregulated forestry and agriculture has already impacted on water quality of streams and rivers and ultimately on estuarine and coastal habitats e.g. fringing reefs (Edinger et al. 1998) (Figure 5) and processes in parts of the region (e.g. East Kalimantan, north coast of Jawa). For example, rates of progradation of the Solo River Delta are of the order of 70 m per year (Spalding et al. 2001), partly the result of natural processes but with a contribution from human impacts in the catchment. In the Jawa Sea, enormous quantities of sediment are lost to coastal waters annually (Edinger et al. 1998), carrying high loads of particle-bound nutrients. This has, in turn, contributed to massive levels of eutrophication (e.g. Jakarta Bay, see Eutrophication).

Quantitative data of sediment loss for most Indonesian rivers are not generally available. As noted earlier, the Mahakam River, which drains about one third of East Kalimantan, is very turbid with suspended particulate matter (SPM) concentrations reaching 80 mg/l. The river has a potential to discharge from 4 million tonnes (Dutrieux 1991) up to 10 million tonnes sediments per year (Eisma et al. 1989 in Hopley & Suharsono 2000). Fluvial sediments extend up to 50 km offshore and the Mahakam River plume can extend up to 400 km to the southeast and is considered by Tomascik et al. (1997) to be responsible for the general lack of coral reefs along a large part of the East Kalimantan coastline. These figures are almost certainly enhanced by land degradation within the Mahakam River Basin, especially as the soils developed on the Tertiary sedimentary rocks are highly erodable (Hopley 1999a).

Wallacea

Environmental impacts from suspended solids are moderate in streams, rivers and coastal waters throughout most of Wallacea, particularly in Sulawesi and western Lombok. Close to the major urban centres, such as Makassar, the affected zone extends up to 50 km from the city (Hopley & Suharsono 2000). Industrial mining is a major contributing factor. Mega-mines across the sub-system are already adding prodigious volumes of ground-up rock to the bays. The biggest and newest is the Batu Hijau copper and gold mine, opened last year on Sumbawa. It will discharge more than 1 billion tonnes of tailings over the next decade or so into

the local bay. No mine in Indonesia has ever dumped so much over so wide an area (Pearce 2000).

In the more heavily settled areas, a doubling or more of sediment yield and an increase in run-off as vegetation has been cleared is possible. Pollnac et al. (1997 in Hopley & Suharsono 2000) report sediments from the Tondano River, North Sulawesi, affecting the nearby Molas coast and spreading towards the Bunaken National Park situated in the neighbouring GIWA region Sulu-Celebes Sea. In a quantitative study of five coral reefs (in Jawa and Eastern Indonesia), Edinger et al. (1998) showed that a variety of land-based pollutants caused reductions in coral diversity of about 30 - 60%, with greater impacts where the reefs were subjected to combined sewage and sedimentation (Figure 5) (Hopley & Suharsono 2000).

Sahul

Environmental impacts from suspended solids are minor throughout most of Sahul, with some erosion from forestry concessions and mining. Here also, mines (e.g. nickel mine on Gebe Island) lose significant quantities of ore to the sea during loading or from tailings disposal, but usually with highly restricted spatial impact (Done et al. 1997). Future plans for sub-marine tailings disposal in developing mines are the subject of considerable controversy in relation to their likely impacts from suspended solids and chemical pollution (Pearce 2000, Kahn pers. comm.).

Solid wastes

Sunda

Environmental impacts from solid wastes in the Sunda sub-system are severe, particularly in the Jawa Sea and around the cities, towns and villages where waste management is unable to keep pace with production (Figure 7). Massive amounts of plastic bags and other waste products flow into Jakarta Bay and foul the Pulau Seribu islands (see e.g. report by Willoughby et al. in Brown 1986).

Figure 7 Waste in a local canal, Jakarta, Indonesia.
(Photo: J. Oliver, Reefbase)

Wallacea and Sahul

Environmental impacts from solid wastes have had severe impact locally, particularly around major cities, towns and villages, but have caused slight (Sahul) to moderate (Wallacea) environmental impact overall. Plastic and other floating wastes wash ashore on many beaches and clog outboard motors of boats.

Spills

Sunda

Environmental impacts from spills in Sunda are moderate, with widespread contamination by hazardous or other materials from shipping and oil exploration and transport in the Jawa Sea, and industrial discharges into rivers and streams. Jawa Sea forms part of both the main and ULCC oil tanker routes between the Indian and Pacific Oceans, with regular discharge of ship ballast waters. International trade is expected to triple by 2020, and much of this trade will be transported by sea (Chua pers. comm.). Increased tanker traffic has the potential for damaging spills to oceanic and coastal habitats, mangroves and coral reefs. Indonesia has yet to ratify the International Convention on Prevention of Marine Pollution from Ships (MARPOL), and there is an urgent need for developing oil spill contingency planning. Little spill control equipment is in place and implementation of emergency procedures is not well developed.

There is chronic pollution from production facilities and oil refineries in Sunda. Blowouts have occurred at offshore platforms near Balikpapan in East Kalimantan. Most production is exported and tanker traffic is concentrated in three major shipping lanes: Malacca Strait, Makassar Strait and Lombok Strait. Between 1974 and 1994, 36 major tanker spills were reported in Indonesian waters, 66% of which were in the Malacca Strait (Hopley & Suharsono 2000).

Wallacea and Sahul

Environmental impacts from spills are slight overall, but with moderate impact in some areas, where spills have occurred during tanker delivery to urban centres (e.g. Makassar). Ships discharge ballast waters near Take Bone Rate and there are tar balls from ballast in Lombok Strait and Makassar Strait, forming part of the ULCC oil tanker route between the Indian and Pacific Oceans. These impacts notwithstanding, spills occurring in Wallacea and Sahul are much fewer than those in Sunda. Edinger and Browne (in press in Hopley & Suharsono 2000) believe that the ability of the Indonesian network to respond to a major spill has not yet been tested.

As with Sunda, there is an urgent need for developing oil spill contingency planning. Little spill control equipment is in place and implementation of emergency procedures is not well developed. In Sahul, spills of hazardous materials, mostly associated with mining and offshore shipping, have only small-scale adverse effects with no significant avian mortality.

Socio-economic impacts

Sunda

The economic, health and other social and community impacts of pollution are severe for the Sunda sub-system. Most socio-economic impacts are concentrated in and around the major urban centres, coastal villages and Jawa Sea. Indeed, Jawa is the top source of domestic, agricultural and industrial pollution in Indonesia. The key impacts and threats, focused in Jawa and the Jawa Sea, are mostly unquantified at the sub-system scale, but include, according to the GIWA Experts, impacts such as increased risks to human health, and increased costs of human health protection, including preventive medicine and medical treatment as well as loss of water supplies (e.g. potable water) and increased costs of water treatment. There has also been losses of tourism, recreational or aesthetic values, and also in fisheries, including negative effects on subsistence artisanal fisheries and aquaculture; together with reduction in options of other uses of freshwater and future costs of disruption to shipping and other contingency measures.

Wallacea

Socio-economic impacts from pollution range between slight to severe. Most impacts are related to aquaculture, fisheries, tourism and mining and are concentrated in the major urban centres or mine discharge sites. Tailings are discharged into the Buyat Bay from the Minahasa mine on North Sulawesi and, as noted above, people living around the Bay have complained about mud and dead fish being washed up along the shoreline, empty fishing nets, and skin rashes among people exposed to the seawater (Pearce 2000). Impacts from inadequate waste disposal are widespread among the urban centres, and are also likely to affect international tourism (e.g. Bali).

Sahul

Socio-economic impacts from pollution are slight for the three components of the three indicators. Most impacts are concentrated in the major urban centres and in streams affected by mine tailing wastes.

Conclusions and future outlook

Water pollution of sufficient severity to cause massive fish kills, harvest failure in aquaculture ponds and threats to human health is found in virtually all populated and/or highly industrialised areas of Indonesia (Dahuri 1999, Hopley & Suharsono 2000). Point sources include rivers and discharge pipes, with more widespread pollution from groundwater seepage. No sewage treatment plant is available for any major coastal city in Indonesia (Edinger et al. 1998), and the problem is aggravated by recent increased intensity of rice cultivation and application of chemical fertilisers (Ministry for Environment/UNDP 1997 in Hopley & Suharsono 2000). Continuing deforestation, at the rate of some 1.6 million ha annually is a major contributor to suspended solids in watercourses. Coral reefs throughout the region are also at significant risk (Figure 8), with major future socio-economic implications (see Habitat and community modification and Unsustainable exploitation of fish and other living resources below).

In Sunda, present levels of environmental impact from pollution as a whole are severe, particularly for microbiological pollution (mostly sewage and agriculture), chemical pollution (industrial and agricultural inputs), suspended solids (deforestation and erosion) and solid wastes. Environmental impacts from pollution in streams and rivers, the inter-tidal zone, and waters of the Jawa Sea are likely to deteriorate further, with overall impact remaining severe. This is primarily because of the predicted major increases in population, in the major sectors of forestry, agriculture and aquaculture and expanding industrialisation. These increases are expected to override improvements in infrastructure and regulations. For the socio-economic indicators, future economic deterioration is expected, with health and other social and community impacts remaining stable. Thus, the socio-economic prognosis for the future is severe for economy, health and other social and community aspects from water pollution, despite regulatory and other interventions.

In Wallacea, present levels of environmental impacts of pollution are slight whereas the overall impacts of pollution were assessed as moderate. However, environmental impact of suspended solids, solid wastes and spills are already moderate to severe in some areas. For example, Makassar (Sulawesi), with a population of over 1 million, has heavy industry and no primary sewage treatment. The Berang and Tello rivers, with a combined catchment of over 1 150 km^2, are major sources of terrigenous sediments and run-off to which the sewage loading of Makassar is added (Hopley & Suharsono 2000). The effects of the chronic pollution gradient across the adjacent coral reef tract are clear. The water quality indicators are closely paralleled by ecological responses, most especially coral cover and coral diversity. Over the next 20 years, environmental impacts are likely to deteriorate, becoming moderate overall. For economic impacts, future improvements are expected and health and other social impacts will remain the same.

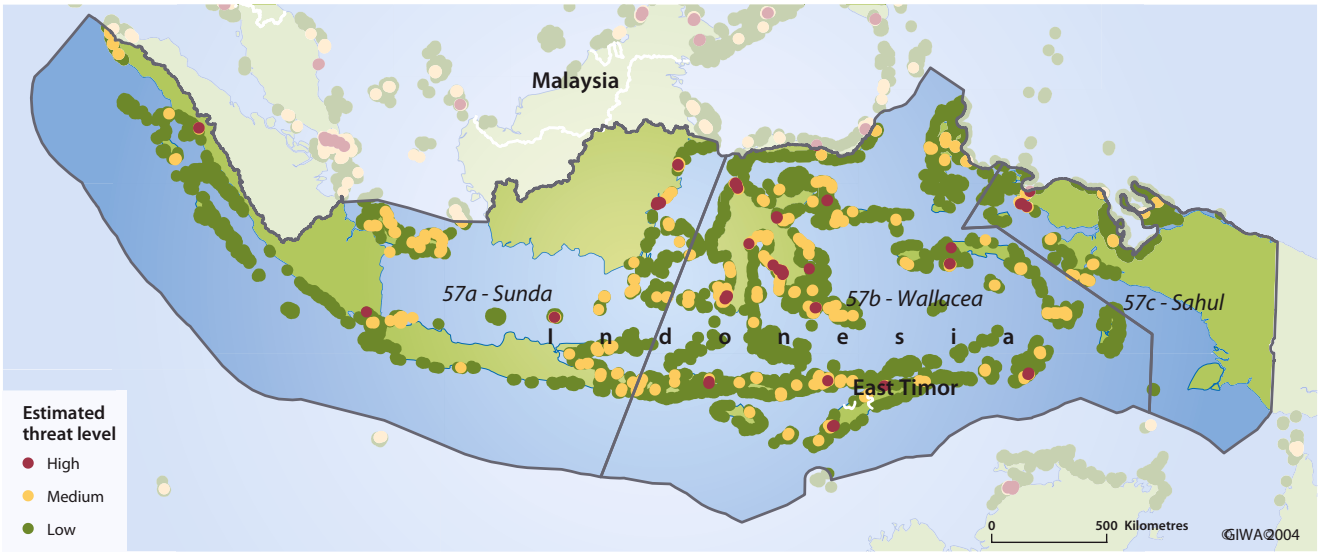

Figure 8 Reefs at risk due to marine pollution.
(Source: Burke et al. 2002)

In Sahul, the environmental impacts from pollution are slight at present; being highly restricted both geographically and sectorally, primarily to mining, forestry and urban wastes. Over the next 20 years, environmental impacts are likely to deteriorate markedly, becoming moderate, primarily because of the predicted increases in forestry, mining and agriculture, and a major increase in population without major improvements in infrastructure. Future deterioration is also expected for the economic impacts. By contrast, there is expected to be a slight improvement in health, while other social and community aspects may remain stable.

Remedial interventions

Indonesia is adopting industrial water pollution control standards similar to those in developed countries. However, formal regulation has been greatly hampered by the absence of clear and legally binding regulations (UNDP 1991), as well as limited institutional capacity, lack of appropriate equipment and trained personnel, and inadequate information on emissions (Hettige et al. 1996).

Indonesia began formal regulation in 1992 (Pargal et al. 1997) with establishment of maximum allowable volumes and concentrations (in kg/tonnes of output) for emissions of Biological Oxygen Demand (BOD) and other water pollutants from 14 broadly defined industry sectors (e.g. textiles, wood pulping). Although self-reported BOD emissions are now mandated by law, reporting was extremely sparse until recently. Until 1995, the only consistent programme of monitoring and pressure for compliance was a voluntary arrangement instituted in 1989. This PROKASIH or Clean Rivers programme covers about 5% of Indonesian manufacturing facilities in 11 river basins on the Sunda Islands of Jawa, Sumatra and Kalimantan. While it has succeeded in eliciting significant pollution reductions from some of Indonesia's largest polluters, PROKASIH represents only the first stage of regulation.

Yet, despite weak or non-existent formal regulation, there are many clean industrial plants. However, there are also many plants that are among the world's most serious polluters (Hettige et al. 1996). The analysis of Hettige et al. (1996) demonstrated that pollution intensity was negatively associated with scale, productive efficiency, and the use of new process technology. It was strongly and positively associated with public ownership, but foreign ownership had no significant effect once other plant characteristics were taken into account. Among external sources of pressure, community action, or informal regulation, emerged as a clear source of interplant differences. Hettige et al. (1996) suggested that local income and education are powerful predictors of the effectiveness of informal regulation. The results also showed that existing formal regulation had measurably beneficial effects, even when it was quite weakly developed. Abatement is generally subject to significant scale economies; within-country variations in labour and energy prices have little impact on pollution intensity; and community incomes have a powerful negative association with pollution intensity (Pargal et al. 1997). Although the plant and firm characteristics are important in Indonesia, community income is particularly important, since this suggests a powerful role for informal regulation whether or not formal regulation is in place.

Indonesia's Environmental Impact Management Agency (BAPEDAL) has recently initiated PROPER-PROKASIH. This programme gives participating industrial and other manufacturing plants colour-coded grades indicating their compliance with pollution regulations. PROPER-PROKASIH is continuing and preliminary results suggest it has had a positive impact on polluter behaviour as well as BAPEDAL's capacity for regulation.

In fostering sustainable agriculture, the Integrated Pest Management Program (IPM) was initiated in 1986, after implementation of the Presidential Instruction that banned use of 57 pesticides on rice, and also cut off subsidies. Some 1 million farmers have now been trained in IPM, with some 2 700 full-time government IPM trainers and 1 200 part-time trainers now operating. In terms of funding for sustainable agriculture, the sector was allocated almost 10% of the national expenditure in 1999-2000, down slightly from the previous year. Additional financial support is provided by sustainable agriculture networks in Australia, France, Thailand, Japan, the EU and Morocco (UN 2002).

In response to deforestation, the Government has classified forests according to function as production forest, protection forest, and nature reserve. In 1999, total forest area was some 120.3 million ha (UN 2002), of which 66.3 million ha was production forest, 33.5 million ha was protected forest, and 20.5 million ha was nature reserve.

Substantial areas are being converted from production forests to protection forest. For example, in 1999, a total forest area of 1 298 990 ha had been converted from production to protection forest or nature reserve. Recent legislation, including Law No. 41/1999 on Forestry, has provided a new direction for forest development planning, which must be transparent; integrated; and participatory (also see Annexes III-V). The Law allows for the role and right of people living in and around conservation areas in forest management (UN 2002). Furthermore, President's Instruction No. 5/2001 details the abatement of illegal logging and distribution of illegal forest products.

Several government agencies hold jurisdiction of forests, including:

- Directorate General of Production Forests, under the Ministry of Forestry and Crop Estates, the primary government agency, authorises release of logging concession rights;
- Department of Trade and Industry, issues permits for establishing timber and forestry enterprises;
- Department of Agriculture, conversion of forests to agricultural land;
- Department of Mines and Energy, grants mining rights in areas that include forests.

Other organisations and agencies involved in forest protection include:

- Consultative Group of Indonesian Forestry, established in 1994 as a coalition of institutions for various donor countries;
- Inter-Departmental Committee on Forestry, organised to formulate the National Forest Programme.

Funding for forest management has been provided by the World Bank, Asian Development Bank, Canadian, German and Japanese government aid agencies, among other donors. Continuing activities include the establishment in forest villages of forest production centres and forest and ground fire control centres. The former support community-based forest management, with routine patrols and intelligence operations checking for illegal logging and illegal distribution of forest products. The latter, in association with a national coordinating team for the control of forest and ground fires, focus on prevention of forest fires. The Government has also established forest rehabilitation programmes with the participation of local communities, and in 1999-2000 targeted 155 688 ha for reforestation and afforestation (UN 2002).

Despite these and other pollution mitigation initiatives, future deterioration is expected in all four environmental and socio-economic indicators, particularly in Sunda. Addressing water security alone is a major challenge (as noted in the section on Freshwater shortage above), and insufficient progress is being made in addressing the other major forms of water pollution at present. For example, river and coastal aquaculture projects are growing rapidly, with little regulation or enforcement. Up to 1 million ha of land, mostly mangrove forests, were allocated by the government for the shrimp hatchery industry during the 1980s and 1990s. By 2001, about 70% of the shrimp farms had been abandoned, because the operators found them unsustainable due to the high concentrations of chemicals and the destruction of the mangrove habitat.

Habitat and community modification

The GIWA region Indonesian Seas is located in the heart of the Indo-West Pacific centre of diversity, supporting mega-diversity on both land and in the sea (Roberts et al. 2002), hosting some 17% of all known species (UN 2002), including:

- 11% of flowering plants;
- 12% of mammals;

- 15% of amphibians and reptiles;
- 17% of birds;
- 37% of fishes;
- >60% of reef-building corals.

Ecosystems range from icy mountain areas in Papua of more than 5 000 m altitude, to humid tropical lowland rainforest, from deep lakes, including the largest volcanic lake in the world at Lake Toba, to immense shallow swamps, mangrove forests, seagrass beds, coral reefs and deep ocean basins. A major discontinuity in floral and faunal diversity occurs along the "Wallace's Line", where the Asiatic and Australasian biogeographic realms converge (also see Boundaries of the region).

On land, tropical forest support outstanding levels of diversity and endemism across most plant and animal groups, with Sulawesi, Papua and the Mentawi Islands hosting exceptional levels of endemism. Indonesia is the centre of genetic diversity for cloves (*Syzgium* sp.*)* durian (*Durio* spp.), banana (*Musa* spp.) and rambutan (*Nephelium* spp.), with more than 6 000 plant and animal species used daily by Indonesians (UN 2002).

In the sea, biodiversity and habitat complexity are no less outstanding. Some 13 species of seagrasses are present, along with 47 species of mangroves, among the richest diversity on Earth. Mangrove forests cover an area estimated at between 2.49 million ha (Tomascik et al. 1997) to 4.25 million ha (Wilkinson 1994). Most mangroves are located in Sahul (Papua, estimated at 29 000 km^2) and Sunda (Sumatra 4 170 km^2, Kalimantan 2 750 km^2, Jawa 343 km^2) (Priyono & Sumiono 1997), representing more than 67% of the total area of mangroves in South East Asia. Seagrass beds are even more extensive (30 000 km^2 according to Tomascik et al. 1997) and exist in varied habitats from intertidal mudflats to shallow sandy beaches to coral reef flats. However extensive cutting for timber, conversion for aquaculture and other forms of coastal development and extensive siltation/sedimentation have caused major fragmentation and reduction in the area of these habitats.

Despite the continuing loss and fragmentation of seagrass habitat, the dugong (*Dugong dugon*) is still present, particularly in areas of Wallacea (Sulawesi, Bali and Flores) although these were once more common in suitable seagrass habitats throughout the entire region. Marsh et al. (2001 in Perrin et al. 2002) describe dugongs as rare or depleted throughout their original range in the Indonesian archipelago, with a rough population estimate of perhaps 1 000 animals in 1994. In Indonesia, declines in dugong abundance and distribution, including extirpation of local populations, are likely to continue and may even accelerate.

In addition to the Irrawaddy dolphins, other species and populations of coastal cetaceans face similar and equally severe threats (Perrin et. al. 2002). In many provinces there has been an increase in the rates of extraction of natural resources, including rampant and uncontrolled logging, large- and small-scale mineral mining, expanded coastal developments and industrialisation, and increased mariculture, together with ever-growing coastal and pelagic fisheries. Hence, Perrin et al. (2002) concluded that many cetacean populations that inhabit Indonesia's estuaries and coastal waters may be in decline. Similarly for the oceanic cetacean species, fishery by-catch has probably caused significant reductions in abundance, especially for small cetaceans but possibly also for large cetaceans such as sperm whales and blue whales in the eastern provinces (Table 4).

The region supports populations of six species of sea turtles (Green, Hawksbill, Olive ridley, Loggerhead, Flatback and Leatherback) and some 29 species of marine mammals (Jacinto et al. 2000, Kahn & Pet 2003). In Komodo National Park alone, observations over the period May 1999 - April 2001 recorded 18 species of whales and dolphins (Kahn & Pet 2003).

Indonesia also forms part of the "coral triangle" of highest coral reef biodiversity (e.g. more than 500 reef-building coral species and some 2 500 species of reef-associated fishes) and has an unmatched variety of coral reef habitats. Wallace and Wolstenholme (1998) classified 15 different types of major habitat. Depth of water immediately offshore

Table 4 Overview of environmental impacts of relevance to Indonesia's marine mammals.

Impacts	Habitats affected		
	Riverine	Coastal	Oceanic
Habitat destruction - Forest logging	√	√	
Habitat destruction - Coastal development	√	√	
Chemical pollution - Industrial and urban wastes, terrestrial run-off	√	√	√
Chemical pollution - The discharge of mining wastes as sea. The disposal of toxins via a procedure termed submarine tailings placement (STP) is of special relevance to Indonesian marine life.		√	√
Acoustic pollution - Destructive fishing practices such as reef bombing. This illegal fishing method can have regional impacts, especially in the vicinity of sensitive marine areas for cetaceans such as preferred feeding and breeding areas as well as migration passages.		√	√
Acoustic pollution - Seismic surveying for oil and gas by offshore industries.		√	√
Acoustic pollution - Military and scientific experiments		√	√
Gill netting in sensitive marine areas for cetaceans.	√	√	√
Traditional hunting, especially in the waters of the East Flores islands.			√
Discarded plastics and fishing gear.	√	√	√
By-catch in local and regional fisheries.	√	√	√

(Source: Perrin et al. 2002, APEX 2004)

may range from a few metres off inshore reefs, to 100 m off reefs on the margins of the continental shelves such as the Spermonde Archipelago, to 2 000 m or more adjacent to the oceanic troughs which lie close to the southern subduction zone (Jompa 1996, Hopley & Suharsono 2000).

In the region as a whole, coral reefs and associated habitats of mangroves and seagrasses have experienced major declines in the past several decades. WWF Indonesia (2000) estimated that 80% of Indonesia's reefs were highly or moderately degraded and remain under threat from human activities. A comprehensive review of Indonesia's coral reefs by the Indonesian Institute of Sciences (LIPI) estimated that 40% of sites were in poor condition, with living coral cover of less than 25% (Chou 2000, Suharsono pers. comm.). By contrast, just 29% of sites were in good to excellent condition, with coral cover of greater than 50%. These data provide clear indications of rapidly declining reef health. Notably, the reefs of eastern Indonesia (Wallacea and Sahul) remain in better condition than those of the western area (Sunda), but are under increasing threat.

As reviewed by Hopley and Suharsono (2000), many summaries and syntheses of the status of coral reefs, especially from survey data from Indonesian Institute of Science (LIPI), have been made over the last 10 years (e.g. Wilkinson et al. 1993, Soekarno 1994, Chou et al 1994, Soegiarto 1997, Chou 1997, 1998, Suharsono 1998, all in Hopley & Suharsono 2002). The synthesis of the results, for various times during this period, is shown in Table 5 and 6. The rate of degradation and loss of productivity of coral reefs of the region is shown in Table 7. A detailed analysis of reef condition for various areas of Indonesia is provided by Hopley and Suharsono (2000).

Table 5 Coral cover of reefs in Indonesia.

Date	Number of stations	Coral cover * (%)			
		Excellent	Good	Fair	Poor
1989	124	5.6	30.6	33.9	29.8
1995	217	4.6	24.4	28.6	42.4
1998	421	6.4	24.2	29.2	40.4
1999	410	6.1	22.7	31.5	39.8

*Note: * Excellent = 76-100% cover; Good = 51-75% cover; Fair = 26-50% cover; Poor = 0-25% cover. (Source: Hopley & Suharsono 2000)*

Table 6 Status of the coral reefs in Indonesia using the 1999 LIPI data.

Area (Sub-system) *	Status of the reefs (%)			
	Excellent	Good	Fair	Poor
Western Indonesia (Sunda)	3.0	14.5	28.9	53.6
Central Indonesia (Sunda and Wallacea)	6.7	25.4	38.8	29.1
Eastern Indonesia (Wallacea and Sahul)	10.0	31.8	26.4	31.8
All Indonesia	6.1	22.7	31.5	39.8

*Note: * The three areas only roughly correspond to the three sub-systems dealt with in this report. (Source: Modified from Hopley & Suharsono 2000)*

Table 7 Coral reef degradation in Indonesia.

Area (Sub-system) *	Degraded reef (%)		Loss of productivity (%)	
	50 years ago	1993	50 years ago	1993
Western Indonesia (Sunda)	20	60	10	60
Central Indonesia (Sunda and Wallacea)	10	40	5	30
Eastern Indonesia (Wallacea and Sahul)	10	50	10	20

*Note: * The three areas only roughly correspond to the three sub-systems dealt with in this report. (Source: Modified from Hopley & Suharsono 2000, as modified from Chou et al. 1994 ASEAN report).*

Processes regulating diversity and recovery of coral reefs following disturbance also vary enormously within the Indonesian Seas region (Tomascik et al. 1996, 1997, DeVantier et al. 1999, Edinger et al. 1998). In some areas (e.g. Banda Islands), recovery following catastrophic mortality (from volcanic eruption and lava flow) is among the fastest yet documented (Tomascik et al. 1996, 1997). In other areas, and with other forms of disturbance, natural recovery is much slower or non-existent, particularly where the underlying reef substrate has been modified through sedimentation (i.e. terrestrial run-off) or breakage (i.e. rubble production during blast fishing). This wide spectrum in recovery potential is of significant importance in both management and remediation, illustrating the stark contrast between some natural and human impacts and their medium to long-term effects. Local-scale remediation in circumstances of blast damage producing unstable rubble fields may rely on rebuilding solid substrate for recruitment e.g. Komodo National Park (see Box 1) (TNC 2000, Mous and Pet pers. comm.).

Ambient waters may range from highly turbid to as clear as anywhere in the world, and a full range of energy levels are found from the southern oceanic swell coastlines of the islands of Sumatra, Jawa, Bali and Nusa Tenggara, to the almost constantly smooth waters of the Bay of Tomini (Wallace & Wolstenholme 1998). High regional biodiversity levels are maintained because different types of reefs, with almost unlimited permutations of contrasting environmental conditions, are often found in close proximity (Hopley & Suharsono 2000).

Loss of ecosystems

Overall in Indonesia, somewhere between 20% and 70% of habitats are considered lost, with extinction of species occurring at one per day (UN 2002). Of the better known groups, IUCN considers that 126 Indonesian birds, 63 mammals and 21 reptiles are endangered.

Box 1 Restoration of coral reefs following blast fishing.

Illegal fishing with homemade bombs or dynamite is rampant throughout South East Asia and has devastated many coral reefs in the region. In addition to fish and other organisms being indiscriminately killed, coral skeletons are shattered by the blasts, leaving fields of broken rubble. This rubble shifts in the current, abrading or burying any new coral recruits, thereby slowing or preventing reef recovery.

Due to effective management, blast fishing has decreased in Komodo National Park (KNP), making restoration efforts worth investigating. Based on 4 years of pilot data testing three different methods (rock piles, cement slabs, and netting pinned to the rubble) rocks were selected for large-scale rehabilitation. Many more corals per m^2 grew on the rock piles compared to untreated rubble. Rocks also provided the most natural, complex substrate, were easiest to scale up, and are relatively inexpensive compared to reef rehabilitation methods being investigated elsewhere. Mid-scale rock piles were installed in 2000; cover by hard corals on the rocks continued to increase as of this most recent visit (March 2003).

In 2002, rehabilitation efforts in Komodo National Park were further scaled up, testing four rock pile designs at each of four different rubble field sites, covering more than 6 000 m^2 total. If the rubble fields have adequate source coral larval supply from nearby live coral, using rocks for simple, low-cost, large-scale rehabilitation could be a viable option to restore the structural foundation of the reefs, thereby facilitating the return of coral, fish, and other reef-associated life.

(Source: Excerpted from Fox et al. 2003)

Sunda

The environmental impacts of habitat loss in the Sunda sub-system are severe. More than 30% of the surface area of mangroves in north Jawa has disappeared during the last 150 years (also see Box 2). For most habitats, notably marshes, swamps, riparian belts, fast flowing stony bottomed streams and slow flowing sandy/muddy floodplain rivers, extensive habitat fragmentation has already occurred. Seagrass beds, muddy and sand-gravel bottoms and fringing coral reefs are also impacted by trawling. Development and expansion of ports has resulted in foreshore reclamation and channel dredging, with major destruction of reefs, and indeed their associated coral islands (cays, e.g. Jakarta Bay) (Soemodihardjo 1999).

There is little information on the population status of Indonesia's cetaceans (Perrin et al. 2002) except for the Irrawaddy dolphins of the Mahakam River, East Kalimantan. The population there has been declining rapidly and is currently estimated at less than 50 animals, possibly only 35-42 (Kreb 2002 in Perrin et al. 2002). The earliest estimates, in 1978 by the Directorate of Forest Protection and Natural Conservation, were 125-150 animals for the same population. In 1993 the population was at 68 individuals (Priyono 1993 in Perrin et al. 2002). Although these numbers cannot be used for a rigorous trend analysis, the extremely small size of this apparently isolated population was regarded as sufficient cause for IUCN to list it as critically endangered in 2000.

Wallacea and Sahul

The environmental impacts of habitat loss in Wallacea and Sahul are less severe than Sunda and were rated as moderate to slight, with reduction/loss of mangroves, particularly around major ports (e.g.

Box 2 Mangrove clearance and development for aquaculture ponds.

There are various estimates for the area of mangroves in Indonesia. Wilkinson (1994) quotes an area of 4.25 million ha, representing about 70% of the total for South East Asia or 25% of the global area. Atmadja and Soerojo (1994) estimated that in 1992, 32.4% of the mangrove area had been lost. There are numerous studies on the valuation (e.g. Turner & Adger 1996) and exploitive impacts (e.g. Brown 1997) of mangroves in relation to clearing for fishponds. Apart from the loss of biodiversity, mangrove loss has immediate impact on fish stocks, destabilises the coastline and affects a variety of resource uses (Atmadja & Man 1994). Conversion to fish ponds include the following impacts:

- Detrimental impact on wild stock as large brood stock are raided for larval rearing;
- Use of antibiotics, bacterial pond treatments, chemicals and feed can severely affect water quality both within the ponds and beyond;
- Water quality may also decline as flushing of the ponds, unless planned carefully, which can be far less than in natural coastal and deltaic channels;
- In even semi-intensive situations there is a real threat of disease which can pass to the wild stock;
- Construction of ponds in mangroves often leads to the formation of acid sulphate soils with serious consequences for the impounded species and wild stock.

Restoration of abandoned fish ponds is not easy. Many of the quoted impacts have important transboundary implications. Further, there are examples in Indonesia where the investment in prawn factories which process the local product for export are owned and/or financed by overseas capital, especially from Japan. The market for the farmed product extends across South East Asia, including Australia. A comprehensive assessment of the problem is provided by e.g. MacKinnon et al. (1996), Tomascik et al. (1997) and Marsden (1998). The Mahakam Delta of Kalimantan Timur illustrates the seriousness and complexity of the mangrove clearance problems (Hopley 2001). Salient features of this are:

- The Mahakam Delta with an area of 150 000 ha is one of the most important and extensive areas of Nypa (palm) and mangrove wetlands in East Kalimantan, but over the last few years has seen a rapid and unplanned clearing for aquaculture. In 1992 the approximate area of ponds was only 2 800 ha, mainly on land which was previously converted to coconut plantations; by 1998 the area was about 13 800 ha or 9% of the delta and expanding.
- The industry is now well established and is the economic basis and main employee for much of the population of the delta. It is an important export earner, producing about 1 400 tonnes of mainly *Penaeus monodon* prawns per year, about half of which are exported to Japan via two processing factories located in Anggana.
- Apart from the direct effects of wetland clearing, environmental impacts to date appear limited due to the extensive nature of the aquaculture system (no supplementary feeds etc.) and the well-flushed waters of the delta.
- However, because of the ad hoc development of the industry there is a developing conflict of interest as tambak spread into areas utilised by the delta's other major industry, oil and gas extraction. This is not only dangerous, as ponds are built over pipelines, but potentially creates a situation in which the oil industry could be blamed for any downturn in aquaculture production which is due to other causes.
- Environmental problems which may arise include impacts on wild fish over a very large area as fish and crustacean nursery grounds are lost, erosion of delta front and estuary banks because of clearing of the protective vegetation, and decline in water quality from acid sulphate soils, overdevelopment of tambak and possibly from the middle and upper reaches of the Mahakam River. Disease could become a major problem though the discrete nature of the delta lobes could help in any quarantine exercise.
- Socio-economic problems have also been recognised in other areas where rapid and unplanned expansion of aquaculture ponds has taken place. Conflicts arise from land use competition, land ownership and distribution of economic benefits, especially as new people are drawn into the area. In part, this may result from the lack of awareness of the direct non-market values of wetlands.
- The major problem in the development of the industry and in its current phase of rapid expansion is the lack of direction and management with little government involvement above the sub-district level. Even existing regulations including those which provide for green zones and buffer zones at the delta front, estuary banks and along oil and gas pipelines, are not observed.

(Source: Courtesy of D. Hopley)

Makassar) and indications of fragmentation of riparian and stream habitats from mining in the past several decades.

Modification of habitats

Sunda and Wallacea

Environmental impacts from habitat modification in the Sunda and Wallacea sub-systems were assessed as having severe impacts. These impacts include major changes in species complement due to introduction of alien species in freshwaters basins (e.g. *Tilapia* and water hyacinth), with at least 60 of the 1 400 freshwater fish species threatened with extinction (World Bank 1999, WRI 2000). Development-aid projects aimed at improving agricultural productivity can impact adversely on habitats. For example, the Government is implementing a crash programme in Repelita VI to improve 1.0 million ha of village irrigation systems and to develop a 600 000 ha rice estate by swamp reclamation in central Kalimantan. Reclamation of swamps will undoubtedly cause the fragmentation of these important habitats. In total, Indonesia has an estimated 39 million ha of coastal and inland swamps. The extent of arable swampland has not been assessed in detail but is estimated to be 7.5 million ha. In 1996, the tidal and non-tidal swamp area used for irrigation (mainly for rice) was about 1.18 million ha. The environmental impacts of swamp and other reclamation projects need to be considered carefully before implementation, with much improved integration among the relevant government departments and agencies.

There have also been major changes in population structure and functional group composition, notably on coral reefs (e.g. DeVantier et al. 1999) and massive changes in ecosystem services of coral reefs and mangroves. Many coral reefs have been degraded in terms of destructive fishing practices and overfishing (e.g. Edinger et al. 1998) and the important fisheries nursery-ground roles of large sections of mangroves and seagrass beds have been seriously depleted (see Box 2 above). Muro-ami, blasting (see Box 1 above) and poison fishing have damaged or destroyed large areas of coral reef. For example, World Resources Institute's Reefs at Risk in South East Asia reports (Bryant et al. 1998, Burke et al. 2002) estimate that up to 50% of some 51 000 km^2 of reef have already been degraded, with 85% threatened by human activities, which includes coastal development, overfishing, and marine-based pollution (Figure 2 in Regional definition). In the last 50 years, the proportion of degraded reef has increased from 10% to 50% (Hopley & Suharsono 2000). In central Indonesia, currently 40% of coral reefs are classified as being in poor condition and only 6% in excellent condition (Hopley & Suharsono 2000). However, because of the paucity of long-term monitoring and data, exact figures are difficult to obtain (Jompa 1996, Wilkinson 1998, 2000, 2002, Llewellyn in press).

Sahul

The environmental impacts of habitat modification are moderate and are less intense than in Sunda or Wallacea. Although the coral reefs of Eastern Indonesia may be in better condition than those of the west, they are still declining at a rapid rate. In the far eastern region, 32% are in poor condition, and just 10% are in excellent condition (Hopley & Suharsono 2000). There has been destructive fishing in some reef areas (e.g. Gag and Gebe Islands, Rajah Ampat area) (Done et al. 1997), changes in species compliment from introductions (e.g. water hyacinth), and some modification of mangroves and disturbance to soft bottom benthic habitats from trawling. Coral reefs in other parts of the sub-system are thought to be in relatively good condition, notably in the Rajah Ampat Islands, and with a large marine national park established in Teluk Laut Cendrawasih.

Socio-economic impacts

Major economic costs are accruing from loss and modification of coral reef habitats, which are of immense economic value. In South East Asia generally, reef fisheries alone are estimated to be worth some 2.4 billion USD per year (Burke et al. 2002). The reefs of Indonesia provided annual economic benefits of 1.6 billion USD per year in 2002, based on their value in food security, employment, tourism, pharmaceutical research and shoreline protection, however, over the next 20 years, human impacts, notably overfishing, destructive fishing and sedimentation, could cost Indonesia some 2.6 billion USD (Burke et al. 2002).

In the case of destructive fishing, the bombs, usually constructed from soda bottles stuffed with explosive potassium nitrate, detonate underwater, killing or stunning fish so that they are easy to collect. There is considerable collateral damage to reef communities, with localised death and injury to all incident species, and coral mortality rates of 50% to 80% (Hopley & Suharsono 2000). For the fisherman, the short-term gains from bombing may be impressive, with a 1-2 USD investment returning up to 15-40 USD in profit on the local market. Moreover, given the ease with which fish bombs are assembled (potassium nitrate is a common component of fertiliser) fishermen seldom make the switch to more sustainable, but time-consuming, technology like spears and hooks. As a result, in many coastal areas, bombed reef fish often dominate local markets. But the practice has a devastating effect on coral reefs, which may take more than 50 years to recover.

According to Burke et al. (2002), destructive fishing practices are the single largest threat to Indonesia's reefs. While the benefits to an individual fisherman may be high in the short-term, the costs as a whole are staggering. The report estimates that the cost from fish

Figure 9 Retaining wall made from coral.
(Photo: J. Oliver, Reefbase)

bombing alone over the next 20 years will be at least 570 million USD (Burke et al. 2002). That sum is more than 10% of the debts recently rescheduled with Indonesia's international lenders.

Cyanide use can be nearly as destructive as blast fishing, but its focus is often the international market, rather than local supply. Prized reef food fish like grouper (Serranidae) and Napoleon wrasse (*Chelinus undulatus*) are chased into corals, where the diver uses cyanide-filled squirt bottles to stun the fish for capture and sale on the live reef fish market. These fish are usually shipped aboard large cargo ships to discerning diners in Hong Kong, Singapore, Taiwan and the Chinese mainland, where the fish are picked out of aquariums just prior to cooking. The cyanide does more than stun the fish, though, as coral is killed as well, particularly since the divers often have to tear apart the coral structure with crowbars to pull the fish out.

The cost to Indonesia from cyanide use is estimated to be 46 million USD annually (Burke et al. 2002). By comparison, the report estimates the annual economic benefit to Indonesia from its reefs, which not only harbour valuable fish, but protect shorelines from erosion and facilitate the growth of coastal mangroves and seagrass beds, at 1.6 billion USD, as noted above.

Coral mining is another significant socio-economic (and environmental) problem (Figure 9). Mining and quarrying of coral reefs is widespread at both subsistence and commercial levels, although banned by various provincial governments (1973 in Bali, 1985 in East Nusa Tenggara) (Hopley & Suharsono 2000). The COREMAP project noted that coral mining was practiced at nearly all sites visited during their 1997 reconnaissance visit (COREMAP 1997, DeVantier pers. obs.). As noted by Hopley and Suharsono (2000), corals are mined to provide house foundations (especially in Kalimantan, Sulawesi and Maluku) and to build seawalls and jetties. They are also used to provide foundations for roads, to manufacture lime for mortar and other building purposes, to line shrimp ponds, as well as for decorative outlining of gardens and properties and for export as decorative pieces. In the early 1990s 642 000 pieces were exported to the USA (Cesar 1996).

Some examples illustrate the scale of the problem:

- In the Sekotong region of Lombok, there are 116 limekilns each requiring 2 784m^3 of corals per month. In addition, they require almost 7 000 m^3 of firewood which is taken from adjacent hill slopes (COREMAP 1996).
- In west Lombok, the production of lime has been in operation since at least 1935. The kilns here require 600 m^3 of coral per month for 30 kilns (Djohani 1995 in Hopley & Suharsono 2002).
- Also in Lombok, 60 families have been mining a 2 km stretch of fringing reef over a 10 year period, with each family producing about 25 kg of lime each year (Cesar 1996).
- In Bali, even in 1980 some 144 000 m^3 of corals were being removed for construction and in 1981 there were 400 coral mining enterprises (Nikijuluw 1998b in Hopley & Suharsono 2000). 2 880 people were working in the industry, which still exists.
- In Lasolo, Southeast Sulawesi, 20 tonnes of coral have been used to construct a dock (COREMAP 1997).
- The scale of coral usage is also illustrated from Nias in Sumatra where coral heads from the adjacent fringing reef were used as a road foundation between Gunung Sitoli and Teluk Dalam, a distance of about 100 km on Pulau Nias.

The related increase in turbidity impairs coral regrowth, while local fisheries decline and beach erosion increases where beaches are no longer well protected by the reef. Hotels in Bali and Lombok are estimated to spend over 100 000 USD per year to mitigate beach erosion caused in this way (Cesar 1996).

Additional socio-economic impacts can accrue from tourism, usually at two stages in the development of the industry (Hopley & Suharsono 2000). The early construction phase may employ damaging techniques of land clearing and quarrying of the reef for resort construction (see above). After the resort is occupied, damage may result from sewage disposal, anchor damage at dive sites (mooring facilities are not normally installed) and breakage of corals by inexperienced divers and snorkelers (when operators are not trained to give environmental advice to the tourists). Tourism may also create conflict with the local communities (Djohani 1995 in Hopley & Suharsono 2000). For example, tourism in Kepulauan Seribu National Park (Jawa Sea, Sunda) has grown rapidly, without comprehensive planning, since the 1970s, and caused a great deal of environmental and socio-economic impact. With 80 000 visitors in 1991 (Cheung et al. 2002) and despite a large amount of derived revenue, less than 5% of the local island population is employed in the industry. This worsens the conflict of interest between two major users; local fishermen and tourism developers/operators, and stimulates resentment among the local community.

In Lombok (Wallacea), seaweed cultivation has been stopped close to resorts, and in the Gili Islands of Lombok Strait ornamental fish collectors have deliberately bombed tourist reefs from which they are now excluded (Hopley & Suharsono 2000). Nonetheless, the industry contributes some 16% of Lombok's GNP, and even more in Bali. Cesar (1996) puts an economic value for tourism for Indonesian reefs at about 3 000 USD per km^2. Tourism has a far greater chance of being sustainable than the majority of other uses to which Indonesian reefs are put (Hopley & Suharsono 2000), provided it is well managed and as far as practicable integrated into local society, with the potential to help generate alternative incomes for villagers.

Loss of riparian and coastal vegetation also has enormous socio-economic implications, with up to 1 million ha of land, mostly mangrove forests, allocated by the government for the shrimp hatchery industry. By 2001, about 70% of the shrimp farms had been abandoned, because the operators found them unsustainable due to the high concentrations of chemicals in the mud and the destruction of the mangrove habitat. Local NGOs claim that the donor agencies (including the World Bank) should be held accountable for environmental destruction caused by shrimp farming, and that the government should establish clear criteria for sustainable shrimp farming and ways to rehabilitate damaged mangroves. In other parts of the region, similar habitat modification and destruction has taken place, and this has also led to human conflict. Progress in managing human use of habitats (see Causal chain analysis and Policy options section) is not expected to be sufficient to fully mitigate the damaging effects of population growth.

The socio-economic impacts of habitat loss and modification in the Sunda and Wallacea sub-systems were considered severe. Health impacts range from slight to severe, depending on the degree to which spread of mosquito-borne diseases can be attributed to modification of swamps and of mangrove habitats. There are serious economic issues in fishing communities and also from loss of mangrove habitats. There are also health issues arising from habitat loss and modification.

Key socio-economic issues remain unquantified at the sub-system scale, but clearly include:

- Reduced capacity to meet basic human needs (food, fuel) for local populations, particularly among poor coastal fishing villages heavily reliant on subsistence fisheries;
- Changes in employment opportunities for local populations and associated changes in social structures, particularly in poor coastal communities;

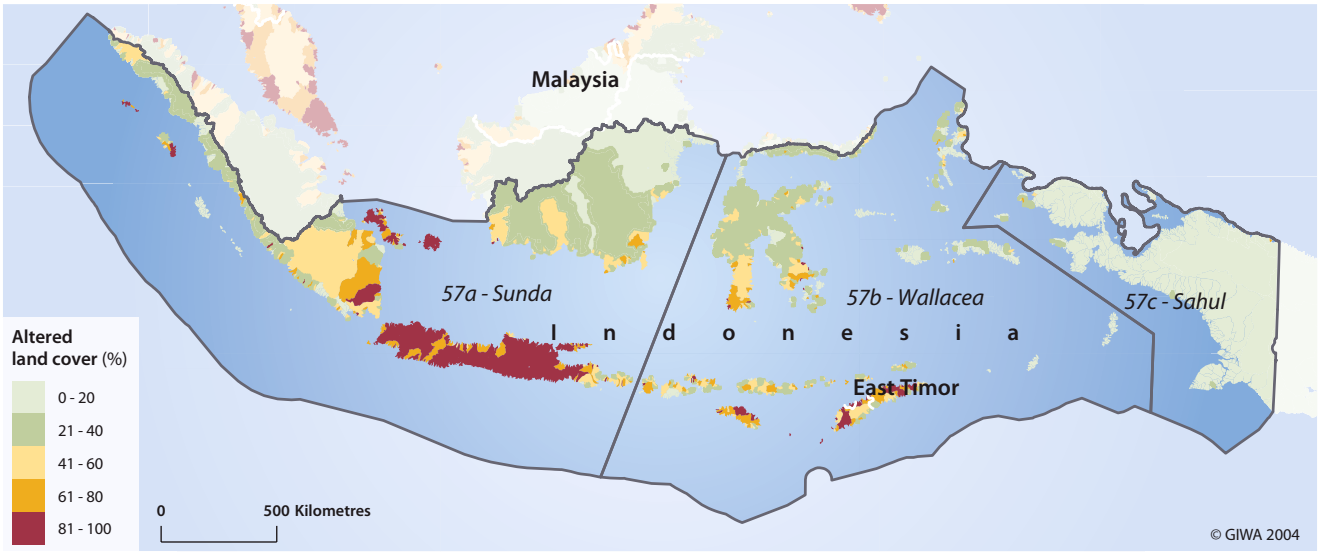

Figure 10 Reefs at risk due to alteration of land cover.
(Source: Burke et al. 2002)

- Loss of aesthetic/recreational values and tourism opportunities, with associated economic loss of existing income and future opportunity for investment income and foreign exchange from fisheries, tourism, etc., particularly in Wallacea;
- Human conflicts, e.g. in West Nusa Tenggara (Wallacea) marine police have been the subject of death threats, and fish bombs have been thrown at police boats that approach illegal fishermen;
- Loss of educational and scientific values, with many undescribed species, notably on coral reefs;
- Modification or loss of cultural heritage, particularly among coastal and sea-going people;
- Costs of controlling invasive species (e.g. *Tilapia* and water hyacinth in freshwaters) in both sub-systems;
- Costs of restoration/rehabilitation of modified ecosystems, including mangroves and marshes from aquaculture, coral reefs from destructive fishing (see Box 1 above), riparian vegetation from unsustainable forestry in both sub-systems;
- Intergenerational inequity, particularly among traditional fisher families.

By contrast with Sunda and Wallacea, socio-economic impacts of habitat loss and modification in the Sahul sub-system were considered slight, and are concentrated around mining sites.

Conclusions and future outlook

Factors responsible for loss of biodiversity in the region include:

- Inappropriate economic policies and strategies;
- Weak law enforcement;
- Overexploitation of natural resources;
- Introduction of alien species;
- Inappropriate agricultural and forestry policies.

In the present analysis, the major causes of loss and modification of the freshwater, coastal and marine habitats include:

- Siltation, conversion for aquaculture, agriculture, industrial development affecting marshes, swamps, rice paddies and riparian belts, notably in Jawa, Sumatra and Kalimantan;
- Deforestation: siltation, damming and waste disposal affecting rice paddies and rivers (Sumatra, Kalimantan and increasingly Papua);
- Aquaculture conversion and timber collecting affecting mangroves (many areas);
- Sediment run-off: siltation and dredging affecting sea-grass beds and coral reefs (many areas, especially north Jawa);
- Destructive fishing and overfishing affecting coral reefs (much of the region);
- Mid-water trawling, drift netting and other forms of pelagic fisheries, oil and gas exploration and pipelines affecting oceanic habitats (many areas, especially Jawa Sea).

At present, these impacts are most severe in Sunda and Wallacea and of less concern in Sahul (Figure 10). Until recently, most habitats were only poorly represented in protected areas and of those, most were not well-managed. For example, coral reefs in the Kepulauan Seribu National Park have been severely degraded by destructive fishing, pollution, and a lack of enforcement (Alder 1996, DeVantier et al. 1999).

Levels of environmental impact vary across the region, with the most intensive and extensive impacts occurring in Sunda, followed by Wallacea and Sahul. Environmental impacts in Sunda are already severe. Over the next 20 years, impacts are likely to deteriorate further, remaining severe. This is primarily because of the predicted increases in population, and increases in the major sectors of fisheries, forestry, agriculture and aquaculture, mining and industrialisation overriding improvements in regulations and management, including protected areas (see later). For the socio-economic indicators, future deterioration is expected with severe impacts to economy and other social and community aspects and moderate to severe impacts to health, despite regulatory and other interventions.

Environmental impacts in Wallacea are also already moderate to severe, primarily because of modification to coastal and marine habitats. Over the next 20 years, environmental impacts are likely to remain stable. This is primarily because of improvements in regulation and expansion/improved management of protected areas balancing the predicted increases in population and the major sectors of fisheries and aquaculture/mariculture. The socio-economic prognosis is for further deterioration such that the impacts on the economic and other social and community aspects of the sub-system are expected to remain severe, while health impacts are expected to be slight.

Sahul

Environmental impacts in Sahul are slight to moderate, primarily because of modification to streams and mangroves. Notably most coral reef areas of the north coast (e.g. Rajah Ampat Islands) remain in relatively good condition (Turak, Veron pers. comm.) and with a large marine national park established in Teluk Cendrawasah. Over the next 20 years, environmental impacts are likely to improve, remaining as moderate. This is primarily because of improvements in regulations and management of protected areas. For the socio-economic impacts there is expected to be future deterioration in the economic situation, a stabilisation of health and improvement in other social and community aspects.

Remedial interventions

As noted above, terrestrial and marine habitats in the Indonesian Seas region, including forests and riparian areas, mangrove forests, seagrass beds, coral reefs, and the deep sea, are among the most biologically diverse on Earth, and conservation of representative habitats and communities through ongoing development of protected areas remains a global priority.

To specifically protect biodiversity, the Indonesian Government has instituted legislation, notably since 1990, including Law No. 5/1990 on conservation of living resources and their ecosystems and Law No. 5/1994 ratifying the Convention on Biological Diversity (CBD) (also see Annexes III-V). To specifically protect marine resources, the Indonesian Government has implemented Law No. 6/1996 on Indonesian waters and Law No. 9 on Fisheries, and has ratified UNCLOS (1982, Law No. 17/1985) and MARPOL (Presidential Decree No. 46/1986).

Biodiversity conservation initiatives are coordinated by the Directorate General of Forest Protection and Nature Conservation within the Ministry of Forests and Crop Estates. The State Ministry for the Environment coordinates all government activities that have an impact on the environment, and developed a National Biodiversity Strategy in the early 1990s (UN 2002). The Biodiversity Action Plan for Indonesia has been recently revised as the Indonesian Biodiversity Strategy and Action Plan.

Thus, some important changes have taken place in the new Reformasi Era. In 1992, the Spatial Use Management Law was provided for provincial and local government to regulate the use of coastal and marine areas. However, it was only in 1999 that powers and financial support were delegated to provincial and local governments. At the end of 1999, the Ministry of Marine Exploration and Fisheries was established. These new initiatives may create the long awaited vertical and horizontal integration of Indonesia's coastal and marine management that has been so lacking in the past (Hopley & Suharsono 2000). Thus, Indonesia's capacity to implement remedial interventions has been building since the 1990s, and considerable expertise and commitment now resides in government, academia and NGOs.

A strategic biodiversity agenda was formed in 2001 by the Indonesia Biodiversity Forum, with three main programmes:

- Strategic alliance in education and awareness;
- Policies and laws;
- Data and information.

The Indonesia Biodiversity Forum, in partnership with the State Ministry of Environment, LIPI and several NGOs is also developing a Biodiversity Clearing House mechanism. At national level, coastal zone and marine management currently focuses on four main programmes:

- Sustainable utilisation;
- Conservation;
- Promoting public participation;
- Spatial planning.

The Directorate for Controlling Coastal and Marine Ecosystem Degradation is developing an Integrated Sustainable Coastal and

Marine Program, focused on conserving ecological functions of the coastal environment to support sustainable development. Other large-scale coastal and marine projects, most with both government and international donor backing, include:

- Marine Resources Evaluation and Planning Project (MREP);
- Marine Resources Evaluation, Management and Planning Project (MAREMAP);
- Coral Reef Rehabilitation and Management Project (COREMAP);
- Marine and Coastal Resources Management Project (MCREP);
- Development of Sustainable Mangrove Management Project.

The Indonesian Government, with substantive donor support, and international NGOs are thus working towards assessment and management of critical biodiversity sites. Indonesia forms part of the Global Coral Reef Monitoring Network (GCRMN) (Wilkinson 1998, 2000, 2002) and presently conducts annual biophysical survey and monitoring expeditions to many parts of the archipelago. Conservation International and The Nature Conservancy, among others, have also conducted major biodiversity surveys in recent years (e.g. Roberts et al. 2002, Veron and Turak pers. comm.).

Plans drawn up in 1984 were aimed to develop 85 marine protected areas covering 10 million ha by 1990 and 50 million ha by 2000 (Hopley & Suharsono 2000). This has not yet been realised, although in 2000, 356 terrestrial and more than 30 marine conservation areas were designated in Indonesia (Table 8) (UN 2002). As noted above, at present the MPA network covers an area of some 4.6 million ha. However, only six have National Park status with just three having implemented management plans. There are two World Heritage sites (Komodo and Ujung Kulon) conserving coral reefs and related habitats in the region (Spalding et al. 2001).

Table 8 Terrestrial and marine conservation areas in Indonesia.

Conservation area	Terrestrial		Marine	
	Number	Area (ha)	Number	Area (ha)
Wildlife preserve	-	-	3	65 220
Game reserve	47	3 440 085	7	208 780
National park	34	11 050 743	6	3 682 955
Recreation park	79	293 682	-	-
Hunting park	15	247 392	-	-
Grand forest park	15	247 876	-	-
Nature reserve	166	2 464 722	-	-
Total	356	17 744 500	16	3 956 955

(Source: UN 2002)

The Komodo National Park comprises some 2 200 km^2 and in addition to coral reefs includes other coastal and marine habitats and the islands conserving the endemic Komodo dragons for which the park was initially established. The site is recognised as a biologically diverse coral reef system of importance for maintenance and replenishment of harvested species, and forms part of the key management areas in The Nature Conservancy's reef management initiatives (TNC 2000).

The Ujung Kulon National Park and adjacent Krakatau National Reserve cover some 1 200 km^2 of coastal and marine areas on the southwestern tip of Jawa and Jawa Strait. As with Komodo, the park was not established for its coral reef attributes, rather for the presence of the Javan Rhino (Ujung Kulon) and for the geological and biological processes represented by the 1883 eruption and subsequent ecological colonisation of Krakatau.

In association with the Indonesian Government, The Nature Conservancy (TNC), World Wide Fund for Nature (WWF) and other NGOs are working towards developing additional well-managed protected areas. The Nature Conservancy has major programmes underway or in planning in Wakatobe area of Sulawesi, Komodo Islands, Bali Barat, Ujung Kulon, Derawan area of East Kalimantan, Rajah Ampat Islands, Papua and elsewhere, and with UNESCO undertook a thorough assessment of the World Heritage values of the Banda Islands in 2002 (Mous, Djohani pers. comm.).

The land, coastal and sea area to the east of East Kalimantan and Jawa and encompassing Sulawesi, Halmahera and the Molucca Islands, Bali, Lombok and Nusa Tenggara and east to Aru is recognised as a special management area by WWF (the Wallacea Bioregion). With their adjacent Sulu-Sulawesi Sea Marine Ecoregion, the Wallacea Bioregion is ranked among the top global priority sites for coastal and marine management (Putra, Miclat pers. comm.). Objectives of the WWF programme are to conserve the outstanding biodiversity of the area through improved implementation of ecologically sustainable forms of development that allow traditional communities to practice customary fishing rights, while also providing for commercial fisheries and seabed management. The approach includes both conservation planning in the long-term and implementation of immediate conservation actions in key pilot sites (Bali and Bunaken).

Several smaller community-based management initiatives have proven very successful at protecting coral reefs and are facilitating replenishment of reef-based fisheries. Detailed case-studies have conclusively demonstrated the flow-on and spill-over benefits to reef fisheries of even small no-take reserves (e.g. Komodo Islands) (TNC

Box 3 Remedial actions for mangrove loss in the Mahakam Delta.

1. A lead government agency needs to be recognised which can coordinate the regulation of the aquaculture industry in the Mahakam Delta, monitor its progress, make sure existing regulations are strictly adhered to and work closely with the export processing factories and villagers involved in the industry.

2. Further information is required on a number of issues including the extent of the acid sulphate soil problem, socio-economic impacts of the rapid expansion of aquaculture and the total value of the Nypa and mangrove wetlands to East Kalimantan. All information should be supplied to government agencies.

3. An education or extension programme, preferably carried out at the sub-district level is required to provide the information needed to the aquaculturists to make the industry environmentally and economically sustainable.

4. Private enterprise, for example the oil and gas industry, could contribute to the information and extension programmes. They should also maintain, and be seen to maintain, high environmental standards in their own operations.

5. To maintain sustainability, the aquaculture industry must remain extensive and should be incorporated into a delta-wide strategic integrated coastal zone management plan as soon as possible.

Subsequently, a number of recommendations were made (Hopley 1999b) (see also Policy options):

Unplanned expansion of aquaculture in the Mahakam Delta over the last 10 years has produced the need for integrated coastal zone management. A land use plan is advocated as part of a more comprehensive strategic plan for the delta which involves all stakeholders and complies with provincial and national government policies and obligations. Because of difficulties of rehabilitation and the economic and social value of aquaculture, most of the present 18 000 ha of aquaculture ponds are recommended for retention but the industry must be made compatible with other users, notably the oil and gas industry and the wild fishery, and must develop in a way which maintains economic and ecological sustainability. Environmental parameters which will influence the future expansion of ponds include the preference of Nypa areas for aquaculture, water quality, tidal range and the need to avoid acid sulphate soils. The landward limit of clearing for tambak should be a minimal tidal range of 1.5 m and water with moderate salinity. What is termed here the "Dutrieux line" limits potential aquaculture sites to the outer 82 000 ha of the delta. The delta morphology consisting of relatively discrete lobes and islands can determine the pattern for future land use and also aid in the isolation of specific areas of the delta if quarantine measures need to be taken in the future.

Specific recommendations include:

- Only the outer 82 000 ha of the delta be considered for aquaculture;
- All green zones adjacent to the delta front, channels and alongside oil and gas installations be strictly applied;
- Fish ponds not be developed more than 1.5 km from open channels so as to avoid the over concentration of effluent;
- Representative areas of the major ecological zones of the delta be set aside as protected zones, and these be chosen from the less developed delta lobes and islands. Such measures will help protect the wild fisheries of East Kalimantan;
- Special provisions will be needed to set aside appropriate areas of land for future oil and gas extraction.

These measures should result in an upper limit of 30 000 ha under fish ponds with 25 000 ha set aside in the outer delta as protected areas. This represents a 12 000 ha increase in the present area for aquaculture but will be sustainable only if the present extensive methodology of low stocking rates and avoidance of artificial feeds is continued.

(Source: Courtesy of D. Hopley)

2000), provided such reserves are not themselves exploited through ineffective policing (also see Russ 1985, Russ and Alcala 1996a, b, Jackson et al. 2001, Pauly et al. 2002).

For the specific case of mangrove loss in the Mahakam Delta of East Kalimantan, a detailed strategy has been developed (Box 3), with opportunities for wider application.

In relation to land conversion issues more generally, Indonesia's Agenda 21, following from the United Nations Conference on Environment and Development in Rio and recent Johannesburg World Summit on Sustainable Development, recommends the inclusion of both long-term planning and environmental concerns in all major policies and programmes (UN 2002). These include legal restrictions on land conversion, monitoring and management of soil nutrition, water use, and control of pesticide use.

Although much of the coordinating legislation, strategies, programmes, projects and other initiatives are now developed, major problems for management of Indonesia's biodiversity and protected areas remain, including lack of facilities for management, lack of funds; insufficient political or legal support to enforce regulations, and lack of trained personnel to apply scientifically based management (Hopley & Suharsono 2000). See also Box 4.

There are today no management plans or activities for the majority of MPAs, and only minimal levels of management in most national parks (Cheung et al. 2002), notably with NGO and donor support (e.g. Komodo and Bunaken National Parks). For example, and despite the drafting of a management plan in 1982 and a zoning plan in 1986, Kepulauan Seribu National Park was not fully managed in 1995, and had degraded significantly between 1985 and 1995 (DeVantier et al. 1999). The long delay resulted largely from inter-agency jurisdictional disputes, confusion over island ownership, lack of human and financial resources

Box 4 Challenges for effective management of an expanding protected network.

Despite a very early start in the traditional sasi and much aid from inter-governmental (FAO and UNDP), international (WWF, and The Nature Conservancy) and national non-government organisations, management has not been able to keep pace with the expanding protected areas network. Causes include the lack of funds, training and capable managerial personnel and consequent lack of organisational capability, technical personnel, motivation and enforcement. Personnel and capabilities were originally oriented towards the management of the terrestrial environment. There is also an inadequate management framework for identifying and controlling resource use, excessive centralisation in management and low local community participation. The total number of existing and proposed parks, reserves and protected areas, for example, is over 700, including marine areas. Mangroves are not well represented in the current protected areas system. Of the 700, some 79 sites are priority in terms of biodiversity protection, but only 31 (including terrestrial) have complete management plans, and not all have been implemented. Specifically, of the six Marine National Parks, only three have management plans being implemented. A large part of the 368 established protected areas has not been surveyed, mapped or has clear boundaries. There are also conflicts between national and local plans, conservation objectives and actual use (including mining and oil exploration initiatives). Fortunately management is being directed towards greater integration; local communities are being involved and their concerns addressed.

(Source: Excerpted from Cheung et al. 2002).

and inability to reach consensus over the zoning plan (Hutomo et al. 1993). Similarly, the draft management plan for Take Bone Rate National Park, completed in 1994 awaits implementation (Cheung et al. 2002).

Thus, the above programmes and initiatives notwithstanding, there remains a serious lack of resources for effective management of biodiversity at present, which are limiting the effectiveness of the above initiatives. Moreover, the large-scale of Indonesia's territory makes uniform application of policy and legislation, enforcement and protection all but impossible. To minimise such difficulties, the development of additional protected areas should as far as practicable follow the successful models, and include extensive community and stakeholder consultation, education and regulations offering real protection, with agreement and strong support from the customary resource owners and users. Proposals for new and/or expanded marine protected areas, to improve integration of the developing network, include in Irian (Rajah Ampat Islands and elsewhere), northern and southern Sulawesi, East and Southwest Kalimantan, and the islands south and west of Sumatra (Cheung et al. 2002).

Given that the region lies at the centre of global marine biodiversity (with adjacent regions of Sulu-Celebes (Sulawesi) Sea and South China Sea), more extensive and intensive intervention is required. See also the Policy option section.

Unsustainable exploitation of fish and other living resources

Sunda **Wallacea** **Sahul**

The Large Marine Ecosystem of Indonesian Seas is a moderately high (150-300 gC/m^2/year) productivity ecosystem (based on SeaWiFS global primary productivity estimates) and has major seasonal variations in fish abundance (Zijlstra & Baars 1990 in LME 2003). During upwelling connected to the southeast monsoon in August, fish stocks and the general productivity of the ecosystem are enhanced. The changing conditions influence phytoplankton and zooplankton species composition. Fish species harvested in the region are for example Giant gouramy (*Osphronemus goramy*), Common carp (*Cyprinus carpio carpio*), Milk fish (*Chanos chanos*), Skipjack tuna (*Katsuwonus pelamis*), tilapia, tuna, barramundi, anchovy, trevally, mackerel, garfish, shrimp, thumb nail (parrotfish), octopus, squid, crab, and lobster. Black marlin (*Makaira indica*) is a highly mobile species, fished recreationally. The coral reef environment harbours all kinds of reef fish. Indonesian waters are known worldwide for their ornamental fish species exported to the United States, Japan and Germany including the clownfish (*Amphiprion*), damselfish (*Dascyllus*), and wrasse (*Coris gaimardi*).

At present, rigorous data describing the condition of the fish stocks in the Indonesian Seas region are scant and, as a consequence, the status of these resources are poorly known. Historical fisheries statistics indicate that catches during the 1960s in the Indonesian Seas LME were around 200 000-300 000 tonnes of predominantly finfishes, molluscs, crustaceans, echinoderms (e.g. holothurian 'beche-de-mer') and sharks and rays (Large Marine Ecosystems 2004). This tonnage increased relatively gradually to the late 1970s, when almost 800 000 tonnes were taken. The fisheries increased rapidly in the following few years, to a large peak in 1988-1990 with almost 1.2 million tonnes of catch, and the catches have continued to increase to around 1.8 million tonnes in 2000 (Figure 11) (see also Box 5).

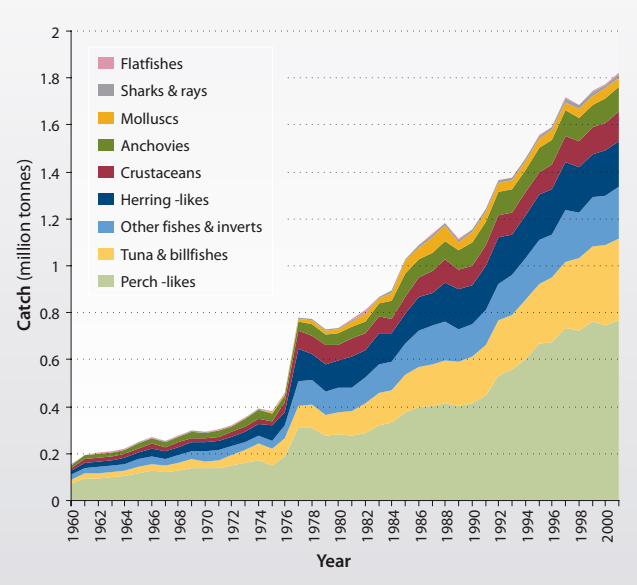

Figure 11 Catches of various fish resources in the Indonesian Seas.
(Sourc:e Large Marine Ecosystems 2004)

Overexploitation

Sunda, Wallacea and Sahul

The use of maximum sustainable yield (MSY) as an indicator of fishing pressure and overexploitation is now almost universally recognised as outdated (e.g. Jackson et al. 2001, Pauly et al. 2002) and could be replaced by more appropriate criteria based on the proportions of spawning biomass for individual species and a 'whole of ecosystem' approach to multi-species fisheries such as Indonesian Seas (also see Annex VII). As noted by Kahn and Fauzi (2001) for the adjacent Sulu-Sulawesi Sea

Box 5 The importance of coral reef fisheries in Indonesia.

In 1992 fish production in Indonesia (including freshwater fish) was estimated at 3.5 million tonnes (of which 2.6 million tonnes was marine) with demand by 2000 lifting this to an estimated 4.25 million tonnes. In part this is due to increasing population, but it is also the result of increasing domestic consumption (15.9 kg per capita per year in 1991 to 19 kg in 2000) with fish now contributing more than 60% of animal protein consumed and development of new export industries including prawns from mariculture ventures and the live fish trade. In 1997 total marine fish production was 3.6 million tonnes with many of the fish being reefal. Indicative are the figures for groupers. In 1997 the total catch weight was 42 164 tonnes and apart from 1995 the catch has grown steadily since 1988 when the total was only 16 665 tonnes. 47% of the 1997 catch came from the area of Eastern Indonesia, with 29% from Sulawesi waters alone. Maximum sustainable yield (MSY) for Indonesian fisheries has been estimated at 5.3 million tonnes (more recently 6.6 million tonnes including EEZ fisheries) with the wild fishery alone estimated at exploiting only 48% of MSY. However, with 85% of Indonesian fishers exploiting the coastal zone the effect is very uneven and coral reef fisheries even in the more remote areas of Eastern Indonesia are generally regarded as being under extreme pressure. On coral reefs this pressure comes mainly from the traditional artisanal fishers, still sustaining local coastal communities, but now using more modern gear and equipment. In addition the industrial fishery has also expanded. In 1994, 87 749 Indonesian and 937 foreign owned vessels between 60 and 800 tonnes were operating in Indonesian waters. As Wilkinson et al. (1994) have noted, such vessels operating near reefs can catch species migrating between reefs, with 40% of the catch being regarded as trash and discarded. Figures for total marine fishery production in the main fishing provinces of Eastern Indonesia (see Table) provide a general picture of the relative exploitation by province. South Sulawesi ranks second behind only North Sumatra in marine fish production, but all provinces are important producers, with production increasing during the 1990s. The percentage of the total catch marketed locally as fresh fish shows the high local consumption in Sulawesi. For the other provinces a more complex pattern is evident. In Irian Jaya, 54% of the catch is frozen for export (also 29% of the catch in Maluku). Elsewhere, freezing facilities are limited. In Nusa Tenggara, drying is the principal method for preservation, with approximately one third of the catch processed this way.

Marine fish production			
Province	**1991** (tonnes)	**1993** (tonnes)	**Fresh market** (% in 1993)
West Nusa Tenggara	64 825	79 200	70
East Nusa Tenggara	56 604	62 189	58
South Sulawesi	233 396	241 059	70
Southeast Sulawesi	105 795	141 617	70
Maluku	167 851	185 450	57
Irian Jaya	90 860	104 294	42

(Source: Excerpted from Hopley & Suarsono 2000)

(GIWA region 56), but with broad applicability across Indonesian Seas: "Overall, the state of (environmental and socio-economic) assessment of … fisheries resources is not very accurate and there is a great amount of uncertainty. Based on the limited data available it can be concluded that some of the fisheries have already reached or surpassed their limits. For others, the total lack of information indicates that further expansion would be inappropriate…. It is estimated that 90% of the fishery effort in Indonesia is carried out by artisanal and subsistence fishermen whose catches go unrecorded by official government statistics and it is partly for this reason that government estimates of annual catches… are considered to be gross under-estimates".

At present, neither the current status nor the future viability of most fish stocks are understood, and for many stocks, their status may be summarised as being Illegal, Unreported, and Unregulated (IUUF) (also see Annex VII). Nevertheless, with fish now contributing more than 60% of animal protein and with increasing per capita consumption and a growing total population, safe biological limits of Indonesian fisheries in many areas are already being exceeded, with resultant declines in catches (Hopley & Suharsono 2000). Aquaculture has also burgeoned in recent years, with a major need for effective management (Chua et al. 1989).

For all three sub-systems, many stocks are considered to be exploited well beyond safe biological limits causing severe environmental impacts. Overexploited stocks include holothurian sea cucumbers, giant clams and *Trochus*, crayfish, many species of reef fish such as groupers, and threatened and endangered species such as sea turtles and dugong. The benthic invertebrate fisheries for sedentary species of holothurian sea-cucumbers (trepang or beche-de-mer), trochus, green snails and clams are overfished, particularly around the major coastal population centres. Large-scale commercial operations have also targeted beche-de-mer and shark, and according to the GIWA Experts there is clear overexploitation of sharks, tuna, billfish and other pelagic species. Indonesia produces more than 200 000 tonnes of tuna annually (sixth largest global producer and largest in East Asia) (Talaue-McManus 2000). Sharks are also caught as by-catch of the trawl fisheries (Sharma 2000) and the tuna long-line fishery.

There has also been a significant increase in effort in the pelagic fisheries, with many foreign boats working in Indonesian waters. Poison fishing for demersal reef fish to supply the live fish food trade in Hong Kong, Taiwan and China has burgeoned in the 1990s (Johannes & Riepen 1995, Cesar et al. 2000), with prices increasing but catch per unit effort (CPUE) declining sharply. Many of Indonesia's coral reefs are heavily overfished, producing less than 5 tonnes/km^2/year (Pauly 1989, Pauly et al. 1998), in comparison with the remaining reefs which produce of the order of 15-20 tonnes/km^2/year. Many of these reefs have been chronically overfished over the past several centuries, with major loss of production and serious adverse cascading effects to other components of the ecosystems (Carlton 1998, Jackson et al. 2001). In addition to the reduction in population sizes (e.g. major declines in Bluefin and Yellowfin tuna populations) and local extinctions, overfishing has led to: decreased CPUE, smaller size fishes and reduced catch sold at markets, high 'by-catch' of rare and endangered species, decrease in commercially exploited seashells (e.g. spider shells), and degraded habitats through use of destructive methods.

Excessive by-catch and discards

Sunda, Wallacea and Sahul

For all three sub-systems, the present level of environmental impact from excessive by-catch is severe. As with Sulu-Celebes (Sulawesi) Sea

(GIWA region 56) and South China Sea (GIWA region 54), there is little or no by-catch or discards in the traditional sense, because virtually all of the greatly diminished catch – including turtles, sharks (FAO 1998), dugong and whales – is kept and eaten. An exception to this is the by-catch produced by foreign fising fleets.

Perrin et al. (2002) note that by-catch is the major threat to all marine mammals in Indonesian waters, and especially to small cetaceans and dugong (Box 6), the latter caught unintentionally using gill and mesh nets, dynamite fishing, ghost fishing (fish caught in lost or discarded gear) and bamboo fish traps.

The level of marine cetacean by-catch is likely to have increased significantly due to the greatly expanded national and foreign fishing fleets in Indonesian waters; both long-range long-liners and drift-netters (e.g. Rossiter 2002). No by-catch monitoring system is operational, and fisheries data on sharks and marine mammal species are particularly poor, there is no indication that this problem has been addressed in a meaningful or satisfactory way anywhere in the region. Illegal and unregulated fishing by distant-water commercial fleets is a major problem for South East Asian countries (Sharma 2000). Exclusion of such vessels from one country's territorial waters all too often simply displaces the problem. An example is the Taiwanese tuna driftnet fishery in the Arafura Sea (Perrin et al. 2002). Australia banned this fishery within its EEZ after large by-catches of dolphins had been documented. Rather than ending its operations, however, this Taiwanese fishery simply relocated to international waters and is now believed to be operating in Indonesian waters with little or no monitoring or regulation.

Box 6 Impacts and threats to marine mammals.

By-catch of cetaceans and dugongs in fisheries is a large and growing problem in South East Asia. Unless this problem is addressed in an immediate, aggressive manner, major losses of biodiversity are inevitable. Such losses are more than aesthetic or academic; they eliminate future options for sustainable use, simplify ecosystem structure, and increase the risk of catastrophic declines in marine productivity, with severe implications for food security. A Regional Action Plan to address by-catch of small cetaceans and dugongs in South East Asia is both feasible and desirable. Such a plan should be developed and implemented in a phased manner, beginning with a public awareness and education phase. While valuable information on by-catch has been obtained from rigorous interview/questionnaire studies, accurate assessment of by-catch levels is generally impossible without independent on-board or site-based direct observation at a statistically appropriate scale. To complement data on by-catch, per se, it is important to develop accurate quantitative information on characteristics of the fishing industry, e.g., fleet size, temporal and spatial allocation of effort by gear type. Some approaches to by-catch mitigation will need to be fishery-specific.

The expansion of live-capture operations directed at vulnerable coastal and riverine small cetaceans may be contributing to the depletion of some local populations. While it is recognised that exposure to cetaceans in captivity may benefit conservation in the long-term by changing public attitudes, the frequent claims by live-capture proponents that their facilities are engaged in "captive breeding" for conservation are generally unfounded and misleading. "Tiger nets" set in movement passages in Indonesia pose a clear, undeniable threat to populations of cetaceans and other large marine organisms. Such nets are, by their very essence, highly damaging to the environment, and their use should be prohibited. The recent evidence linking military sonar activities to lethal mass strandings of beaked whales gives cause for concern about similar activities in South East Asian waters. Some kind of risk assessment should be undertaken, and appropriate mitigation measures should be identified and implemented

(Source: Excerpted from Perrin et al. 2002).

For the oceanic cetacean species, fish by-catch has probably caused significant reductions in abundance, especially for small cetaceans but possibly also for large cetaceans such as Sperm whales and Blue whales (Perrin et al. 2002).

Destructive fishing

Sunda, Wallacea and Sahul

For all three sub-systems, the present level of environmental impacts from destructive fishing is already severe. Reef bombing remains widespread and occurs regularly, and has been attributed to increasing competition among fishers and corresponding declines in catches. As detailed in the section on Habitat and community modification above, many reefs in the region have also been targeted for the lucrative live fish food trade in Hong Kong and mainland China (with prime live reef fish worth 100 USD/kg), initially using potassium cyanide or sodium cyanide and more recently using poisons derived locally from plants. Poison fishing has also been used in collection of ornamental reef fishes for the international aquarium trade. Blast and poison fishing are illegal but particularly difficult to enforce in remote locations (Johannes & Riepen 1995) (also see the Causal chain analysis and Box 7).

In spite of the release of poisons into the sea being illegal (since 1995 through Law No. 9), as is also the export of some target species, the extensive returns from the live food fish trade mean that cyanide fishing is often the technique of choice, especially during the Asian economic crisis. The most productive crest and fore slopes of reefs are targeted, with target species for the live food trade being Napoleon wrasse (*Chelinus undulatus*), Barramundi cod (*Cromileptes altivelis*), Coral trout (*Plectropomus* spp.) and large grouper (Serranidae) (Pet & Pet-Soede 1999). Spawning aggregation sites are especially targeted and vulnerable. The cyanide is squirted from plastic bottles by divers either in front of large fish or more commonly into reef crevices, with the coral often having to be broken to retrieve stunned fish. The solution is made from one to six 20 g tablets dissolved in the bottle and the tablets cost only 6 USD/kg (Cesar 1996). COREMAP (1997) suggest that up to 640 tonnes of cyanide are used each year on Indonesian reefs, about equally divided between the live fish trade and the aquarium trade.

Three scales of operation have been identified by Pet and Pet-Soede (1999):

- Large-scale operators working from mother ships with crews of about 20, using floating cages and land-based concrete holding pens. Such operations use about 750 bottles of poison per month

Box 7 Destructive fishing methods in Indonesia.

The practices and their effects have been widely described. Many of the methods have been used for only 50 years or so (blast fishing, cyanide fishing) yet are so firmly entrenched in the region that they are regarded locally as traditional. They are practiced especially in the more remote areas of Eastern Indonesia, even in totally protected areas such as the Komodo Islands. Fishing methods regarded as destructive include:

Blast fishing
The bombs, originally made from World War II explosives, are now made with artificial fertiliser (ammonium or potassium nitrate). Schooling reef fish (fusiliers, surgeon fish, rabbit fish and snappers) are targeted and bombs thrown from only 5 m distance. Dead and stunned fish are collected by divers often using 'hookah' equipment. Although illegal, bribery or fishing in unpatrolled waters (or in the case of Biak, in Irian Jaya, setting off the explosion at the time of incoming aircraft) mean that the practice is rife with travelling Bugis, Bajau, Makassarese and Maduran fishers most involved. The yield is about 30 kg of fish on intact reefs and 7.5 kg on regularly bombed areas. However, as the fish may be damaged, they fetch about one third lower price than catches by other methods and, as they do not keep as well are usually sold only on the local market. In East Nusa Tenggara, and probably elsewhere, the practice is most in use during the doldrum seasons (April-May, October-November), with 20 to 30 explosions heard daily in local areas. Individual boats may explode 1 to 3 bombs a day but larger, far-reaching vessels may stay out up to 10 days and return with up to two tonnes of fish. Damage to the coral reefs is catastrophic. A single beer bottle bomb can destroy an area of 5 m^2, a larger gallon container up to 20 m^2. On regularly bombed reefs coral mortality may be 50% to 80%, even in national parks. Reefs may take up to 40 years to regain a 50% coral cover.

Poison fishing and the live fish trade
The use of poisons to stun or kill fish is longstanding in Indonesia. The early Dutch naturalist Rumphius commented on this practice in the 17th century when crushed roots and stems containing rotenone were used. However, since the 1960s, the use of sodium or potassium cyanide has become very common, as it has throughout the ASEAN region. Three fisheries all centred on coral reefs are involved:

- The live fish food industry, almost entirely developed since 1990;
- The ornamental aquarium fish industry;
- The collection of rock lobsters (*Panulirus* sp.).

(Source: Excerpted from Hopley & Suharsono 2000)

(average cruise time) and collect about 2 500 kg of live fish per trip. Income profit is about 35 000 USD per month. Large operators work mainly in more remote parts of Eastern Indonesia where fish stocks still make this scale of fishing profitable.

- Medium-scale operators with about 5 crew on 3 day trips. Usually at least 2 'hookah' divers are in the crew. About 15 bottles of poison are used each trip for an average catch of about 20 kg. Monthly profit is about 413 USD. The reefs of the Makasser Strait are potentially targeted by these fishers.
- Small-scale operators, free diving from outrigger canoes. They are limited to inshore shallow reefs and sell their catch from floating cages. They earn about 100 USD per month, which is a significant sum. They use up to 1 kg of cyanide per day.

The effects of cyanide fishing are multiple. Corals are broken retrieving fish, and a wide range of larvae and small fish are killed even by the low concentrations. Corals are also bleached from the cyanide, at concentrations far below those used. *Pocillopora damicornis* exposed to 4% cyanide for only 10 minutes bleached within 4 hours and 9 out of 10 specimens died within 4 days (Johannes & Riepen 1995). It may take about 30 to 55 years for the corals to recover (Cesar 1996). Erdmann (pers. comm.) has suggested that the use of clove oil (*Eugenia caryophyllata*) may reduce the bleaching effect as corals subsequently recover. Without political will to enforce existing laws, even National Parks such as Karimunjawa and Bunaken will continue to be raided by the cyanide fishermen (Llewellyn 1999).

Accurate figures for the live fish trade are difficult to obtain as official records are for gross weights, which often include the water in which the fish are transported. In the case of ornamental fish, both freshwater and marine fish are exported in the same boxes (Suharsono pers. comm.). Figures presented in Table 9 for live fish exports should be taken with some reservation. However, a steady decline appears to have set in both the aquarium and food fish exports, though whether or not it is as dramatic as the figures suggest is dubious.

Table 9 Live fish exports for Indonesia 1996-1998.

Type of fish	Fish export (kg)		
	1996	1997	1998
Marine ornamental fish	1 708 751	528 217	166 920
Other live fish	3 261 271	1 098 234	741 934

(Source: Hopley & Suharsono 2000)

In Johannes and Riepen (1995) forecasted the collapse of the live fishing industry in Indonesia and this does appear to be happening in many areas (e.g. Bentley 1999). Reefs with several years of cyanide fishing are little more than "bleached calcium carbonate deserts" (Pet-Soede & Erdmann 1999). Areas such as the Banggian Islands, which have been fished for 10 years or more, are being abandoned for "new" reefs such as the Togian Islands, Tukung Besi Archipelago and the Banda Sea and Irian Jaya. This pattern of eastward movement through the Indonesian Archipelago is similar to that of the blast fishing industry.

Decreased viability of stocks

Sunda

The present level of environmental impact from decreased viability of stocks is severe, however no data is available to support this. According to the GIWA Experts, aquaculture stocks of the shrimp *Penaeus monodon* from North Sumatra have introduced a disease in wild stocks of the Jawa Sea, causing major mortality there.

Wallacea

The present level of environmental impact from decreased viability of stocks is slight in Wallacea. However, there are some developing problems arising from the increased occurrence of red tides and diseases spread from aquaculture farms which have affected pearl shells, particularly on Ambon and Aru Islands.

Sahul

There is no known impact from decreased viability of stocks in the Sahul sub-system.

Impact on biological and genetic diversity

Sunda

The present level of environmental impact in the Sunda sub-system on biological and genetic diversity is severe. Introduced Tilapia and other species have replaced wild stocks of endemic fishes, with local extinctions and corresponding changes in community structure and diversity. At least 60 freshwater fish species are threatened (Daws & Fujita 1999). There has also been a clear decrease in heterozygosity in cultured fish stocks.

Wallacea and Sahul

The present level of environmental impact on biological and genetic diversity is slight. However, it was not clear as to the degree to which Tilapia and other aquaculture/mariculture species have replaced wild stocks of endemic fishes causing local extinctions and corresponding changes in community structure and diversity in the two sub-systems. The introduced water hyacinths have also caused significant damage to many freshwater communities.

Socio-economic impacts

Socio-economic impacts of unsustainable exploitation of living resources were considered having severe to slight impacts, with Sunda being the worst affected. There are, however, important gaps in socio-economic data (FAO 2000), particularly in relation to commercial connections among population centres and peripheries in terms of resource extraction, traditional village engagement with the marine environment and the extent to which police and military are involved in resource extraction, both legally and illegally (Kahn & Fauzi 2001). Some fishermen have been injured or killed from diving and blasting accidents. Fisher families' children are malnourished as more fish are exported. There are few alternative options, particularly on the smaller islands, and the levels of poverty are such that many children are trapped into becoming fishermen, often using destructive fishing practices.

As noted by Hopley and Suharsono (2000):

"The use of explosives in fishing was introduced into Indonesia by the Japanese during World War II. It was made illegal in 1985 (Law No. 9, Directorate General for Fisheries) but until the Asian Economic Crisis had seen increasing use because of the perceived economic benefits to individual fishers and boat owners. Crewmembers typically earn high salaries (55 to 197 USD per month) and boat owners 1 100 USD per month. In the Spermonde Archipelago up to 15% of fishers use the method, which produces 10 to 40% of the catch over 16 000 km^2 of coral reefs. The economic cost is equally impressive. The total cost to Indonesia over the next 20 years is conservatively estimated at 3 billion USD, or 306 800 USD per km^2 of reef where there is a high potential value of tourism and coastal protection and 33 900 USD per km^2 where the potential value is low. The economic loss to Indonesia of …(poison fishing) damage is (also) high, quantified at 46 million USD with the industry collapsing within 4 years by the maintenance of current catch levels. Conversely a sustainable hook and line fisheries option could create net benefits of 321.8 million USD. However, with prices in Hong Kong for live Napoleon wrasse reaching 60 to 80 USD per kg, the incentives are high to maintain this destructive fishing practice. Demand from Hong Kong, China, Taiwan and Singapore continues to control supply, even as catches decline in size and quality."

Foreign fleets that continue to threaten the region, both within and outside MPAs (see Box 8) also pose severe socio-economic impacts. Key socio-economic issues remain unquantified at the sub-system scale, but clearly include:

- Reduced economic returns to poor fisher families;
- Loss of employment/livelihood to poor fisher families;
- Conflict between user groups for shared resources (e.g. between locals and foreign fishermen, see Box 9);
- Loss of food sources (e.g. sources of protein) for human and animal consumption;
- Reduced earnings in one area by destruction of juveniles in other (migrating populations);
- Loss of protected species (e.g. dugongs and turtles, see Box 6);
- Reduced commercial value resulting from tainting (e.g. shellfish in Jawa Sea);

Box 8 Impacts and threats to marine mammals.

For decades now, Indonesia's rich and extensive marine natural resources have been plundered at will by foreign fishing vessels. Some operate under official licenses (purchased from Indonesian middlemen) and even fly the Indonesian flag, while others simply poach into the vast archipelagic seas, bolstered by the slim chances of encountering Indonesian Navy vessels and the knowledge that they can usually pay their way out of any inconvenient situations that might arise if they do. Many are said to simply work with the various enforcement agencies that should be preventing their activities. As fish wars erupt between nations all over the world, Indonesia must realise and protect what is potentially its most sustainable and valuable natural resource; its fisheries. In acknowledgement of the importance of this issue, Minister Sarwono recently suggested that the losses in revenue accrued to the Indonesian economy as a result of foreign fish stealing may top 4 billion USD! Foreign fleets continue to threaten Indonesia's fisheries, including those in national park(s), albeit in a less direct manner. Fishermen increasingly report conflicts with foreign tuna fishermen, and are now actively vandalising foreign fishing gears when they encounter them (such as long line radio buoys, fish aggregating devices, etc). The local fishermen face a double whammy, with Filipino boats actively poaching the waters, while Taiwanese, Korean and Hong Kong boats (with official licenses also) work the seas. The latter have greatly increased in number since the spread of violence in Ambon, when a number of foreign fleets relocated from Maluku to Bitung as their home port. Unfortunately, as these bigger and more technologically advanced foreign fleets decimate stocks, fishermen must travel further and further to catch fish (often 3-5 hours travel outwards by wooden speedboat) and now increasingly resort to spearfishing and gillnetting in order to catch fish to feed their families. Tourism and fishing, once compatible, are now increasingly enemies. In large part due to the activities of foreign fishing fleets.

(Source: Excerpted from Perrin et al. 2002).

- Increased risks of disease in commercially valuable stocks (e.g. prawns in Jawa Sea);
- Inter-generational equity issues (access to resources);
- Human health impacts: fishermen die and many more are injured each year from diving accidents (Johannes & Djohani 1997), and numbers of people affected by tainted/poisoned seafood are unknown.

Conclusions and future outlook

Levels of fishing pressure within the region as a whole range from moderate to severe, providing a complex management challenge, with important linkages to the application of marine protected areas in stock replenishment (Annex VII) (TNC 2000, Pauly et al. 2002). Many of the region's coral reef and pelagic fish have been or are becoming chronically overfished (Figure 12), including major use and increasing threat of destructive techniques, with major loss of production and serious adverse 'cascading' effects to other components of the ecosystems. For example, data from reefs of the adjacent Sulu-Celebes (Sulawesi) Sea region (GIWA region 56) indicate that carnivorous families of reef fish will not fully recover their pre-fished levels of biomass for 20 to 40 years after effective protection has been implemented, when 20 to 25 kg of catch may be taken from 1 000 m^2 of reef area annually (equivalent to 20 to 25 tonnes per km^2) (A. Alcala pers. comm.). Similar impacts and threats are occurring to dugong and cetaceans (Perrin et al. 2002).

As Hopley and Suharsono (2000) conclude:

"Locally some fisheries have already collapsed, for example the trepang fishery in West Nusa Tenggara and even the live fish trade is forecast to decline rapidly in the near future. The pattern of exploitation has been from the north and west, towards the south and east usually in association with the specialised fishing populations such as the Bajau, Bugis and Makassarese who have not only migrated into the islands and reefs to the south and east but have also developed considerable mobility for exploitation. In the last 50 years even the most remote reefs have been exploited, and pressures developed have led to increasing numbers of incursions of Indonesian fishermen into the territorial waters of Indonesia's neighbours. Simultaneous with this increasing and spreading trend of exploitation has been a decline in traditional management practices and increasing tensions between local populations and outside fishers. Many recommendations have been made by the various project teams working in Eastern Indonesia. Some involve changes to fishing practices, such as banning 'hookah' equipment and ensuring compliance with even existing laws. It has also been noted that there is a need to divert fishing effort from the overfished reef resources to the under-fished pelagic stocks, but there are currently no incentives to do this. The far-flung and remote characteristics of many of the islands of Eastern Indonesia necessitate management processes which safeguard the livelihood of the people at the village level. Community management and secure marine tenure creating a recognisable core of stakeholders whose legitimate interests lie in the care and management of marine resources, appear central to these processes."

Because of Indonesia's increasing coastal population, greater commercialisation, decline in fish stocks from overexploitation and destructive fishing, lack of effective regulation and poor or non-existent enforcement, there is expected to be continuing deterioration

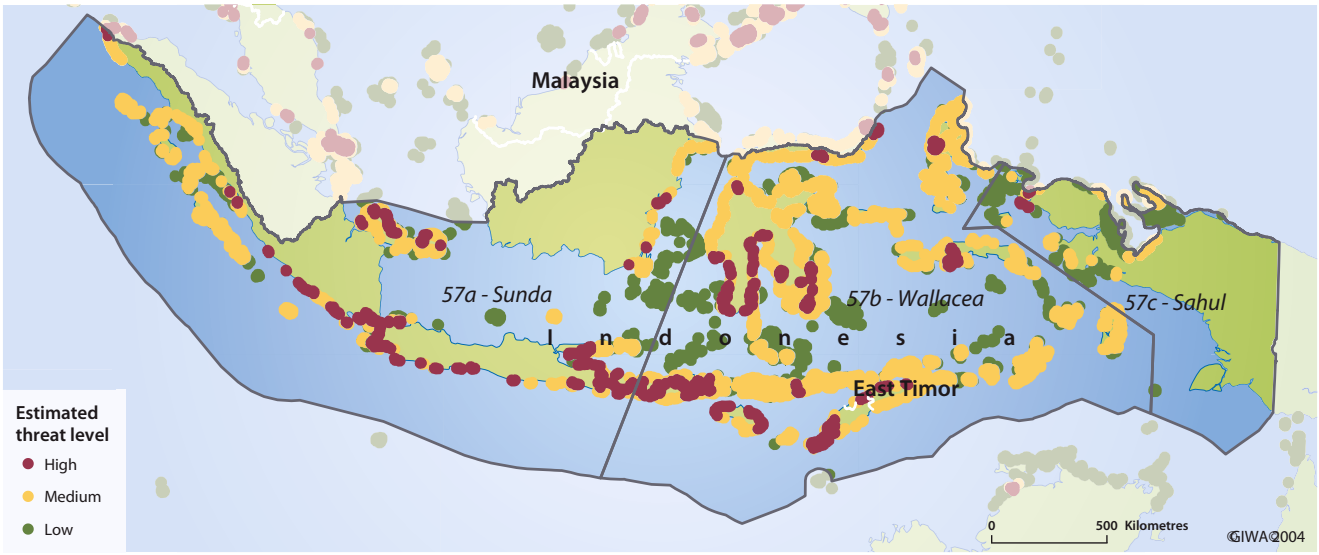

Figure 12 Reefs at risk threat analysis for overfishing.
(Source: Burke et al. 2002)

Figure 13 Fish for sale at local market, Unjung Pandang, Sulawesi.
(Photo: J. Oliver, Reefbase)

in fisheries. This will be manifested mostly through overexploitation, lack of by-catch and discards, destructive fishing and changes in diversity, and also with the potential for decreased viability of stocks. Most socio-economic impacts are also expected to deteriorate or at best remain stable.

Environmental impact in Sunda at present is severe, with all five issues assessed as severe. Environmental impacts of overexploitation are expected to worsen, similarly with the economic impacts which also are expected to deteriorate, remaining as severe. Social and community impacts associated with overexploitation are expected to remain stable and severe. Health impacts are expected to remain as slight.

The overall environmental impact at present is severe in the Wallacea sub-system. Three of the five issues unequivocally rated as severe, and two issues (decreased viability of stock and impact on biological and genetic diversty) rated as slight, although their impact was contentious. As with Sunda, environmental impacts of overexploitation are expected to worsen in teh future. Similarly, the economic impacts are expected to deteriorate, remaining severe. Social and other community impacts associated with overexploitation are expected to remain stable and severe and health impacts are expected to remain as slight.

The overall environmental impacts of unsustainable exploitation of living resources in the Sahul sub-system at present is moderate. Three of the five issues unequivocally rated as severe, one issue (decreased viability of stock) rated as no known impact and the remaining issue (impact on biological and genetic diversity) was slight although contentious among the Task team. As with the Sunda and Wallacea sub-systems, environmental impacts of overexploitation are expected to be severe in the future, although of the three sub-systems Sahul has the least exploited resources. The economic impacts are expected to deteriorate but remain at a moderate level of impact. Social and other community impacts associated with unsustainable exploitation are expected to deteriorate and health impacts are also expected to deteriorate, but remain as slight.

Remedial interventions

In a recent assessment of management options, Pet-Soede (2000) has advocated the need for co-management, a decentralised system creating a feeling of ownership in the local community but fitting into more holistic planning. However, according to Pet-Soede (2000) "Implementation of co-management principles remains complex and difficult. Especially the tropical multi-species and multi-gear fisheries include socio-economic and socio-cultural processes at the local level and complex legal and regulatory processes at the national and provincial level, that make involving and satisfying all stakeholders in the management process difficult".

Pet-Soede (2000) also points out the need to agree to the current status of the fishery. Fishers, fisheries planners and government all have different perceptions of the status of fish stocks although all attribute a general decline between 1987 and 1997 (in Spermonde Archipelago, Wallacea) to an increased number of fishers. "… provincial authorities will not easily find arguments for effort restrictions in their official data statistics, so that national support for restrictive management will be limited. Moreover, the current tendency of Indonesia's government to upgrade the fishery will make it more difficult for officers to convince managers (of) the need for restrictions of fishing effort. Still, the tendency of fishers to frequent remote grounds, partly as a consequence of falling catch rates, is already captured … by the trends in the number of motorised boats. If these data could be used to rework the presently used number of fishing trips into a better measure for fishing effort, catch statistics will hold a closer relation to the actual developments in the fishery. The possibilities to evaluate data for ecological or physical entities rather than for administrative entities should be elaborated as their potential already exists" (Pet-Soede 2000).

Given all of the above, four major remedial interventions are required to enhance long-term ecological and economic sustainability of the fisheries:

Improved surveillance and enforcement

Increased use of automated methods of vessel and catch monitoring may reduce the cost of management and reduce the incidence of illegal, unregulated or unreported fishing. This is being addressed in developed nations through use of satellite transponder technology to identify locations of licensed fishers, and to thereby aid in detection of illegal poaching activities. In Indonesian Seas, this remains a major challenge, even within the few MPAs and fishery reserves.

Marine protected areas

MPAs and MPA network strategies are crucial tools for sustainable fisheries management and resource protection. Networks of well-designed and well-managed MPAs, with improved surveillance and stock assessment and reactive management, should form the core of the fisheries management (and marine conservation) strategies. There is extreme urgency for development of a functional MPA network and an immediate need for substantial no-take zones, with development of enabling policy and legal frameworks.

Improved education and communication

A sense of stewardship over the resources within all sectors of the fishing industry, including both commercial and subsistence fishers, is crucial to long-term sustainability. In future, opportunities for audited and accredited co-management and self-management should develop and so reduce the overall costs of managing for sustainability. There is also a pressing need to educate the consumer side of the industry (both within and outside the region) that there are severe costs to the ecosystems and future sustainability through many forms of extractive fishing. Positive change may be fostered by better-informed consumers (that is, market demand for products from sustainable fisheries).

Better stock assessment and input for reactive management

Accurate field data and better models of both fish stocks and ecosystem responses to fishing (Pauly et al. 2002), as well as system responses to natural changes, particularly climate fluctuations are required. The foundation of and input to these models should be built using improved time-series survey-based environmental and population data, with major opportunities for regional scientific collaboration.

Global change

Sunda


Wallacea


Sahul

The Indonesian archipelago stands between the Pacific and Indian Oceans and is influenced by annual and inter-annual variations in surface temperature due to a reversing monsoonal system. Some places receive more than 3 000 mm of rain annually. By contrast, parts of the lowlands, coastal areas and other areas in rain-shadows receive far less rain (less than 1 000 mm/year), and may experience severe water shortages, notably islands of Nusa Tenggara to the east of Lombok.

The entire marine region is a "heat engine" of global atmospheric circulation, with complex ocean-atmospheric dynamics. The warm ocean and its links to the atmosphere create the El Niño Southern Oscillation (ENSO) phenomenon. The influence of El Niño, La Niña

and the Australian and Asian monsoons contribute to the unique climate conditions. The region also has complex oceanography, with oceanic input from the Pacific and Indian Oceans in the Indonesian Through-flow. The Through-flow is thought to be influenced by, and may influence in turn, ENSO. The Through-flow exports warm, relatively fresh (low salinity) thermocline water from the North Pacific, providing a major freshwater source for the Indian Ocean. Strong ocean mixing influences sea surface temperature and nutrient concentrations (Annex VI) (LME 2003). Hopley and Suharsono (2000) provide a useful summary of these key regional features (see Box 9).

The generally equable characteristics of Indonesian waters notwithstanding, strong current flow associated with the Indonesian Through-flow and tides can generate major local-scale sea temperature anomalies, of the order of 10°C. For example, the corner of the Island of Nusa Lembongan in the Lombok Strait east of Bali receives a localised upwelling from the Strait, with sea surface temperatures of 16°C, compared with 28°C in adjacent unaffected waters (DeVantier pers. obs.).

Box 9 Charactestics of eastern Indonesia which affect the scale and response of climate change.

The Indonesian Through-flow phenomenon
The water properties of both the western Pacific and eastern Indian Oceans are strongly influenced by the through-flow of warm water from the Western Pacific Warm Pool to the Indian Ocean. Although the complexity of the Indonesian seas act as a filter and tranfuser of the water properties of the through-flow, this is one of the Earth's most important transfers of energy which influences the global thermohaline circulation, the distribution of sea surface temperature and the air/sea transfers of energy which drive the global atmospheric circulation. Indonesian Seas inevitably will play (are playing) a role in global climate change.

El Niño Southern Oscillation (ENSO) events
Inter-annual variation in the through-flow especially on the Western Pacific Warm Pool which forms then retreats eastwards is a major part in the mechanism of ENSO and La Nina events. As some global change predictions incorporate a more forceful ENSO scenario in their predictions, the environmental perturbations associated with recent ENSO events may be a guide to future climate. This is especially important in regions such as eastern Indonesia for which no specific forecasts are available. In an El Niño event, the Western Pacific Warm Pool retracts and there is reduced outflow through Indonesian Seas to the Indian Ocean. Low rainfall and droughts even in equatorial areas such as Kalimantan occur during ENSO events. A heat build up in South East Asia occurs before the retreat of the Warm Pool. Harger believes there is evidence for increasing temperatures in Jawa over the last 100 years which are part of the global trend rather than just an urban heat island effect. The results of an El Niño in Indonesia are increased temperatures, especially between September and November, and also May-June and widespread drought. The economic consequences of widespread forest fires and crop failure have been well documented but for coral reefs the major impacts come after the collapse of the event. At the start of the contrasting La Nina period, heavy rains fall on hill slopes poorly protected by reduced vegetation cover. Erosion is rapid and the problems of siltation on coastal reefs are severely aggravated.

The equable characteristics of Indonesian waters
In spite of the part they play in global climate variability, the Indonesian Seas are remarkably equable in their physical and chemical oceanographic conditions. This is largely because of their equatorial location (and lack of strong seasonality) and the degree of mixing which takes place as the result of strong tidal currents and complex bottom topography. The effect is a very small amount of variability in, for example, ocean temperatures, even in shallow coastal waters. Typically sea surface temperatures range from just over 25°C to just below 30°C and decrease only one or two degrees with depth. This may be important for Indonesia's coral reefs as bleaching has been shown to be the result not of absolute temperatures, but of temperature variations beyond a norm. Relatively small temperature excursions may have a potential for severe bleaching responses.

(Source: Excerpted from Hopley & Suharsono 2000)

Considering the extensive damage caused to the world's coral reefs as a result of El Niño driven increases in sea temperature in 1998 and 2002 and the implications arising from large-scale coral mortality for the human population dependent on coral reef resources (Hopley 1999d, Wilkinson et al. 1999), the impacts of changes in sea surface temperature were also assessed, as an additional GIWA issue.

At present, there are no known environmental impacts associated with increased UV-B radiation as a result of ozone depletion or changes in ocean CO_2 source/sink function in any of the three sub-systems. These issues will therefore not be further discussed.

Changes in hydrological cycle and ocean circulation

Sunda, Wallacea and Sahul

Changes in the local/regional water balance in recent decades arising from global change, and increased variability of current regimes (including those caused by changes in ENSO events) have had moderate environmental impacts in all three sub-systems. There is evidence for recent increases in ENSO and other extreme climate events, causing major impacts in Sumatra and Kalimantan (Sunda), Seram and the smaller islands (Wallacea) and the island ecosystems of Sahul, although considerable uncertainty remains. For example, iron fertilisation by the Indonesian wildfires during the 1997 Indian Ocean Dipole (IOD) was considered sufficient to produce an extraordinary phytoplankton bloom (red tide) causing extensive reef death in the islands off eastern Sumatra (Abram et al. 2003). This highlights the potential relation between climate, wildfire and impacts to coastal marine ecosystems. However, van Woesik (2004) has suggested that the iron fertilisation from wildfires was not necessary for the coral mortality. Rather it may simply have been a function of nutrient, temperature and sea level change associated directly with the IOD-induced upwelling. The degree to which the IOD upwelling was a natural phenomenon, or linked with global change remains unclear.

Sea level change

Sunda, Wallacea and Sahul

Environmental impacts of sea level change at present are slight in the Sunda and Wallacea and unknown in the Sahul sub-systems, with limited evidence of recent and unprecedented flooding in low-lying coastal areas of the three sub-systems. As noted above, significant sea level changes occurred during the 1997 IOD upwelling along the south coasts of Indonesia, although the degree to which the IOD was driven by global change remains unclear.

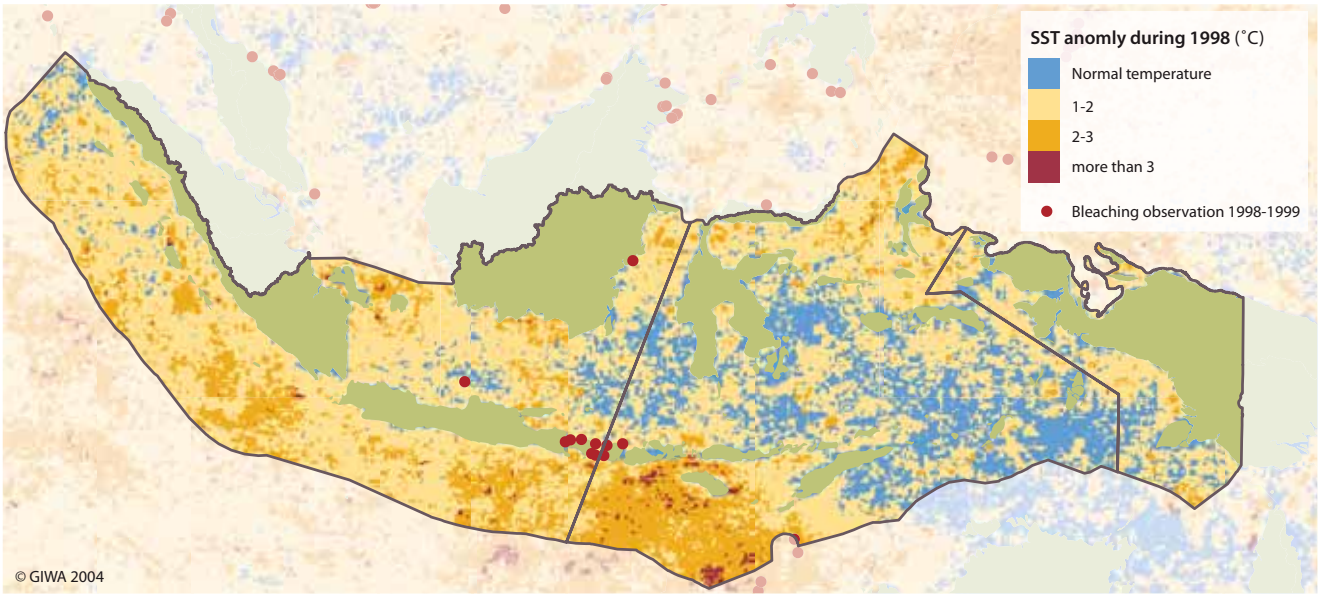

Figure 14 Sea surface temperature anomalies during 1998 in the Indonesian Seas region.
(Source: Burke et al. 2002)

Changes in sea surface temperature

Criteria used for scoring this issue are appended in Annex VI.

Sunda and Wallacea

Changes in Sea Surface Temperature (SST) are already having moderate environmental impact in Sunda and Wallacea, with changes in the structure of coral reef communities during coral reef bleaching events since 1983, notably in Pulau Seribu (Sunda) (Brown & Suharsono 1990, Glynn 1996) and with increasingly severe and widespread impact since 1998 (Figure 14) (Suharsono 1997, 1999, and reviewed in Wilkinson 2000, 2002, Wilkinson et al. 1999, Goreau et al. 2000). As noted above, massive mortality to coral communities along the south coasts of western and central Indonesia occurred during the 1997 IOD (Abram et al. 2003, van Woesik 2004), although the degree to which the IOD was driven by global change remains unclear.

Sahul

Changes in SST have had slight impact in Sahul, where the scant anecdotal information suggests that reefs have been less affected than in other parts of Indonesia (Veron and Turak pers. comm.).

Socio-economic impacts

There are little or no known socio-economic impacts that could be categorically assigned to global change at present in the three sub-systems, other than some sea level/sea inundation effects in low-lying coastal villages. There have been considerable economic and health effects associated with drought and linkages to habitat loss (clearing and forest fires) and freshwater shortage; particularly overextraction of freshwaters and salinisation of wells. Damage to coral reefs during coral bleaching events also has the potential for major socio-economic impacts (Wilkinson et al. 1999), and has likely produced economic effects already. However, definite assignment to global change impact is not possible at present.

The key socio-economic indicators remain unquantified at the scale of the sub-systems but clearly include freshwater availability, with predicted increases in intensity and frequency of ENSO (Timmerman et al. 1999) likely to severely alter rainfall and drought in the region, as well as food (water) and employment security. Other indicators are changes in productivity of agriculture, fisheries and forestry, linked with ENSO fluctuations, response costs for extreme events, as foreshadowed by the major forest fires and drought in Sumatra and Kalimantan associated with the 1997 ENSO, loss of income and employment, including foreign exchange from fisheries, loss of opportunity for investments (both domestic and foreign), and increased costs of human health care.

Conclusions and future outlook

Global change as a whole has had only slight overall environmental impact at present in the three sub-systems. Despite the uncertainties, there is likely to be moderate environmental and slight to moderate socio-economic effects in the future. These will be manifested through impacts on freshwater shortage and oceanography (through predicted changes in frequency and intensity of ENSO), and on habitat loss and modification and fisheries.

The increasing populations in Indonesia will exacerbate local production of greenhouse gases, compounded by increasing per capita release of carbon dioxide and harvesting of timber. However, there remains considerable uncertainty in climate model predictions of changes in temperature and sea level. Additional uncertainty is caused by the region's complex geological dynamics, and also by the capacity for acclimation and adaptation of species and resilience of ecosystems (Done 1999). See also Box 10.

Impacts to freshwater resources and loss of forests from land clearing and desertification are expected to increase, with some 8.1 million ha inside and 15.1 million ha outside forest areas considered as critical land (UN 2002). Continuing land and catchment degradation is largely attributable to forest clearing and the effects of wildfires, particularly in ENSO years, and the extent of critical land is presently expanding at 400 000 ha annually. Indonesia is party to the Convention to Combat Desertification, and the Ministry of Forestry and Crop Estates has been designated as the focal point for implementation of appropriate policies and interventions. Indonesia is in the initial stages towards implementing a National Action Program to mitigate land degradation and will also attempt to rehabilitate critical land, soil and water. Up to 2003, 2.6 million ha outside and 1.2 million ha inside forest areas were targeted for rehabilitation. However, to date, success has been marginal, in part because of the lack of coordination among institutions involved in the programme (UN 2002). The Meteorology and Geophysics Agency has forecasted future prolonged drought in certain areas in all three sub-systems, however funding for remedial interventions is scarce and it is hoped that international donors will provide additional funds within the framework of the Convention to Combat Desertification.

Sea level rise over the next century is predicted to affect large numbers of people, with some 2 million people living within a 2 m elevation of present sea level (Hopley & Suharsono 2000). Sea level rise, even in the next 50 years, is likely to see the displacement of many coastal villages, especially those on low lying coral islands, particularly in Wallacea. Thus, the potential scale of the problem, in terms of total numbers of people likely to be affected (but not in terms of proportion of total population) in future is far greater than that for the atoll island nations of the Maldives or Kiribati, to which much attention has already been drawn. Atolls, such as Taka Bone Rate, have populations of over 20 000 whilst smaller coral cays may support villages of at least several hundred people (Hopley & Suharsono 2000). Many reef islands may disappear in 50 years.

Coral reef ecosystems are likely to be particularly badly affected through predicted changes in SST (bleaching) (Hoegh-Guldberg 1999) and ocean chemistry (CO_2 source-sink function which affects capacity for calcification and reef growth (Kleypas et al. 1999). Recent experimental studies have demonstrated the controlling function of both parameters on coral growth and reef development, and the likely importance of

Box 10 The scenario for climate change in Indonesia.

To assess the severity of impact of global change over the next century it is necessary to first identify the most probable scenario of change. The IPCC Third Assessment (IPPC 2001) and other regional data including recent Internet releases by the Commonwealth Scientific & Industrial Research Organisation Australia (CSIRO) are the basis for the following predictions to 2100.

- Temperature: Although the global temperature increase is between 1.4°C and 5°C, Indonesia's increase will be at the lower end of the scale.
- Sea surface temperature: Again the Indonesian scenario will be far lower than average increases possibly 2°C.
- Rainfall: Both increases (in the wetter areas of Indonesia) and decreases (in the eastern islands) are predicted but most important will be an increase in variability and extreme events
- El Niño: More frequent and more severe.
- Climate variability: Much greater, meaning that even if average conditions change little, extreme fluctuations will pass natural systems through important thresholds.
- Sea level: Global rise of between 0.1 m and 0.88 m, about 0.5 m is considered the most probable.

The various implications of this scenario with special reference to Indonesia have been discussed by Hopley (1999d), Cox (1999) and Holmes (1999)). Climatic impacts can be grouped as follows:

- Atmospheric and sea surface temperatures: Likely to affect the zonation of high montane forests and shallow marine ecosystems, especially coral reefs, via bleaching.
- Rainfall, El Niño and climatic variation: Even without any increase in rainfall, the greater variability and incidence of El Niño events is likely to produce sequences of drought, followed by severe flooding and enhanced erosion. Forest fires as occurred in 1997, but also previously occurring in other El Niño years, including 1982-1983 which burnt 3.7 million ha and in 1991 (see Harger in Tomascik et al. 1997) will become more frequent. All problems associated with increased run-off including sedimentation, nutrient loss and flooding especially in urban areas in the lower courses of streams will increase. A natural geomorphological response of increasing channel size to cope with higher flood planes will be seen as serious bank erosion.
- Sea level rise: This will have the greatest impact on Indonesia and its seas, even if limited to only 0.5 m in the next 100 years. More than half of Indonesia's 210 million people live near the coast. In particular, low lying urban areas need identification, especially where tidal range is negligible for example around the Jawa Sea. Most impacted will be the numerous low coral reef islands, which will become uninhabitable even if they do not disappear totally. Saltwater intrusion will occur both here and in other low lying coastal zones. Pressure on Indonesia's coastal population will increase the need for transmigration, and increase the associated social and environmental problems (Kramer & Simanjuntak 2003 in Hopley & Suharsono 2000). Whilst there may be some positives for coral reefs (e.g. Hopley 1997, Kench & Cowell 2002) other shallow marine ecosystems will be severely squeezed. The need of mangroves, seagrass beds etc to migrate landward as sea level rises will be blocked by existing human land uses which currently dominate much of the coast. For example, along the coast of Central Jawa, rice paddies, already protected by embankments, are found immediately behind mangrove fringes.

Indonesia itself has a pivotal role in future global changes because of its climatic and oceanographic locations. Whilst per head of population, its contribution to greenhouse gases is low (1995: 0.41 tonnes carbon per capita cf Australia 4.43 and USA 5.27) it does depend on fossil fuels including oil, gas and coal for much of its overseas income and is thus susceptible to global mitigation policies. Another significant figure is that even as far back as 1980, Indonesia was identified as producing 12% of global emissions from deforestation (Falk & Brownlow 1989 in Hopley & Suharsono 2000), a figure which can only have increased. Unlike in many developed countries, the full implications of global

(Source: Courtesy of D. Hopley)

their synergism in the short-term future of reefs (see e.g. Leclercq et al. 2000, 2002, Reynaud et al. 2003).

Remedial interventions

Global climate change must be addressed both uni- and multi-laterally e.g. following recommendations of the Intergovernmental Panel on Climate Change (e.g. IPCC 1996, 2001) and through international legislative instruments such as the Kyoto Protocol, when ratified, and as with most nations in the region, Indonesia is currently engaged in climate change negotiations. For the forest catchments, concerted efforts need to be focused on minimising fires and other forms of land-clearing (see Pollution, Remedial interventions), particularly during ENSO events, through enforcement and education, and through enhanced development and improved management of protected areas. For coastal and marine ecosystems, the strategy for an integrated network of MPAs, some of which are purpose-designed to best mitigate changes in SST (Salm & Coles 2001, West & Salm 2003), needs to be adopted as a matter of extreme urgency.

Priority concerns for further analysis

Future scenarios for Indonesia as a whole suggest a human population increase of between 1 to 4% (1.8% nationally from 1980-1998, declining to 1.2% from 1998-2015) per year to more than 250 million by 2015 (World Bank 2003). The population is expected to double, to some 400 million, by 2035, with increasing urbanisation and increasing reliance on extractive industries. Conversion of agricultural to non-agricultural land is a major issue, with urban areas increasing by some 367 500 ha from 1980 to 1995, an average increase of some 25 100 ha per year (UN 2002).

Within the region, population trends should be similar to the national average, although with higher population growth among poor agricultural and coastal communities likely to have important implications for most international waters concerns, from land-conversion to fisheries. The increasing urbanisation will impact on both freshwater shortage and pollution as growth is expected to outpace successful interventions. International trade is expected to increase significantly, and there are also likely to be significant increases in mining (with potential for expanded offshore oil and mineral exploration), artisanal and industrial fishing, various forms of plantation agriculture and forestry, and production of manufactured goods. There will be limits on other sectors from freshwater shortage, loss of habitats and fish and other concerns.

The strong trends of increasing commercial agriculture and forestry are also expected to impact adversely on levels of water pollution, particularly through increasing use of chemical fertilisers and pesticides and sediment loss to watercourses, streams and rivers. Predicted increases in all forms of fishing are expected to impact adversely on both biodiversity and stock replenishment, with severe socio-economic implications for poor coastal populations. Industrial exploitation, particularly of commercial meso-pelagic fisheries, is expected to increase. Reef fisheries, while continuing to provide essential sustenance to artisanal fisherman and their families throughout the region, are expected to be placed under increasing pressure to supply commercial quantities of high value products for export to expanding international, national, and local markets. There are also plans to expand aquaculture and mariculture operations substantially, with the potential for further adverse impact to coastal habitats.

Given the above, total pressures on international water resources are likely to increase moderately to severely over the next 20 years, most severely in the more developed areas of Jawa and Sunda, causing significant deterioration in both the environment and socio-economic structures, despite improved regulation. The worst affected areas are expected to face severe environmental impacts and severe socio-economic hardship in the future. Despite major advances and improvements since the 1970s, there remains a lack of capacity for effective policing or enforcement of regulations or for developing measures for alleviation of existing water-related problems. There are already serious health issues arising from episodic freshwater shortage and habitat loss in some areas. The rate of deterioration can be minimised by on-going and future planned interventions, including those at multi-lateral, national, provincial and local government levels and through the concerted efforts of NGOs. Nonetheless, continuing international assistance will be required in the short-term for major improvement in international waters-related issues and concerns.

There are expected to be substantial differences among the three sub-systems in terms of their future trends in population/demographics, consumption and output, sectoral composition, use and impacts.

In the Sunda sub-system the total pressures are expected to increase considerably, primarily because of increasing population pressures, despite major improvements in coordination, application and enforcement of regulations. This increase in total pressures is expected to cause socio-economic hardship, particularly to rural and poor urban populations, but with improved awareness and interventions (e.g. health care, protected areas, fisheries monitoring systems).

In the Wallacea and Sahul sub-systems the total pressures are expected to increase moderately. There are expected to be improvements in coordination among different government levels and with NGOs although the expected improvements in regulations will still have local level differences in application. The increasing population, and increasing demands by multi-national industrial firms (mining, forestry, plantation agriculture, aquaculture) will cause a moderate increase in impacts on catchments, rivers, coastal and oceanic waters despite improved regulations and enforcement. This is expected to cause moderate to severe socio-economic hardship, particularly to the mostly rural population but with some improvement in awareness and interventions.

Prioritisation of the GIWA concerns was achieved through assigning equal weight to environmental, economic, human health and social and community impacts in each of the three sub-systems.

In the Sunda sub-system the concerns were prioritised as follows:

1. Pollution
2. Freshwater shortage
3. Habitat and community modification
4. Unsustainable exploitation of fish and other living resources
5. Global change

At present, four of the five GIWA concerns are already severe. Pollution was of highest priority, followed closely by Freshwater shortage, Habitat and community modification and Unsustainable exploitation of fish and other living resources. Global change was of fifth priority, with only slight environmental and socio-economic impacts. It is clear that the international waters environment and socio-economy of Sunda are already under severe impact, and this will worsen, as exemplified by coral reefs. Continued interventions are urgently needed for any chance of amelioration in the short to medium-term.

Even with ongoing and planned future interventions, there is still expected to be deterioration in the environmental and economic impacts in the Sunda sub-system, with stabilisation/improvement in some health and other social and community aspects. Pollution scored the maximum value, followed closely by Habitat and community modification, Unsustainable exploitation of fish and other living resources and Freshwater shortage. Global change is expected to have moderate environmental and other social and community impacts and minor economic and health impacts in the future. Future impacts from Global change were sufficiently uncertain for this to remain as the least of the concerns.

In the Wallacea sub-system the concerns were prioritised as follows:

1. Habitat and community modification
2. Unsustainable exploitation of fish and other living resources
3. Freshwater shortage
4. Pollution
5. Global change

There was an unambiguous overall prioritising of the five GIWA concerns in this sub-system. Habitat loss and community modification was of highest priority, with severe levels of environmental, economic and other social and community impacts. There was considerable uncertainty in regard to the levels of health impact from Habitat and community modification. Unsustainable exploitation of fish was of near-equal priority, followed by Freshwater shortage. Pollution, with only slight to moderate present levels of impact, was of fourth priority and of much less concern than Sunda. Global change was of fifth priority, with only slight present environmental and socio-economic impacts. The international waters environment and socio-economy of Wallacea are presently in better condition than those of Sunda. Nonetheless, moderate to severe impacts are already occurring, and will continue from Habitat and community modification and Unsustainable exploitation of fish and other living resources (as exemplified by coral reefs, Figure 2 in Regional definition) and are a major focus of government and NGO interventions.

Because of the ongoing and planned interventions, there is expected to be a stabilisation of some environmental impacts of Habitat and community modification in the Wallacea sub-system, but with continued deterioration in stocks of fish and other living resources, Freshwater shortage, Pollution and Global change. Unsustainable exploitation of fish and other living resources, Habitat and community modification and Freshwater shortage all assessed as having moderate to severe future impacts. Pollution and Global change were of less priority.

In the Sahul sub-system the concerns were prioritised as follows:

1. Unsustainable exploitation of fish and other living resources
2. Habitat and community modification
3. Pollution
4. Freshwater shortage
5. Global change

There was an unambiguous overall prioritising of the five GIWA concerns. Unsustainable exploitation of fish and other living resources was of highest priority, with moderate to severe levels of environmental, economic and other social and community concerns. Habitat and

community modification ranked second, being of equal priority from environmental impact, but of less priority in socio-economic terms. Pollution and Freshwater shortage were of third priority, followed by Global change, with only slight environmental and socio-economic impacts. The international waters environment and socio-economy of Sahul are in better condition than either Wallacea or Sunda, primarily because of the relatively small population (less than 10 million people). Nonetheless, environmental impacts of Unsustainable exploitation of fish and other living resources and Habitat and community modification require intervention.

There is expected to be future deterioration in most concerns in the Sunda sub-system. Unsustainable exploitation of fish and other living resources remained as highest priority, followed by Habitat and community modification and Pollution. Global change was of fourth priority followed by Freshwater shortage.

Owing to the severe environmental and socio-economic impacts across much of Indonesian Seas, scoring highly in all three sub-systems, and the major transboundary influence of the live food fish and aquarium trades which promote the use of destructive fishing practices, particularly poison fishing using cyanide, Unsustainable exploitation of fish and other living resources was prioritised for further analysis.

Potentially strong linkages were identified among all major concerns. Global change effects on Freshwater shortage are likely to be manifested through changes in the frequency and intensity of ENSO events. During the 1990s, ENSO caused water shortages in some parts of the region and flooding in others, and future predicted increases in ENSO are likely to have major environmental and socio-economic impact, particularly given that the human population is expected to double by 2035. The effects of global change on habitats are predicted to be manifested through both freshwater shortages (drought and associated forest fires) and flooding, particularly in lowland stream, river, marshland and riparian communities. Potentially severe global change effects are also expected for coral reef habitats, through the synergistic effects of changes in ocean alkalinity affecting reef calcification processes and through elevated SSTs causing widespread coral bleaching and death (Hoegh-Guldberg 1999, Kleypas et al. 1999, Leclercq et al. 2000, 2002, Reynaud et al. 2003). There are also expected to be severe consequences from complex linkages between Habitat and community modification and Unsustainable exploitation of fish and other living resources and Pollution and Unsustainable exploitation of fish and other living resources.

Causal chain analysis

This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involves a step-by-step process that identifies the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA Causal chain analysis also recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. In order to ensure that the final outcomes of the GIWA are viable options for future remediation, the Causal chain analyses of the GIWA adopt relatively simple and practical analytical models and focus on specific sites within the region. For further details, please refer to the chapter describing the GIWA methodology.

The Causal chain analysis for Indonesian Seas is focused on Unsustainable exploitation of fish and other living resources, and the issue destructive fishing practices. This concern and issue was chosen as it has severe environmental and socio-economic impacts across much of Indonesian Seas, scoring highly in all three GIWA sub-systems (Sunda, Wallacea and Sahul). Within the context of destructive fishing, one method; poison fishing to supply the live food fish and aquarium trades, is of particular future concern. It has major transboundary implications, both in terms of target species populations and replenishment, and in terms of the driving forces, and is thus the main focus of the following causal chain analysis. The other major immediate causes of destructive fishing; blast fishing, muro-ami and inappropriate trawling, are not explicitly considered in this causal chain, although many of the immediate, intermediate and root causes are similar.

System description

The key aspects of the system are described in detail in the Regional definition and Assessment (Habitat and community modification and Unsustainable exploitation of fish and other living resource) sections. The coral reef fishery resources of Indonesian Seas, as with much of South East Asia in general, have been heavily targeted by the live fish food trade since the early 1990s, to supply primarily Chinese markets in Hong Kong, Shanghai, Taipei and other major cities. A secondary fishery to supply ornamental species for the global aquarium trade has also targeted these areas. The ornamental and aquarium trade is an international, multi-million dollar industry with 36% of the global trade coming from South East Asia (UNEP/WCMC 2004).

The live food fish and ornamental aquarium fisheries in the region and elsewhere are destructive because of the widespread use of sodium cyanide and/or potassium cyanide and/or various other soluble plant-derived poisons to narcotise the fish. In Indonesia, cyanide is widely used to capture both live reef food fish and aquarium fish. Weber (1998) assessed the status of some 200 fisheries around the world and concluded that the live reef fishery of South East Asia is one of the most threatened fisheries on the planet.

The poisons used to capture the fish have the detrimental side-effect of also poisoning and usually killing the non-target, sessile, sedentary and site-attached reef species in the vicinity, most notably the corals (Johannes & Riepen 1995). This has caused loss of considerable coral cover in many areas of Indonesian Seas and elsewhere in the greater South East Asian region, with secondary and tertiary effects on the structure and function of the associated coral reef communities.

There has been rapid expansion of the live fish trade in Indonesian Seas over the past two decades, since concerns were first raised in the early

1990s (see Johannes & Riepen 1995 for initial review and Pratt 1996). The official export information demonstrates that exports from South East Asia increased from some 400 tonnes in 1989 to more than 5 000 tonnes in 1995. However, by 1996 there was a 22% decline in recorded exports, suggesting overfishing (Bentley 1999). Of the total exports, Indonesia accounted for some 60% from 1990-1995.

History of the Indonesian fishery is traced back to the late 1970s and early 1980s, when reefs of western provinces (Sunda) were targeted. As these reefs were progressively overexploited, the rich resources of eastern Indonesian reefs (Wallacea and Sahul) were targeted and by 1993 accounted for more than 75% of all recorded exports (Bentley 1999). Reflecting the regional reduction in exports in 1996, exports from eastern Indonesia dropped by more than 450 tonnes that year. For example, Johannes and Riepen (1995) wrote: "…the information… paints an alarming picture of the extent and impact of the trade…the volumes of fish being traded are a poor indicator of the magnitude of the trade's environmental impact…because of the extensive collateral environmental destruction the trade is causing".

The full extent of poison fishing in Indonesian Seas is unknown (Johannes & Riepen 1995, Burke et al. 2002), because it targets some of the most isolated coral reefs where little if any scientific work has been conducted. However, in conducting a detailed threat analysis of destructive fishing in South East Asia, Burke et al. (2002) identified many of the reef areas of Sulawesi (Wallacea), offshore areas of the Jawa Sea and Sumatra (Sunda) and areas off Papua (Sahul) as all facing the highest level of threat. As noted by Bentley (1999): "The live food reef fish trade… is complex. Involving several tiers of trade, the characteristics vary… and have changed over time. Although the fishery began with foreign vessels and crew, there was a rapid turnover to local operations… Exporters found it cheaper to employ locals."

The mode of export has also changed and diversified in recent years, from various forms of ship-based transport to the more widespread use of airfreight, with exports by air from Indonesia rising from 5% to 40% from 1991 to 1995 (Bentley 1999, Cesar et al. 2000).

The causal chain for the issue of destructive fishing/poison fishing shares many similarities across the three Indonesian Seas sub-systems, as indeed with neighbouring regions of Sulu-Celebes (Sulawesi) Sea and South China Sea.

Causal chain analysis

The Causal chain analysis was founded in the extensive background knowledge and publications of the GIWA Task team and additional information provided by various government agencies, academic institutions, NGOs and other agencies, as cited herein (also see Annexes VII and VIII). Nonetheless, some large gaps in information remain. In particular, there is a serious lack of long-term socio-economic data on human use patterns. Figure 15 illustrates the causal links for destructive fishing practices in the Indonesian Seas region.

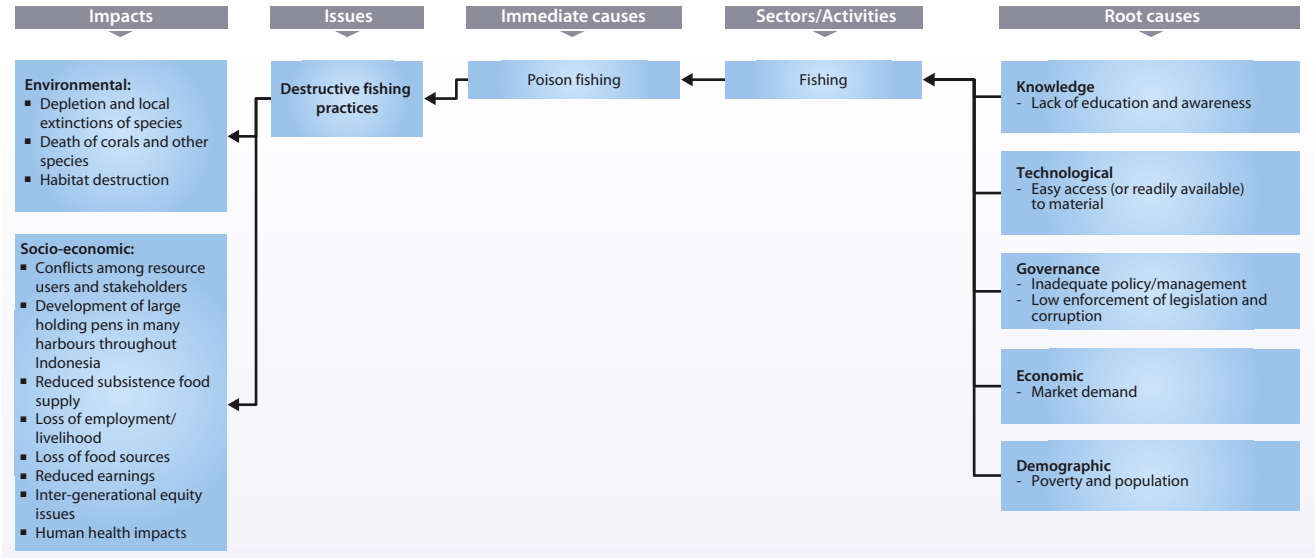

Figure 15 Causal chain diagram illustrating the causal links for destructive fishing practices.

Environmental impacts

- Depletion and local extinctions of targeted and non-targeted species;
- Death of corals and other sessile, sedentary and site-attached species, with concomitant changes in community structure;
- Loss of coral cover, with effects on the structure and function of the associated coral reef communities.

Socio-economic impacts

- Conflicts among resource users and other stakeholders and foreign vessels involved in the live reef fish export trade;
- Development of large holding pens in many harbours throughout Indonesia (Figure 16);
- Reduced subsistence food supply through reduced Catch Per Unit Effort (CPUE) to small-scale local village fishermen;
- Loss of employment/livelihood among local village fishermen;
- Loss of food sources (e.g. sources of protein) in parts of Indonesia;
- Reduced earnings in one area by destruction of juveniles and brood stock in other areas;
- Inter-generational equity issues (access to resources) among poor local fisher families;
- Human health impacts, particularly to divers.

Figure 16 Live fishholding pens, Anambas & Natuna Archipelago, Indonesia.
(Photo: J.L.N. Sivasothi, Reefbase)

There is strong and unequivocal evidence for all of the above indicators in the ecological data and in socio-economic assessments conducted as part of various MPA and coral reef management projects (e.g. Komodo National Park, Bunaken National Park, COREMAP project (see also Annexes VII, VIII).

Immediate causes

Poison fishing

The topical application of the poison; various forms of cyanide and other poisons, usually by surface-supplied ´hookah divers´ using easily prepared 'squirt bottles' (usually old detergent bottles or similar) directly in the vicinity of the target species allows for ease of collection. The poisons are cheap to purchase and widely available; so this is not limiting the spreading of the fishery.

The divers often work at night, when most species of target fish are more easily collected, systematically removing fish (either food fish or ornamental aquarium species) along entire reef slopes. Concurrently, the input of hundreds of tonnes of cyanide and other poisons per year to Indonesia's coral reef communities, particularly targeting the larger brood-stock and spawning aggregations of reef-associated fishes, has had disastrous consequences both for the populations of the target species themselves, and for the incident reef communities. The removal of brood-stock and targeted collection of spawning aggregations has resulted in broad-scale depletion of reproductive stocks and likely major decline in reproductive output and recruitment back to the fisheries. This is now beginning to be evidenced in the reduction in large fishes and relatively high number of small-size fishes being sold at local markets.

On the one hand, the live food fish and aquarium trades have become highly organised over the decade since the early 1990s, with large operations of up to 20 'hookah divers' with air supplied from the surface working together in dories operating from larger vessels to supply the lucrative Chinese and developing global markets. On the other hand, small-scale village operators also deplete their local reefs, either to supply visiting buyers or to support their own or other villagers' aquaculture activities, particularly for reef groupers (Serranidae). Thus, there are both highly commercial and 'subsistence' aspects to the trade.

Root causes

The current harvesting practice of the trade is unsustainable (Johannes & Riepen 1995, Burke et al. 2002). Poison fishing remains the predominant technique for reef fish capture in Indonesian Seas. The economic benefits for the fishers themselves are minimal, with the greatest profit margins limited to the middle men and restaurant points of sale (e.g. in Hong Kong). The live reef food fish trade (particularly in China) and ornamental aquarium trade (global) are lucrative industries where reef food fish can fetch prices of up to 100 USD/kg and ornamental species (e.g. reef angel fish) more than 100 USD per pair. For the very rarest of ornamental species, prices in the thousands of USD have been

charged (DeVantier pers. comm.). Between 1996 and 1999, the share of the United States ornamental fish market coming from South East Asia increased from 67-78% (US Fish & Wildlife Custom declarations unpubl. data).

Knowledge

Lack of education and awareness

Destructive poison fishers often have little education and lack awareness and appreciation of the environment. Many fishermen in Indonesia have only rudimentary education and little to no basic understanding of the ecology of the fishes or indeed coral reefs generally. Because of their poverty, the fishermen have little option than to participate in the fishery when offered comparatively lucrative returns for their effort. Moreover, there is a widely held misconception amongst fishers that the use of destructive fishing is better because it yields a bigger catch for the least effort. The coincident widespread lack of awareness about the destructive aspects of the fishery, combined with the typical viewpoint of 'if not me then someone else will do it' has led to the 'Tragedy of the Commons' situation common and almost axiomatic in many fisheries worldwide.

Figure 17 Live reef fish, including large groupers *Epinephelis* and *Plectropomus* spp. for sale in restaurants, Hong Kong.
(Photo: C. Cheung)

Figure 18 Live reef fish, including Barramundi cod *Cromileptes altivelis* for sale in restaurants, Hong Kong.
(Photo: C. Cheung)

Technological

Easy access to (or readily available) material

The ready availability of the poisons (e.g. from electro-plating industry) has contributed to their widespread use. Training has also been provided to locals by the exporters in some areas.

Economic

Market demand

The almost insatiable market demand for live seafood, particularly from China and from Chinese people in other areas, has created a class of willing fishers who will use any fishing methods to achieve goals of maximum yield at the minimal effort. Both the commercial (export) and local (grow-out for mariculture) ends of the live fish market offer comparatively lucrative rewards for effort, relative to hook-and-line and trap fishing (the other main modes of supplying live fish) (Bentley 1999). This demand is largely focused on a few groups of reef fishes. Notable are the food fish groupers Serranidae (Figure 17), especially various species of Coral cods (*Epinephelis* spp. and *Cephalopholis* spp.), Coral trout (*Plectropomus* spp.) and the Barramundi cod (*Cromileptes altivelis*) (Figure 18), snappers (Lutjanidae) and emperor bream (Lethrinidae) and the labrid Maori wrasse (*Chelinus undulates*) (Figure 19). The ornamental aquarium trade tends to target the gaudy site-attached or home-ranging fish species, particularly the angelfishes, tangs, anemone (clown) fishes and butterfly fishes. The lack of accountability and responsibility, both among fishers themselves and in some cases

Figure 19 Live reef fish, including Maori wrasse *Chelinus undulatus* for sale in restaurants, Hong Kong.
(Photo: C. Cheung)

at the point of sale and the absence of any effective education and awareness campaigns or surveillance and enforcement, exacerbates the situation.

Governance

Inadequate policy/management

The administrative structure has traditionally been cumbersome, divisive and top heavy. Until very recently (e.g. Butarbutar et al. 1999), power has rested almost exclusively with a multitude of central government agencies with provincial, regional and village levels poorly equipped to take on any significant responsibility, being little recognised in the legislative process. Legislation and regulation has traditionally favoured exploitation of coastal and marine resources rather than conservation (Annexes III-IV). Additionally, there are inadequate resources and capacity to develop policy and legislation more suited to addressing the identified impacts or to effectively execute relevant existing legislation.

These difficulties are exacerbated by the civil strife that has developed in some parts of Indonesia, particularly since the 1990s, and also by the three-tiered government system. National, provincial and local government levels are not well integrated in many areas in terms of making best use of the existing legislation. As a general rule, even where legislation is in place at provincial and local levels, surveillance and enforcement agencies have little or no capacity to implement it, except in a few small MPAs receiving both government and NGO support (e.g. Komodo National Park, Bunaken National Park) (Annexes VII and VIII).

Low enforcement of legislation and corruption

The lack of capacity in enforcing legislation has contributed to the establishment and continued increase in destructive fishing (e.g. Susiloweti 1998). This is exacerbated by widespread corruption and the fact that many destructive fishing activities are carried out in remote places, whereas enforcement capability is largely restricted to the few well-managed MPAs (e.g. Komodo, Bunaken National Parks).

Demographic

Poverty and population growth

The coastal fishing communities of Indonesia, as indeed throughout much of South East Asia, are often characterised by large families, high populations and extreme poverty. Coastal communities in general are the poorest in Indonesia. With low incomes, lack of access to credit, a lack of opportunity for alternative incomes and a general lack of social infrastructures, these communities contribute to the environmental decline, and through their subsistence activities are pushing many coastal resources beyond their sustainable limits (Hopley & Suharsono 2000).

These are strong driving forces behind most negative environmental and socio-economic impacts of fisheries in the region. The dependence of most of the coastal people on their fisheries resources, for their subsistence on the one hand and for hard currency on the other, is so strong that most resources will be extracted unless alternative livelihoods and other concerted long-term interventions, at the scale of the region, are implemented, far beyond those that are already occurring.

Providing alternative livelihoods for poor coastal people can be difficult, as they need to be convinced that they would get a better deal with a new initiative. An example of this is poison fishing, whereby the fishers need to be convinced that: (i) a new (less destructive) method will yield the same if not better catch; and/or (ii) removal of unsustainable numbers of fish, including brood-stock, will cause collapse of the fishery, threatening both their own and their childrens' future livelihoods.

Recent attempts at developing alternative livelihoods, including some forms of ecologically-sustainable mariculture of species where all life-cycle stages have been 'closed' to exclude the need for wild-capture, and where food is sourced non-destructively (e.g. not trash fish from benthic trawling), are proving successful on small-scale trials (e.g. Hon Mun MPA, Nha Trang, Vietnam, in GIWA region 54 South China Sea).

Conclusions

In summary, constraints which have retarded Indonesia's coastal and marine management include (Hopley & Suharsono 2000):

- Lack of integration both vertically between different tiers of government and horizontally between a wide array of agencies;
- Lack of a conservation ethic and political will;
- Social and cultural constraints resulting from low levels of awareness, education, community participation in the management process, and high levels of poverty which limit the alternatives to activities such as destructive fishing;
- The weaknesses of the marine protected area system;
- Insufficient scientific, social and cultural data for effective management and lack of access to the data which is available;
- Insufficient human resources leading to lack of implementation of laws, regulations and management plans.

Destructive fishing, and particularly poison fishing to supply the highly lucrative international live fish food trade and ornamental aquarium trade, is an increasing problem (Pratt 1996, Barber & Pratt 1997) that

impacts all three sub-systems, both in terms of fisheries and habitat loss. The most significant root causes are the interactions among population growth, poverty and market trends, notably the insatiable international demand for live seafood. Population growth is exacerbating unemployment and poverty, which are placing greater pressure on stocks of fish and other living resources. Lack of enforcement of laws governing destructive fishing, abetted through corruption within enforcement agencies and some government officials, allows the illegal fishing practices to flourish. Economics and market trends drive the unsustainable use of resources and also influence corruption and the illegal practices.

Key government departments, including the enforcement agencies, are hampered by a lack of qualified and experienced staff, and also by funding shortfalls and cutbacks in part related to currency depreciation and shifts in government spending. Despite a recent trend towards decentralisation in governance, there remains insufficient capacity for effective stewardship and control of the renewable resources. What is currently lacking is coordination and capacity to apply the existing legislation, particularly at local government levels, and to review and amend the legislation to improve its functionality, particularly cross-sectorally and at provincial and local levels.

Policy options

This section aims to identify feasible policy options that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment. Recommended policy options were identified through a pragmatic process that evaluated a wide range of potential policy options proposed by regional experts and key political actors according to a number of criteria that were appropriate for the institutional context, such as political and social acceptability, costs and benefits and capacity for implementation. The policy options presented in the report require additional detailed analysis that is beyond the scope of the GIWA and, as a consequence, they are not formal recommendations to governments but rather contributions to broader policy processes in the region.

Definition of the problem

The GIWA region Indonesian Seas is at the centre of the world's marine biodiversity, supports a rapidly growing coastal population, and has rapidly deteriorating marine ecosystems with the likely imminent collapse of many of its coral reef and pelagic fish populations. As detailed in the Assessment section above, destructive fishing contributes to overexploitation as well as habitat loss and modification (McManus et al. 1997). The two major forms of destructive fishing in the Indonesian Seas region, poison and blast fishing, are already illegal, with the overall management of fish stocks overseen by the Directorate General of Fisheries under the Ministry of Fisheries and Marine Affairs (Kahn & Fauzi 2001) (see also Annexes III-V).

Management is, in accordance with national policies and objectives:

- To raise income and standard of living of small-scale fishermen and fish farmers;
- To increase productivity of fishing effort and to boost national fish production;
- To increase fish consumption;
- To increase export of fish products;
- To have better control of the utilisation and management of fish resources.

However, these objectives are not necessarily the most appropriate for either long-term ecological and economic sustainability or conservation of habitats, as demonstrated by a recent analysis by The Nature Conservancy presented in Annex VII.

Important policy issues

- There are already severe environmental and socio-economic impacts from unsustainable exploitation of fish, and particularly destructive fishing, in the region as a whole.
- The environmental and socio-economic impacts are expected to continue to worsen over the next 20 years, except in the few well-managed MPAs (e.g. Komodo National Park, Bunaken National Park), where strong surveillance, enforcement, education and alternative income generation programmes are already being implemented.
- The human population is growing rapidly, with widespread religious and cultural traditions fostering large family sizes, exacerbated by inadequate policy focus towards developing and implementing population stabilisation strategies.
- There are more than 16 million fishermen in the region and many coastal people rely on subsistence level fishing for survival.
- There is widespread continued use of inappropriate (destructive) fishing methods and clear evidence of impending collapse in the ecological sustainability of the reef fisheries sub-sector.

- Most of the target reef fish populations are transboundary, occurring on reefs throughout the central and western Indo-Pacific, many of which have also already been severely overexploited, leading to major reductions in effective population sizes and overall reproductive output and local extinctions.
- As elsewhere, the political situation is focused strongly on the short-term (5 year cycles) rather than on developing longer term strategies.
- Recent political instability, fuelled in part by religious conflicts and separatist movements, with related civil strife and increased poverty levels, has further reduced the institutional capacity to address destructive fishing in particular and environmental issues more generally.
- At present, environmental concerns are of less importance than development pressures, some of which are explicit government policy (e.g. expansion of fisheries, Annex VII), and many of which are counter-productive to ecological and socio-economic sustainability.
- There are major opportunities for improved understanding of the real status and future potential of the fisheries in government, particularly in relation to long-term ecological and economic sustainability.
- There is an urgent need to better integrate fishery-related sectors in policy, with linkages among food security - poverty - natural resources - environment pressures - market forces and governance, with major opportunities for improvement in the political situation and from private sector and national/international NGOs.
- Most forms of destructive fishing are already illegal in national and provincial legislation but are not adequately enforced, including some corruption across the various enforcement and legislative agencies.
- Contributing to the illegal practices, most national and provincial laws and regulations are either not known or not well accepted by local populations.
- There is an urgent need to strengthen local levels of governance and policing, particularly in relation to implementation of the existing provincial and national legislation addressing destructive fishing.
- As with other nations in the region, a 'critical mass' of expertise and frameworks for change are developing, involving government and NGOs, academia and the private sector.
- Local to large-scale interventions by government and NGOs (e.g. WWF, TNC, IUCN) have the potential to slow the rate of deterioration significantly, provided these receive adequate political, fiscal and logistic support.

Construction of the policy options

At present, policy and legislation are neither sufficiently well developed nor integrated to facilitate implementation of the most urgent remedial measures, particularly in relation to co-management of renewable marine resources and protected areas. Addressing the synergistic impacts of population growth, political instability and widespread poverty (Djohani 1998, 1999) among coastal populations in an integrated way (Kusumaatmadja 1999) is at the core of developing successful policy options (McManus 1988, Chua 1989, Chua & Garces 1994) and implementing interventions to address the developing fisheries crisis.

Towards this goal, the Directorate General of Fisheries of the Ministry of Marine Affairs and Fisheries (PKA) has recently implemented a project "Study on Fisheries Development Policy Formulation", under the Japan Bank for International Cooperation (JBIC Loan No. IP-403). The goal was to formulate a new policy for Indonesian fisheries based on principles of sustainability, taking into account the needs of the poor as well as to implement the Precautionary Approach to Management and the FAO Code of Conduct for Responsible Fisheries, to which the country subscribes (Pet pers. comm.). The project listed the following policy recommendation to the Government of Indonesia: "Create, build and arouse awareness to change the perception and mindset of the people to stop romanticizing that the country's seas have over-abundant or overflowing resources, in particular fisheries resources".

The project also provides the following policy advice on marine protected areas (MPAs): "It is definitively in the country's economic and environmental interests to set aside at least 10% of its 81 000 km coastline and 5.8 million km^2 marine territory as marine protected area to conserve and protect its remaining rich marine bio-diversity. There are clear benefits to be gained from investment establishing more marine protected areas in Indonesian waters, not only as a tool to manage and conserve the fisheries and its rich genetic resources but also equally for mariculture as a source of seed and broodstock".

In light of the above, recommended policy options from the present GIWA analysis, from the broad-scale to the fine-scale, for the supply-side of the issue within Indonesian Seas, include:

- Improved integration of local - provincial - national laws and regulations, to maximise effectiveness of the legislative instruments to control destructive fishing at local - national levels, and to better encompass all sectors and meet obligations under international conventions and treaties.

Figure 20 Collecting fish from holding cages for live fish market, Kapoposang Island, Sulawesi.
(Photo: J. Oliver, Reefbase)

- Much-improved surveillance, enforcement and effective policing of laws to reduce the illegal fishing practices, including development and effective implementation of export quotas, catch and fish size limits.
- Ongoing and expanded community education programmes.
- Improved incomes for fishermen through generation of ecologically viable alternative/additional income (e.g. well planned and ecologically-sustainable mariculture).
- Development of alternative legal supply lines for live fish, particularly through mariculture, with increased supply of such maricultured species to supplement reductions in wild-caught stocks.
- Expand research and development to 'close' the reproductive cycles of the key mariculture species in captivity, and to develop ecologically sustainable food sources for mariculture species, with opportunities for increased regional collaboration.
- Major expansion of the MPA network, with improved management, including major focus on community co-management, with development of 'no-take' zones, and protection of spawning aggregation sites.

National surveillance strategies, with participation from all levels of government, NGOs and local communities may be the best way of bridging the gaps between formulation, legislation and enforcement of regulations. This may be best focused on the ports themselves, where large holding pens for live reef fish are often established and where initial catch quotas and fish size limits can be enforced at the initial points of sale and export.

Recommended policy options for the demand-side of the issue, mostly outside Indonesian Seas, include engagement of the live food and aquarium fish industries themselves in the management process e.g. with strategies like the international Marine Aquarium Council (MAC) certification-accreditation system (MAC 2004).

The United Nations Environment Programme's World Conservation Monitoring Centre (UNEP/WCMC) has conducted the first detailed global assessment of the state of the marine aquarium trade in its report "From Ocean to Aquarium: The Global Trade in Marine Ornamentals" (Wabnitz et al. 2003). The report analyses data provided by exporters and importers from around the world who are working with the MAC and WCMC to ensure accurate information on the trade is available. In the accompanying UNEP press release, UNEP Executive Director Klaus Toepfer noted that the collection of tropical fish fuels an important, and mostly legitimate, industry, and highlighted the fact that the global trade in marine species has great potential as a source of desperately needed income for local fishing communities. UNEP/WCMC Director Mark Collins also noted that with effective management, the aquarium industry could support long-term conservation and sustainable use of coral reefs in regions where other options for generating revenue are limited.

Most recently, the Indonesian Ministry of Marine Affairs and Fisheries signed a memorandum of understanding (MoU) with the MAC in July 2003, formalising the strong government support for the MAC's work in Indonesia. At the field level, progress towards MAC Certification is being made. The recent MoU regarding collection and export of ornamental aquarium fish can also provide a useful model for the live food fish industry. The industry, when well managed and with the destructive fishing elements controlled, has great potential as an ecologically sustainable and economically viable industry for the region and indeed for the region as a whole.

Without such measures, the 'business as usual' scenario will result in the continued local extinctions of the target aquarium and food fish species from much of their distribution ranges, perhaps surviving in small numbers in the few effectively-managed reserves. These small populations themselves will be at high risk of extinction from catastrophic events. Indeed, several of the most sought after food fish species (e.g. Napoleon wrasse *Chelinus undulatus*) are already considered as 'vulnerable' in much of their distribution ranges. This major depletion in target species abundance will be accompanied by the continued widespread collateral damage to incident reef communities from the application of poisons. Such a scenario is of no long-term benefit to the fishers themselves, and will ultimately cause total collapse of the wild-stock live food fishery.

On the positive side, there are many national, regional and international "players" actively pursuing sustainable development initiatives, and best use of this developing network should be made during future policy implementation. Government projects such as COREMAP and MCREP and NGO programmes such as the Wallacea Bioregion (WWF), Komodo National Park Management Plan (TNC 2000) and other projects provide useful models for future improvements in fisheries and habitat protection.

Because of the major international driving force of market demand for live reef fish, mostly by Chinese consumers of food fish and more widespread aquarists, policy issues also have a major transboundary aspect. This is focused, in the case of live food fish, on the major consumer cities of Asia, notably Hong Kong, Shanghai, Taipei and Singapore, and to a lesser extent most cities with significant Chinese populations. For aquarium fish, the market is extremely broad and diffuse across the developed world. Thus, policy options also need to address the demand side of the poison fishing issue.

Identification of recommended policy options

A wealth of information has been developed since the mid-1990s detailing the various policy options and remedial/mitigatory measures that could be adopted in relation to poison fishing (see e.g. Johannes & Riepen 1995, Pratt 1996, Bentley 1999, Cesar et al. 2000, and the journal "SPC Live Reef Fish Information Bulletin" for details). Johannes (1996) made eight key recommendations in this respect, some of which are now beginning to be implemented, and all of which are worth reiterating here:

- Convince government regulatory agencies that the live fish trade is a distinctive form of fishery requiring special controls. (Significant progress has been made).
- Provide villagers with the incentive to protect their marine resources by giving them the legal right to exclude outsiders from their fishing grounds - or where that right already exists, provide stronger government backing. Train, deputise and support village fishermen as fish wardens. (Some progress, notably in community-based MPAs).
- Ban the possession of dynamite on boats and the use of cyanide as Papua New Guinea has don. (Some progress - blast and poison fishing are now illegal but rarely enforced).
- Commission a study to determine the kinds of research and development needed to raise selected grouper species and humphead (maori) wrasse from the egg commercially in order to reduce the demand for wild-caught fish. (Some progress).
- Where logistics permit, set up cyanide detection laboratories (in import destinations such as Hong Kong as well as source countries) in order to monitor live reef food fish and marine aquarium fish operations, as pioneered in the Philippines. (Little if any progress).
- Support research on the effects of cyanide on corals and coral reef communities to get a better idea of their vulnerability and the magnitude of the clear-cutting effect. (Little published to date).
- Carry out research to improve non-destructive methods of catching species targeted by the trade. (Significant progress, particularly in relation to aquarium trade).
- Work multi-laterally with the governments of Indonesia, Thailand, Philippines, Vietnam, Malaysia and China to ban the use of cyanide in the electro-plating industry and thus reduce its availability, as has already been done elsewhere. (Little progress).

In the years since Johannes' recommendations, some progress has been made. However, many of the recommendations remain key to addressing the issue. Considerable capacity building is still required, both in policy development and on-site in education and awareness, surveillance, policing and other interventions. These measures must be accompanied by alternative income generation strategies for the fishers themselves. In these regards, there has been recent convergence in views among scientists and resource managers on the crucial importance of MPAs and MPA network strategies as tools for sustainable fisheries management and resource protection (Box 11 and Annexes VII and VIII).

Box 11 Benefits of a well managed Marine Protected Area in Komodo National Park.

The major conclusion on the current status of Indonesia's fisheries sector is that a shift in objectives of fisheries management should occur. To assure that maximum benefits accrue from the fisheries, the objectives must change from increasing landings to assuring sustainable exploitation and survival of the resources. More investments are needed to produce more fish. But such investments must not expand fishing capacity but increase the capacity to manage the remaining fisheries resources. Today, protective management of Indonesian fisheries is no longer a matter of choice. Protective management through implementation of a network of marine protected areas (MPAs) is inevitable if the remaining fisheries are to be sustained for the present and future generations. While MPAs are often designed to provide for a range of uses, it is extremely important to reserve an adequate area in "no-take zones" providing full protection to the resources. Only such fully protected MPAs can offer the full range of benefits including protecting biodiversity, enhancing fisheries, boosting tourism, providing economic opportunities and reducing conflict. Successful reserves require a great deal of effort to establish followed by long-term commitment from stakeholders and decision makers to maintain effective protection. This can only be achieved by designing and implementing effective co-management structures with the capacity to process essential inputs from stakeholders depending on the survival of the resources. The development of innovative co-management structures is essential to ensure the highest quality staff involved in management and protection of the resources. Rather than administrative commitments to marine protected areas, the single most important factor underlying whether or not a MPA will be successful and beneficial is the presence of a dedicated individual or group of individuals to carry it forward.

(Source: Pet pers. comm. also see Pet & Djohani 1996)

Policy recommendation

Networks of well-designed and well-managed MPAs should form the core of the fisheries management (and marine conservation) strategies. There is extreme urgency for the development of a functional MPA network and an immediate need for the establishment of substantial 'no-take' replenishment zones, with the development of policy and legal frameworks that will facilitate the process. As noted above, the benefits from an MPA to fisheries are through two key biophysical processes:

- Spillover: the export of adults and juveniles of target species to the fishery;
- Larval export: the distribution of propagules of the target species into settlement areas, from where they will eventually recruit into the fishery.

The third key benefit to be derived from fisheries sanctuaries is 'enhanced fisheries stability' (Pet pers. comm.). Sanctuaries provide the basis for a more precautionary management strategy for fisheries.

The successful establishment and effective management of a functional MPA network offering best returns to fisheries will require improved integration among government departments, international donor agencies and NGOs. Better allocation and use of government funds and continuing international donor assistance are urgently required in the short-term. Continuation, expansion and better integration of the various local, provincial, national and international programmes identified herein will help to ameliorate the severe environmental and socio-economic impacts from destructive fishing and other forms of unsustainable exploitation of Indonesian Seas.

This will also require a high degree of local intervention and community-based support, including application and local enforcement of the no-take replenishment areas and protection of fish spawning aggregation sites, and also reliable stock assessment and monitoring. These need to be founded in the 'ecosystem approach', with an improved understanding of the population biology of the target species, synecology and issues of ecological scale and connectivity in relation to replenishment, including:

- Catch volumes and CPUE;
- Traditional knowledge (e.g. locations of spawning aggregation sites of major commercial species), for development of protection measures;
- Natural changes in diversity, distribution and abundance of major commercial species, in relation to seasonality effects, predator-prey relationships, and recruitment fluctuations.

Cheung et al. (2002) provide a comprehensive list of Priority Actions for success, reiterated here:

- Update and complete the national inventory of all existing and proposed MPAs and protected areas and verify their official and management status.
- Review the designation of existing MPAs, and revise these to accommodate traditional uses and sustainable development where appropriate.
- Define clear boundaries in the establishment of new MPAs and revise boundaries and zonation of existing MPAs where necessary (also see Annex VIII). Manage adjacent and linked MPAs as one and emphasise buffer zone planning and management.
- Considering the vulnerability of MPAs to external influences (including terrigenous processes and hydrological forces that may carry pollutants from outside), employ integrated coastal zone management, incorporating integrated buffer zones linking land and sea, and improve communication and cooperation between authorities responsible for land and sea.
- Switch the emphasis on small, isolated, highly protected MPAs to a system of MPAs allowing multiple-use principles and networking.
- Conduct strategic assessment of manpower requirements during the planning and management of individual MPAs and the MPA system.
- Develop unified survey and monitoring procedures, mapping, GIS and database systems within the Directorate General for Forestry Protection and Nature Conservation (PKA) to facilitate overall planning of, and exchange within, the MPA system.
- Strengthen NGO capabilities in community conservation programmes.
- Consider the need for more, and more effective, marine protected areas where these are least represented, especially in the centre of coral reef diversity in the world (East Sulawesi), and also the Indonesian waters between east and west Malaysia, where destructive fishing is also high and the Strait of Malacca.
- Continue to pursue the goal of PHPA (PKA) to establish a 30 million ha network of marine protected areas.
- Other priority action points as identified in UN (2002).

In light of all of the above, two major foci for action are apparent:

- The urgent need for effective management of the existing MPA network (also see Annexes VII-IX).
- Careful planning and continued support for expansion of the network in terms of integration, particularly of cluster and transboundary MPAs in Indonesia and with neighbouring nations in the region and particularly in relation to the increasing effects of global change (also see Annex X).

Figure 21 Local boat, Kaposang Island, Sulawesi.
(Photo: J. Oliver, Reefbase)

Performance of the chosen option

Effectiveness

The chosen option has had demonstrable success in several major MPAs where support across the different levels (international - local) has been developed, notably Komodo National Park and Bunaken National Park (see Annex VIII). However, other MPAs have been far less successful (e.g. Kepuluan Seribu National Park, Jawa Sea) (Brown 1986, Hutomo et al. 1993, Alder 1996, DeVantier et al. 1999), and overall effectiveness of the policy option is thus rated as medium (also see Chua 1989, Chua & Garces 1994, Crooks & Foley 1995). Levels of environmental and socio-economic impact are expected to increase in most of the region to 2020, despite present and planned interventions, including protected areas and improved surveillance and enforcement. Effectiveness can be improved markedly with more equitable use of funds and continuing donor, government and NGO support. Effectiveness correlates with basic management activities such as enforcement, boundary demarcation, and direct compensation to local communities, suggesting that even modest increases in funding would directly increase the ability of protected areas to minimise destructive fishing, restore harvested species and protect tropical biodiversity.

If management of the existing MPAs can be improved markedly, as recommended herein, there already exists a well distributed network covering all major IUCN biogeographic divisions except Division 1, with more MPAs in the larger and more complex Divisions II and III, and some concentration in Jawa (Cheung et al. 2002). Furthermore, with future gazettal and effective management of the proposed MPAs (see also Assessment, Habitat and community modification), the major biogeographic gap (west Sumatra) will be filled.

Importantly, at least 10 of Indonesia's MPAs are rated as regionally or globally significant (Cheung et al. 2002) providing strong support for continued international assistance in developing effective management.

Efficiency

The efficiency is rated as medium to high, because of the clearly prioritised objectives and goals and the development of transparent systems for implementation, but with major remaining impediments of corruption across all levels from local to national, and unresolved political instability (e.g. separatist movements) in parts of the region. Clearly, efficiency is linked closely with effectiveness, and thorough evaluation of efficiency will require expansion of future policy assessments beyond standard cost-benefit analysis, particularly considering the impact of social capital on the costs of managing fisheries.

As Rudd et al. (2003) conclude: "In the short term, the amount of social capital that communities possess and the capacity of the state to support the rights of individuals and communities will affect the relative efficiency of marine reserves. Reserves may be the most efficient policy option when both community and state capacity is high, but may not be when one and/or the other is weak. In the longer term, the level of social capital that a society possesses and the level of uncertainty in ecological and social systems will also impact the appropriate level of devolution or decentralisation of fisheries governance. Determining the proper balance of the state and the community in tropical fisheries governance will require broad comparative studies of marine reserves and alternative policy tools".

Equity

Equity is rated as medium to high, with increasing stakeholder involvement and major education and awareness campaigns occurring. The special circumstances of local subsistence fishers are now beginning to be addressed explicitly in MPAs.

Political feasibility

Political feasibility is rated as low to medium, with unresolved gaps in jurisdiction among the various government levels placing serious impediments on resolution of some of the key environmental and socio-economic issues in MPAs (also see Crooks & Foley 1995). Current decentralisation policies have yet to prove to be effective in empowering local government authorities.

Implementation capacity

The implementation capacity is rated as low to medium, with significant capacity-building required among government, NGO and community groups for effecting change, but with considerable international donor support and some excellent models (see Annex VIII). There is also increasing recognition among the communities themselves that interventions are crucial to their longer term sustainability. However, Indonesian Seas are very large and poorly known, with insufficient biodiversity and fisheries assessments and monitoring undertaken to date. There remain serious deficiencies in capacity in 'on the ground' implementation, including unresolved difficulties in effective surveillance and policing (see Annexes IX and X), providing challenges for implementation, and at present, levels of funding for these initiatives are not assured. For the successful implementation of effective management, the key root causes of overpopulation, poverty and market demand, compounded here by differences in cultural - religious beliefs, need to be addressed.

Conclusions and recommendations

At present, severe environmental concerns facing GIWA region 57 Indonesian Seas include most of those considered by GIWA; Freshwater shortage, Pollution, Habitat and community modification and Unsustainable exploitation of fish and other living resources. These concerns are also having severe socio-economic impacts in large parts of the region. Thus, the overall present situation and future prognosis for Indonesian Seas is that:

- The human population is growing rapidly, with an expected 300 million people by 2020, most in Sunda - with widespread religious and cultural traditions fostering large family sizes, exacerbated by inadequate policy focus towards developing and implementing population stabilisation strategies.
- Millions of coastal people are living near or below the poverty level and rely on subsistence level fishing for survival.
- There is widespread continued use of inappropriate technologies and clear evidence of impending collapse in ecological sustainability.
- Most national and provincial laws and regulations are either not known or not well accepted by local populations, with significant inter-provincial differences in the application of national legislation.
- There are also significant differences in international waters concerns among different areas, requiring definition and assessment of three GIWA sub-systems: Sunda, Wallacea and Sahu.
- There are already severe environmental and socio-economic impacts within these sub-systems, with Sunda being worst affected, Wallacea being intermediately affected and Sahul being least affected.
- There is inadequate enforcement of the relevant regulations, including corruption across the various enforcement and legislative agencies.
- Most of the environmental impacts are expected to worsen over the next 20 years, other than in the few well-managed MPAs (e.g. Komodo National Park), where strong surveillance, enforcement, education/awareness and AIG programmes are already being implemented.
- There may be some stabilisation and improvement in the socio-economic indicators.
- There is a pressing need to better integrate international water-related sectors in policy, with linkages among food security, poverty, natural resources, environment pressures, market forces and governance.
- It may be possible to slow down the rate of increase of impacts although at present environmental concerns are of less importance than development pressures, many of which have inappropriate environmental effects.
- There are major opportunities for improvement in the political situation and from private sector and national/international NGOs.
- Local to large-scale interventions by government and NGOs (e.g. MCREP, COREMAP, WWF Wallacea Bioregion programme, TNC Komodo programme and others) have the potential to slow the rate of deterioration significantly, provided these continue to receive adequate political, fiscal and logistic support.
- A 'critical mass' of expertise and frameworks for change are developing, involving science, policy, people, private sector and government.
- There is misallocation of significant amounts of local and international funds, with major opportunities for better allocation and use.
- The rapidly changing global situation will continue to cause changes in international funding priorities.
- There is a pressing need for better allocation of local funds and continued international donor funds to alleviate the present situation and to work towards improving future scenarios.

The Indonesian Seas region, with its neighbouring Sulu-Sulawesi Sea and South China Sea, lies at the centre of the world's marine biodiversity, supports a rapidly growing, generally poor, human population and has rapidly deteriorating riverine, coastal and marine ecosystems with possible collapse of many of its international water resources.

Indonesian Seas are of central global importance in terms of International Waters, global climate (ENSO) and Biodiversity, and these three universal attributes are under extreme threat, as posed by the complex combination of socio-political factors identified above. Addressing the severe impacts and threats through the identified policy options will require real commitment from much of civil society, and place major responsibilities on governments, non-governmental organisations, educational institutions and the private sector. The challenge of gathering the cooperation necessary for the sustainable development of this critical region is great, but not insurmountable (PEMSEA 2002). In recognition of this, the GIWA Task team suggests that the Indonesian Seas Region, with its neighbours Sulu-Celebes (Sulawesi) Seas and South China Sea, be afforded the highest priority by the Global Environment Facility.

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Dr. Ian Dutton	The Nature Conservancy Coastal and Marine Program Indonesia, Jakarta	Indonesia	Marine protected areas – assessment, planning, management and policy
Ms. Dyah Ernawati	11 March University – Solo, Indonesia and James Cook University of North Queensland	Australia	Tropical natural resources management
Dr. Mark Erdmann	Natural Resources Management (USAID), Bunaken National Park, Manado, North Sulawesi	Indonesia	Marine protected areas and coral reef biodiversity - assessment, planning, management and policy
Dr. Stefano Fazi	UNESCO, Jakarta	Indonesia	Natural resources management and protected areas
Dr. Jamal Jompa	University, Makassar, Sulawesi	Indonesia	Coral reef ecosystems and fisheries
Dr. Benjamin Kahn	APEX Environmental	Australia	Cetacean biology and ecology
Mr. Maarten Kuijper	UNESCO IOC/WESPAC Secretariat, Bangkok	Thailand	Tropical natural resources management and protected areas
Mr. Mirza Kusrini	Bogor Agriculture University, Indonesia and James Cook University of North Queensland	Australia	Tropical forests and natural resources management
Dr. David Lawrence	International Marine Project Activities Centre, Townsville	Australia	Natural resources management and socio-economics
Mr. Semuel Littik	UNPATTI- Ambon, Indonesia and James Cook University of North Queensland	Australia	Tropical natural resources management
Dr. Jacobus Mosse	James Cook University of North Queensland	Australia	Fisheries and tropical natural resources management
Dr. Peter J. Mous	The Nature Conservancy Coastal and Marine Program Indonesia, Denpasar, Bali	Indonesia	Tropical marine resources management and protected areas
Dr.Ir. Jos S. Pet	South East Asia Center for Marine Protected Areas (SEACMPA) The Nature Conservancy Indonesia, Sanur, Bali	Indonesia	Tropical natural resources management, fisheries and protected areas
Dr. Lida Pet-Soede	WWF Indonesia - Wallacea Program	Indonesia	Fisheries, tropical natural resources management and protected areas
Dr. Srihartiningsih Purnomohadi	Coastal and Marine Environmental Management Policy, The State Ministry for Environment, Jakarta	Indonesia	Coastal and marine environmental policy – socio-economics
Mr. Ketut Sarjana Putra	WWF Indonesia-Wallacea Bioregion Programme, Denpasar, Bali	Indonesia	Coastal and marine environmental management

Dr. Sapta Putra	Departemen Kelautan dan Perikanan/Ministry of Marine Affairs and Fisheries (DKP), and James Cook University of North Queensland	Australia	Coastal and marine environmental management, socio-economics and policy
Mr. Fayakun Satria	Departemen Kelautan dan Perikanan/ Ministry of Marine Affairs and Fisheries (DKP) Jakarta, Indonesia and James Cook University of North Queensland	Australia	Fisheries – assessment, policy, resource economics
Ms. Heidi Schuttenberg	East Asian Seas Regional Coordinating Unit (UNEP EAS/RCU), Bangkok	Thailand	Tropical natural resources management, coral reefs and global change
Dr. David Souter	GIWA Core Team, Kalmar University	Sweden	Coral reef ecosystems and tropical natural resources management
Prof. Robin South	International Ocean Institute Regional Centre for Australia and the Western Pacific, Townsville	Australia	Coral reef ecosystems and tropical natural resources management
Dr. Posa Skelton	International Ocean Institute Regional Centre for Australia and the Western Pacific, Townsville	Australia	Coral reef ecosystems and tropical natural resources management
Dr. Jan Steffan	UNESCO, Jakarta	Indonesia	Tropical natural resources management, planning and policy
Dr. Suharsono	Indonesian ministry of Sciences (P3O-LIPI), Jakarta	Indonesia	Coral reef ecosystems – biodiversity, status and global change
Dr. Chua Thia-Eng	GEF/UNDP/IMO Regional Programme on Partnerships in Environmental Management for the Seas of East Asia (PEMSEA), Quezon City, Manila	Philippines	Coastal and marine environmental management – planning, socio-economics and policy
Dr. Clive Wilkinson	International Marine Projects Activities Centre and CRC Reef Research Centre, Townsville	Australia	Tropical marine ecosystems – assessment, monitoring, management and policy
Mr. Windarti	Riau University-Pekanbaru and James Cook University of North Queensland	Australia	Natural resources management
Ms. Nuning S Wirjoatmodjo	UNESCO, Jakarta	Indonesia	Coastal and marine environmental management and planning
Mr. Simon Woodley	CRC Reef Research Centre, Townsville,	Australia	Coastal and marine environmental management and planning – resource economics

Annex II
Detailed scoring tables: Sunda

I: Freshwater shortage

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
1. Modification of stream flow	2	N/A	Freshwater shortage	3
2. Pollution of existing supplies	3	N/A		
3. Changes in the water table	3	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Economic impacts		**3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	3	N/A
Degree of severity	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Health impacts		**3**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	3	N/A
Degree of severity	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Other social and community impacts		**3**	

Note: N/A = Not applied

II: Pollution

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
4. Microbiological	3	N/A	Pollution	3
5. Eutrophication	2	N/A		
6. Chemical	3	N/A		
7. Suspended solids	3	N/A		
8. Solid wastes	3	N/A		
9. Thermal	1	N/A		
10. Radionuclide	0	N/A		
11. Spills	2	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Economic impacts		**3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	3	N/A
Degree of severity	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Health impacts		**3**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	3	N/A
Degree of severity	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Other social and community impacts		**3**	

Note: N/A = Not applied

III: Habitat and community modification

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
12. Loss of ecosystems	3	N/A	Habitat and community modification	3
13.Modification of ecosystems or ecotones, including community structure and/or species composition	3	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Economic impacts		**3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	N/A
Weight average score for Health impacts		**2**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	3	N/A
Degree of severity	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Other social and community impacts		**3**	

Note: N/A = Not applied

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	3	N/A	Unsustainable exploitation of fish	3
15. Excessive by-catch and discards	3	N/A		
16. Destructive fishing practices	3	N/A		
17. Decreased viability of stock through pollution and disease	3	N/A		
18. Impact on biological and genetic diversity	3	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Economic impacts		**3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	N/A
Degree of severity	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	N/A
Weight average score for Health impacts		**2**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	3	N/A
Degree of severity	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Other social and community impacts		**3**	

Note: N/A = Not applied

V: Global change

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	2	N/A	Global change	1
20. Sea level change	1	N/A		
21. Increased UV-B radiation as a result of ozone depletion	0	N/A		
22. Changes in ocean CO_2 source/sink function	0	N/A		
23. Increase in sea surface temperature	2	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small Very large 0 1 2 3	1	N/A
Degree of impact (cost, output changes etc.)	Minimum Severe 0 1 2 3	2	N/A
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	1	N/A
Weight average score for Economic impacts		**1**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small Very large 0 1 2 3	0	N/A
Degree of severity	Minimum Severe 0 1 2 3	0	N/A
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	0	N/A
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small Very large 0 1 2 3	1	N/A
Degree of severity	Minimum Severe 0 1 2 3	0	N/A
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	1	N/A
Weight average score for Other social and community impacts		**1**	

Note: N/A = Not applied

Comparative environmental and socio-economic impacts of each GIWA concern

Concern	Types of impacts								Overall score	Rank
	Environmental score		Economic score		Human health score		Social and community score			
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)		
Freshwater shortage	3	3	3	3	3	2	3	2	**2.8**	**2**
Pollution	3	3	3	3	3	3	3	3	**3.0**	**1**
Habitat and community modification	3	3	3	3	2	2	3	3	**2.8**	**3**
Unsustainable exploitation of fish and other living resources	3	3	3	3	2	1	3	3	**2.6**	**4**
Global change	1	2	1	1	0	1	1	2	**1.1**	**5**

Annex II
Detailed scoring tables: Wallacea

I: Freshwater shortage

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
1. Modification of stream flow	2	N/A	Freshwater shortage	2
2. Pollution of existing supplies	2	N/A		
3. Changes in the water table	3	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Economic impacts		**3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	N/A
Degree of severity	Minimum – Severe 0 1 2 3	2	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Health impacts		**2**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	2	N/A
Degree of severity	Minimum – Severe 0 1 2 3	2	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Other social and community impacts		**2**	

Note: N/A = Not applied

II: Pollution

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
4. Microbiological	1	N/A	Pollution	1
5. Eutrophication	1	N/A		
6. Chemical	1	N/A		
7. Suspended solids	2	N/A		
8. Solid wastes	2	N/A		
9. Thermal	0	N/A		
10. Radionuclide	0	N/A		
11. Spills	2	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Economic impacts		**3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	N/A
Degree of severity	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	N/A
Weight average score for Health impacts		**2**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Other social and community impacts		**1**	

Note: N/A = Not applied

III: Habitat and community modification

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
12. Loss of ecosystems	2	N/A	Habitat and community modification	3
13.Modification of ecosystems or ecotones, including community structure and/or species composition	3	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Economic impacts		**3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	2	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Health impacts		**2**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	3	N/A
Degree of severity	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Other social and community impacts		**3**	

Note: N/A = Not applied

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	3	N/A	Unsustainable exploitation of fish	3
15. Excessive by-catch and discards	3	N/A		
16. Destructive fishing practices	3	N/A		
17. Decreased viability of stock through pollution and disease	1	N/A		
18. Impact on biological and genetic diversity	1	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Economic impacts		**3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Health impacts		**1**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	3	N/A
Degree of severity	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Other social and community impacts		**3**	

Note: N/A = Not applied

V: Global change

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	2	N/A	Global change	1
20. Sea level change	1	N/A		
21. Increased UV-B radiation as a result of ozone depletion	0	N/A		
22. Changes in ocean CO_2 source/sink function	0	N/A		
23. Increase in sea surface temperature	2	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small Very large 0 1 2 3	0	N/A
Degree of impact (cost, output changes etc.)	Minimum Severe 0 1 2 3	0	N/A
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	0	N/A
Weight average score for Economic impacts		**0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small Very large 0 1 2 3	0	N/A
Degree of severity	Minimum Severe 0 1 2 3	0	N/A
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	0	N/A
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small Very large 0 1 2 3	0	N/A
Degree of severity	Minimum Severe 0 1 2 3	0	N/A
Frequency/Duration	Occasion/Short Continuous 0 1 2 3	0	N/A
Weight average score for Other social and community impacts		**0**	

Note: N/A = Not applied

Comparative environmental and socio-economic impacts of each GIWA concern

Concern	Types of impacts								Overall score	Rank
	Environmental score		Economic score		Human health score		Social and community score			
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)		
Freshwater shortage	2	3	3	3	2	2	2	2	**2.4**	**3**
Pollution	1	2	3	2	2	2	1	1	**1.8**	**4**
Habitat and community modification	3	3	3	3	2	1	3	3	**2.6**	**1**
Unsustainable exploitation of fish and other living resources	3	3	1	3	1	1	3	3	**2.3**	**2**
Global change	1	2	0	2	0	1	0	1	**0.9**	**5**

Annex II
Detailed scoring tables: Sahul

I: Freshwater shortage

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
1. Modification of stream flow	2	N/A	Freshwater shortage	1
2. Pollution of existing supplies	1	N/A		
3. Changes in the water table	1	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	1	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Economic impacts		**1**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Health impacts		**1**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Other social and community impacts		**1**	

Note: N/A = Not applied

II: Pollution

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
4. Microbiological	1	N/A	Pollution	1
5. Eutrophication	0	N/A		
6. Chemical	1	N/A		
7. Suspended solids	1	N/A		
8. Solid wastes	1	N/A		
9. Thermal	0	N/A		
10. Radionuclide	0	N/A		
11. Spills	1	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	1	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Economic impacts		**1**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Health impacts		**1**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Other social and community impacts		**1**	

Note: N/A = Not applied

III: Habitat and community modification

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
12. Loss of ecosystems	1	N/A	Habitat and community modification	2
13.Modification of ecosystems or ecotones, including community structure and/or species composition	2	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	1	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Economic impacts		**1**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Health impacts		**1**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Other social and community impacts		**1**	

Note: N/A = Not applied

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	3	N/A	Unsustainable exploitation of fish	2
15. Excessive by-catch and discards	3	N/A		
16. Destructive fishing practices	3	N/A		
17. Decreased viability of stock through pollution and disease	0	N/A		
18. Impact on biological and genetic diversity	1	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	2	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	2	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	N/A
Weight average score for Economic impacts		**2**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	1	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Health impacts		**1**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	3	N/A
Degree of severity	Minimum – Severe 0 1 2 3	3	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	3	N/A
Weight average score for Other social and community impacts		**3**	

Note: N/A = Not applied

V: Global change

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	2	N/A	Global change	1
20. Sea level change	0	N/A		
21. Increased UV-B radiation as a result of ozone depletion	0	N/A		
22. Changes in ocean CO_2 source/sink function	0	N/A		
23. Increase in sea surface temperature	1	N/A		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	0	N/A
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	0	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/A
Weight average score for Economic impacts		**0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	0	N/A
Degree of severity	Minimum – Severe 0 1 2 3	0	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	0	N/A
Weight average score for Health impacts		**0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	N/A
Degree of severity	Minimum – Severe 0 1 2 3	0	N/A
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	N/A
Weight average score for Other social and community impacts		**1**	

Note: N/A = Not applied

Concern	Types of impacts								Overall score	Rank
	Environmental score		Economic score		Human health score		Social and community score			
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)		
Freshwater shortage	1	1	1	1	1	1	1	1	**1.0**	**4**
Pollution	1	2	1	2	1	1	1	1	**1.3**	**3**
Habitat and community modification	2	2	1	1	1	1	1	1	**1.3**	**2**
Unsustainable exploitation of fish and other living resources	2	3	2	2	1	1	3	3	**2.1**	**1**
Global change	1	2	0	1	0	1	1	1	**0.9**	**5**

Annex III
List of important water-related programmes and assessments

Major intergovernmental agreements and actorsin the Indonesian Seas region

UN Economic and Social Commission for Asia and the Pacific (ESCAP)

Within the Water Resources Programme under its Environment and Natural Resources Development Division, the UN ESCAP organises seminars and workshops on various issues relating to water resources, including: Water resources assessment; Integrated water resources development and management; Protection of water resources, water quality and aquatic ecosystems; River basin development and management; Promotion of infrastructure development and investment for drinking water supply and sanitation; Water pricing and promotion of private investment in the water sector; Water demand management, water saving and economic use of water; and Mitigation of water-related natural disasters, particularly flood loss reduction.

Association of South East Asian Nations (ASEAN)

ASEAN was established in 1967 and has ten member countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam. The ASEAN Declaration states that the aims and purposes of the Association are: to accelerate the economic growth, social progress and cultural development in the region through joint endeavours in the spirit of equality and partnership in order to strengthen the foundation for a prosperous and peaceful community of South-east Asian nations, and to promote regional peace and stability through abiding respect for justice and the rule of law in the relationship among countries in the region and adherence to the principles of the United Nations Charter. In 1995, the ASEAN Heads of States and Government re-affirmed that "Cooperative peace and shared prosperity shall be the fundamental goals of ASEAN." See also ASEAN work on water conservation (incl. ANWRA) and seas and marine environment; ASEAN Network of Water Resources Agencies (ANWRA); the Strategic Plan of Action for the Environment (see below), adopted by the ASEAN Ministers of Environment; ASEAN 1997 Jakarta Declaration on Environment and Development.

UNEP Regional Office for Asia and the Pacific (ROAP)

Working closely with the Division of Regional Cooperation and Representation in UNEP's Nairobi-based headquarters, the Regional Office for Asia and the Pacific (ROAP) looks to adopt global environmental policy to regional priorities and needs. It acts as a catalyst, coordinator, facilitater and mobiliser of resources. It puts particular emphasis on building partnerships with regional and regional intergovernmental fora, other UN agencies, national governments, NGOs, the private sector, academic and research institutions, and civil society, and the media.

East Asian Seas Regional Coordinating Unit (EASRCU)

Information on the UNEP East Asian Seas Programme can be found on the web site of the Coordinating Unit, which is located with ROAP. The Unit is the coordinating body for the East Asian Seas Action Plan (see below).

Financial institutions

Asian Development Bank (ADB)

The Asian Development Bank, a multilateral development finance institution, was founded in 1966 by 31 member governments to promote the social and economic progress of the Asia-Pacific region. It now has 58 member countries - 42 from within the region and 16 non-regional. ADB gives special attention to the needs of the smaller or less-developed countries, and to regional, subregional, and national projects and programmes. Promoting sustainable development and environmental protection is a key strategic development objective of the Bank. (See also about environment.) To fulfil this objective, the Bank (i) reviews the environmental impacts of its projects, programmes, and policies; (ii) encourages DMC governments and executing agencies to incorporate environmental protection measures in their project design and implementation procedures, and provides technical assistance for this purpose; (iii) promotes projects and programmes that will protect, rehabilitate, and enhance the environment and the quality of life; and (iv) trains Bank and DMC staff in, and provides documentation on, environmental aspects of economic development. The Asian Development Fund (ADF) is the concessional lending window of the Bank.

Action programmes, strategies and research

ASEAN Strategic Plan of Action on the Environment

The Strategic Plan of Action on the Environment for 1994-1998 has the following five objectives:

1. To respond to specific recommendations of Agenda 21 requiring priority action in ASEAN;
2. To introduce policy measures and promote institutional development that encourage the integration of environmental factors in all developmental processes both at the national and regional levels;
3. To establish long term goals on environmental quality and work towards harmonised environmental quality standards for the ASEAN region;

4. To harmonise policy directions and enhance operational and technical cooperation on environmental matters, and undertake joint actions to address common environmental problems;
5. To study the implications of AFTA on the environment and take steps to integrate sound trade policies with sound environmental policies.

Despite the impacts of the recent economic crisis on the natural resources and environmental conditions, the ASEAN Environment Ministers at their Fifth Informal Meeting in April 2000 discussed the importance of keeping their commitment to environmental protection and sustainable development. Hence, to move forward towards the future goals and directions that the ASEAN leaders expressed in ASEAN Vision 2020 and the Hanoi Plan of Action (adopted in 1997 and 1998 respectively) the Ministers adopted the ASEAN Strategic Plan of Action on the Environment (SPAE) for 1999-2004. It consists of the key activities to be implemented by ASOEN (ASEAN Senior Officials on the Environment) and its subsidiary bodies over the next five years, including the areas of coastal and marine environment, nature conservation and biodiversity, multilateral environmental agreements, management of land and forest fires and haze, and other environmental activities.

Partnership in Environmental Management for the Seas of East Asia (PEMSEA)

A GEF project, focusing on "building partnerships within and among governments of the region, as well as across public and private sectors of the economy. The goal is to reduce or remove barriers to effective environmental management, including inadequate or inappropriate policies, disparate institutional and technical capabilities and limited investment in environmental facilities and services". PEMSEA is "based on two management frameworks developed and tested in an earlier GEF Project: Integrated coastal management, addressing land-water interactions and the impacts of human activity in coastal areas; and risk assessment/risk management, applying to subregional sea areas and the impacts of human activities on marine ecosystems.

UNEP Regional Seas Programme

The Regional Seas Programme was initiated in 1974 as a global programme implemented through regional components. The Regional Seas Programme is UNEP's main framework in the field of the coastal and marine environment. It includes 14 regions and three partner seas, involves more than 140 coastal states, and focuses on sustainable development of coastal and marine areas. Each regional action plan is formulated according to the needs and priorities of the region as perceived by the Governments concerned. Regional conventions are in place for several areas. See a map of all regional seas, and go to more information on the Black Sea, Wider Caribbean, Mediterranean, East Asian Seas, South Asian Seas, Eastern Africa, Kuwait Region, North West Pacific, Red Sea And Gulf of Aden, South East Pacific, North East Pacific, South Pacific, Upper South West Atlantic, and West and Central Africa. The UNEP Regional Seas web site also contains information on What's at stake, Major threats, and Actions.

East Asian Seas Action Plan

On the initiative of the five States of the East Asian region - Indonesia, Malaysia, Philippines, Singapore and Thailand - the Governing Council of UNEP in 1977 decided that "steps are urgently needed to formulate and establish a scientific programme involving research, prevention and control of marine pollution and monitoring " for a regional action plan in East Asia. An Action Plan for the Protection and Sustainable Development of the Marine Environment and Coastal Areas of the East Asian Region was adopted in 1981, with a decision making body, the Coordinating Body on the Seas of East Asia (COBSEA). A revised Action Plan and a Long-term Strategy for the COBSEA for the 1994-2000 period were developed in 1994 and Australia, Cambodia, China, Korea and Vietnam joined the Action Plan. A new East Asian Seas Action Plan - "Leading the EAS Action Plan to the 21st Century" - has been elaborated for the period 2000-2009.

State of the regional environment

GEO 2000 State of the Environment: Asia and the Pacific

Global Enviroment Outlook 2000. GEO is a global environmental assessment process, the GEO Process, that is cross-sectoral and participatory. It incorporates regional views and perceptions, and builds consensus on priority issues and actions through dialogue among policy-makers and scientists at regional and global levels. GEO outputs, in printed and electronic formats, including the GEO Report series. This series makes periodic reviews of the state of the world's environment, and provides guidance for decision-making processes such as the formulation of environmental policies, action planning and resource allocation. Other outputs include technical reports, a web site and a publication for young people.

GEF Projects in the region: Projects under implementation

Building Partnerships for the Environmental Protection and Management of the East Asian Seas

The objective of the project is to assist the riparian countries of the East Asian Seas to collectively protect and manage their heavily stressed coastal and marine environments through intergovernmental and intersectoral partnerships. These countries include the Republic of Korea which for the first time is a GEF recipient. Building upon

the methodologies, approaches, typologies, networks and lessons learned from the pilot phase, the project would enhance and complement national and international efforts by removing or lowering critical barriers regarding policy, investment, capacity, which are having negative effects on the management of the coastal/marine environment in the region. Together with several waterbody-based projects in the area, these projects constitute GEF's programmatic approach to these coastal and marine waters with globally significant ecosystems that are experiencing severe degradation.

Prevention and Management of Marine Pollution in the East Asian Seas

Development of policies and plans to control marine pollution from land-based and sea-based sources, upgrading of national and regional infrastructures and technical skills, and establishment of financing instruments for project sustainability. Project will include selection of demonstration sites, establishment of regional monitoring and information network, and involvement of regional association of marine legal experts to improve capacity to implement relevant conventions.

World Bank/GEF/Biodiversity.

Coral Reef Rehabilitation and Management Project (COREMAP), Indonesia

Supported by a multi-donor group, COREMAP will establish a coral reef management system in priority areas in 5 eastern Indonesian provinces. Strengthen coral reef management through improving management capacity and inter-agency coordination; capacity-building to prepare and implement strategies, plans and policies targetting coral reef rehabilitation and management; establishing coral reef management and information networks; increasing public awareness and participation in coral reef management. The PDF phase is supporting the regional task forces preparing the project, and social assessments at priority sites.

Other actors, initiatives and resources

International Centre for Living Aquatic Resources Management (ICLARM)

An international research organisation "devoted to improving the productivity, management and conservation of aquatic resources for the benefit of users and consumers in developing countries". ICLARM is one of the research centres of CGIAR, Consultative Group on International Agricultural Research. ICLARM, in collaboration with the the Food and Agriculture Organization of the United Nations (FAO) and other partners, and with support from the European Commission, has developed FishBase, a global information system on fishes for research scientists, fisheries managers, zoologists and many more. FishBase contains full information on 23 500 species. ICLARM has also developed similar systems on coral reefs and their resources (ReefBase) and management of fish stocks in Asia (TrawlBase).

International Coral Reef Initiative (ICRI)

An environmental partnership that brings stakeholders together with the objective of sustainable use and conservation of coral reefs for future generations. ICRI is an informal mechanism that allows representatives of over 80 developing countries with coral reefs to sit in equal partnership with major donor countries and development banks, international environmental and development agencies, scientific associations, the private sector and NGOs to decide on the best strategies to conserve the world's coral reef resources.

Coral Health and Monitoring Programme (NOOA)

The mission of the NOOA Coral Health and Monitoring Program is to provide services to help improve and sustain coral reef health throughout the world. Long term goals: Establish an international network of coral reef researchers for the purpose of sharing knowledge and information on coral health and monitoring. Provide near real-time data products derived from satellite images and monitoring stations at coral reef areas. Provide a data repository for historical data collected from coral reef areas. Add to the general fund of coral reef knowledge. See also Global Coral Reef Monitoring Network (GCRMN).

The Indonesian Seas - a Large Marine Ecosystem (LME)

A Large Marine Ecosystem (LME) is a "region of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundary of continental shelves and the seaward margins of coastal current systems. It is a relatively large region characterised by distinct bathymetry, hydrography, productivity, and trophically dependent populations." See also Rhode Island University map of LMEs.

Recent international meetings relevant to marine conservation and integrated coastal management

(information courtesy of Stacey A. Tighe, Senior Technical Advisor Proyek Pesisir)

- World Commission on Protected Areas (Bangkok, May 9-11, 2002),
- Coastal Zone Asia-Pacific (Bangkok, May 12-16, 2002)
- National Coastal Conference (KONAS III) (Bali, May 20-24)
- World Summit on Sustainable Development (Bali, May 27-June 7)

The Nature Conservancy (TNC), the Worldwide Fund for Nature (WWF), and the U.S. Agency for International Development (through its Natural Resources Management Project and Proyek Pesisir) are collaborating

and joining their efforts with their Indonesian partners to maximise the benefits and impacts for marine conservation derived from the conferences above. Indonesia has an excellent opportunity to make major advances in its strategic planning and capabilities in marine conservation and integrated coastal management by using the synergy and momentum of these four international conferences to focus attention on and support for evolving Indonesia's policies on these issues.

World Commission on Protected Areas

The objective of this meeting is to discuss the design and coordination of a regional network of marine protected areas (defined here as any officially designated marine area in which resource use is limited by specific regulations) for South-east Asia. Experts from the region will share information on the economics, ecology, management, design and enforcement of MPAs and develop recommendations for a regional MPA network. In support of MPAs in Indonesia, TNC will be supporting an environmental policy expert to participate and to then present the outcomes of the state-of-the-art of MPA design at a Pre-KONAS III Symposium on MPAs, as well as the presence of their staff who chairs the WPCA/Asia team WWF is supporting the writing of a technical paper to summarise the most current knowledge on the economics of MPAs NRM/EPIQ Program is supporting their coral reef expert to attend, present the economic paper and work with the Indonesian team, Proyek Pesisir is supporting an Indonesian marine resource economist from IPB to attend the meeting, learn the newest information on economics, and report back at the Pre-KONAS III Symposium. In addition, they are supporting two of their technical experts and four technical experts from the Ministry of Marine Affairs and Fisheries (DKP) to participate in the conference for Indonesia.

Coastal Zone Asia-Pacific:

The objective of this first regional coastal meeting is to share information and to develop research and policy priorities for the regional scale issues. Approximately 250 coastal professionals from the region will attend. In support of Indonesia's new marine ministry, approximately 15 technical experts from DPK, including the Minister will be supported by Proyek Pesisir to attend. The DKP and Proyek Pesisir team of four staff and three regional counterparts will work with a facilitator to capture the information presented and its relevance to DKP and Indonesia's programmes. Five presentations from the team will be made at CZAP.

National Coastal Conference (KONAS III) and Pre-Conference Symposiums

The objective of the KONAS 4-day Conference is to share information on new developments in coastal zone management. All of the partners (CI, TNC, WWF, NRM/EPIQ Project and Proyek Pesisir) will be supporting several of their counterparts to attend and present papers at KONAS III. In addition, just prior to the Conference, there will be two half-day symposiums for national and regional decision-makers attending the Conference: one on Marine Protected Areas Science and Strategies, and the second on the new Coastal Zone Law under development. The objective of this half-day MPA symposium will be: to present the latest information on the science, economics and policies of MPAs to the audience of coastal decision-makers; to present a request from the WCPA for Indonesia to participate in a regional MPA network; and to present a Call to Action by the government lead agencies (Forestry, DKP) to expand and revise the national MPA strategy. Proyek Pesisir will be providing the venue for both Symposiums, WWF and NRM will be moderating the meeting, TNC and Proyek Pesisir will be supporting speakers as a joint co-hosting. An output from the MPA Symposium will be a briefing document based on the presentations and discussions developed by the team. An additional event at KONAS will be the selection and announcement of Indonesia's new ICM logo, developed by an inter-agency and NGO team with support from Proyek Pesisir.

World Summit on Sustainable Development-Prep Comm:

This event is a preparatory meeting for the World Summit on Sustainable Development (WSSD or Rio Plus 10) to be held in South Africa in September this year. Environmental Ministers from around the world will be attending to discuss the text and policies to be finalised at Rio Plus 10. For this event, TNC will be supporting two initiatives that will be announced by DKP, a National Marine Whale Sanctuary proposal and the String of Pearls MPA programme. The MPA briefing document from the Pre-KONAS Symposium will be available for distribution, and the ICM Logo and Campaign can be presented and launched as well. WWF and ICRAN are presenting a coral reef exhibit in connection with the WSSD. Minister Rokhmin Dahuri of the Ministry of Marine Affairs and Fisheries will be hosting an event at their exhibit. There he has indicated that he will make a pledge for Coral Reef MPAs, and announce a Whales Sanctuary and IUU on marine resources exploitation in Indonesia.

Existing research programmes for marine mammals and dugong

(excerpted from Perrin et al. 2002)

Prior to 1997, only a limited number of scientific studies had been conducted on marine mammals in Indonesian waters. Ecological aspects such as species-specific habitat preferences in Indonesia were (and still are) largely unknown.

Surveys of the critically endangered Irrawaddy dolphin, or pesut, population of the Mahakam River in East Kalimantan are ongoing

(Doc. 12; Kreb 2002). The focus is to obtain data on the distribution, abundance and ecology of this declining population and to develop a conservation programme for Indonesia's sole freshwater dolphin population. Kreb (2002) estimated total abundance in the Mahakam during 1999--2000 at only 35-42 dolphins.

In recent years, visual and acoustic cetacean surveys and ecological studies on oceanic cetaceans have been periodically conducted in eastern Indonesian waters. Research areas since 1997 have included North Sulawesi and the Sangihe-Talaud Archipelago 1997 (Kahn 1999, Kahn 2001), as well as Komodo National Park since 1999 (Kahn et al. 2000, Pet and Yeager 2000, Kahn and Pet 2001) and the eastern Flores to western Alor region, including the islands of Adonara, Solor, Lembata, Pantar and Alor since 2001 (Kahn 2002c). For each area, surveys have been conducted at least annually and often seasonally during inter-monsoon periods. The surveys focus on the following cetacean management and conservation priorities in eastern Indonesia:

1. Identify which species are present in the research area and adjacent waters and provide data on relative abundance, seasonality, habitat use, migratory passages of regional importance, tourism potential and environmental impacts.
2. Integrate survey outcomes with other marine conservation actions such as the establishment of additional Marine Protected Areas.
3. Initiate ecology-focused research on priority cetacean species using photographic, genetic and telemetric techniques.
4. Involve government, industry and community stakeholders in cetacean monitoring and outreach programmes.

Indonesia is located in an equatorial region where natural inter-oceanic exchange of marine flora and fauna occurs. Cetacean movements between the tropical Pacific and Indian Oceans can occur through the passages between the Lesser Sunda Islands (Nusa Tengarra) which span over 900 km between the Sunda and Sahul shelves. The routes of whales entering or leaving the Indian Ocean from or to the Pacific Ocean lie exclusively in Indonesian seas. The ecological significance of these passages remains poorly understood, yet their importance as migration corridors has been established (PHPA 1984, Kahn and Pet 2001, Kahn 2002b).

Cetaceans that use these passages for local or long-range movements are vulnerable to directed catches, habitat destruction, subsurface noise disturbances (e.g., reef bombing), entanglement in fishing gear, marine pollution and overfishing of marine resources (Hofman 1995; Fair and Becker 2000). Most, if not all, of these phenomena occur in the waters of Indonesia and would affect both resident populations and transient populations. On-going research is intended to assess the role of eastern Indonesia's island passages as migratory corridors and improve the management of large migratory marine animals. Kahn reported that additional research is being conducted on spinner dolphins along north coast of Bali.

Results of completed research in east Kalimantan, Sulawesi and Nusa Tengarra have been disseminated to various stakeholders, ranging from local fishermen and coastal communities to the central government in Jakarta, where cetaceans are increasingly considered as a national marine conservation priority. Progress has been made on capacity building and making educational materials available, including brochures on species, cetacean ecology, fisheries interactions, marine mammal stranding and rescues.

Annex IV
List of conventions and specific laws that affect water use

Key international conventions and treaties

Indonesia is signatory to several international conventions and has enacted various national laws and regulations that are relevant to water-related issues in the region:

- United Nations Convention on the Law of the Sea (UNCLOS);
- International Convention on the Protection of Pollution from Ships (MARPOL);
- United Nations Convention on Conservation on Biological Diversity (CBD);
- Convention on International Trade in Endangered Species (CITES);
- Ramsar wetlands convention;
- United Nations Framework Convention on Climate Change (UNFCCC);
- World Heritage Convention.

Indonesia has sovereign rights to the 12 nautical mile limit and has also declared a 200-mile Exclusive Economic Zone. Indonesia unilaterally uses the 'Archipelagic Doctrine' to define its territorial waters. Several government sectors concerned with use of natural resources have proposed policies or legislation relevant to obligations under the various International Conventions. However, it is apparent that despite the ratifications, there has been little progress to date in implementation and the resolution of related problems. This has been attributed to the lack of action by the various governments in addressing their obligations under the Conventions. A recently developed 'Environmental Strategy for the Seas of East Asia' provides many pertinent recommendations and solutions to these problems (Chua Thia-Eng, PEMSEA pers. comm.).

Key national legislation

Environmental legislation in Indonesia (from Cheung et al. 2002)

- 1932 & 1941: Colonial Nature Protection Ordinances;
- 1945: Constitution;
- 1949: Independence;
- 1971: Establishment of the Directorate of Nature Conservation and Wildlife;
- 1980: Trawling Ban (Sardjono 1980);
- 1982: Basic Environmental Law;
- 1985: Directorate General for Fisheries Law No. 9 (Ban on blast fishing);
- 1990: Conservation of Living Natural Resources and their Ecosystems Act;
- 1992: (Act No. 24) Spatial Planning Act;
- 1997: (Act No. 23) The Management of the Living Environment;
- 1999: (Act No. 22) Decentralisation of authority from central government to provincial and district governments;
- 1999: Creation of the Ministry of Marine Affairs and Fisheries.

Some important changes have taken place in the new Reformasi era. In 1992 the Spatial Use Management Law provided for provincial and local government to regulate the use of coastal and marine areas. However, it was only in 1999 that powers and financial support were delegated to provincial and local governments. At the end of 1999 a new Ministry of Marine Exploration and Fisheries was established. These new initiatives should create the long awaited vertical and horizontal integration of Indonesia's coastal and marine management, which has been so lacking in the past (Hopley & Suharsono 2000).

The State Ministry for Environment (LH), as the national coordinating agency for environmental management and policy formulation, is committed to integrating environmental concerns into coastal management (Sloan & Sugandhy 1994). LH has been assigned the following specific responsibilities:

- To enhance the capability of marine and coastal zone management in order to achieve the optimal, effective use of marine and coastal resources.
- To design a policy and planning framework as a basis for marine and coastal zone management activities which have a strategic role in national and regional development. The management structure should focus on the integration of an institution for the coordination and synchronisation of the sustainable use of marine natural resources.

The action plan for achieving this, Program Laut Lestari, (Sustainable Marine Program) began in 1992 to stimulate implementation of integrated and sustainable marine resource use. The foci of this action plan are the 27 provincial administrations, each of which have coastal zone resources for which they are responsible.

Water resources legislation (from FAO Aquastat)

The 1945 constitution declared national water and land resources to be controlled by the State and that they should be utilised in an equitable manner for the benefit of the people. The responsibilities for the development and management of water resources and irrigation schemes are specified in laws, presidential instructions and government regulations. The most important are:

- Presidential Instruction No. 1 (1969), on the management of irrigation water and maintenance of irrigation networks;

- Law on water resources development No. 11 (1974);
- Government regulations on: beneficiaries contribution for maintenance cost of water resources facilities No. 6 (1981);
- Water management No. 6 (1982);
- Irrigation, No. 23 (1982);
- Rivers (1991) and swamps (1991);
- Decree of the Minister of Mining and Energy concerning underground water resources management (1983).

Numerous institutions are presently involved in water resources management. Their tasks and responsibilities are clearly stated in national legislation:

- The Ministry of Public Works, with its Directorate General of Water Resources Development, is responsible for planning, design, construction, equipment, O&M, and guidance in water resources development;
- The Ministry of Forestry is responsible for catchment area development;
- The Ministry of Environment is responsible for environmental quality development and management;
- The Environmental Impact Management Agency is responsible for environmental impact control.

Legislation relevant to marine mammals (from Perrin et al. 2002).
All land and water natural resources are controlled by the state, in accordance with Article 33(3) of the 1945 Constitution. The state (the central government) thus has responsibility for protecting species. The National House of Representatives - Dewan Perwakilan Rakyat (DPR) - has enacted several laws (undang-undang) that relate, either specifically or generally, to the protection of marine mammals. Taken together, these laws (1) confirm state authority and responsibility for management of living marine resources, including marine mammals, and their habitats; and (2) establish a loose and amorphous legal framework through which living marine resources, including marine mammals, are to be protected and conserved for their intrinsic value and for benefit of Indonesians, present and future; and (3) can provide specific protections for certain marine mammals that are listed as endangered or threatened.

Several national laws include references to the fact that marine mammals are protected throughout Indonesian waters. Nevertheless, the legal status of cetaceans and the dugong in Indonesian waters is unclear. Existing legislation is inadequate in several respects, not least of which is that it lacks implementation and enforcement mechanisms. Laws relating to marine mammals are vague, with few specific requirements. Terms such as 'protection' are not well defined, and the protected status does not address the traditional (sperm) whaling activities in Lamalera, Lembata and the continued directed takes of small cetaceans in eastern Indonesia and elsewhere, nor does it recognise the numerous environmental threats faced by cetaceans and dugongs in Indonesia's waters or recognise important international conventions and specific management needs for endangered and vulnerable marine mammal species and populations. In addition, laws relating to marine mammals are confused by secondary fisheries laws, some of which classify marine mammals as fish and seek to promote and regulate fish harvest. In some regions the protected status of cetaceans and dugongs is unknown or ignored. Habitat destruction and directed catches of small cetaceans especially are widespread.

To address these issues, a recent discussion paper has been produced at the request of the Ministry of Marine Affairs and Fisheries to outline the possible establishment of a marine mammal 'no-take zone'. This marine mammal sanctuary, referred to a "Protected Marine Mammal Fisheries Area" would extend throughout Indonesia's national waters and economic exclusion zone (EEZ). It would prohibit commercial and scientific takes of marine mammals and strengthen specific fisheries regulations that benefit to marine mammals (Kahn 2002a). Importantly it would a) integrate the existing laws within a unified marine mammal conservation strategy, b) identify and address the current gaps in legislation and legal prescriptions, c) provide a clear management tool for the strategy's implementation on the ground, and d) incorporate both major environmental threats and international treaties relevant to (migratory) marine mammal management.

Both the Ministry of Forestry and Ministry of Fisheries and Marine Affairs have initiated programmes to improve marine mammal management and conservation at both national and site-specific levels. A national strategy for the conservation of migratory marine life was completed in 2001 and includes descriptions of marine mammals and management recommendations (DKP/IPB 2001).

Marine mammal conservation and management issues are increasingly being considered in protected areas such as Bunaken Marine Park and Komodo National Park. In the latter, extensions to the Park's boundaries and additional buffer zones have been adopted by the management authorities and will be incorporated into a 25-year management plan, in order to protect sensitive marine areas, such as migration corridors, for cetaceans (Pet and Yeager 2000). Needed conservation actions have been identified for the critically endangered pesut population of the Mahakam River in East Kalimantan (Doc. 12). Strong and continued government commitment to implementation is urgently needed to avoid extirpation of this population in the near future. The effective implementation of these government and non-government marine mammal conservation initiatives will greatly improve the status of Indonesia's marine mammals.

Ministry/Agency	Major function and responsibility in coastal resource management	Relevant legislation
List of ministries or central agencies and their function in coastal resource management *		
National Development Planning Board (BAPPENAS)	Coordination and policy for all sectoral and regional planning and development, formulation of 5-year development plan (Repelita) and 25 year development plan (GBHN), and international coastal projects.	Spatial Act No. 24/1992 Presidential Decree No. 80/1967
State Ministry of Environment (SME)	National coordination of coastal environment policy and to ensure all development programmes comply with environmental management policy.	Environmental Act No. 23/1997
Environmental Impact Management Agency (BAPPEDAL)	Coordinating environmental impact assessment, controlling pollution and coastal resource degradation.	Environmental Act No. 23/1997
Ministry of Home Affairs, Regional Development (BANGDA)	Supervise provincial and local government agencies to manage their coastal resources in a sustainable manner, and to develop self-reliance groups at the villages.	Local Govt Act No. 22/1999
Ministry of Marine Exploration and Fisheries	To administer and manage fishery development, including aquaculture, processing fishing boat permits, leasing marine water for mariculture.	Fishery Act No. 9/1985
Ministry of Tourism	To facilitate marine eco-tourism development.	Tourism Act No. 9/1990
Ministry of Forestry	To manage marine conservation areas, mangroves, wetlands and marine parks, through Directorate General Forest Protection and Nature Conservation PHPA	Forestry Act No. 5/1967 Biodiversity Conser Act No. 5/1994
Ministry of Mining and Energy	To regulate oil and gas exploration and production, other mineral mining, and power stations on the coast.	Mining Act No. 11/1967 Oil and Gas Act No. 8/1973
Ministry of Industry and Trade,	To administer industrial development in coastal areas, processing permit for industry.	Industrial Act No. 5/1984
Ministry of Communication	To supervise the management of ports, harbours, shipping, navigational aids and safety; and oil spill contingency plans.	Shipping Act No. 21/1992
Ministry of Housing and Area Development	To coordinate and implement coastal engineering, erosion control and coastal infrastructure.	
Ministry of Defence and Security,	National and regional security, hydrographic mapping.	National Defense Act No. 20/1982
State Ministry of Research and Technology (BPPT)	To test and apply the innovation and new technology on coastal resources development.	
National Coordinating Agency for Surveys and Mapping (BAKOSURTANAL)	To coordinate survey and mapping of coastal areas and marine waters.	
Indonesian Institute of Science (LIPI)	To carry out marine research and provide scientific advice to other agencies.	
State Ministry for Investment	To promote and facilitate local and foreign investment.	
National Maritime Council	To coordinate all marine and coastal related activities and overcome institutional barriers.	Presidential Decree No. 77/1996 revised to 1999
List of provincial government agencies and their function in coastal resource management		
Regional Development Planning Board (BAPPEDA I)	Coordination of all regional planning, formulation of 5-year regional development plan (Repelitada) and 25 year regional development plan (Pola Dasar), to coordinate provincial coastal resources management	Spatial Act No. 24/1992 Presidential Decree No. 77/1980
Regional Environmental Management Agency	Coordinating environmental impact assessment, controlling pollution and coastal resource degradation at provincial level	Environmental Act No. 23/1997
Community Group Development Office	Supervise local government agencies to develop self-reliance groups at the village level.	Autonomy Act No. 22/1999
Fishery Agency	To administer fishery development, and to supervise fishers organisations	Fishery Act No. 9/1985
Tourism Agency	To facilitate marine eco-tourism development, to provide recommendations for investment	Tourism Act No. 9/1990
Forestry Agency	To manage soil conservation areas and reforestation of degraded forest.	Forestry Act No. 5/1967
Mining Agency	To regulate oil and gas exploration and production, other mineral mining, and power stations on the coast.	Mining Act No. 11/1967
Industry and Trade Agency	To promote industrial development and recommend permits for industrial development.	Industrial Act No. 5/1984
Public Work Agency	To implement coastal engineering devt. and coastal infrastructure.	
Regional Investment Board	To promote and facilitate local and foreign investment to its province	
List of local government agencies and their function in coastal resource management		
Local Development Planning Board (BAPPEDA II)	Coordination for all local planning, formulation of 5-year regional development plan (Repelitada) and 25 year regional development plan (Pola Dasar), to coordinate district/city coastal resources management	Spatial Act No. 24/1992 Presidential Decree No. 77/1980
Community Group Development Office	Supervise local government agencies to develop self-reliance groups at the village level.	Village Govt Act No. 5/1979
Fishery Agency	To administer fishery development, and to supervise of fishers organisations	Fishery Act No. 9/1985
Tourism Agency	To facilitate marine eco-tourism development, to provide recommendations for investment	Tourism Act No. 9/1990
Forest and Conservation Agency	To manage soil conservation programme on critical farm lands	Forestry Act No. 5/1967
Mining Agency	To regulate oil and gas exploration and production, other mineral mining, and power stations on the coast.	Mining Act No. 11/1967
Industry and Trade Agency	To promote industrial development and recommend permits for industrial development.	Industrial Act No. 5/1984
Public Work Agency	To implement coastal engineering development, and coastal infrastructure.	

*Note: * These do not take into account the formation of the New Ministry of Maritime Exploration and Fisheries*

Hopley & Suharsono (2000) provide a comprehensive overview of legislation and coordination, with many pertinent recommendations relevant to the present analysis, as reproduced below:

BAPPEDA is responsible for the coordination and formulation of planning for natural resource management and economic, social and cultural development. For example, in recent years 10 BAPPEDAS have formulated provincial strategic plans for integrated coastal management within the Marine Resources, Evaluation and Planning Project (MREP).

In summary, national agencies represent legislation relating to their sector, the provinces apply to laws locally. Complexities and overlapping interests are evident in all areas and determine a highly sectoral rather than integrated approach to coastal management in Indonesia. The relationship between local and national agencies with regional offices has been described as one of "legal and administrative ambiguity" (Morfit 1986) and intergovernment agency conflict is the norm rather than the exception. This produces vagueness and the avoidance of coming to grips with crucial policy issues. Lack of clear boundaries of responsibility leads to lack of communication. "Informal discussions are the norm and they are mediated by a wide range of personal relationships and connections that underline the formal government structure" (Llewellyn 1998).

Without high political and bureaucratic support for implementation, conservation policies have been unlikely to lead to practical results under this form of institutional culture.

The New Ministry for Maritime Exploration and Fisheries

Since the initial commissioning of this review a most important development has taken place, the full significance for which has yet to be determined. In the 1999 government of President Abdurrahman Wahid is a new Ministry of Maritime Exploration and Fisheries specifically concerned with the definition and development of marine and coastal resources, particularly fisheries (Dahuri & Dutton 2000). The basic structure of this Ministry is seen in figure 7.1. The Minister is a former Minister of the Environment Sarwono Kusumaatmadja who has stated commitments to integrated coastal zone management (Kusumaatmadja 1999 a) and cooperative management (Kusumaatmadja 1999 b). Within the Ministry is the Directorate General of Coastal, Beaches and Small Island Affairs led by Dr. Rokhmin Dahuri, formerly Director of the Centre for Coastal and Marine Resource Studies at Bogor Agricultural University, who's concerns for the coast and coral reefs in particular are well known (e.g. Dahuri 1999). The opportunity for integrating and simplifying Indonesia's coastal and marine management appears greater than at any time in the past.

Legislative framework

Structure and jurisdiction

The Terrestrial Waters Law No4 (1960) defined Indonesia's marine sector and adopted the archipelagic waters concept. However, as the result of Chapter 18 of the 1945 Constitution, until 1960 local not national government had jurisdiction from low water mark to 3 nautical miles. In 1960 the government issued the Maritime Act No4 (1960), which was revised in 1996 to No6 (1996) (Undang – Undang Pokok Perairan Indonesia), which declares that all coastal and marine resources are under the central government's jurisdiction, thus overriding all local government jurisdiction.

Current Indonesian environmental legislation began in 1982 with Law No4 (1982) "Basic Provisions for The Management of the Living Environment". Sustainable environmental use, ecosystem maintenance and provisions for controlling environmental impacts and pollution are linked with human welfare in this law (Sloan and Sugandhy 1984). However, this is only one level in a very complex hierarchical legal system consisting of:

- The basic constitution;
- General assembly decrees;
- Laws and acts;
- Government regulations;
- Presidential decrees;
- Ministerial decrees;
- Provincial government regulations;
- District or city regulations.

Structure of Department of Marine Exploration and Fisheries

These are operated within a framework of long term development periods (PJPT) of 25 years, which are broken into 5-year plans (Repelita). In addition, Indonesia has recognised its obligations under several international conditions.

International obligations

Indonesia cooperates in international marine and coastal environmental initiatives that, in part, shape the nations coastal management (Sloan and Sugandhy 1994, Hildreth 1999). These are at global (e.g. UNCLOS), regional (e.g. APEC) and South-east Asian subregional (e.g. ASEAN) levels. In 1985 Indonesia ratified the United National Convention on Law of the Sea of 1982. It supports the 1992 UN Conference on Environment and Development (UNCED) action programme of Agenda 21. Collaboration with other Pacific and Asian countries on marine resources and conservation is undertaken through Asia-Pacific Economic Cooperation and in the ASEAN organisation Indonesia has been active in multinational marine issues such as oil pollution since the 1970s.

Some of indonesia's international obligations.

Title	Date	Significant aspect
UNCLOS	1982	Pollution from land-based sources Pollution from seabed activities subject to national jurisdiction Pollution from activities in the area Pollution from vessels Pollution from or through the atmosphere Coastal zone management
IMO Conventions (Marine Pollution)	1969	Civil Law Liability
	1971	International Fund System
	1989	Toxic and hazardous disposal
UN Framework Convention on climate change	1992	Emission Greenhouse gases Climate system Adverse effects Regional economic integration
UN Convention on Biodiversity		Conservation Sustainable use Fair and equitable sharing of the benefits
ASEAN Treaty	1985	Natural resources utilisation, management and planning, including pollution control and EIA
Tripartite Agreement	1977	Regional agreement on civil and public liability
	1992	Regional revolving fund system
Mining Law	1974	Pollution from sea-bed activities
Navigation Law	1992	Pollution from vessels
Water Pollution Control Regulation	1990	Pollution from land-based sources
Air Pollution Control Regulation	1974	Pollution from or through the atmosphere

National legislation

The basic Law No4 (1982) gave rise in 1986 to the environmental impact assessment process (Analysis Mengenai Dampak Lingkungan, AMDAL) which was revised in 1993. Environmental impacts in development planning are supposed to be on a site-specific basis and in 1990 the Environmental Impact Management Agency (BAPEDAL) was created within the Ministry of the Environment. However, specific guidelines for marine and coastal AMDAL were not formulated.

Recognising the need, to conserve all diverse and interconnected ecosystems, Law No5 (1990) "Conservation of Living Natural Resources and their Ecosystems" firmly links sustainable resource use with ecosystem integrity. In 1992 all legislation relating to management of air, land and sea in a spatial context was integrated into "Spatial Use Management" Law No24 (1992). The inclusion of marine space in Article 9 recognises the importance of coastal waters and the use of coastal resources. It also provides an opportunity for provincial and local government to regulate the use of coastal and marine areas. However, there were no further regulations to support Local Governments to take these steps.

In 1996 the government issued Presidential Decree No77/1996 to form a National Marine Council (Sitepu 1999). Its function was to coordinate strategic policy on the over-use and conservation of coastal marine resources, but it was disbanded in 1999. Recently the Ministry of Justice and Law submitted a Coastal Marine Resource Use Bill to the House of Representatives and the Director General Regional Development proposed a Presidential Decree to give clear jurisdiction to the Provincial Governments for the management of their own resources. However, the Director General Sea Communication and D.G. Fisheries have refused to devolve some of their jurisdiction to the provinces. Nonetheless in 1999, legislation was passed (Autonomy Laws No 22/99 and No 25/99) which finally give jurisdiction to the Provincial governments and give financial support for implementation.

In a follow up to the 1992 UNCED conference in Rio de Janeiro, the Indonesian government worked with the United Nations Development Program to formulate a national Agenda 21 strategy. This was launched in March 1997 (Min. for Environment/UNDP 1997) and is described as a "one policy package" to make sustainable development, with an environmental perspective, a reality in Indonesia (Dutton 1999 a). Chapter 18 deals specifically with "Integrated Management and Sustainable Development of Coastal and Marine Areas" and has 7 programmes:

- Integrated Planning and Resource Development in Coastal Zones;
- Monitoring and Protecting Coastal and Marine Environments;
- Sustainable Utilisation of Marine Resources;
- Enriching and Empowering Coastal Communities;
- Sustainable Development of Small Islands;
- Monitoring Security of the Exclusive Economic Zone;
- Managing the Impacts of Climate Change and Tidal Waves.

A basis for action was outlined within Repelita VII (1998-2003) and for the period 2003 to 2020. It remains to be seen how far these laudable programmes will be carried out and to what extent the tangled jurisdictional responsibilities of central and provincial governments will become untangled. However, the opportunity is there especially with the formation of the new Ministry of Maritime Exploration and Fisheries the full mandate for which has yet to be determined (Dahuri and Dutton 2000).

Local government legislation

Although Provincial Governments operate within the national environmental legislative framework, they are responsible for managing resources and enforcing regulations within their region. They can modify regulations to fit local conditions, providing the modifications are complementary with prevailing legislation. For example, with no national legislation dealing with coral reefs in 1987 the South Sulawesi government independently issued a Government Decree No7/1987 for the protection of coral reefs along the South Sulawesi

Coastline. However, as noted above, the Spatial Use Planning Law No5 of 1992, passed responsibility for the Sea Space on to the Provincial Governments. This process of devolvement has been slow, not least because marine charts of suitable scale have not been available (Sloan and Sugandhy 1994). Only in May 1999 did the House of Representatives pass the Autonomy Law No22/1999 which declares that Provincial Governments have jurisdiction out to 12 nm from low water mark, and district and city governments have responsibility to 4 nm. It is supported by the fiscal law No 25/99 which may allow implementation.

This latter decision is important because in the past most villages assumed they had control of their near-shore resources, a situation which has led to ambiguity and conflict. For example, if a private investor has wanted to develop a resort within a coastal village with off-shore diving areas, their permit from the central government has overridden the traditional rights of the villagers. Further, since the local governments (provincial and district) have had no clear authority, they have been reluctant to provide adequate staff, facilities or budget to implement coastal management requirements.

Some specific issues

Coordination

The problems of lack of both vertical and horizontal integration in Indonesia's coastal management jurisdiction and agencies have been noted in almost every review available on the subject (see for example Suharsono 1999 b, Hildreth 1999, Black and Wiryawan 1998, Sloan and Sugandhy 1994). This has led to weak governance, lack of consultation with stakeholders and made the implementation of integrated coastal zone management incorporating both land and sea, an impossible task.

The absence of a strong unifying arrangement has even led to recommendations for institutional change ahead of technical innovation (e.g. Sloan and Sugandhy 1994). One suggestion has been the formation of a super agency absorbing the coastal mandates of existing agencies. Sloan and Sugandhy (1994), however, regard this as too daunting a task and believe that it goes against the Indonesian culture of decision making based on deliberation and consensus. Hildreth (1999), also called for a national framework for integrated coastal zone management using a coordinating council for relevant agencies rather than the formation of a new agency. This may be the direction being taken for, as Buturbutar et al. (1999) report, the Director General, Regional Development has implemented a development strategy which:

- Emphasises local administrative institutions;
- Focuses on devolving officials who have marine science backgrounds;
- Clarifies administrative boundaries and jurisdictional issues pertaining to resource management;
- Alleviates international budgets for ICZM;
- Coordinates foreign aid programmes that support ICZM.

The next task is to coordinate this with the mandate of the new Ministry for Maritime Exploration and Fisheries.

Issues related to fishing

Policies related to fishing are particularly complex and illustrate the problems of fragmented responsibility. Whilst the mangroves which provide the nursery grounds for many fish species, and their harvest, are part of the responsibility of the Forestry Ministry, fishing per se comes under Agriculture. Conservation as a whole is in Forestry. However, the laws and regulations, which include inter alia protection for all 6 species of turtles occurring in Indonesian waters (the green turtle has not had full protection), all marine mammals and 16 marine invertebrates (Sloan and Sugandhy 1994), are rarely fully implemented. In some cases, the law is just ignored, in others loopholes are easily found. For example, it is legal to use cyanide as an anaesthetic for live fish transport which makes it nearly impossible to prosecute vessels with cyanide on board or even with cyanide tainted fish (Erdmann 1999). Compliance and regulation are the main problems (Susilowati 1998). In Komodo National Park The Nature Conservancy believes that rather than revision of the law, regulation at the level of the fishing gear (for example banning the hookah and restricting mesh sizes) would be more effective. They also believe that exclusive rights of access to local populations in National Parks would also lead to better compliance and more effective awareness of requirements. One of the problems of fishing on Eastern Indonesia's reefs is that many fishermen responsible for overfishing and destructive fishing practices travel from other provinces and may be completely unaware of local provincial requirements. For example, in Komodo National Park only 21% of the fishing effect is from local fishermen, 36% from communities surrounding the Park, 29% from East Sumbawa and 14% from outside the region (Pet & Djohani 1998).

Tenure

Secure marine tenure is regarded as essential for effective environmental management at the local level as it creates a recognisable core of stakeholders whose legitimate interests lie in the continuing care and management of valuable resources (Fox 1995). However, Fox believes that nowhere in Eastern Indonesia does local marine tenure exist in a secure enough fashion to sustain local resources.

In some areas such as the Maluku coast of Minahasa, North Sulawesi, where the pressure on fishing resources is not critical there may be

relatively open access to local fishers. Elsewhere in Eastern Indonesia, particularly in Maluku, traditional marine tenure (Hak Ulayat Laut or petuanan) may be quite strong regardless of national or provincial legislation (Malik et al. 1999). The systems vary from simple tenure of fish traps to more complex systems of tenure over specific sea areas known as labuhan (Fox 1995). Tenure rights may be vested in quasi corporate bodies or adat groups (families, clans) which are not recognised in provincial or national legal systems.

Some attempts have been made to reassign such traditional rights to the village but generally this has not been upheld in the courts. Poaching of local resources by mobile fishing groups and resulting conflict remains a problem.

Traditional management (Sasi)

While customary laws (hukum adat) and communal property rights (hak ulayat/hak petuanan) are not mentioned in Indonesia's fisheries management statutes, they are actually accounted for in management decisions under these statutes (Hildreth 1999). The exercise of such customary rights can be a key factor in the effectiveness of marine protected areas and reserves in Indonesia. The local people should play an integral part in reef conservation, since it is they who are dealing with the day to day management of the marine environment and have a deep knowledge of and affinity with the sea (Djohani 1998). Djohani sees their stewardship as an evolving form of traditional management with even the much maligned Bajau people becoming important managers as they settle into more permanent coastal villages. For example, a boundary system for fishing grounds among the Bajau communities of the Togian Islands has been developed and Djohani advocates the employment of Bajau people as national park rangers who are responsible for the monitoring and enforcement of protected areas.

However, Pet (pers.comm 1999) believes that: "traditional community-based management is only feasible under conditions such as clear physical boundaries of fishing grounds, sedentary fish stocks (low mobility of resource), cohesive communities and use of simple gear. These conditions were generally met in traditional coral reef fisheries by small communities in Eastern Indonesia, where traditional management institutions have evolved. However traditional forms of community-based management in coral reef fisheries are becoming less and less feasible in Indonesia. This is the result of decreasing cohesiveness of coastal communities through expansion of markets (no longer subsistence), increasing population density, increasing consumer aspirations, mixing of ethnic groups through migration and intruding private enterprise".

Implementation

The multitude of laws and regulations related to the management of coastal and marine resources in Indonesia is greatly hindered by the fact that they are not generally enforced (Djohani 1999). In part this is due to a lack of awareness of such requirements at the village level and to ambiguity in the wording of much of the legislation (Llewellyn & Azhar 1998). However, there is also a lack of capacity and political will: "the general sentiment still holds among Indonesian politicians that conservation is only desirable if it can demonstrate economic benefits" (Llewellyn & Azhar (1998).

As Thorburn (1998) has maintained for the Kei Islands, Malaku, erratic and uneven enforcement of regulations, combined with collusion and self-interest on the part of various parties, threaten both the resouces and the institutions that have succesfully and sustainably managed them in the past.

Recommendations

Appropriate and understandable legislation

- There is a great need to simplify existing regulations, to produce compatibility at all levels of government and eradicate all ambiguity.
- Coral reefs should be clearly identified in national legislation as being an important target for conservation.
- Clear linkages should be provided between national, provincial and local legislation with further reinforcement of the Spatial Use Planning Laws of 1992/1999 giving great control to provincial and local governments.
- Local customs and traditions which have encouraged sustainable use in the past should be encouraged and where possible formalised into the legal system.
- Traditional tenure should be recognised and exclusive local rights of access to control and marine resources become more formalised thus reducing the amount of nomadic type fishing currently responsible for much of the damage to remote Eastern Indonesian reefs.
- New regulations need to be established which combat destructive fishing practices and other damaging activities such as coral mining. It has been suggested (e.g. Pet & Djohani 1998) that measures such as banning the use of cyanide completely, making materials for bombs (such as underwater fuses) more difficult to obtain or banning the use of hookah compressors may be more effective than more general legislation.
- Laws and regulations need to be fully implemented with political and economic support which will allow effective monitoring of activities.

A fully integrated coastal management structure

- Effective coastal management requires a higher level of appreciation of the environment and conservation. Whilst this may be slowly happening through education and international contact, it may be accelerated through some of the economic measures outlined in 10.2.5.
- Coordination needs to be both vertical (National, Provincial and Local levels) and horizontal between agencies.
- Strong support is needed for the new Ministry for Marine Exploration and Fisheries so that it can give the lead in the integrating process.
- Many of the problems facing Indonesia's coral reefs result from what is happening on the adjacent land. Catchment management needs to be part of coastal management efforts.
- Where possible traditional management such as Sasi should be incorporated into coastal and marine care at the village level.
- Recognition should be given to the great variety of environments, social and economic systems in Indonesia which allows for different methods of local scale management.
- The private sector, such as tourist resorts, dive operators etc. should be encouraged to play a more proactive role in management.
- Stakeholders should be involved in all stages of planning and implementation of coastal and marine resource management.
- Management plans should go through the full management cycle i.e. monitoring of the implementation stage should allow for assessment of the effectiveness of management processes and lead to review and revision.

Annex V
The large marine ecosystem of Indonesian Seas

(Source: Dalzell & Pauly 1990, GEF/UNDP/IMO 1997, Kadri et al. 1999, Moore In press, Morgan 1989, NOAA. 1991, UNESCO, 1995, Zijlstra et al. 1990)

Brief description

The Indonesian Sea Large Marine Ecosystem is a tropical LME of about 400 000 km^2. The Indonesian Sea extends from east to west across a distance of 5 000 km. It contains the Banda and Aru basins and is separated from the Arafura Sea by a series of islands. Geologically, it lies at the confluence of three tectonic plates: the Eurasian Plate, the Indo-Australian Plate and the Pacific Plate. There are active volcanoes and earthquake occurrences. The Indonesian archipelago stands between the Pacific and Indian Oceans and the LME is heavily influenced by annual and interannual variations in surface temperature due to a monsoonal system. It has strong tidal currents, and the pattern of surface currents varies during the south-east and northwest monsoon. This marine region is a "heat engine" of global atmospheric circulation, with complex ocean-atmospheric dynamics. The warm ocean and its links to the atmosphere create the El Niño Southern Oscillation (ENSO) phenomenon. The influence of El Niño, La Nina and the Australian and Asian monsoons contribute to the unique climate conditions in this region, an object of global climatology research.

Productivity

The Indonesian Sea LME is considered a Class II, moderately high (150-300 gC/m2-yr) productivity, ecosystem based on SeaWiFS global primary productivity estimates. The Banda Sea, and the Aru Basin in particular, are areas of extensive upwelling, relating to the monsoonal system. For locations of upwelling during both monsoons (see Zijlstra and Baars 1990). Strong ocean mixing influences sea surface temperature and nutrient concentrations. The links of tides to regional climate are being investigated. The Indonesian Through-flow is the exchange of ocean water between the Pacific and Indian Oceans. It is thought to be influenced by, and may influence in turn, ENSO. The Indonesian Through-flow exports warm, relatively fresh (low salinity) thermocline water from the North Pacific, providing a major freshwater source for the Indian Ocean. Current research attempts to relate seasonal cycles of primary and secondary marine productivity to the Through-flow, to winds, and to tidal currents. Pelagic fish resources appear to be significantly higher during periods of seasonal upwelling.

Fish and fisheries

There are major seasonal variations in fish abundance (Zijlstra and Baars, 1990). During upwelling connected to the south-east monsoon in August, fish stocks and the general productivity of the ecosystem are enhanced. The changing conditions influence phytoplankton and zooplankton species composition. Fish species harvested in this LME are giant gouramy, common carp, milk fish, tilapia, tuna, skipjack tuna, barramundi, anchovy, travelly, mackerel, garfish, shrimp, thumb nail (parrotfish), octopus, squid, crab, and lobster. Black marlin is a highly mobile species, fished recreationally. The coral reef environment harbors all kinds of reef fish. Indonesian waters are known worldwide for their ornamental fish species exported to the United States, Japan and Germany. These include the clownfish (Amphiprion), damselfish (Dascyllus), and wrasse (Coris gaimardi). Tortoises and turtles, as well as exotic species of crabs and mollusks living both in salt and fresh water, are found in this LME. Pearl oysters grow in the waters of the eastern Indonesian Sea. Harmful fishing practices that can impact endangered sea turtles occur in the course of commercial shrimp harvesting. Artisanal methods and aquaculture appear to have less harmful effects. The Central Research Institute for Fisheries (CRIFI) is under the Indonesian Ministry of Agriculture. The University of British Columbia Fisheries Center has detailed catch statistics for this LME.

Pollution and ecosystem health

Indonesia, the most extensive archipelago in the world, has thousands of kilometres of coastline bordering this LME. Not much is known about the status of the ecosystem in regards to pollution or coastal habitat alteration. One issue is heavy fishing. Urban expansion and industrialisation have resulted in water pollution from industrial wastes, sewage problems, and air pollution. Oil spills, slowly degrading toxic wastes from chemical and non-chemical industries, agricultural runoff and the dumping of materials such as metals threaten inland and coastal waters. Toxic materials settle into sea-floor sediments where they accumulate as hazards to living organisms that feed on bottom mud. Long-lasting chemicals may enter the food web and contaminate fish and shellfish. There are threats to the reefs and mangroves. For information on ozone depletion and the greenhouse risk, see Kadri et al. 1999.

Socio-economics

People of different ethnicities, religions and languages border the LME. Economic development and a tremendous growth in population have taken place in this extremely coastal country with thousands of islands scattered across a huge area. The climatic fluctuations within the Asian-Australian monsoon region have important implications for the society and the economy. Indonesian waters play a major role, providing food

resources for millions of people, as well as a mode of transportation and area of exploration and production of minerals and natural gas. The coastline areas are sites for industrial and other economic activities. Ports of importance are Ujung Pandang, Kalianget, Surabaya, Jakarta, Arjuna, Cirebon, Tegal and Semarang. Tourism is an important economic activity. UNESCO is funding projects on the socio-economic development of communities.

Governance

The LME is governed by Indonesia and by the recently independent state of East Timor. When Indonesia obtained its independence it enacted laws to govern the seas in accordance with its unique geographic structure as an archipelagic state. In Law of the Sea negotiations it has balanced the need to allow freedom of trade and international passage through straits with the need to protect its thousands of kilometres of coasts from potential pollution threats. The Indonesian government has declared its commitment to sustainable development in the oceans by ratifying a number of conventions and formulating programmes and projects that aim to defend and conserve the environment, taking into account the needs of the next generation. It has established national marine parks at Laut Banda (1977), Bunaken (1991), and Taluk Cendrawa (1990). Endangered species needing protection are the giant clam, the hawksbill turtle, the green turtle, and dugongs. Indonesia is party to conventions on Biodiversity, Climate Change, Desertification, Endangered Species, Hazardous Wastes, Law of the Sea, Nuclear Test Ban, Ozone Layer Protection, Ship Pollution, Tropical Timber 83, Tropical Timber 94, and Wetlands.

Annex VI
Criteria for scoring environmental impacts

Issue 23: Changes in ocean surface temperature	
This refers to the impact on populations, species, and communities from changes in Sea Surface Temperature as a result of global change.	
Score 0 = No known impact	No measurable or assessed effects of SST increase.
Score 1 = Slight	Slight impact is determined when one or more of the following criteria are met or exceeded: Measured assessed effects of SST are causing a behavioral change in some species without affecting the viability of the population
Score 2 = Moderate	Moderate impact is determined when one or more of the following criteria are met or exceeded: Community structure is measurably altered as a consequence of changes in SST. Populations are declining.
Score 3 = Severe	Severe impact is determined when one or more of the following criteria are met or exceeded: Measured/assessed effects of changed SST are leading to massive loss of communities or a change in biological diversity.

Annex VII
Marine protected areas and benefits to the fishery

(Compiled by Dr. Jos Pet and Dr. Peter J. Mous, The Nature Conservancy - Indonesia Coastal and Marine Program. Comments and additions in italics, text that is quoted in normal type.)

Marine Protected Area

Geographic area with discrete boundaries that has been designated to enhance the conservation of marine resources. This includes MPA-wide restrictions on some activities such as oil and gas mining and the use of zones such as fishery and ecological reserves to provide higher levels of protection. (Source: National Research Council 2001)

Overfishing

Fishing with an effort (number of boats, nets, fishing days, etc.) that results in a catch volume which is actually lower than could be sustained at a lower fishing effort. If a stock is overfished, reduction of the fishing effort will result in stabilisation of the catch at a level that is higher than in the overfished situation, preceded by a short-term drop in the catch.

Indonesian context - policies in relation to fishery development and marine conservation

Already in the mid-nineties, fishery statistics that were available were either unreliable or they suggested that many of the fish populations were over-fished,. ... it may be high time to switch attention (from finding new resources) to management of existing fisheries, in order to prevent overfishing ... in the light of the overall uncertainty no further investment or effort increase in any shrimp fishery should be considered ... It is very clear that the 1991 estimates for small pelagic fish are unfounded and overoptimistic and that any plan based on those estimates should be shelved... the Workshop had come to the conclusion that it is not prudent at this stage to stimulate a further expansion of any tuna fleet ... The present knowledge of fisheries resources in areas designated for development in Eastern Indonesia is so scanty that any development at this stage includes a very large risk factor ... the shrimp resources in the Arafura Sea are over-exploited. It is suggested that effort should be reduced to about 50% of the effort in 1993 to keep the catch around the Maximum Sustainable Yield. ... it appears that in several sub-areas the present landings are lower than the peak landings, which might indicate overfishing ... it appears that there are seven (of the 11) coastal areas where the six selected small species groups are already over-exploited (Source: Venema 1996).

In the mid-nineties, reef fish in Eastern Indonesia still seemed to offer scope for further development, but scientists already warned about the danger of overfishing (note that the trade in live reef fish was not yet receiving much attention): However, it is necessary to be cautious with rapid developments of such fisheries. The fish population in unfished areas consist of old to very old fish, which take a long time to replace. A very steep drop in catch rates will be experienced once more vessels enter into the fishery and when many boats enter at the same time irreparable damage can be done. (Source: Venema 1996)

Already in the mid-nineties, there was a call for a change in the objective in fishery management: The major conclusion of this study is that a shift of objectives of fisheries management should occur. To assure that maximum benefits accrue from the fisheries, the objectives must change from increasing landings to assuring sustainable exploitation.. (Source Gillet 1996).

The tragedy is, that Indonesian government officials misinterpret the conclusions from fishery scientists on the Maxiumum Sustainable Yield. Whereas fishery scientists state that the current state of the fishery is at 60% of the Maxiumum Sustainable Yield because the fishing effort is too high, many policy makers think that the fishery can be further optimised by increasing the effort. (Source: Undated leaflet from the Research Centre of Marine Technology, Ministry of Marine Affairs and Fisheries)

Whereas the concept of Maximum Sustainable Yield is widely used in Indonesia, even a basic understanding of the rationale behind the concept is lacking with policy makers. Fishery scientists fall short in explaining the uncertainties, applicability and the take-home message in their reports. The following are excerpts from the recommendations in a recent FAO report: (a) A major problem is the working concept that the difference between present fish catches and the potential yield represents a surplus which is available for harvesting by additional fishing effort. (b) Although the concept of MSY is widely used in Indonesia, as the fisheries develop and effort increases, the MSY concept becomes less relevant and information from the fishery assumes a greater importance in determining any remaining potential. (c) Those individuals that make the resource estimates should also take on the responsibility of conveying to the users of the information an idea of how accurate the information is. (Source: Gillet 2000).

The Indonesia/FAO/DANIDA Workshop (Venema 1996) and the DGF/FAO Workshop on Strengthening Marine Resource Management (Gillet 1996) found that the system which is presently used to calculate the Optimum Effort in terms of numbers of licences (= number of active

vessels per year) is incorrect and the expected effects are alarming to say the least. (Source: Djohani et al. 1998).

A challenge for effective fishery management is that policy makers still perceive Illegal Unreported and Unregulated Fishing (there is even an acronym for this, IUUF) as the main concern, rather than overexploitation by 'legal' fishers. There is a strong focus within the Ministry of Marine Affairs and Fisheries to deal with this problem, whereas the establishment of Marine Protected Areas is not on the political agenda. For example, the Ministry did not even propose a single project in support Marine Protected Areas in its project portfolio presented at PrepCom IV. Hence, there is a niche for a conservation alliance to carry the concept of Marine Protected Areas forward (Source: Ministry of Marine Affairs and Fisheres 2002).

Although overfishing is mentioned as a real problem in general terms, one does get the impression that the main agenda remains to expand the fishery, in combination with curbing illegal fishing and making the domestic fishery more capital-intensive. It is also noteworthy that the Government of Indonesia formulates clear benchmarks for development of the fishery, whereas there is nothing concrete on conservation and how sustainability is being ensured. The following is an excerpt from a speech by the Minister of Marine Affairs and Fisheries: (Indonesia's) contribution of (the) fisheries sector to the national GDP is only about 2%. ... although the total length of the coastal line in South Korea and Japan is only 2 731 and 34 386 km respectively, the contribution of the fisheries sector to the national GDP already fetch 37 and 54 percent respectively. Likewise, although the total length of the coastal line in Thailand is only about 2 600 km, but they manage to tap more then 5 billion US$ of foreign-exchange earnings from fisheries export annually. For these obvious reasons, the Indonesian Government has decided to launch an integrated fisheries management programme to optimise the use of fisheries resources on a sustainable basis. Under this scheme, the contribution of fisheries export to the foreign-exchange earnings is projected to reach 5 billion dollars and the share of the fisheries sector to the national GDP is expected to reach 5%. One of the main constraints to achieve the above objectives is the fact that artisanal fishermen, characterised by small scale, low capital and labor intensive in nature, mostly dominate the Indonesian fisheries. ... The widespread increase of Illegal unreported and unregulated fishing has also been incriminated for the severe damage of fisheries resources in the Indonesian waters as well as excessive loss of revenue. We need to work together to strengthen our capacity building and technical know-how. I would like to take this opportunity to seek the indulgence and cooperation of all stakeholders to assist Indonesia to overcome and gradually minimise Ilegal unreported and unregulated fishing. In this juncture, I would like to re-emphasise our desire to strengthen our capability and policy instruments and law enforcement against IUU fishing.. (Source: official transcript of the keynote speech by the Minister for Marine Affairs and Fisheries at the International Seminar on Sustainable Development in the EEZ and the EEZ as an Institutional for Cooperation or Conflict. Denpasar, Bali, June 4, 2002).

A recent address by the President of Indonesia shows that the Government of Indonesia seeks to expand the fishery in Indonesia's seas: President Megawati Soekarnoputri, while expressing concern about the environment, called on local businessmen to make more of Eastern Indonesia's waters, home to an abundance of fish and other marine life. "Most businessmen have been reluctant to open new ventures in this unexplored and rich marine resource area because they consider it technically and economically unfeasible," said the President, during the opening ceremony of a three-day conference, exhibition on Indonesian livestock and fish at Nusa Dua resort complex on Wednesday. Participating in the conference and expo were delegates and fishing companies from 22 foreign countries, including Australia, the United States, Germany and France. "We now have to start thinking about how to wisely explore our rich and diverse marine resources, as well as to boost agriculture," she said. (Source: Widiadana 2002).

In a recent report to the Ministry of Marine Affairs and Fisheries, again the need for better management rather than further expansion was noted. ... more investments are needed to produce more fish. But such investments must not expand fishing capacity but to complement and supplement effort to manage the remaining fisheries resources. (Source: Pacific Consultants International 2001).

A recent report to the Ministry of Marine Affairs and Fisheries listed the following policy recommendation: Create, build and arouse awareness to change the perception and mindset of the people to stop romanticising that the country's seas have over-abundant or overflowing resources, in particular fisheries resources. (Source: Pacific Consultants International 2001. Study on Fisheries Development Policy Formulation. Volume I. White Paper. Report by Pacific Consultants International under Jakarta Fishing Port / Market Development Project (Phase IV: JBIC Loan No. IP-403). 234 p. + Annexes).

It is not clear how the Government of Indonesia translates the advice offered through costly consultancies into management action, given the ubiquitous call for reduction of the fishery among experts and the equally ubiquitous call for intensification of the fishery among policy makers. Even consultants seem to have concerns about this issue, see the appeal at the end of the following excerpt from a recent 3-volume

report commissioned by the Ministry of Marine Affairs and Fisheries to Pacific Consultants International: ... the former Directorate General of Fisheries, now restructured into the Directorate General of Capture Fisheries and Directorate General of Culture Fisheries, had tasked a project, Study on Fisheries Development Policy Formulation, as an integral part of the Jakarta Fishing Port/ Market Development Policy Formulation, as an integral part of the Jakarta Fishing Port/Market Development Project Phase IV under the Japan Bank for International Cooperation (JBIC Loan No. IP-403) to evolve and formulate a new and bold policy for Indonesian fisheries and aquaculture based on the principles of equity and sustainability, taking into account the needs of the vulnerable poor as well as to implement the Precautionary Approach to Management and the Code of Conduct for Responsible Fisheries, to which the country subscribes.... Today, management of Indonesian fisheries is no longer a matter of choice. There is no choice. Management is inevitable if the remaining fisheries is to be sustained for the present and future generations. With fisheries facing certain depletion and imminent collapse, not only in Indonesia but also throughout the world a continuing emphasis on uncontrolled or unmanaged development and expanded production as had been pursued in the country over the last 30 years is clearly ill advised. To check further uncontrolled expansion and reverse overfishing, a different set of fresh policies and strategies is needed. ... The country and its policy-makers and planners, as also its fisheries managers and fishers must rid themselves of their mental trap that every available resource in the country is still underutilised and huge potentials remain for its expanded exploitation and production. In a country as vast as Indonesia is and with over 200 million people and with a structurally-centralised governance system concentrated in Jakarta and Jawa, it cannot be that its natural resources are still underutilised. For Indonesian fisheries and its future sustainable development, we would like that our Study be on the list of `must read' report for as many Indonesians as possible, especially those responsible for making policies, which provide the broad thrusts and direction, goals, signals, incentives, nuances and its wherewithals on how these remaining resources are used for nation building. (Source: Pacific Consultants International 2001. Study on Fisheries Development Policy Formulation. Volume II. Review and Analysis of Policies and Performances and Recommendations. Report by Pacific Consultants International under Jakarta Fishing Port / Market Development Project (Phase IV: JBIC Loan No. IP-403).

In a report prepared by the Food and Agricultural Organization of the United Nations, the danger of the government focusing on increasing production is highlighted: Both individuals and the private sector can and do carry out action leading to increased production from fisheries resources. However in many respects only the government can serve as a guardian of the fisheries resources to prevent overexploitation. If the staff of DGF are largely preoccupied with increasing fisheries production, there appears to be no government agency which has as its major concern the protection of fisheries resources. (Source: Gillett 2000).

In principle, the objectives, policies and activities of the Ministry of Marine Affairs and Fisheries are compatible with the development of a network of Marine Protected Areas. Objectives: (1) optimisation of the catch to increase welfare of the Indonesian people; (2) conservation of fishery resources. Policies: (1) Control of fishing activities, (2) Development of aquaculture, (3) Improvement of quality. Control of fishing activities is to take place through re-registration of fishing licenses and development of surveillance and law-enforcement capabilities. (Source: Undated leaflet from Ministry of Marine Affairs and Fisheries).

A recent report to the Ministry of Marine Affairs and Fisheries says the following on Marine Protected Areas: ... it is definitively in the country's economic and environmental interests to set aside at least 10% of its 81 000 km coastline and 5.8 million km^2 marine territory as marine sanctuary or marine protected area and marine park to conserve and protect its remaining rich marine bio-diversity ... There are clear benefits to be gained from investment in identifying, declaring and establishing more marine protected areas in Indonesian waters, not only as a tool to manage and conserve the fisheries and its rich genetic resources but also equally for aquaculture, in particular mariculture or sea farming as a source of seed and broodstock (Source: Pacific Consultants International 2001. Study on Fisheries Development Policy Formulation. Volume I. White Paper. Report by Pacific Consultants International under Jakarta Fishing Port / Market Development Project (Phase IV: JBIC Loan No. IP-403). 234 p. + Annexes).

Global context – Marine Protected Areas and fishery management

On the limits to exploitation of the seas: ... the philosophy expressed by Hugo Grotius, a Dutchman in the 1600s, that the sea could not be harmed by human deeds and therefore needed no protection. His thinking established the principle of "freedom of the seas", a concept that continues to influence ocean policy despite clear evidence that human impacts such as overfishing, habitat destruction, drainage of wetlands and pollution threaten the long-term productivity of the seas. (Source: Committee on the Evaluation, Design, and Monitoring of Marine Reserves and Protected Areas in the United States, National Research Council 2001. Marine Protected Areas. Tools for sustaining ocean ecosystems. National Academy Press, Washington, D.C. 272 p.)

What is common to the greatest number (of people) gets the least amount of care. Men pay most attention to what is their own: they care less for what is common; or, at any rate, they care for it only to the extent to which each is individually concerned. (Source: Aristotle (384-322 BC), Politics , Ideal States in Theory, Chapter III, §4. In: E. Barker (1958). The Politics of Aristotle. Oxford University Press, London, Oxford, New York. 411 p.).

Overfishing is not a recent phenomenon. Ecological extinction caused by overfishing precedes all other pervasive human disturbance to coastal ecosystems, including pollution, degradation of water quality, and anthropogenic climate change. Historical abundances of large consumer species were fantastically large in comparison with recent observations. Paleoecological, archaeological, and historical data show that time lags of decades to centuries occurred between the onset of overfishing and consequent changes in ecological communities, because unfished species of similar trophic level assumed the ecological roles of overfished species until they too were overfished or died of epidemic diseases related to overcrowding. (Source: Jeremy B. C. Jackson, Michael X. Kirby, Wolfgang H. Berger, Karen A. Bjorndal, Louis W. Botsford, Bruce J. Bourque, Roger H. Bradbury, Richard Cooke, Jon Erlandson, James A. Estes, Terence P. Hughes, Susan Kidwell, Carina B. Lange, Hunter S. Lenihan, John M. Pandolfi, Charles H. Peterson, Robert S. Steneck, Mia J. Tegner, Robert R. Warner (2001). Historical Overfishing and the Recent Collapse of Coastal Ecosystems. Science 293. p. 629 – 638).

... our relative inexperience in using marine reserves to manage living resources should not serve as an argument against their use. Rather, it argues that implementation of reserves should be incremental and adaptive, through the design of areas that will not only conserve marine resources, but also will help us learn how to manage marine species more effectively. The dual realities that the Earth's resources are limited and that demands made on marine resources are increasing, will require some compromise among users to secure greater benefits for the community as a whole. Properly designed and managed marine reserves and protected areas offer the potential for minimising short-term sacrifice by current users of the sea and maximising the long-term health and productivity of the marine environment. (Source: Committee on the Evaluation, Design, and Monitoring of Marine Reserves and Protected Areas in the United States, National Research Council 2001. Marine Protected Areas. Tools for sustaining ocean ecosystems. National Academy Press, Washington, D.C. 272 p.).

Based on evidence from existing marine area closures in both temperate and tropical regions, marine reserves and protected areas will be effective tools for addressing conservation needs as part of integrated coastal and marine area management. (Source: Committee on the Evaluation, Design, and Monitoring of Marine Reserves and Protected Areas in the United States, National Research Council 2001. Marine Protected Areas. Tools for sustaining ocean ecosystems. National Academy Press, Washington, D.C. 272 p.).

Even at a global level, it seems that fishery statistics should be interpreted with extreme care: ... we show that misreporting by countries with large fisheries, combined with the large and widely fluctuating catch of species such as the Peruvian anchoveta, can cause globally spurious trends. Such trends influence unwise investment decisions by firms in the fishing sector and by banks, and prevent the effective global management of international fisheries. (Source: Watson & Pauly 2001).

Given the uncertainty in fishery statistics and the status of fish stocks, MPAs may provide a last line of defense against overfishing. It is important to consider the FAO code of conduct for responsible fisheries in this light.. States and subregional and regional fisheries management organisations should apply a precautionary approach widely to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment, taking account of the best scientific evidence available. The absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment. (Source: Article 6, General Principles of the FAO code of conduct, accessed at http://www.fao.org/fi/agreem/codecond/ficonde.asp#6 on July 17, 2002).

Worldwide, the marine area that is currently being protected is extremely small. At the moment MPAs cover less than half of a percent of the world's oceans, few protect very much and 71% appear to have no active management. (Source: Roberts &. Hawkins 2000)

Marine reserves and protected areas have received inadequate attention from fisheries managers in the region, at least they do not feature clearly in formal arrangements. (Source: Msiska et al. 2001).

Fully protected reserves in a nutshell. (1) Fully-protected reserves enhance the production of offspring which can restock fishing grounds. (2) Fully-protected reserves allow spillover of adults and juveniles into fishing grounds. (3) Fully-protected reserves provide a refuge for vulnerable species. (4) Fully-protected reserves prevent habitat damage. (5) Fully-protected reserves promote development of natural biological

communities which are different from communities in fishing grounds. (6) Fully-protected reserves facilitate recovery from catastrophic human and natural disturbances. (Source: Roberts &. Hawkins 2000).

There is compelling, irrefutable evidence that protecting areas from fishing leads to rapid increases in abundance, average body size, and biomass of exploited species. It also leads to increased diversity of species and recovery of habitats from fishing disturbance. Reserves are often portrayed as working only on coral reefs. In fact, they have been successful in a wide range of habitats in environments ranging from tropical to cool temperate zones. Reserves are a valuable tool globally. (Source: Roberts &. Hawkins 2000).

There is now compelling scientific evidence that marine reserves conserve both biodiversity and fisheries, and could help to replenish the seas, says a scientific consensus statement signed by 150 of the world's leading marine scientists. (Source: press release dated February 2001 from the annual American Association for the Advancement of Science (AAAS) meeting).

'I am very proud of the role of the industry and the part I have played in promoting a no-take reserve for Florida's Dry Tortugas' – Tony Iarocci, Commercial fisherman, USA. 'But most fisherman respect the reserve because they believe, in time, it will bring benefits to them'. – Commercial fisherman, St Lucia, Caribbean. 'We need to try something different. No-take marine reserves could be the answer' – Commercial fisherman, Cornwall, UK, 'It's asking a lot to close areas to fishing when communities need to fish to survive, but it may be the only hope we have to replenish reefs that have been overfished for so many years'. – Commercial fisherman, Philippines. (Source: WWF Leaflet. Marine Reserves: Like Money in the Bank!)

Major Recommendation: Marine protected areas (MPAs) have the potential to play a much bigger role in the successful management and sustainable use of fisheries resources on coral reefs and associated ecosystems. In particular, participatory development of no-take zones and protection of essential fisheries habitat in the context of an ecosystem management approach should be encouraged, where appropriate, at both the community level and for larger areas. (Source: Dight et al. 1999).

The designation of no-take marine reserves may be necessary for sustaining fishery yields over the long term, due to their ability to preserve genetic variation in the expression of fish size and growth rates, according to a study published in the 5 July 2002 issue of the journal Science. This is because in exploited situations, the fishery selectively removes larger individuals, giving smaller, less fertile individuals a selective advantage (Source: MPA News, Vol. 4, No. 1, p. 4).

The conservation argument for marine reserves is predictable and undeniable; the fisheries and other socioeconomic benefits will be bonuses (Source: Bill Ballantine, Leigh Marine Laboratory, University of Auckland, New Zealand. In: MPA News, Vol. 4, No. 1, p. 5. MPA Perspective: MPAs Improve General Management, While Marine Reserves Ensure Conservation).

The Australians have begun to set up networks of MPAs in advance of definitive quantitative evidence that they benefit fisheries - the obvious conservation benefits are seem as sufficient and I agree with that. I think US policy us going the same way. (Source: Dr Tony Pitcher, Professor of Fisheries, Director University of British Columbia Fisheries Centre, in an e-mail communication dated July 16 2002).

Within 5 years of creation, a network of five small reserves in St Lucia increased adjacent catches of artisanal fisheries by between 46 and 90%. In Florida, reserve zones in the Merritt Island National Wildlife Refuge have supplied increasing numbers of world record-sized fish to adjacent recreational fisheries since the 1970s. (Source: Roberts et al. 2001).

Our findings indicate that in 5 years, reserves have led to improvement in the Soufrière Marine Management Area (Saint Lucia) fishery, despite the 35% decrease in area of fishing grounds. There were more fish in the sea, and evidence for little initial impact of reserves on total catches in the first year of implementation, together with constant fishing effort since protection began, indicates a greater weight of total landings. Interviews with local fishers (conducted in Creole via an interpreter) showed that most felt better off with reserves than without. Younger fishers were especially positive about the benefits. (Source: Roberts et al. 2001).

We find that reserve creation can produce win-win situations where aggregate biomass and the common license (lease) price increase. (Source: Sanchirico & Wilen 2001).

On effectiveness of terrestrial Parks: We found that the majority of parks are successful at stopping land clearing, and to a lesser degree effective at mitigating logging, hunting, fire, and grazing. Park effectiveness correlates with basic management activities such as enforcement, boundary demarcation, and direct compensation to local communities, suggesting that even modest increases in funding would directly increase the ability of parks to protect tropical biodiversity. (Source: Bruner et al. 2001).

On effectiveness of terrestrial Parks: The findings of this study suggest three basic conclusions. First, the claim that the majority of parks in tropical countries are "paper parks"— i.e., parks in name only—is not substantiated. Tropical parks have been surprisingly effective at protecting the ecosystems and species within their borders in the context of chronic underfunding and significant land-use pressure. They have been especially effective in preventing land clearing, arguably the most serious threat to biodiversity. Second, despite their successes, there is a clear need to increase support for parks to improve effectiveness against all threats, perhaps especially against hunting. Finally, these findings suggest that parks should remain a central component of conservation strategies. Both creating new parks and addressing the tractable problem of making existing parks perform better will make a significant contribution to long-term biodiversity conservation in the tropics. (Source: Bruner A.G., Gullison R.E., Rice R.E. & da Fonseca G.A.B. 2001. Effectiveness of parks in protecting tropical biodiversity. Science 291. p. 125-128. Note that hunting is the terrestrial analogue to fishing).

To restore fish populations and protect ecosystems, fishery managers should develop policies aimed toward substantially reducing fishing, says Sustaining Marine Fisheries, a new report by a committee of the National Research Council. Management plans should include not only commercial fishing but also recreational and subsistence fishing. More coastal and ocean areas should be designated as protected, where fishing would not be permitted. In addition, managers should consider taking action such as assigning exclusive fishing rights to individuals or communities, to discourage overfishing. (Source: The National Academies, http://www4.nas.edu/news.nsf/isbn/0309055261?OpenDocument, accessed on July 17, 2002).

Marine protected areas are most effective when they are established where vulnerable species usually live, breed, or feed, the committee said. Creating these areas has quickly restored populations of fish, snails, and crabs, reduced pollution, and provided habitats for other marine organisms in some regions, including the Florida Keys, the Philippine Islands, and the coast of Japan. Less than a quarter of 1 percent of coastal sea areas are designated as marine protected areas. To ensure the greatest benefit to depleted fish stocks, many more protected areas should be set aside that are or once were active, productive fishing areas, the committee said. Moreover, fishermen should be involved in planning and designating protected areas. (Source: The National Academies, http://www4.nas.edu/news.nsf/isbn/0309055261?OpenDocument, accessed on July 17, 2002).

On the Great Barrier Reef Marine Park, a multiple-use area of 88 679 km^2 with a 16 398 km^2 no-take area: ... identified concerns include bycatch, especially of vulnerable and threatened species, excess capacity in some fisheries, and the need for increased surveillance and enforcement. (Source: Tanzer 1998).

Some scientists think that Marine Protected Areas are not a universal panacea for fisheries conservation problems, but there seems to be agreement that coral reef fisheries are especially suitable for management by establishing MPAs. For marine ecosystems that are more or less well defined spatially, such as coral reefs, protecting areas of manageable size appears to offer good potential for protection of fisheries resources. (Source: Williams 1998). (Note that recent legislative changes in 2004 to the GBRMP have increased the size of no-take areas substantially).

Migratory behaviour does not preclude reserves from benefiting a species, but it demands that we apply different principles in designing them. (Source: Roberts & Sargant 2001).

On the efficiency of MPAs as a fishery management tool as compared to quota regulations. We show that it is possible that the use of MPAs of certain sizes can be a more advantageous management tool than traditional quotas. (Source: Armstrong & Reithe 2001).

Many reef fish aggregate at certain sites for spawning. MPAs can help to protect these spawning aggregation sites that are extremely vulnerable to subsistence or commercial fishing. ... the presence of an important spawning aggregation site would in some cases be justification in itself for the establishment of a marine reserve ... no-fishing zones should be established over spawning aggregation sites in large, multiple-use marine protected areas. (Source: Johannes R.E. 1998. Tropical marine reserves should encompass spawning aggregation sites. Parks Vol. 8 No. 2, p. 53-54).

On the economic benefit of protecting grouper spawning aggregation sites. The implications of these results for management authorities are significant. First, they provide an economic rationale for aggressively protecting known and potential spawning aggregation sites. Second, at KNP, the value of such aggregation sites is equal in economic significance to the recreational value of the park as a whole. Finally, overall protection efforts are consistent with protecting a regional demersal fishery on which many households living outside of the park depend. (Source: Ruitenbeek 2001).

On benefits of MPAs for tourism. Significant benefits have become evident in several places where the coral reefs have been protected including the following sites: the Netherlands Antilles (Bonaire Marine Park),

where diving tourism increased; the Seychelles (Ste. Anne National Marine Park), where the park is used by both residents and tourists for swimming, sailing, snorkelling, diving and glass-bottom boat excursions; Fiji (Tai Island), where subsistence catches have increased, tourist activity has expanded and the holders of traditional fishing rights are involved in resort management and boat hire; Cozumel Island (Mexican Caribbean) where increasing numbers of foreign and national tourists are coming to observe the coral-dwelling fish; and Kenya (Malindi/Watamu National Parks and Reserves, where tourism generates revenues through gate, guide and camping fees, rental of boats and equipment and hotel expenses. It also has indirect benefits through the creation of jobs in hotels and for guides and boatmen. (Source: McNeely et al. 1994)

Our results suggest that accounting for the non-consumptive economic value of increased Nassau grouper abundance and size may have a large impact on the economic viability of ecologically functional MPAs. (Source: Rudd et al. 2001).

Market shares increased significantly for (dive) sites with increased Nassau groupers abundance and mean size. (Source: Rudd & Tupper 2002).

Published data on how much of the sea should be protected from fishing. If the objective is risk minimisation: (a) reserves of 31-70% of the fishing grounds, (b) more than 40% of the management area, (c) so large, that the exploited population is at 75% of their unexploited size, (d) reserves of 20 and 30% of the management area guaranteed persistence of an initially heavily exploited stock for 20 and 100 years respectively, (e) so large, that the fish population is above 20% of their unexploited size, (f) so large, that the population is above 70% of the unexploited population size, (g) so large, that the population is above 40% of the unexploited population size, (h) 30 – 50% of the management area, (i) between 20-40% of the management area. . If the objective is yield maximisation, the area mostly depends on the fishing effort in adjacent fishing grounds, but for must fisheries, the reserve area is between 8% for light exploitation levels and 80% for intensive fisheries (averaging 30-40%, results from 13 studies). (Source: Roberts & Hawkins 2000).

The optimal area of the marine reserve is found to be between 15% and 25% (of the fishing grounds) ... if the fishing intensity in the adjacent fishery does not exceed 40% of the exploitable biomass. (Source: Rodwell et al. 2001).

Under policy options that included ecological considerations, maximum benefits were derived from an MPA that covered 25-40% of the North Sea, placed along the southern and eastern coasts. (Source: Beattie et al. 2001).

On a study on a fishery of spiny lobster. The results of this study indicate that opposition to marine reserves by the lobster fishing industry based on the assumption that the removing spatial access to fishing grounds will lead to a reduction in catch rates, may be unfounded. (Source: Kelly et al. 2001).

... spillover from marine reserves may under certain circumstances greatly reduce the long-term losses of local fishers after the establishment of a marine protected area. (Source: Kelly et al. 2002).

On the importance of network reserves: (a) Isolated reserves have many benefits but will only be able to protect a limited fraction of marine biodiversity. (b) Large number of marine species have open water dispersal phases and can potentially be transported long distances from where they were spawned. (c) Individual reserves may be able to sustain self-recruiting populations of species that disperse short distances, but networks will be necessary to protect many of the species that disperse long-distances (d) Reserves in networks need to be close enough for protected populations to interact through dispersal, ideally being closer together than a few tens of kilometres. (Source: Roberts & Hawkins 2000).

On the importance of dedicated staff: 'rather than administrative commitments to marine protected areas and strong capacities for managing marine areas, the single most important factor underlying whether or not a MPA will be successful and beneficial is the presence of a dedicated individual or group of individuals to carry it forward' (Source: Agardy 1997, Roberts & Hawkins 2000).

Annex VIII
Models for development of a fully integrated PA network in Indonesian Seas

Status and future of MPAs in Eastern Indonesia

(from Hopley and Suharsono 2000):

Indonesia has fallen well short of its targeted 30 million ha of MPAs by 2000. Moreover, the present network does not conform to the principles laid out in the 1984 "National Marine Protected Areas System". Exploitation of marine resources has continued to have higher priority than conservation and the MPA network has developed haphazardly.

Management effectiveness is also variable. It appears to be at its most effective in both planning and implementation where international NGOs and agencies are involved. Prime examples include the work of The Nature Conservancy in Komodo National Park and Operation Wallacea in Wakatobi, but many smaller agencies have and still are contributing to the effectiveness of the MPA system. Major problems, which will be discussed in more detail in Section 9 include:

- Lack of facilities for management;
- Lack of funds;
- Political and legal support to enforce regulation;
- Lack of trained personnel who can appreciate the scientific principles.

Lack of effectiveness can be illustrated by the fact that of all the Marine Protected Areas in Indonesia, only in Komodo and Bunaken have destructive fishing practices almost been eliminated. Many large and probably important regions remain without significant areas set aside for conservation, and elsewhere, for example throughout Maluku areas set aside are probably too small to be fully effective. Strategic areas in which gaps are particularly obvious are the Halmahera region and adjacent waters linking New Guinea to the node of high diversity of the Banda Sea, and the islands off the east coast of Central Sulawesi, especially the Togians and the Kepelauan Banggai. The 1997 PHPA map of protected areas indicates that the Togians are a proposed area, though government action does not as yet appear to have been taken. PHPA has also undertaken surveys to assess the possibility of declaring the Sembilan Islands off the east coast of South Sulawesi, a marine conservation area.

Notably, many initiatives for conservation areas are coming from NGO sources. Programmes being implemented, for example by COREMAP and Proyek Pesisir, where specific areas are chosen for intensive programmes are in effect unofficial declarations of protection. COREMAP sites of Eastern Indonesia are listed in Table 6.3. Proyek Pesisir (Coastal Resources Management Project of Rhode Island University, funded by USAID) has sites in East Kalimantan (Balikpapan) and in North Sulawesi where 3 small villages in the Minahasa Regency (Blongko, Talise and Bentenan/Tumbak) have been selected for projects which will upgrade coastal resources (Malik and Kusen, 1999). One result has been the formation of a 6 ha marine sanctuary near Blongko, containing mangroves and coral reefs (Fraser et al, 1998 b).

Another example is Conservation International's programme in the Togian Islands (Surjadi and Supriatna, 1999). In partnership with Indonesian NGO YABSHI, C.I. has formed Konsorsium Togean with the goal of developing integrated marine and terrestrial protected areas in the Togians in which local communities, local government and other stakeholders can achieve consensus upon the designation, delineation and management of the area.

Although Chapter 18 of Indonesia National Strategy for Sustainable Development (Agenda 21) in 1997 produced the specific aim to "establish new marine parks and marine reserve areas and improve existing marine parks and reserves to protect critical habitats and coastal eco-systems such as coral reefs, mangroves and seagrass beds from further degradation", as Djohani (1999) has noted in the current economic and political crisis, it is not realistic to expect the government to expand its system of marine protected areas. The long term will may be there and the establishment of the new Ministry of Maritime Exploration in the government of President Abdurrahman Wahid, in which there is a specific division for coasts and small islands, appears promising. In the meantime the importance of NGO activities, usually with both provincial and central government support, cannot be overstressed.

Key recommendations

(from Hopley and Suharsono 2000).

A Strategically Planned Network of Marine Protected Areas

- Indonesia needs to reexamine the reports of the 1980s to produce an integrated system of marine protected areas which is appropriate to the needs of biodiversity conservation and sustainable use of natural resources. It should be representative of the major biogeographic regions of Indonesia and the variety of ecological niches. It should also take into account patterns of coral reproduction and larval recruitment so that natural replenishment of communities and species stocks in nearby exploited areas can take place.

- The original target of 30 million ha of marine protected areas should be resurrected.
- Using the most recent research results the minimum size of marine protected areas, buffer zones and other special use areas should be determined for and applied to existing and proposed marine protected areas.
- Management plans should be drawn up and implemented for all marine protected areas with sufficient political and economic support including trained personnel, facilities and budgets for management.
- Management should entail regular monitoring, and enforcement of laws and regulations.

Information for Management

- Scientifically based management has to be encouraged through the provision of data appropriate to management purposes.
- Much data is already collected in Indonesia but by a variety of agencies. Some uniformity is required in the collection of the data so that results from different areas are comparable.
- Methods for monitoring the status of coral reefs may be improved, or at the very least, the data which is already collected subjected to more sophisticated analysis.
- Accessibility of the data needs improving so that it is available to all levels of management. This may involve an improved national data base system.
- Priority for information gathering should be in existing and proposed marine protected areas.
- Specific targets for further information should include the basic distribution of coral reefs and related ecosystems, further taxonomic information to fully describe the biodiversity of Eastern Indonesia, giving increased priority to the collection of data on environmental variables and most importantly gathering data which will allow scientifically based fisheries stock assessment. More social and economic data is also required by management. The coastal mapping programme at 1:50 000 scale needs to be completed as soon as possible.

The Effective Use of Economic Tools in Management

- To date development economics have been partly responsible for the decline in Indonesia's coral reefs. In any evaluation of coastal and marine resources the total value of the environment including use and non-use values should be determined.
- In banning activities such as destructive fishing practices, the economic effects on fishermen and their families needs to be acknowledged and alternative sources of income sought in enterprises such as tourism, aquaculture or pelagic fisheries.
- Government investment and regulation is necessary in ventures such as pelagic fishing and aquaculture to ensure that they are both economically and environmentally sustainable.
- International aid and development agencies including the World Bank and Asian Development Bank should continue to ensure that investment in coastal and marine located projects entails environmental responsibility.

Appropriately Trained Management Personnel

- Continuation of training programmes for scientists and managers both within Indonesia and overseas should be encouraged.
- Development of networks of organisations, especially marine oriented university departments should be encouraged so that resources and experiences can be shared.
- Consideration should be given to changing present career paths of trained personnel (increased salary, status) to retain them in their area of speciality for a longer period.
- There is a need to increase the awareness of the value of field data collection.
- Different training or education given through bilateral programmes and aid agencies should be complementary and reinforce existing skills rather than being discrete programmes.
- There is a need for a more equable distribution of trained personnel across the whole of Indonesia.

Fully Informed and Involved Stakeholders

- Stakeholders should be involved at all stages of coastal and marine resource management.
- Village level extension programmes using appropriate media should be available in all areas.
- School curricula should include environmental programmes
- Models for education and extension should be taken from existing NGO programmes.

Marine Protected Area Case Study: Bunaken National Park, N Sulawesi, Indonesia

The continuing development of Bunaken NP provides important lessons for implementation of the recommended policy option in several key areas. For example, improved management capacity is crucial for overall success. Management of Bunaken NP has recently been reviewed and provides several useful case-studies.

Improving the Capacity of the Management Advisory Board

(from 'Natural Resources Management Program Headline News' Issue 17, 2002, information courtesy of Nancy Dahl-Tacconi and Mark Erdmann)

In late December 2000, the North Sulawesi government passed

a Governor's Decree (SK Gubernor No 233/200) mandating the formation of the Bunaken National Park Management Advisory Board (BNPMAB). The main purposes of the board are to manage the new entrance-fee system of the Bunaken National Park; to assist the Balai Taman Nasional Bunaken in developing, coordinating and funding conservation programmes; to facilitate and encourage community awareness and participation in the park management activities; and to instill sense of ownership by the local communities. The board was created with 15 equal seats, including seven government representatives and eight non-government representatives. This is an innovative system for managing and coordinating activities in a national park in Indonesia and the region. If successful, it will provide a best-practices example for coordinated multi-stakeholder marine park management in Indonesia and South-east Asia. The board was granted a two-year trial period, which will conclude in December this year.

Long standing management challenges for Bunaken National Park include cultural conflicts and mistrust amongst local stakeholders and managers; damaging fishing and land-use practices; rapid and poorly planned coastal development; unethical business and political practices; corrupt law enforcement systems; and unorganised management strategies. Since the boards inception, management processes have become more transparent and participatory, and management outputs have increased dramatically. Despite the initial successes of the board and the new entrance-fee system, many management challenges remain. The current evaluation of the board will contribute significantly to its capacity and potential for improving management processes, coordinating management and conservation activities in the park and raising stakeholder awareness and participation in management.

Codification of the roles and responsibilities of the Park Management Advisory Board with regard to conservation of Bunaken National Park is an essential Best Practice to effective decentralised co-management. The document, Basic Regulations for the Bunaken National Park Management Advisory Board clarifies this effort. While it guides the day-to-day functioning of the Park Management Advisory Board, it is also of value to others exploring decentralised co-management of protected areas in Indonesia (R. Merrill pers. comm.).

As with most Protected Areas in the Sulu-Celebes (Sulawesi) Sea, Bunaken NP is a multiple-use MPA, with different zones allowing and regulating different levels of exploitation and conservation. Initial difficulties in management arose from the initially complex zoning scheme, with a major revision recently undertaken. The rezoning provides useful lessons for policy implementation in the region (see Case Study).

Co-management

(from 'Natural Resources Management Program Headline News Issue 30, 2001):

"One of the most important initiatives has been the establishment of the Dewan Pengelolaan Taman Nasional Bunaken/DPTNB (Bunaken National Park Management Board), whose primary functions are to coordinate the policies and activities of all stakeholders with jurisdiction within the park and to plan and finance several conservation programmes at BNP, such as, a patrol system and a trash management system. In order to achieve these functions most effectively, the DPTNB is comprised of representatives from all major stakeholders in the park, including the local community, tourism sector, Balai Taman Nasional Bunaken (BTNB), environmental NGOs, universities, North Sulawesi province, Manado city and Minahasa regency government institutions. The DPTNB is the first of its kind in Indonesia, and is considered a two-year pilot project by the Ministry of Forestry.

Besides the DPTNB, a number of organisations are now helping with management issues in TNB. The Forum Masyarakat Peduli Taman Nasional Bunaken (FMPTNB) was established in October 2000 as a means of connecting and representing the management aspirations of the approximately 30 000 residents of TNB. With three districts (north, south and surrounding islands) and representatives in all 21 villages within the park, the FMPTNB is slowly becoming an effective voice for the community in the management of TNB. Additionally, several environmental NGOs, including Yayasan Kelola, Forum Petuan Ketoupan, Yayasan Kendage URuata, WWF, and Yayasan Suara Nurani are working within the park on a range of environmental issues. Within the tourism sector, the North Sulawesi Watersports Association (NSWA) and Himpunan Pengelola Wisata Lokal Bunaken represent dive operators and cottage owners who are concerned about management of TNB. The increasing cooperation within and between these groups is supporting the concept of a keluarga besar Taman Nasional Bunaken yang mendukung pengelolaan dan pemanfaatan sumber daya alam yang berkelanjutan. (Bunaken National Park big family that supports sustainable natural resources management and utilisation).

Another exciting development for the management of Bunaken has been the introduction of a revolutionary new entrance fee system - the first in Indonesia. Unlike other national park entrance fees in Indonesia (where all money collected goes into the National Treasury), 80% of the Bunaken entrance fees are managed by the DPTNB to fund conservation programmes in the park. Since April 2001, over 8000 local and international tourists have paid the entrance fee, amounting to over Rp 360 million in income for conservation programmes. The DPTNB has

also received grants from WWF-Indonesia and USAID to help finance its conservation programmes. An example of an important programme currently being managed by the DPTNB is a joint patrol system. The patrol system is currently based on Bunaken Island and includes jagawana BTNB (rangers), SATPOLAIRUD, and community members who can be on a 24-hour patrol per day. This patrol system successfully apprehended more than seven groups of cyanide and bomb fishers who were operating illegally in the park. The patrol team also regularly conducts sweeping operations to ensure that all visitors have paid their entrance fees.

Until now, much of focus of these programmes has been on Bunaken and the surrounding islands of Manado Tua, Mantehaga, Siladen and Nain. However, the DPTNB realises that it is extremely important to also include the northern and southern mainland sections of the park, including Tiwohu, Tongkeina, Meras, Molas, Teling, Kumu, Poopoh, Pinasingkulan, RapRap, Sondaken, Popareng dan Wowontulap". (Mark V. Erdmann, Marine Protected Areas Advisor, NRM/EPIQ Sulawesi Utara,

Co-Management Initiative

(from Erdmann et al. 2003a)

Since 1998, USAID's Natural Resources Management Program (NRM) has been working actively to implement a co-management initiative in the park. Prior to this initiative, the management of BNP was centralistic and legally under the authority of the Ministry of Forestry's Bunaken National Park Office (BTNB). Local park users (particularly the fisherfolk and the dive tourism industry) were not effectively involved in park management, and local government agencies were highly resentful of the management authority vested in the BTNB. Funding for conservation and management activities in the park was minimal, the enforcement system ineffectual, and the park zonation system was largely misunderstood and ignored by the local populace. In most respects, Bunaken National Park qualified as a "paper park".

Objective of Initiative

The goal of the Bunaken National Park co-management initiative is to develop an effective and sustainably-financed Indonesian model of multistakeholder co-management of a national marine park which will thereby serve as a marine protected area (MPA) center of excellence for Indonesia and SE Asia. The key to achieving this goal has been a massive socialisation effort to draw the various stakeholders from the park (including 30 000 villagers, an active marine tourism industry, local conservation NGO's, academia, and three tiers of government agencies) into a single "community" with a strong sense of awareness and ownership of the valuable but threatened marine resources in the park.

Components of the Co-Management Initiative

Participatory zonation revision of BNP: NRM is assisting the BNP Office (BTNB) to work with the two primary park user groups (local villagers and the marine tourism sector) to revise the park's zonation system, realising that a well-designed, easy to understand and thoroughly socialised zonation system is the foundation for effective management of the park.

Improved villager involvement in BNP management decisions through institutional development of the BNP Concerned Citizen's Forum (FMPTNB). The FMPTNB is now active in all 22 villages in BNP and serves to represent the aspirations of ~30 000 villagers in management decisions, as well as serving to socialise management policy to its constituents.

Fostering private sector involvement in BNP management: NRM provides technical assistance to the North Sulawesi Watersports Association (NSWA) and actively fosters the involvement of other private sector groups (cottage owners, traditional fishers' association, and charter boat operators) in BNP management. Facilitation of multistakeholder co-management of BNP via institutional development of the BNP Management Advisory Board (DPTNB). NRM provides development support to the executive secretariat of the DPTNB, which consists of representatives from national, provincial and local government agencies, village stakeholders, the private tourism sector, academia, and environmental NGO's. The "crown jewel" of the Bunaken co-management initiative, the DPTNB represents a drastic departure from the traditional Indonesian model of top-down management of MPAs, and strives to make decentralised, participatory, transparent and accountable MPA management a reality.

Development of a portfolio of sustainable conservation financing mechanisms for BNP: A ground-breaking decentralised park entrance fee system has now placed the DPTNB on the road to financial self-reliance. Other components in the developing financing portfolio include an international volunteers system to lower management costs, diversified government agency support, in-kind support from the local dive tourism sector, national and international grant support, visitor center merchandising and a possible endowment fund.

Development of an effective 24-hour patrol system for BNP: An experimental joint patrol system involving park rangers, water police officers and local villagers has proven highly effective in decreasing destructive fishing practices in the park.

Institutionalisation of a scientific monitoring programme to monitor effects of management activities on park resources: In conjunction with WWF

Wallacea, NRM is supporting park stakeholders in monitoring coral condition (using manta tows and line intercept transects) and reef fish stocks (visual census of select reef species and monitoring of grouper and Napoleon wrasse spawning aggregation sites).

Select accomplishments to date

- Participatory zonation revision completed for Bunaken, Manado Tua, Mantehage and Siladen Islands and ongoing in 14 remaining villages.
- Institutionalisation of the 15 seat multistakeholder BNP Management Board (DPTNB) and the 22 village BNP Concerned Citizen's Forum (FMPTNB) and widespread socialisation of these two institutions.
- Strong participation of private sector in management via the NSWA, which has instituted a programme of "3 E's" (employment, education and enforcement) within the park.
- Development of a decentralised park entrance fee system whereby 80% of the revenues are earmarked for BNP management programmes. The system succeeded in raising 42 000 USD in its first year of operation (2001) and 109 000 USD in 2002, and is eventually targeting up to 250 000 USD/year.
- Implementation of a joint patrol system that includes villagers and that has virtually eradicated blast and cyanide fishing from the park and greatly limited illegal coral mining and mangrove cutting.
- Multimedia park socialisation campaign to instill a sense of BNP community using posters, zonation calendars, townhall meetings, community information billboards, a 30 base station VHF community radio network, local television shows and local, national and international newspaper and magazine articles.
- Sharing of lessons learned from Bunaken with MPA managers from Bali Barat NP, Komodo NP, Wakatobi NP, Cenderawasih NP, Berau Islands and Tomini Bay in Indonesia and Hon Mun Marine Reserve in Vietnam.
- Recorded an 11% increase in live coral cover in a one and a half year period on the reefs which have already completed zonation revision and are protected by patrol system.
- Selection as the Asian MPA ecotourism demonstration site for the International Coral Reef Action Network (ICRAN).

Selected lessons learned

Over the past five years, a number of important lessons have been learned in attempts to strengthen decentralised co-management of Bunaken National Park. While it is beyond the scope of this executive summary to discuss these in detail, we list the most important of these lessons learned in the hopes that they may be of interest to other tropical MPA managers currently utilising or considering a co-management approach:

- It is necessary to balance ecological values with socio-economic values to generate essential stakeholder political support for conservation of protected areas in regions with population pressures and/or priorities on economic growth and development.
- Building informed participation is a long-term process, requiring extensive capacity building and facilitation. Villagers, government and non-government stakeholders with long-term involvement in conservation management provide more innovative solutions and productive support for conservation management.
- Park managers and the rangers tasked with field management of the park commonly lack the community facilitation skills critical to ensuring broad stakeholder support and understanding of park management objectives. Training in facilitation skills for these park management personnel is an essential capacity-building measure before co-management can be effectively implemented.
- Co-management starts with the development of constituency-based partnerships, and then evolves to true co-management when the constituency-based partnerships then start working with each other. The evolution to co-management results in collaboration among often competing constituencies. Strong constituency partnerships provide a solid foundation for co-management.
- Community conservation campaigns through schools, mosques and churches can build effective local support for and pride in conservation initiatives. People will support conservation of their environment if they take pride in it. Of course, pride alone will not achieve conservation. Also important are economic incentives and enforcement of rules and regulations.
- Decentralisation of conservation management works when roles and responsibilities are clear, and when there is a shared vision of goals and objectives. Decentralisation does not work when there is competition over management authority or significant divergence in goals and objectives. Decentralisation also stimulates stronger grass-roots democracy and principles of good governance.
- Co-management requires active involvement of all relevant stakeholders. This is site-specific in nature. In Bunaken it includes dive operators, communities, different levels of government, universities and NGOs. Co-management must be inclusive, and must provide for reasonably equal voices for relevant stakeholder groups.
- The composition of multistakeholder co-management boards is absolutely critical to their success. The optimal ratio of governmental to non-governmental representatives and those advocating different functions of the protected area (economic development, conservation, sustainable resource use) will vary from site to site, but will have profound consequences for the effectiveness of these multistakeholder boards. There must be a balance between the competing interests represented, and this

will not always entail equal numerical representation; in many cases the stakeholder group(s) that are the most hesitant to advocate strong positions may require a larger allocation of seats on a multi-stakeholder board to achieve truly equal representation.

- Community stakeholders support patrol and enforcement programmes, as they are directly linked to increased livelihoods. Many illegal activities within protected areas come from outsiders. Communities with a stake in conservation management or sustainable utilisation of park resources have a strong and rational interest in seeing rules and regulations enforced so natural resources are sustained.
- "Alternative livelihood programmes" aimed at stakeholders currently involved in destructive activities in the coastal zone are ineffective and largely rejected by local communities. Community conservation/improvement programmes should focus on rewarding those that have chosen sustainable livelihoods, while those that persevere with destructive activities should be dealt with by a strong enforcement system.
- Local self-financing mechanisms are key to providing local stakeholders with the fuel to manage local conservation interventions. Decentralised co-management requires the capacity to generate and then manage finances locally.
- Development-oriented stakeholders, particularly from government, support conservation when it can be linked to regional economic development. Conservation of protected areas is better described within the context or regional economic development than altruism.
- Involvement of the private sector in co-management of MPAs can be highly beneficial. Once potential business competitors focus upon the benefits of cooperating to protect the resources in the MPA upon which their income depends, they become one of the strongest proponents of good management and bring considerable financial and human resources to the table.
- Tourists are willing to pay reasonably high entrance fees as long as they see their money is resulting in visible conservation management. Willingness-to-pay for effective conservation management is high, but can only be sustained when tourists see results from their payments.
- Funding for conservation management needs to be diverse. Reliance on a single source like user fees is dangerous. This is demonstrated by the sudden drop-off in revenues from the Bunaken entrance fee system after September 11 and the Bali Bombing. Long-term sustainability requires significant financial diversification.
- Monitoring and evaluation are key to ensuring on-going success of conservation management interventions. This is important for convincing stakeholders that interventions are working and/or providing guidance on how to adapt interventions if they are not working well. This includes the use of both ecological as well as socio-economic indicators in an integrated management effectiveness monitoring system
- Multiple-use MPA zonation plans are valuable management tools for mitigating conflict among stakeholders and balancing effective conservation with sustainable development in developing country MPAs with large population pressures. These plans are most effective if based upon a combination of scientific/ecological considerations and input from a range of primary user groups who have received facilitation in understanding and accepting compromise.
- Zonation schemes should use a minimal number of zone types, with names that clearly indicate their purpose, explicit rules for allowed and disallowed activities, and clearly demarcated borders that utilise natural or otherwise well-known landmarks whenever possible.
- The use of focal interest group meetings instead of relying only on large village meetings is essential for ensuring broad-based community participation and equitable decision making. This ensures the involvement of many of the more marginalised or traditionally quiet community members.
- Representation of larger groups (villages, the private sector, etc) in marine resource management decision-making is a new and poorly-understood concept in Indonesia. The individuals chosen to represent larger groups often neglect their responsibility to communicate actively with their constituents, while constituent groups often resent those chosen to represent them. This democratic principle needs continuous facilitation.
- Decentralised co-management supports the principles of good governance. Although it must be carefully managed (and well-designed at the outset in order to prevent dominance by any one stakeholder group), one of the greatest strengths of the co-management approach is in utilising the diverse interests and motivations of various stakeholder groups to prevent corruption, collusion or nepotism.
- Establishment of a sense of pride and ownership of local marine resources is a key step in generating strong support for conservation measures. Even in the absence of traditional or legal marine tenure systems (where communities directly own resources), ownership of the management of those resources engenders strong conservation support.
- Human resource development and institutional strengthening is best achieved through long-term, learning-by-doing mentoring processes rather than short-term, highly specific technical training programmes. Technical training can meet specific needs, but broad-based capacity building for conservation is best achieved through long-term, medium-input mentoring.

More information on the Bunaken National Park co-management initiative can be found at www.bunaken.or.id and www.bunake.info.

Revised zoning

(from Erdmann and Merrill 2003)

Clearly a balance between inputs from science and stakeholder participation is necessary in producing a functional and enforceable multiple-use zonation plan. One additional element of the Bunaken zonation revision process that is strongly in need of improvement is the involvement of local park managers and/or rangers in the zonation facilitation process. Unfortunately, the participatory zonation process relies strongly upon excellent facilitation skills that are generally lacking in park management staff; training opportunities to acquire these skills are also noticeably absent. It is highly likely that this situation is endemic to developing country MPAs, and conservation and development aid organisations interested in promoting effective MPAs should pay particular notice to this widespread need for better community facilitation skills in park managers…

The actual siting of individual zones was based upon a combination of scientific and stakeholder input and a commitment to include at least 20% of each island's reef area in "no-take" zones where fishing is not allowed (in accordance with the US Coral Reef Initiative and a number of other MPA design guidance papers). Both the strict conservation and tourism use zones are "no-take", and were sited to include known reef fish spawning aggregation sites, unique reef features and long-established dive sites. Village fishers were persuaded to agree to these 20% closures using careful explanations of the fisheries enhancing benefits of no-take zones.

To date (2002), these revised zonation plans have been extremely successful in terms of compliance and the overarching objective of allowing multiple uses of this highly valuable national asset while preventing stakeholder conflict. The resource base has also shown marked improvements; on Bunaken Island alone, the reefs have shown an incredible 11.3% increase in live coral cover and significant increases in size and abundance of commercially valuable fish species in the two years since the zonation plan was agreed upon (Erdmann, unpub. data). This success has encouraged Indonesia's Department of Nature Conservation to use the Bunaken experience as a basis for their new national technical guidance paper on MPA zonation (PHKA, 2002)" (also see Usher and Merrill 2000, PHKA 2002 and Annex X).

Lessons learned from the rezoning

(from Erdmann and Merrill 2003).

A number of useful lessons learned that may have wider applicability (especially to developing country tropical MPAs) can be drawn from the Bunaken zonation experience. These include:

- Multiple-use MPA zonation plans are an incredibly valuable management tool for mitigating conflict among stakeholders (eg, tourism operators and local fishers) and balancing effective conservation with sustainable development in developing country MPAs with large population pressures. These plans are most effective if based upon a combination of scientific/ecological considerations and input from a range of primary user groups who have received facilitation in understanding and accepting compromise.
- Zonation schemes should use a minimal number of zone types, with names that clearly indicate their purpose, explicit rules for allowed and disallowed activities, and clearly demarcated borders that utilise natural or otherwise well-known landmarks whenever possible.
- The process of creating a multiple use zonation plan (including wide stakeholder participation, facilitated compromise between groups, and widespread socialisation of the eventual zonation plan) is as important as the actual details of the eventual zonation system in terms of building support for and compliance with the system. However, an adequately participatory process is often long (measured in years) and requires significant financial commitments and excellent facilitation skills on behalf of the implementing agency(s).
- While stakeholder participation is essential, there is no one single best participatory approach to involving stakeholder groups in zonation plan development. The best participatory approach is one that has been carefully crafted to achieve maximum stakeholder involvement and acceptance based upon knowledge of the social dynamics of the individual user group targeted (which is often best gained from direct feedback from members of that group).
- Widespread socialisation of zonation schemes using a variety of media is absolutely essential to their success, but is not sufficient to ensure compliance. A strong enforcement system is critical to an effective multiple-use zonation system.
- A system which utilises relatively large contiguous zones rather than a series of many small zones is both easier to enforce and, in the case of no-take zones, likely provides greater conservation and fishery benefits.
- The zonation process is best viewed as an iterative process that needs evaluation and revision on a regular basis.

Surveillance and enforcement

(from Erdmann & Toengkagie 2003)

Additional difficulties associated with surveillance and enforcement were addressed in early 2001, when the Bunaken National Park Management Advisory Board (DPTNB) initiated a joint patrol system

that placed community members side-by-side with professional enforcement officers, to increase effectiveness of the patrol system (from Erdmann and Toengkagie 2003).

Forty five villagers, 16 park rangers and 5 water police officers constitute the core of this multistakeholder patrol system, which is focused upon 4 primary activities: 24 hour routine waterborne patrols, entrance fee enforcement, socialisation of the park's rules to villagers and visitors, and routine beach cleanups. While the involvement of civilians in patrols has been at times controversial and posed a number of unique challenges, the joint patrol system has proven a tremendous improvement to the previous system and has resulted in a dramatic decrease in destructive resource uses such as blast and cyanide fishing, mangrove cutting and endangered wildlife capture (also see Annex X).

The increased patrolling and stepped-up enforcement has led to a significant reduction in illegal fishing activities within the boundaries of the National Park. Live coral cover has increased by more than 11% over the past two years (to 2002). Park communities are enjoying community development support from conservation revenues. This success is only possible through the commitment of Park Management Advisory Board members to good governance principles of transparency and accountability.

Lessons learned from a multistakeholder enforcement initiative

While the adaptive management process for the Bunaken joint patrol system is ongoing, already there have been a number of important lessons learned that may prove useful to MPA managers considering the involvement of community members in joint patrol systems. Among the more important are: Involvement of villagers in a joint patrol system has associated costs and benefits, but benefits generally far outweigh the costs (see also Crawford et al. in press, Espeut, these proceedings).

Costs include

- Village patrol members require significant initial training.
- Village patrol members have no authority to arrest or carry weapons.
- Social jealousies can arise from villagers not involved in patrol system.
- Occasional conflicts of interest arise when violations are committed by friends or family members.

Benefits include

- Villagers are on the scene 24 hours/day, and have a vested interest in protecting "their" reefs for the future use of their children and grandchildren.
- Village patrol members have intimate knowledge of local reefs and the people exploiting them (both sustainably and in a destructive manner) – allowing them to quickly and effectively target those activities/user groups that cause most damage to the reefs, and allowing them to resolve resource use conflicts in a more consensual manner than rangers or police might.
- Alternative employment for fishers who would otherwise depend on reef resources.
- Extraordinarily effective socialisation of the conservation and sustainable use goals of the park - village patrol team members "socialise" the park even during their free time when interacting with other villagers on a social basis.

Involvement of a range of stakeholders (eg, rangers, police, and villagers from several villages) in joint patrol teams can greatly decrease the likelihood of corruption, collusion or conflicts of interest in dealing with violations committed by friends and family members. When developing an MPA multistakeholder patrol system that involves local community members, equal representation of all villages (and cultures/religions) within the MPA is an important precursor to acceptance and success of the patrols. Most MPA stakeholders (villagers, tourism operators, and others) support rules and regulations as long as they are clear and equitably enforced. Clear rules are easily understood and clearly posted. Equitable enforcement means that all those that break the rules are treated the same way.

Community stakeholders support patrol and enforcement programmes, as they are directly linked to increased livelihoods. Many illegal activities within protected areas come from outsiders. Communities with a stake in conservation management or sustainable utilisation of park resources have a strong and rational interest in seeing rules and regulations enforced so natural resources are sustained. The overwhelming majority of villagers in BNP has voiced support for a strong patrol system, and actively assist the system as "reef watchers" using the park-wide VHF radio system. Park managers and the rangers tasked with field management of the park commonly lack the community facilitation skills critical to ensuring broad stakeholder support and understanding of park management objectives. Training in facilitation skills for these park management personnel is an essential capacity-building measure.

When building a multistakeholder patrol system, it is imperative to appoint a strong leader who respects the other stakeholder groups but maintains a clear vision for the overall patrol team. This lesson was abundantly clear when comparing the northern and southern patrol teams; the northern patrol team, while receiving the larger amount of funding and facilities, was continuously hampered by poor leadership from the field coordinator – leading to infighting and less than optimal

performance. By comparison, the southern team, while operating on a smaller budget in an area with more hardened bomb fishermen, was highly successful, in large part due to an excellent field coordinator from the BTNB who maintained and nurtured the enthusiasm and commitment of the village patrol members.

It is extremely important to declare and treat marine resource crimes as serious offenses, and to apply enforcement evenly across all levels of society (including villagers, tourists, outside military/police/government officials, etc). Public support for patrols will rapidly decline if powerful individuals are given "special treatment".

Indonesian courts typically treat destructive fishing and other marine resource crimes as light offenses. Education of all levels of the enforcement/prosecution system is required to provide understanding that marine resource crimes rob future generations of their livelihoods and must be punished severely. Enforcement is a continuous, ongoing need **–** there will always be individuals ready to engage in illegal (and profitable) activities if enforcement activities are decreased below effective levels…..

Since its inception, the joint patrol system has consistently ranked the most expensive programme in the DPTNB annual budget. In 2001, the patrol system recorded 222 164 725 Rp (~22 500 USD) in operational costs (including salaries for village patrol members and bonuses for rangers/police, as well as fuel, equipment maintenance, criminal investigation and court costs, and training), plus an additional 9 000 USD in equipment procurement (2 wooden boats with outboard engines). In 2002, with both northern and southern patrols operational for the entire calendar year, overall operational costs totalled 531 000 000 Rp (~59 000 USD), plus an additional 29 000 USD in equipment procurement (VHF radio system, 2 engines and 1 boat). The 2003 DPTNB annual budget includes 673 000 000 Rp (~76 500 USD) for patrol operational costs plus an additional 22 000 USD in equipment procurement (polyethylene hull speedboats with environmentally-friendly four-stroke engines). For all three years, operational costs were funded by entrance fee receipts and two grants from WWF-Wallacea, while equipment procurement was funded by USAID's NRM programme. While it is envisioned that equipment costs should be minimal in the foreseeable future, operational costs are projected to stabilise at the 2003 level. Using this projection, the BNP joint patrol system costs approximately 0.85 USD/ha/year.

It is important to note that while the overall percentage of the DPTNB budget devoted to the patrol system has dropped from over 50% in 2001 to roughly 15% in 2003, the costs have actually risen and there is no indication that these costs will decrease in the future. Unfortunately, even though broad socialisation of park rules has resulted in increased compliance, the economic incentive to illegally extract resources in the park only increases over time (as resources are overexploited outside of the park) – necessitating a continuously vigilant patrol system. BNP experienced this firsthand in January 2003, when a temporary work strike by village patrol members resulted in an immediate spike in blasting and cyaniding activities within the park – in the space of two weeks!

Development and Results of Bunaken Entrance Fee System (2001-2002)

(from Erdmann et al. 2003b)

Since 2000, USAID's Natural Resources Management Program has been assisting the multistakeholder Bunaken National Park Management Advisory Board in developing a model entrance fee system under special "pilot project" status granted by the Indonesian national government. Based upon the highly successful Bonaire Marine Park entrance fee system, the Bunaken system successfully raised nearly 42 000 USD in its first year of operation in 2001. With the strong support of the local tourism sector, the fee for international tourists was doubled in 2002, raising ~110 000 USD from over 8 000 international and 17 000 Indonesian visitors. Revenues from the fee system now fund a park-wide joint ranger/police/villager patrol system, environmental education programmes, and village-level conservation and development programmes.

In its inaugural year, the BNP entrance fee system was quite successful, with total entrance fee receipts of 418 187 500 Rp (~42 000 USD) recorded during the period of 15 March-31 December 2001. These fees were collected from a total of 15 055 visitors to the park (including 5 183 foreign guests, 8 387 adult Indonesians and 1 485 Indonesian students). Taking into account the late start of the entrance fee system and the effects of the 11 September 2001 terrorist attacks on tourism, the overall visitation for the park for 2001 was projected at the level of 25 000 visitors (15 000 Indonesians and 10 000 foreigners). Although they represented only 34% of visitor numbers, international guests generated almost 95% of the entrance fee receipts. In total, 37 countries were represented in the entrance fee database, with the top country of origin being the UK, followed closely by the USA, Italy, Holland, and Germany. A second tier was comprised of Singapore, Japan, France, Taiwan, Hongkong, Switzerland, and Spain.

Of the revenue collected, 20% was distributed to the various levels of government as per provincial law. Approximately 50% of the proceeds were used to fund the joint ranger/police/villager patrol system for BNP,

Table 1 Entrance Fee Schedule for Bunaken National Park as prescribed by North Sulawesi Provincial Law No. 9/2002.

Researcher and Commercial Filmmaker fees are charged in addition to applicable visitor fee. Residents of the 22 villages in the park and their Indonesian house guests are exempt from paying the visitor fee, while researchers from local provincial universities and institutions are exempt from the researcher fee.

Fee Category	Indonesian (Rp)	International (Rp)
Visitor		
Yearly tag	No Data	150 000
Daily ticket	2 500	50 000
Student/child	1 000	No Data
Researcher		
1-7 days	45 000	100 000
8-30 days	75 000	200 000
1-6 months	125 000	400 000
.5-1 year	200 000	600 000
>1 year	250 000	800 000
Commercial Filmmaker		
Documentary film	2 000 000	3 000 000
Documentary video	500 000	1 000 000

while another 10% was used to purchase and install village information billboards in all 30 settlements within the park. The remaining 20% was set aside for use in the following year's BNPMAB budget.

Based upon the overall success of the fee system in 2001 and broad support from the tourism industry, the annual fee for international visitors was doubled in 2002, becoming 150 000 Rp (~17 USD). It is interesting to note that such a rapid raise in the fee is quite unusual for most MPAs and underlines the importance of working closely with the tourism sector; De Meyer and Simal (these proceedings) report that Bonaire tour operators have resisted a fee raise for over a decade. Additionally, a one-day ticket (50 000 Rp) for international guests was introduced at the request of the local cottage owners (see below). Despite a drastic decrease in international visitors following the Bali bombing incident on 12 October 2002, the BNPMAB managed to record total yearly receipts of 983 750 500 Rp (~110 000 USD). These revenues were generated from a total of 25 697 paying guests, composed of approximately 2/3 local Indonesian guests and 1/3 international visitors. Of the 17 435 Indonesian guests, most were adult guests (14 525), while 2 910 students also were recorded. By contrast, a total of 8 262 international guests were recorded from 48 countries. Most of these international guests (5 294) purchased one-year waterproof entrance tags, while an additional 2 968 visitors purchased single-day entrance tickets. Taiwan, Italy and the United Kingdom were the top three countries of origin for international visitors to BNP during 2002, with 1 431, 1 075, and 793 guests, respectively. The notable predominance of the Taiwanese and the significant drop in American visitors can be attributed to the introduction of direct international flights to Manado from Taiwan in early 2002 and the American reluctance to travel internationally in the wake of the 11 September 2001 terrorist attacks.

As with the 2001 revenues, 20% were allocated to national, provincial and local governments, with an additional 40% of the revenues spent on support for the joint patrol system. New in 2002 was an expenditure of over 30% of total revenues on village-level conservation and development programmes (including a 30-station park-wide VHF radio system, beach cleanups, construction of public toilet and water facilities and paved footpaths, and mangrove rehabilitation programmes). Additional expenditures for 2002 included support for a nascent biological monitoring programme and villager environmental education-

A key factor in the continued success of the BNP entrance fee system has been continuous engagement with all levels of the tourism sector to obtain feedback and adapt the system to any perceived shortcomings. One clear requirement from the tourism community has been the need for continuous socialisation of the fee system and full transparency regarding results. The BNPMAB regularly updates FAQ sheets and posts the results of the entrance fee system (monthly revenues and expenditures, etc) on websites, bulletin boards throughout the park, and via email lists. Brief updates on entrance fee results are also submitted to international dive and nature magazines. Another key area of improvement suggested by the tourism industry (and highlighted by the detailed statistics collected by the entrance fee system) was a new focus on meeting the demands of local Indonesian tourists. During the first year of the entrance fee system, the BNPMAB focused on foreign divers and snorkellers as primary customers, devoting most management efforts towards improving patrols and other activities to maintain and improve the quality of the reefs. However, it soon became evident that local tourists are far more numerous, and that they have quite different demands for a "quality MPA experience": clean beaches and public picnic and toilet facilities – with reef quality being largely irrelevant! More recently, the large increase in day-tripping Taiwanese snorkel tourists has required yet another management paradigm shift; unlike BNP's "normal" clientele of relatively experienced (and environmentally-enlightened) divers, this type of tourist requires specific education and patrol programmes to prevent reef trampling. With both of these situations, close monitoring of entrance fee data combined with continuous engagement with the tourism community has allowed adaptive management changes.

Yet another improvement to the fee system suggested by the tourism sector was the provision for an incentive system for tag sales to

further prod uncooperative operators to participate willingly. Under this agreement, a 5% "commission" (7 500 Rp/tag) is offered by the BNPMAB on all entrance tag sales. However, to promote institutional strengthening of the tourism sector and better cooperation, this incentive is not paid directly to individual tourism operators, but rather to the trade association of their choice (including the NSWA, the local cottage-owner association, the charter boat association, and the travel agents' association). Moreover, the commission is only paid on yearly entrance tags, in order to encourage operators to sell the tags instead of one-day tickets. This system has also improved compliance and cooperation, and allowed some interesting initiatives to develop; the NSWA uses the proceeds of these commissions to fund a scholarship fund for local high school students from within the park, and the cottage owner association uses their commissions to fund weekly beach cleanups by local villagers.

A final improvement suggested by the tourism community was the introduction of an entrance tag design contest open to all guests visiting the park. For the first two years, the tag design was decided internally within the BNPMAB. While the tag designs were enthusiastically received and the tags have in fact become a collector's item (the BNPMAB received several requests from abroad to purchase tags without visiting the park!), members of NSWA suggested that a tag design contest would only further promote the entrance fee system. The 2003 tag design contest was announced in June 2002, with a deadline of October 2002 to provide ample time to select and print the winning tag design by December 2002. Participants were allowed to submit up to three photographs or graphic designs each for consideration, with the winning prize being a return airfare from Singapore to Manado (donated by SilkAir) and a 5 day all-inclusive diving package at one of 6 participating dive resorts. Importantly, any submitted photos or designs become the non-exclusive property of the BNPMAB for use in printed conservation materials (posters, brochures, and calendars) for the park. The contest has proven very popular and is now in its second year.

Future plans

In the long run, the BNPMAB is targeting up to 250 000 USD a year from the entrance fee system. The projected increase in revenues is assumed to come from a combination of increased visitor numbers and eventual fee raises (both for local and international visitors). At the same time, NRM is now working with the BNPMAB and the tourism sector to set visitor carrying capacity limits and legislate these limits to prevent the onset of mass tourism. Increased user fees will likely be one tool that will be used in the future to limit visitor numbers to a sustainable level.

At the same time, the BNPMAB is also working to further diversify the BNP funding portfolio to prevent overdependence on the entrance fee system (which is subject to potentially large disturbances to international tourism). Specific targets include an international volunteers system to lower management costs, diversified government agency support, in-kind support from the local dive tourism sector, and national and international grant support. Two additional sources of funding that are currently under development include visitor center merchandising and a possible endowment fund. Finally, BNP has been selected as one of four MPAs to participate in a pilot study to develop business plans for Asian MPAs under the auspices of the World Commission on Protected Areas South East Asia Marine (WCPA SEA Marine) working group. With these initiatives well underway, the BNPMAB is targeting financial sustainability by 2005.

Annex IX
Small versus large PAs in tropical developing nations

(From Natural Resources Program Headline News Issue 35, November 2001, courtesy M. Erdmann, Bunaken National Park).

Considerable recent debate has centred on the relative merits and drawbacks of small (less than 2 hectare) community-based MPAs versus large (tens to hundreds of thousands of hectares), often centrally-managed MPAs - the marine equivalent of the well-known SLOSS (Single Large Or Several Small) debate in terrestrial conservation circles. This debate has particular relevance to Indonesia and the region as a whole at this time, when several large institutions appear to be favoring the small community marine reserve approach based upon an apparent belief that large MPAs are much more difficult to manage and often face significant public opposition. A good case study for Indonesia is the Philippines, where there are reportedly almost 100 small municipal MPAs and relatively few larger MPAs (with Tubbataha being a notable example). Indeed, the increasing prevalence of Philippines fish poachers in Indonesian waters suggests that the Philippines MPA strategy has not been altogether effective!

Several Philippines representatives at the UNEP-sponsored Workshop on Networking of MPAs in the East Asian Seas held in Kota Kinabalu, Malaysia from 8-12 October 2001 argued strongly for the small community reserve approach, citing the strong community support that is often achieved and the resulting efficacy of management. On the other hand, many marine scientists present at the meeting pointed out that current ecological theory on reef organism life histories and recruitment dynamics suggest that such small reserves, even if relatively high in number, cannot maintain viable populations of many important reef species. While small community reserves are an excellent MPA marketing tool to increase village awareness and participation in marine conservation and possibly to increase local fish catches, networks of large reserves (on the scale of tens of thousands of hectares) are critical for the survival of rare, widely-spaced or highly mobile reef species. A commonly-cited example are groupers (fish), which can travel up to 10km or more to spawn in large aggregation sites. Without large reserves that include the entire home range of such groupers (including the spawning aggregation sites), there can be no effective protection of grouper stocks.

It would seem appropriate that the debate raised at the Kota Kinabalu workshop should be revisited in Indonesia for the purpose of formulating this country's future MPA network strategy. The current focus on small community reserves is certainly important and should continue to be encouraged - but not to the exclusion of large reserves. These large MPAs, while often presenting a much more complex management situation, are an essential component of Indonesia's marine conservation efforts.

Annex X
Selection of coral reef marine protected areas

(Courtesy of Rod Salm, The Nature Conservancy).

"Although existing MPA selection criteria and design principles do not define specific management measures to address emerging global threats such as climate related coral bleaching, they retain definite value. They help to define conservation objectives and targets, beginning the process to identify the threats to these, along with their sources or root causes, and to determine management strategies to address the threats. These criteria and principles provide the focus for coral reef conservation planning and – along with various approaches, such as community participation, co-management, and the like – provide the core strategies for effective MPA establishment.

MPA selection criteria do not adequately address survivability. In fact, tourism and fisheries have usually determined the selection of smaller MPAs or the different zones within larger ones. Tourism and fisheries are important sources of revenue and livelihood in most developing countries and so are given high priority. More often than not, MPA selection is frequently determined by opportunity (strong local community and/or government support) or crisis (a high level of threat to a site that is considered important for any reason), which is how tourism and fisheries often lead the process. Opportunities and crises are likely to arise at intervals, but one needs to get ahead of them if MPA selection is to proceed in a planned and orderly fashion. In this context, it is important that we move fast to secure adequate levels of protection for coral areas that are both resistant and resilient to mass bleaching, perhaps one of the greatest emerging threats of this century faced by coral reefs.

In addition to the usual criteria for selection of coral reef MPAs , here are some additional principles and criteria for coral reef MPAs under an entirely new category: survivability.

Additional principles for the selection of coral reef marine protected areas

First principle: The survival prospects of coral reef communities in the face of large scale climate related events, such as their resistance and resilience to bleaching, should receive serious consideration in the selection and design of MPAs. Unless MPAs are designed and managed specifically to survive massive climate-related bleaching and mortality, coral reef communities in even the most effectively managed sites may be susceptible to such events. Thus we need to identify coral reef communities with a high probability of resistance and resilience to such unmanageable events as mass bleaching, afford them high levels of protection, and incorporate these into larger management areas that include as many reef types and habitats as possible.

Second principle: Replication of MPAs along prevailing, larvae-carrying currents (corridors of connectivity) will greatly increase the probability of survival for multiple reef communities and their prospects for reciprocal replenishment. Threats to coral reefs are unprecedented in their severity and extent, and it is not altogether predictable where and when global events will strike. Replication of MPAs and connectivity among them will help some reef communities to escape major impact, aid in the recovery of damaged areas down-current, and increase the prospects for reef survival at current levels of biodiversity. Thus replication of sites and connectivity among reefs (as expressed through larval dispersal along currents and through species movements) should also be applied to the selection of sites.

Third principle: MPAs should be selected to represent the full national or regional range of coral reefs, and should include other functionally linked habitats such as seabed, seagrass, mangrove, and coastal and riparian areas. Patterns of climate-related bleaching and mortality are neither fully understood nor predictable. But it is known that pockets of resistance to bleaching are distributed among reef types and different parts of the same reefs. It is also known that the reef ecosystem extends beyond the physical reef framework to include a range of habitats that are linked by physical and ecological processes, including the transport of nutrients by currents or daily feeding migrations of reef species. These processes help to maintain coral reef communities in a "healthy" state. Thus protection of a range of different reef communities and linked habitats will increase the prospects that some will survive bleaching. Furthermore, maintenance of unimpeded reef processes will enhance the prospects of rapid recovery in areas that suffer different levels of mortality.

The coral reef marine protected areas site selection process

The objective relating to the first selection principle above is: to identify and adequately protect reefs or parts of reefs that reliably have one or more environmental factors present that: have a significant positive effect on coral reef resistance and resilience to climate related bleaching and enhance recovery of affected areas; and are sufficiently reliable and persistent through time in their presence and effect. These sites should be the essential foundation for a network of coral reef MPAs that is designed to conserve representative biodiversity.

The objective relating to the second selection principle above is: to identify and adequately protect reefs and reef complexes that are linked by prevailing currents, larval dispersal where this can be demonstrated, and species migrations. These sites should be the essential building blocks of a network of coral reef MPAs.

The objective relating to the third selection principle above is: to identify and adequately protect reefs of different morphology, species composition, and environmental conditions along with the adjacent habitats that are linked through physical or ecological processes. These areas and their surrounds should be listed as candidate sites for establishment as MPAs. The resistant coral communities should be considered for zoning as strict reserves under the highest levels of protection. The resilient coral communities and adjacent linked habitats should be zoned as strict reserves under high levels of management to enable control of all direct and upstream sources of threat.

Deciding priorities

The four basic steps followed in systematic selection of MPAs (Salm et al. 2000) can be easily adapted to apply specifically to coral reefs. These steps include the collection, analysis and synthesis of data leading to the identification of candidate sites, followed by the application of criteria to select specific sites for protection.

A simple low cost option for data collection is described below:

- Identify areas with high cover of old corals: at the simplest level, and in the absence of any other information, undertake field surveys to identify those places where corals survived an earlier known bleaching event. Having survived one major bleaching event, these sites are more likely to survive a future one and should be listed as candidate sites. Presence of high cover of old corals could also indicate areas where coral communities are at low risk of exposure to bleaching because of their location and prevailing climate and oceanographic conditions. These should also be considered candidate sites.
- In the absence of any capacity, time or resources to undertake a formal oceanographic analysis, refer to existing atlases or texts that could supply information on sea surface temperatures (SSTs), current strengths, presence of upwelling sites, exposure of corals at low tides, and coral communities in or near estuaries, bays and lagoons with predictably turbid waters. Oceanographers, dive operators, researchers and fisheries colleagues may be able to assist.
- Consult atlases, nautical almanacs, oceanographic texts, and oceanographers to produce maps in greatest possible detail of local inshore as well as offshore currents and combine these with data on fish movements obtained from fisheries authorities and reports.
- Supplementary data will need to be collated from the literature, field surveys, interviews, and any other sources to help identify other values (e.g., endangered species habitat, fish spawning aggregations and nurseries, suitability for tourism, and so on depending on identified local or national priorities), levels and types of use, types and severity of threats, relevant oceanographic data, administrative districts, and locations of existing or proposed MPAs.

This procedure will produce a list of candidate sites with high survival prospects and the currents will indicate likely seasonal connectivity among them. Adding other values, levels of use, and degree of threat will help the selection of the most viable sites for conservation investment.

Applying MPA selection criteria

To cope with global threats and the unprecedented fishery and other pressures on coral reefs, there is little doubt that the world will need to go further if we expect reefs to survive. We will need to protect areas that we know have a high probability of surviving a mass bleaching event. Furthermore, we will need to acknowledge the greatly diminished relevance of urgency, opportunity, and political or popular pressure, which in the past have often made the first areas for protection so obvious that there has been no need or opportunity to apply criteria at any stage.

For the purposes of biodiversity conservation, criteria that favor survival are of critical importance. Criteria stressing naturalness, uniqueness, and habitat or species diversity are complementary, as they lead to the selection of sites with maintenance of biodiversity, safeguarding of ecological processes, and species replenishment as the primary management objectives.

The thoughtful identification and application of selection criteria will help to clarify the goals of MPA networks and their component sites. This also helps to ensure representation of all interests and priorities in the MPA networks. Ultimately, MPA networks should aim to include the full range of coral reef types and biodiversity, be interconnected by larvae-carrying currents, and include other functionally linked habitats, whether contiguous or geographically separated.

The assumption that corals which have survived a previous known bleaching event have a high probability of surviving a future one is a useful shortcut to identify MPA sites that are likely to survive bleaching events. These sites can be identified by the presence of living coral colonies covering a range of sizes, including large old ones.

Criteria for the selection of coral reef marine protected areas

Criteria	
Social	Social acceptance, public health, recreation, culture, aesthetics, conflicts of interest, safety, accessibility, research and education, public awareness, conflict and compatibility, benchmark
Economic	Importance to species, importance to fisheries, nature of threats, economic benefits, tourism
Ecological	Biodiversity, naturalness, dependency, representativeness, uniqueness, integrity, productivity, vulnerability, spawning aggregations
Regional	Regional significance, subregional significance
Pragmatic (these are weighted heavily):	Urgency, size, degree of threat, effectiveness, opportunism, availability, restorability, enforceability

(Source: Salm et al. 2000)

This section lists the proposed new survivability criteria for coral reef MPAs. Existing criteria are summarised in the table above below, but are not described in detail in this report.

Examples of MPA selection criteria

Survivability Criteria:Long term survival prospects of coral reef communities in the face of climate-related bleaching can be enhanced by the presence of any of the following environmental factors acting together or in isolation.

Resistance to coral bleaching as manifested by the reliable presence of one or more of the following factors that are not shut down during bleaching events:

- Factors that promote water mixing
- Proximity to deep water and regular exchange with cooler oceanic water
- Localised upwelling of cool water
- Permanent strong currents (tidal, ocean, eddies, gyres)
- Factors that screen corals from damaging radiation
- Deep shade from high land profile
- Shading of some coral assemblages by complex reef structure, multilayered coral communities, or steep slopes
- Orientation relative to the sun (north facing slopes in northern hemisphere, south facing in southern hemisphere)
- Presence of consistently turbid water
- Factors that indicate potential pre-adaptation to temperature and other stresses
- Frequent exposure of corals at low tides
- Highly variable seawater temperature regime (pond effect in shallow back-reef lagoons)
- History of corals surviving climate related bleaching events
- High diversity and abundance of coral reef species
- Wide range of coral colony size and diversity in different reef zones, including centuries old colonies
- High live coral cover
- Factors that favor survival of at least some coral communities
- Stable salinity regime
- Large area with wide depth range and habitat variability
- Low risk of exposure to climate related temperature stress at the location (high latitude)

Resilience to coral bleaching as manifested by the reliable presence of one or more of the following environmental factors that may promote recovery:

- Factors that indicate strong recovery potential
- Strong coral recruitment
- Presence and abundance of coral recruits
- Recruitment success
- Factors that increase coral larval transport to the site
- Strategic location that will maximise both strong and reliable recruitment of all species present, whether from other reefs or from within the same reef complex
- Direct current links with neighboring reefs and the strong likelihood that a proportion of the propagules will effectively seed other areas
- Replication of sites along prevailing currents to insure against the risk of no meaningful recovery after a large-scale event eliminates essentially all corals and/or other taxa.
- Factors that prepare the substrate for successful coral larval recruitment
- Diversity and abundance of different coral reef taxa, especially high herbivore densities, and representative community structure.
- Low abundance of coral feeders, bioeroders and disease.
- Good potential for recovery because effective management regime in place.
- Resilience of mangroves to sea level rise as manifested by extensive salt flats along the inland border of the mangrove and onto which the trees can expand as sea level rises.

Design principles for coral reef marine protected areas

This section is intended to help coral reef MPA planners and managers to select reef components for protection and draw protected area boundaries.

Design principles

Resistance to bleaching (coral colonies don't bleach or bleach but don't die) may vary among different parts of a reef. Reef communities with high resistance to bleaching should be afforded highest levels of protection and should be buffered within larger management areas. These resistant communities play a critical role in reef survival by providing the larvae to recruit to and enable recovery of affected (Salm et al. 2001, West 2001).

Resilience to bleaching (coral colonies bleach and partially or entirely die but the coral community recovers rapidly to its former state) also varies among different parts of a reef and among different reefs in the same complex. Reefs or their components that demonstrate resilience to bleaching need to be included in zones of high levels of protection and should be managed to maintain conditions that facilitate successful coral recruitment and recovery. These resilient areas may support different and complementary elements of biodiversity and will likely play important roles in conservation.

Connectivity within reefs is an important determinant of MPA zone and boundary locations. Strict protection zones that include areas of high resistance to bleaching should be positioned upcurrent of sites with lower resistance to facilitate their recovery by larval recruitment.

Connectivity among reefs is an important determinant of MPA network design. A network of MPAs linked by prevailing currents to each other will facilitate the recovery of damaged areas and the maintenance of biodiversity through larval exchange.

The reef ecosystem extends beyond its physical boundary to include the neighboring habitats with which it interacts, especially seagrass beds and back-reef lagoons, which provide important fish nurseries. All these linked habitats need to be considered and managed as parts of a single functional unit.

Coral reefs are linked intimately by dynamic processes (currents, rivers, and species movements) to distant areas and may be influenced by the activities there. These activities require some form of control if reef communities in a protected area are to survive.

At a *critical minimum reef size*, the diversity of coral, and presumably of other reef organisms, begins to decrease (Salm 1984). The core area of a protected coral reef, including its component resistant and resilient communities, should be as large as possible to preserve high diversity of reef biota. Based on the results of the only study of its kind, the critical minimum size for resilient coral reef communities to enable them to be self-replenishing for all corals is estimated as 450 hectares (Salm 1984). However, it is feasible that clusters of smaller and highly interconnected areas may serve the same purpose. The minimum size for MPAs will need to be much larger to sustain viable populations of large predatory fishes.

Replication of protected resistant and resilient coral communities at multiple sites increases the probability that some will survive bleaching to help the recovery of affected areas. MPAs should be designed to include multiple samples of protected resistant and resilient coral reef communities.

Coral reef users, like traditional fishers, dive operators, and other user groups, should be assisted to understand the principles of coral resistance and resilience to bleaching and should participate early in coral reef MPA selection and design. This will help to ensure clear understanding of the concept of reef survivability, strong grassroots support for conservation at the site, and effective partnership in management where appropriate.

Design process

Site conservation planning is well designed for localized threat abatement and may even help to anticipate some potential stresses linked to distant sources (like sedimentation from a proposed development linked to deforestation in a watershed, as one example). However, "site" conservation planning is linked through its title and intent to a "site:" targets at the site, stresses at the site, sources linked to those stresses at the site, and management strategies for their control or abatement. Global, largely unmanageable stresses do not fit easily into this approach and are better addressed through strategies for mitigation.

We can go about this mitigation process by doing what we should always do for MPA management planning in coral reef areas through the threat abatement process, but would add an extra dimension – planning for survivability in the face of emerging threats. We would start by identifying areas with resistance to bleaching and would give these high levels of protection along with the more usual range of critical habitats like spawning aggregations, nesting islands (for seabirds), beaches (for turtles), nurseries (for fishes), and so on. Also, to enhance the recovery of areas affected by bleaching, we should position resistant sites upcurrent of both resilient areas and others that succumb to bleaching and die. By reducing or eliminating threats in areas prone to bleaching, we can provide conditions favoring larval recruitment and recovery of coral communities.

In addition, we need to establish ecologically sound boundaries for MPAs and their included zones. To determine these boundaries, we need to answer two basic questions (Salm et al. 2000): which habitats should be included in the MPA and its component zones of different uses and management focus and how large should the MPA and each of its zones be?

Which habitats?

To help preserve the full range of coral reef biodiversity, a MPA should contain many different reef zones and habitats for a steady and varied

supply of larvae to replenish naturally damaged areas and to replace dead or emigrated organisms. These habitats should span a broad range of depths, exposures to prevailing winds and currents, and distances from shore. This is particularly important to ensure that some coral communities survive bleaching and provide a source of larvae to settle and help reestablish portions of the reefs that die off.

In practice, three categories of habitats should be considered for inclusion in coral reef MPAs: coral habitats, contiguous habitats (i.e., submerged, intertidal, or above water), and distant linked habitats. Although the latter two categories may not be physically part of the reef community, they are linked closely through function.

Coral habitats

Different reef types, depths and zones within reefs are characterised by different coral communities and different responses to temperature stress and bleaching. There are corals in shallow lagoons, reef flats and reef crests, and others that are found down the reef slope, some of which only occur deeper than about 20 meters. Dominant corals and coral diversity differ in each assemblage; for example, sheltered reefs may have dense overlapping colonies of staghorn coral (Acropora) or large whorls of leafy corals (Montipora, Pachyseris, Echinopora) that are scenic, but have few species. Such reefs may be valuable for tourism, but are less so for conserving a representative range of biodiversity. They also tend to bleach readily and die. It is important to identify all reef types and, as far as possible, the different coral communities within them, and to include multiple examples of each in the protected area where possible.

Contiguous habitats

Examples of the following habitats should be deliberately identified and protected within MPA boundaries.

Reef flats. Corals on reef flats and upper reef crests that are exposed at low tides often exhibit high levels of resistance to bleaching and will be important providers of larvae that may settle in dead areas and aid their recovery. Also, these reef flats often provide vital nurseries for reef fishes that will move onto the reef and help reestablish communities affected by bleaching. Nitrogen and organic material produced on the reef flats or transported from there in the form of feces of herbivorous fishes and other organisms all contribute valuable nutrients to the reef community and aid in its functioning and recovery.

Back-reef lagoons. Coral assemblages in back-reef lagoons, especially shallow lagoons behind fringing reefs, are routinely exposed to wide temperature fluctuations (pond effect) and consequently may exhibit some acclimatisation to temperature stress and resistance to bleaching. They are also important nurseries for fishes. Corals in naturally turbid deeper lagoons also show higher resistance to bleaching than the same species in clear waters over barrier reefs.

Seagrass beds and sand flats. Seagrass beds and sand flats surrounding coral reefs are important feeding grounds for nocturnal feeding fishes, such as snappers and grunts, which shelter on reefs by day. When they return to the reef, these fishes deposit nutrients in the form of feces that are introduced to the reef food web and contribute to the growth and recovery of reef communities.

Mangroves. The generally turbid waters and shading effect of mangroves may also reduce the susceptibility of corals there to bleaching. Mangroves also provide nurseries for juveniles of certain reef fishes (e.g., butterflyfishes, parrotfishes, and snappers). Where they are close enough to reefs, mangroves provide feeding grounds to fishes that shelter on the reefs. They also introduce fixed nitrogen and organic detritus into the trophic system of reefs, as do reef flats and seagrass beds.

Beaches and dunes. Coastlines are dynamic zones. Disturbances to them may cause beach erosion and alteration of the natural cycle of accretion and erosion of sand along the shore, increase turbidity of inshore waters, or even smother living reefs with excessive sediment. This is especially true of sand cays, which have been known to move across reefs and smother corals.

Linked habitats

Sources of stress to coral communities that are not easily identified discernible may be difficult to control, such as deforestation and development in a watershed. While watersheds are not obvious or easy candidates to include in coral reef MPAs, they may be connected to reefs by streams and coastal currents and damaging activities there will need to be controlled by a reefs to ridges approach to MPA planning or complementary coastal zone management approaches.

How large?

In theory, we know that we could help prevent loss of species within an MPA if we maintained a balance between the rate of species loss and the immigration rate of replacement species. If the balance is tipped in favor of extinction by damage and death of corals on the target and up-current source reefs, the protected area will lose species. There are many natural stresses such as tropical storms, from which reefs recover naturally with time. Human activities increase the burden of stress and may prevent normal recovery by increasing the extinction rate or decreasing the immigration rate. Coral bleaching has increased the

stakes – it challenges us to take immediate action based on our best information and to refine our management focus as the science and experience improve. In the meantime, we need to take a precautionary approach and create larger more viable MPAs to safeguard our global coral reef biodiversity and resources.

To maintain the balance between immigration and extinction rates we need to ensure a steady source of recruits (eggs, larvae, and juveniles) to replenish stressed areas. Large reefs may be self-replenishing. They manage to achieve this because their large size allows portions of damaged reefs to be replenished by recruits from undamaged parts of the same reef. Such large reefs are mosaics of communities in different stages of recovery and development.

On balance, fewer large coral reef MPAs are to be favored over a greater number of smaller ones. However, there could be distinct advantages of having clusters of small, strictly protected areas established to protect pockets of high resistance and resilience to bleaching (and other valuable assets, such as fish spawning aggregation sites), if these are embedded in a larger management area.

The optimal size of a coral reef MPA is designed around a strictly protected zone or core or collection of these, each of which encompasses sufficient target coral area to be self-replenishing for all species. This focus on replenishment is particularly important if preserving biological diversity is the principal management objective, but may seem less important for other objectives - for example, maintaining the area's value for recreation, tourism, research, education, and spawning of specific fishes. However, coral bleaching has shown us that replenishment is an important consideration for reef survival, irrespective of the management objective. Bleaching shows no regard for MPA zones, boundaries, regulations, or management efforts, unless these are designed to meet the survivability requirements.

Determining the critical minimum size of coral reef communities for these to be self-replenishing is still very imprecise science. However, if urgency or lack of funds and suitable personnel prevent studies from beginning immediately, core areas should include about 450 ha of bleaching resistant coral areas, if possible, until the estimate can be verified by studies (Salm 1984, Salm et al. 2000). Also, the core should be expanded so that it encompasses as diverse as possible a range of reef habitats. A single reef is preferable, but a cluster of small reefs will probably be equally effective when these are managed as an integrated unit.

The design team should choose carefully from the many objectives for protecting coral reefs - providing for recreational activities, contributing to fisheries, preserving biological diversity, or protecting endangered species or the breeding stock of other valuable species. But primary importance should be given to survivability and the subsidiary objectives worked into this. Objectives are the basis of design, so take care to define and obtain wide consensus on these and to include survivability among them.

Management guidelines for coral reef protected areas

This section is intended to assist coral reef MPA managers develop and implement a series of management actions that focus on enhancing coral reef survivability in the face of climate-related coral bleaching and mortality. As there will be much overlap between management of reefs for survival from bleaching and from other factors, the following actions are intended to supplement, not replace, the usual suite of coral reef management activities that managers would implement in MPAs.

It is more usual for management actions in MPAs to be defined by a site conservation planning approach that leads through problem identification to threat abatement: specific (usually immediately obvious) impacts on the conservation targets are identified and management actions identified to resolve these at the MPA site. The focus of such an approach on coral reefs generally would be to identify areas of dead or damaged reef or depleted species, determine the causes of the damage or depletion and their sources, and design a course of action to address these sources of impact. For example, coral breakage might be the consequence of anchors (the cause) associated with the tourism industry (the source). The remedial management measures might call for placement of moorings, reef closures to facilitate recovery, and a range of regulations and awareness materials to support these actions.

In another example, reduced grouper populations may be the result of fishing of spawning aggregations (the cause) to supply the live reef food fish industry (the source). This could require protection measures at the spawning aggregation sites linked to local and national level government regulations and international codes of conduct and tracking to monitor the trade. These are admittedly simplified examples, but are included to make the point that management in both cases is linked directly to site-based threat abatement, which is our usual practice.

In addition to the basic elements of design introduced above, managers can take some specific actions to help strengthen the resilience of the coral communities in MPAs by helping to (a) ensure the survival of bleaching resistant coral communities, and (b) enhance recovery of bleaching susceptible ones.

The following recommended actions contain some direct management interventions that may be controversial in some cases because they require manipulation of natural systems. Managers should use their own judgement in deciding what they can and cannot do as guided by their organisational policies.

Protecting bleaching resistant communities

- Survey MPAs and their adjacent areas for the presence of environmental factors that cause bleaching resistance and identify coral communities protected by them (see Survivability Criteria).
- For resistant coral communities inside established MPAs, consider securing high levels of protection for them by revision of zone boundaries or establishment of special zones to encompass these sites.
- For resistant coral communities outside established MPAs, consider extending MPA boundaries to incorporate these sites if feasible or the creation of new MPAs to include them.

Tracking bleaching

- Revise monitoring programmes or design new ones to enable recording of the response to bleaching events of as great as possible a selection of different coral communities.
- Track the bleaching widely throughout the MPA to identify areas that either do not bleach or do bleach, but suffer minimal mortality – these are the resistant sites that should be strictly protected.

Preventing damage

- Prohibit all forms of extractive use (other than specific management related removal of damaging species) in the protected, bleaching resistant sites.
- Control visitor access to protected, bleaching resistant sites through either total exclusion or carefully controlled access.

For carefully controlled access to bleaching resistant sites in MPAs:

- Prohibit anchoring, install moorings, and require boats to attach to these;
- In channels through reefs and along walls, consider permitting drift diving as a means to avoid contact with corals;
- Control numbers of visitors and link access to payment of premium access fees to help compensate for the higher management cost of these areas;
- Require accreditation of operators before issuing them special licenses to access resistant sites;
- Implement regular monitoring for visitor damage and close down access for two-year recovery period if damage is detected.
- For bleaching susceptible sites, consider closure or exclusion of certain potentially damaging activities after a bleaching event to enable rapid recovery.

Enhancing recovery

- Conduct regular surveys for coral predators such as predatory molluscs (e.g., Drupella) and echinoderms (e.g., Acanthaster) and remove these on sight from the strictly protected bleaching resistant zones and adjacent, managed, susceptible areas.
- Implement regular surveys of sea urchins, such as Diadema, which can occur in large infestations and inhibit growth of coral recruits.
- Control harvest of herbivorous fishes in recovery sites to enable them to graze down algae that overgrow and exclude coral recruits from establishing themselves.

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The Global International Waters Assessment

This report presents the results of the Global International Waters Assessment (GIWA) of the transboundary waters of the Indonesian Seas. This and the subsequent chapter offer a background that describes the impetus behind the establishment of GIWA, its objectives and how the GIWA was implemented.

The need for a global international waters assessment

Globally, people are becoming increasingly aware of the degradation of the world's water bodies. Disasters from floods and droughts, frequently reported in the media, are considered to be linked with ongoing global climate change (IPCC 2001), accidents involving large ships pollute public beaches and threaten marine life and almost every commercial fish stock is exploited beyond sustainable limits - it is estimated that the global stocks of large predatory fish have declined to less that 10% of pre-industrial fishing levels (Myers & Worm 2003). Further, more than 1 billion people worldwide lack access to safe drinking water and 2 billion people lack proper sanitation which causes approximately 4 billion cases of diarrhoea each year and results in the death of 2.2 million people, mostly children younger than five (WHO-UNICEF 2002). Moreover, freshwater and marine habitats are destroyed by infrastructure developments, dams, roads, ports and human settlements (Brinson & Malvárez 2002, Kennish 2002). As a consequence, there is growing public concern regarding the declining quality and quantity of the world's aquatic resources because of human activities, which has resulted in mounting pressure on governments and decision makers to institute new and innovative policies to manage those resources in a sustainable way ensuring their availability for future generations.

Adequately managing the world's aquatic resources for the benefit of all is, for a variety of reasons, a very complex task. The liquid state of the most of the world's water means that, without the construction of reservoirs, dams and canals it is free to flow wherever the laws of nature dictate. Water is, therefore, a vector transporting not only a wide variety of valuable resources but also problems from one area to another. The effluents emanating from environmentally destructive activities in upstream drainage areas are propagated downstream and can affect other areas considerable distances away. In the case of transboundary river basins, such as the Nile, Amazon and Niger, the impacts are transported across national borders and can be observed in the numerous countries situated within their catchments. In the case of large oceanic currents, the impacts can even be propagated between continents (AMAP 1998). Therefore, the inextricable linkages within and between both freshwater and marine environments dictates that management of aquatic resources ought to be implemented through a drainage basin approach.

In addition, there is growing appreciation of the incongruence between the transboundary nature of many aquatic resources and the traditional introspective nationally focused approaches to managing those resources. Water, unlike laws and management plans, does not respect national borders and, as a consequence, if future management of water and aquatic resources is to be successful, then a shift in focus towards international cooperation and intergovernmental agreements is required (UN 1972). Furthermore, the complexity of managing the world's water resources is exacerbated by the dependence of a great variety of domestic and industrial activities on those resources. As a consequence, cross-sectoral multidisciplinary approaches that integrate environmental, socio-economic and development aspects into management must be adopted. Unfortunately however, the scientific information or capacity within each discipline is often not available or is inadequately translated for use by managers, decision makers and

policy developers. These inadequacies constitute a serious impediment to the implementation of urgently needed innovative policies.

Continual assessment of the prevailing and future threats to aquatic ecosystems and their implications for human populations is essential if governments and decision makers are going to be able to make strategic policy and management decisions that promote the sustainable use of those resources and respond to the growing concerns of the general public. Although many assessments of aquatic resources are being conducted by local, national, regional and international bodies, past assessments have often concentrated on specific themes, such as biodiversity or persistent toxic substances, or have focused only on marine or freshwaters. A globally coherent, drainage basin based assessment that embraces the inextricable links between transboundary freshwater and marine systems, and between environmental and societal issues, has never been conducted previously.

The Global Environment Facility (GEF)

The Global Environment Facility forges international co-operation and finances actions to address six critical threats to the global environment: biodiversity loss, climate change, degradation of international waters, ozone depletion, land degradation, and persistent organic pollutants (POPs).

The overall strategic thrust of GEF-funded international waters activities is to meet the incremental costs of: (a) assisting groups of countries to better understand the environmental concerns of their international waters and work collaboratively to address them; (b) building the capacity of existing institutions to utilise a more comprehensive approach for addressing transboundary water-related environmental concerns; and (c) implementing measures that address the priority transboundary environmental concerns. The goal is to assist countries to utilise the full range of technical, economic, financial, regulatory, and institutional measures needed to operationalise sustainable development strategies for international waters.

United Nations Environment Programme (UNEP)

United Nations Environment Programme, established in 1972, is the voice for the environment within the United Nations system. The mission of UNEP is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

UNEP work encompasses:

- Assessing global, regional and national environmental conditions and trends;
- Developing international and national environmental instruments;
- Strengthening institutions for the wise management of the environment;
- Facilitating the transfer of knowledge and technology for sustainable development;
- Encouraging new partnerships and mind-sets within civil society and the private sector.

University of Kalmar

University of Kalmar hosts the GIWA Co-ordination Office and provides scientific advice and administrative and technical assistance to GIWA. University of Kalmar is situated on the coast of the Baltic Sea. The city has a long tradition of higher education; teachers and marine officers have been educated in Kalmar since the middle of the 19th century. Today, natural science is a priority area which gives Kalmar a unique educational and research profile compared with other smaller universities in Sweden. Of particular relevance for GIWA is the established research in aquatic and environmental science. Issues linked to the concept of sustainable development are implemented by the research programme Natural Resources Management and Agenda 21 Research School.

Since its establishment GIWA has grown to become an integral part of University activities. The GIWA Co-ordination office and GIWA Core team are located at the Kalmarsund Laboratory, the university centre for water-related research. Senior scientists appointed by the University are actively involved in the GIWA peer-review and steering groups. As a result of the cooperation the University can offer courses and seminars related to GIWA objectives and international water issues.

International call for action

The need for a holistic assessment of transboundary waters in order to respond to growing public concerns and provide advice to governments and decision makers regarding the management of aquatic resources was recognised by several international bodies focusing on the global environment. In particular, the Global Environment Facility (GEF) observed that the International Waters (IW) component of the GEF suffered from the lack of a global assessment which made it difficult to prioritise international water projects, particularly considering the inadequate understanding of the nature and root causes of environmental problems. In 1996, at its fourth meeting in Nairobi, the GEF Scientific and Technical Advisory Panel (STAP), noted that: *"Lack of an International Waters Assessment comparable with that of the IPCC, the Global Biodiversity Assessment, and the Stratospheric Ozone Assessment, was a unique and serious impediment to the implementation of the International Waters Component of the GEF"*.

The urgent need for an assessment of the causes of environmental degradation was also highlighted at the UN Special Session on the Environment (UNGASS) in 1997, where commitments were made regarding the work of the UN Commission on Sustainable Development (UNCSD) on freshwater in 1998 and seas in 1999. Also in 1997, two international Declarations, the Potomac Declaration: Towards enhanced ocean security into the third millennium, and the Stockholm Statement on interaction of land activities, freshwater and enclosed seas, specifically emphasised the need for an investigation of the root causes of degradation of the transboundary aquatic environment and options for addressing them. These processes led to the development of the Global International Waters Assessment (GIWA) that would be implemented by the United Nations Environment Programme (UNEP) in conjunction with the University of Kalmar, Sweden, on behalf of the GEF. The GIWA was inaugurated in Kalmar in October 1999 by the Executive Director of UNEP, Dr. Klaus Töpfer, and the late Swedish Minister of the Environment, Kjell Larsson. On this occasion Dr. Töpfer stated: "*GIWA is the framework of UNEP´s global water assessment strategy and will enable us to record and report on critical water resources for the planet for consideration of sustainable development management practices as part of our responsibilities under Agenda 21 agreements of the Rio conference*".

The importance of the GIWA has been further underpinned by the UN Millennium Development Goals adopted by the UN General Assembly in 2000 and the Declaration from the World Summit on Sustainable

Development in 2002. The development goals aimed to halve the proportion of people without access to safe drinking water and basic sanitation by the year 2015 (United Nations Millennium Declaration 2000). The WSSD also calls for integrated management of land, water and living resources (WSSD 2002) and, by 2010, the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem should be implemented by all countries that are party to the declaration (FAO 2001).

The conceptual framework and objectives

Considering the general decline in the condition of the world's aquatic resources and the internationally recognised need for a globally coherent assessment of transboundary waters, the primary objectives of the GIWA are:

- To provide a prioritising mechanism that allows the GEF to focus their resources so that they are used in the most cost effective manner to achieve significant environmental benefits, at national, regional and global levels; and
- To highlight areas in which governments can develop and implement strategic policies to reduce environmental degradation and improve the management of aquatic resources.

In order to meet these objectives and address some of the current inadequacies in international aquatic resources management, the GIWA has incorporated four essential elements into its design:

- A broad transboundary approach that generates a truly regional perspective through the incorporation of expertise and existing information from all nations in the region and the assessment of all factors that influence the aquatic resources of the region;
- A drainage basin approach integrating freshwater and marine systems;
- A multidisciplinary approach integrating environmental and socio-economic information and expertise; and
- A coherent assessment that enables global comparison of the results.

The GIWA builds on previous assessments implemented within the GEF International Waters portfolio but has developed and adopted a broader definition of transboundary waters to include factors that influence the quality and quantity of global aquatic resources. For example, due to globalisation and international trade, the market for penaeid shrimps has widened and the prices soared. This, in turn, has encouraged entrepreneurs in South East Asia to expand aquaculture resulting in the large-scale deforestation of mangroves for ponds (Primavera 1997). Within the GIWA, these "non-hydrological" factors constitute as large a transboundary influence as more traditionally recognised problems, such as the construction of dams that regulate the flow of water into a neighbouring country, and are considered equally important. In addition, the GIWA recognises the importance of hydrological units that would not normally be considered transboundary but exert a significant influence on transboundary waters, such as the Yangtze River in China which discharges into the East China Sea (Daoji & Daler 2004) and the Volga River in Russia which is largely responsible for the condition of the Caspian Sea (Barannik et al. 2004). Furthermore, the GIWA is a truly regional assessment that has incorporated data from a wide range of sources and included expert knowledge and information from a wide range of sectors and from each country in the region. Therefore, the transboundary concept adopted by the GIWA extends to include impacts caused by globalisation, international trade, demographic changes and technological advances and recognises the need for international cooperation to address them.

International waters and transboundary issues

The term "international waters", as used for the purposes of the GEF Operational Strategy, includes the oceans, large marine ecosystems, enclosed or semi-enclosed seas and estuaries, as well as rivers, lakes, groundwater systems, and wetlands with transboundary drainage basins or common borders. The water-related ecosystems associated with these waters are considered integral parts of the systems.

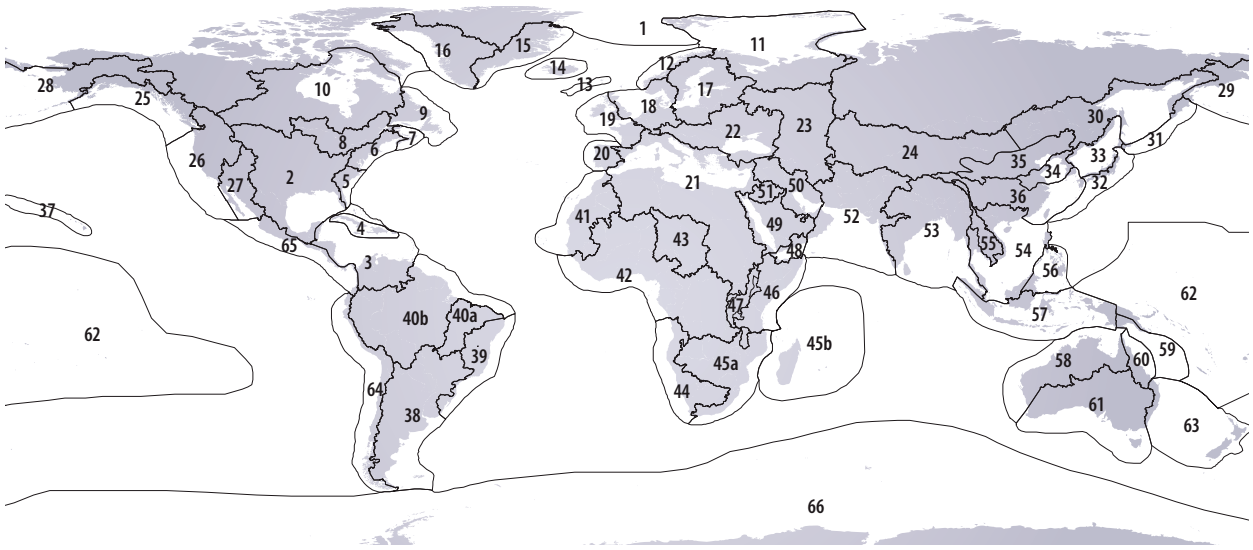
The term "transboundary issues" is used to describe the threats to the aquatic environment linked to globalisation, international trade, demographic changes and technological advancement, threats that are additional to those created through transboundary movement of water. Single country policies and actions are inadequate in order to cope with these challenges and this makes them transboundary in nature.

The international waters area includes numerous international conventions, treaties, and agreements. The architecture of marine agreements is especially complex, and a large number of bilateral and multilateral agreements exist for transboundary freshwater basins. Related conventions and agreements in other areas increase the complexity. These initiatives provide a new opportunity for cooperating nations to link many different programmes and instruments into regional comprehensive approaches to address international waters.

The organisational structure and implementation of the GIWA

The scale of the assessment

Initially, the scope of the GIWA was confined to transboundary waters in areas that included countries eligible to receive funds from the GEF. However, it was recognised that a truly global perspective would only be achieved if industrialised, GEF-ineligible regions of the world were also assessed. Financial resources to assess the GEF-eligible countries were obtained primarily from the GEF (68%), the Swedish International Development Cooperation Agency (Sida) (18%), and the Finnish Department for International Development Cooperation (FINNIDA)



1	*Arctic*	12	*Norwegian Sea (LME)*	24	*Aral Sea*	36	*East-China Sea (LME)*	46	*Somali Coastal Current (LME)*	58	*North Australian Shelf (LME)*
2	*Gulf of Mexico (LME)*	13	*Faroe plateau*	25	*Gulf of Alaska (LME)*	37	*Hawaiian Archipelago (LME)*	47	*East African Rift Valley Lakes*	59	*Coral Sea Basin*
3	*Caribbean Sea (LME)*	14	*Iceland Shelf (LME)*	26	*California Current (LME)*	38	*Patagonian Shelf (LME)*	48	*Gulf of Aden*	60	*Great Barrier Reef (LME)*
4	*Caribbean Islands*	15	*East Greenland Shelf (LME)*	27	*Gulf of California (LME)*	39	*Brazil Current (LME)*	49	*Red Sea (LME)*	61	*Great Australian Bight*
5	*Southeast Shelf (LME)*	16	*West Greenland Shelf (LME)*	28	*East Bering Sea (LME)*	40a	*Brazilian Northeast (LME)*	50	*The Gulf*	62	*Small Island States*
6	*Northeast Shelf (LME)*	17	*Baltic Sea (LME)*	29	*West Bering Sea (LME)*	40b	*Amazon*	51	*Jordan*	63	*Tasman Sea*
7	*Scotian Shelf (LME)*	18	*North Sea (LME)*	30	*Sea of Okhotsk (LME)*	41	*Canary Current (LME)*	52	*Arabian Sea (LME)*	64	*Humboldt Current (LME)*
8	*Gulf of St Lawrence*	19	*Celtic-Biscay Shelf (LME)*	31	*Oyashio Current (LME)*	42	*Guinea Current (LME)*	53	*Bay of Bengal S.E.*	65	*Eastern Equatorial Pacific*
9	*Newfoundland Shelf (LME)*	20	*Iberian Coastal (LME)*	32	*Kuroshio Current (LME)*	43	*Lake Chad*	54	*South China Sea (LME)*	66	*Antarctic (LME)*
10	*Baffin Bay, Labrador Sea, Canadian Archipelago*	21	*Mediterranean Sea (LME)*	33	*Sea of Japan/East Sea (LME)*	44	*Benguela Current (LME)*	55	*Mekong River*		
		22	*Black Sea (LME)*	34	*Yellow Sea (LME)*	45a	*Agulhas Current (LME)*	56	*Sulu-Celebes Sea (LME)*		
11	*Barents Sea (LME)*	23	*Caspian Sea*	35	*Bohai Sea*	45b	*Indian Ocean Islands*	57	*Indonesian Seas (LME)*		

Figure 1 The 66 transboundary regions assessed within the GIWA project.

(10%). Other contributions were made by Kalmar Municipality, the University of Kalmar and the Norwegian Government. The assessment of regions ineligible for GEF funds was conducted by various international and national organisations as in-kind contributions to the GIWA.

In order to be consistent with the transboundary nature of many of the world's aquatic resources and the focus of the GIWA, the geographical units being assessed have been designed according to the watersheds of discrete hydrographic systems rather than political borders (Figure 1). The geographic units of the assessment were determined during the preparatory phase of the project and resulted in the division of the world into 66 regions defined by the entire area of one or more catchments areas that drains into a single designated marine system. These marine systems often correspond to Large Marine Ecosystems (LMEs) (Sherman 1994, IOC 2002).

Large Marine Ecocsystems (LMEs)

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margin of the major current systems. They are relatively large regions on the order of 200 000 km^2 or greater, characterised by distinct: (1) bathymetry, (2) hydrography, (3) productivity, and (4) trophically dependent populations.

The Large Marine Ecosystems strategy is a global effort for the assessment and management of international coastal waters. It developed in direct response to a declaration at the 1992 Rio Summit. As part of the strategy, the World Conservation Union (IUCN) and National Oceanic and Atmospheric Administration (NOAA) have joined in an action program to assist developing countries in planning and implementing an ecosystem-based strategy that is focused on LMEs as the principal assessment and management units for coastal ocean resources. The LME concept is also adopted by GEF that recommends the use of LMEs and their contributing freshwater basins as the geographic area for integrating changes in sectoral economic activities.

Considering the objectives of the GIWA and the elements incorporated into its design, a new methodology for the implementation of the assessment was developed during the initial phase of the project. The methodology focuses on five major environmental concerns which constitute the foundation of the GIWA assessment; Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, and Global change. The GIWA methodology is outlined in the following chapter.

The global network

In each of the 66 regions, the assessment is conducted by a team of local experts that is headed by a Focal Point (Figure 2). The Focal Point can be an individual, institution or organisation that has been selected on the basis of their scientific reputation and experience implementing international assessment projects. The Focal Point is responsible for assembling members of the team and ensuring that it has the necessary expertise and experience in a variety of environmental and socio-economic disciplines to successfully conduct the regional assessment. The selection of team members is one of the most critical elements for the success of GIWA and, in order to ensure that the most relevant information is incorporated into the assessment, team members were selected from a wide variety of institutions such as universities, research institutes, government agencies, and the private sector. In addition, in order to ensure that the assessment produces a truly regional perspective, the teams should include representatives from each country that shares the region.

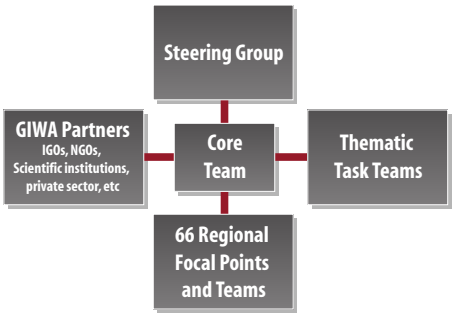


Figure 2 The organisation of the GIWA project.

In total, more than 1 000 experts have contributed to the implementation of the GIWA illustrating that the GIWA is a participatory exercise that relies on regional expertise. This participatory approach is essential because it instils a sense of local ownership of the project, which ensures the credibility of the findings and moreover, it has created a global network of experts and institutions that can collaborate and exchange experiences and expertise to help mitigate the continued degradation of the world's aquatic resources.

GIWA Regional reports

The GIWA was established in response to growing concern among the general public regarding the quality of the world's aquatic resources and the recognition of governments and the international community concerning the absence of a globally coherent international waters assessment. However, because a holistic, region-by-region, assessment of the condition of the world's transboundary water resources had never been undertaken, a methodology guiding the implementation of such an assessment did not exist. Therefore, in order to implement the GIWA, a new methodology that adopted a multidisciplinary, multi-sectoral, multi-national approach was developed and is now available for the implementation of future international assessments of aquatic resources.

UNEP Water Policy and Strategy

The primary goals of the UNEP water policy and strategy are:

(a) Achieving greater global understanding of freshwater, coastal and marine environments by conducting environmental assessments in priority areas;

(b) Raising awareness of the importance and consequences of unsustainable water use;

(c) Supporting the efforts of Governments in the preparation and implementation of integrated management of freshwater systems and their related coastal and marine environments;

(d) Providing support for the preparation of integrated management plans and programmes for aquatic environmental hot spots, based on the assessment results;

(e) Promoting the application by stakeholders of precautionary, preventive and anticipatory approaches.

The GIWA is comprised of a logical sequence of four integrated components. The first stage of the GIWA is called Scaling and is a process by which the geographic area examined in the assessment is defined and all the transboundary waters within that area are identified. Once the geographic scale of the assessment has been defined, the assessment teams conduct a process known as Scoping in which the magnitude of environmental and associated socio-economic impacts of Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, and Global change is assessed in order to identify and prioritise the concerns that require the most urgent intervention. The assessment of these predefined concerns incorporates the best available information and the knowledge and experience of the multidisciplinary, multi-national assessment teams formed in each region. Once the priority concerns have been identified, the root causes of these concerns are identified during the third component of the GIWA, Causal chain analysis. The root causes are determined through a sequential process that identifies, in turn, the most significant immediate causes followed by the economic sectors that are primarily responsible for the immediate causes and finally, the societal root causes. At each stage in the Causal chain analysis, the most significant contributors are identified through an analysis of the best available information which is augmented by the expertise of the assessment team. The final component of the GIWA is the development of Policy options that focus on mitigating the impacts of the root causes identified by the Causal chain analysis.

The results of the GIWA assessment in each region are reported in regional reports that are published by UNEP. These reports are designed to provide a brief physical and socio-economic description of the most important features of the region against which the results of the assessment can be cast. The remaining sections of the report present the results of each stage of the assessment in an easily digestible form. Each regional report is reviewed by at least two independent external reviewers in order to ensure the scientific validity and applicability of each report. The 66 regional assessments of the GIWA will serve UNEP as an essential complement to the UNEP Water Policy and Strategy and UNEP's activities in the hydrosphere.

Global International Waters Assessment

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The GIWA methodology

The specific objectives of the GIWA were to conduct a holistic and globally comparable assessment of the world's transboundary aquatic resources that incorporated both environmental and socio-economic factors and recognised the inextricable links between freshwater and marine environments, in order to enable the GEF to focus their resources and to provide guidance and advice to governments and decision makers. The coalition of all these elements into a single coherent methodology that produces an assessment that achieves each of these objectives had not previously been done and posed a significant challenge.

The integration of each of these elements into the GIWA methodology was achieved through an iterative process guided by a specially convened Methods task team that was comprised of a number of international assessment and water experts. Before the final version of the methodology was adopted, preliminary versions underwent an extensive external peer review and were subjected to preliminary testing in selected regions. Advice obtained from the Methods task team and other international experts and the lessons learnt from preliminary testing were incorporated into the final version that was used to conduct each of the GIWA regional assessments.

Considering the enormous differences between regions in terms of the quality, quantity and availability of data, socio-economic setting and environmental conditions, the achievement of global comparability required an innovative approach. This was facilitated by focusing the assessment on the impacts of five pre-defined concerns namely; Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources and Global change, in transboundary waters. Considering the diverse range of elements encompassed by each concern, assessing the magnitude of the impacts caused by these concerns was facilitated by evaluating the impacts of 22 specific issues that were grouped within these concerns (see Table 1).

The assessment integrates environmental and socio-economic data from each country in the region to determine the severity of the impacts of each of the five concerns and their constituent issues on the entire region. The integration of this information was facilitated by implementing the assessment during two participatory workshops that typically involved 10 to 15 environmental and socio-economic experts from each country in the region. During these workshops, the regional teams performed preliminary analyses based on the collective knowledge and experience of these local experts. The results of these analyses were substantiated with the best available information to be presented in a regional report.

Table 1 Pre-defined GIWA concerns and their constituent issues addressed within the assessment.

Environmental issues	Major concerns
1. Modification of stream flow 2. Pollution of existing supplies 3. Changes in the water table	**I Freshwater shortage**
4. Microbiological 5. Eutrophication 6. Chemical 7. Suspended solids 8. Solid wastes 9. Thermal 10. Radionuclide 11. Spills	**II Pollution**
12. Loss of ecosystems 13. Modification of ecosystems or ecotones, including community structure and/or species composition	**III Habitat and community modification**
14. Overexploitation 15. Excessive by-catch and discards 16. Destructive fishing practices 17. Decreased viability of stock through pollution and disease 18. Impact on biological and genetic diversity	**IV Unsustainable exploitation of fish and other living resources**
19. Changes in hydrological cycle 20. Sea level change 21. Increased uv-b radiation as a result of ozone depletion 22. Changes in ocean CO_2 source/sink function	**V Global change**

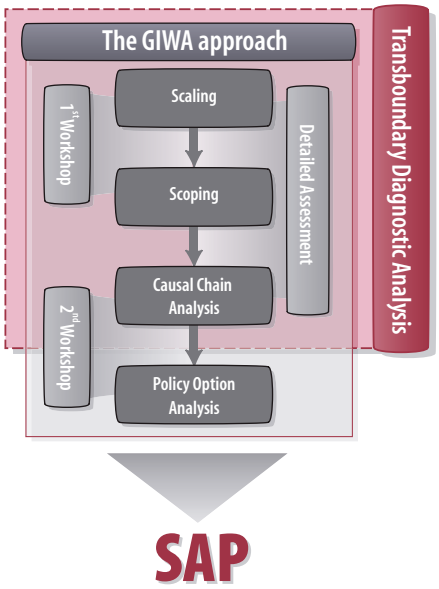

Figure 1 Illustration of the relationship between the GIWA approach and other projects implemented within the GEF International Waters (IW) portfolio.

The GIWA is a logical contiguous process that defines the geographic region to be assessed, identifies and prioritises particularly problems based on the magnitude of their impacts on the environment and human societies in the region, determines the root causes of those problems and, finally, assesses various policy options that addresses those root causes in order to reverse negative trends in the condition of the aquatic environment. These four steps, referred to as Scaling, Scoping, Causal chain analysis and Policy options analysis, are summarised below and are described in their entirety in two volumes: *GIWA Methodology Stage 1: Scaling and Scoping*; and *GIWA Methodology: Detailed Assessment, Causal Chain Analysis and Policy Options Analysis*. Generally, the components of the GIWA methodology are aligned with the framework adopted by the GEF for Transboundary Diagnostic Analyses (TDAs) and Strategic Action Programmes (SAPs) (Figure 1) and assume a broad spectrum of transboundary influences in addition to those associated with the physical movement of water across national borders.

Scaling – Defining the geographic extent of the region

Scaling is the first stage of the assessment and is the process by which the geographic scale of the assessment is defined. In order to facilitate the implementation of the GIWA, the globe was divided during the design phase of the project into 66 contiguous regions. Considering the transboundary nature of many aquatic resources and the transboundary focus of the GIWA, the boundaries of the regions did not comply with political boundaries but were instead, generally defined by a large but discrete drainage basin that also included the coastal marine waters into which the basin discharges. In many cases, the marine areas examined during the assessment coincided with the Large Marine Ecosystems (LMEs) defined by the US National Atmospheric and Oceanographic Administration (NOAA). As a consequence, scaling should be a relatively straight-forward task that involves the inspection of the boundaries that were proposed for the region during the preparatory phase of GIWA to ensure that they are appropriate and that there are no important overlaps or gaps with neighbouring regions. When the proposed boundaries were found to be inadequate, the boundaries of the region were revised according to the recommendations of experts from both within the region and from adjacent regions so as to ensure that any changes did not result in the exclusion of areas from the GIWA. Once the regional boundary was defined, regional teams identified all the transboundary elements of the aquatic environment within the region and determined if these elements could be assessed as a single coherent aquatic system or if there were two or more independent systems that should be assessed separately.

Scoping – Assessing the GIWA concerns

Scoping is an assessment of the severity of environmental and socio-economic impacts caused by each of the five pre-defined GIWA concerns and their constituent issues (Table 1). It is not designed to provide an exhaustive review of water-related problems that exist within each region, but rather it is a mechanism to identify the most urgent problems in the region and prioritise those for remedial actions. The priorities determined by Scoping are therefore one of the main outputs of the GIWA project.

Focusing the assessment on pre-defined concerns and issues ensured the comparability of the results between different regions. In addition, to ensure the long-term applicability of the options that are developed to mitigate these problems, Scoping not only assesses the current impacts of these concerns and issues but also the probable future impacts according to the "most likely scenario" which considered demographic, economic, technological and other relevant changes that will potentially influence the aquatic environment within the region by 2020.

The magnitude of the impacts caused by each issue on the environment and socio-economic indicators was assessed over the entire region using the best available information from a wide range of sources and the knowledge and experience of the each of the experts comprising the regional team. In order to enhance the comparability of the assessment between different regions and remove biases in the assessment caused by different perceptions of and ways to communicate the severity of impacts caused by particular issues, the

results were distilled and reported as standardised scores according to the following four point scale:

- 0 = no known impact
- 1 = slight impact
- 2 = moderate impact
- 3 = severe impact

The attributes of each score for each issue were described by a detailed set of pre-defined criteria that were used to guide experts in reporting the results of the assessment. For example, the criterion for assigning a score of 3 to the issue Loss of ecosystems or ecotones is: "*Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.*" The full list of criteria is presented at the end of the chapter, Table 5a-e. Although the scoring inevitably includes an arbitrary component, the use of predefined criteria facilitates comparison of impacts on a global scale and also encouraged consensus of opinion among experts.

The trade-off associated with assessing the impacts of each concern and their constituent issues at the scale of the entire region is that spatial resolution was sometimes low. Although the assessment provides a score indicating the severity of impacts of a particular issue or concern on the entire region, it does not mean that the entire region suffers the impacts of that problem. For example, eutrophication could be identified as a severe problem in a region, but this does not imply that all waters in the region suffer from severe eutrophication. It simply means that when the degree of eutrophication, the size of the area affected, the socio-economic impacts and the number of people affected is considered, the magnitude of the overall impacts meets the criteria defining a severe problem and that a regional action should be initiated in order to mitigate the impacts of the problem.

When each issue has been scored, it was weighted according to the relative contribution it made to the overall environmental impacts of the concern and a weighted average score for each of the five concerns was calculated (Table 2). Of course, if each issue was deemed to make equal contributions, then the score describing the overall impacts of the concern was simply the arithmetic mean of the scores allocated to each issue within the concern.
In addition, the socio-economic impacts of each of the five major concerns were assessed for the entire region. The socio-economic impacts were grouped into three categories; Economic impacts, Health impacts and Other social and community impacts (Table 3). For each category, an evaluation of the size, degree and frequency of the impact was performed and, once completed, a weighted average score describing the overall socio-economic impacts of each concern was calculated in the same manner as the overall environmental score.

Table 2 Example of environmental impact assessment of Freshwater shortage.

Environmental issues	Score	Weight %	Environmental concerns	Weight averaged score
1. Modification of stream flow	1	20	Freshwater shortage	1.50
2. Pollution of existing supplies	2	50		
3. Changes in the water table	1	30		

Table 3 Example of Health impacts assessment linked to one of the GIWA concerns.

Criteria for Health impacts	Raw score	Score	Weight %
Number of people affected	Very small — Very large 0 1 2 3	2	50
Degree of severity	Minimum — Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short — Continuous 0 1 2 3	2	20
Weight average score for Health impacts		**2**	

After all 22 issues and associated socio-economic impacts have been scored, weighted and averaged, the magnitude of likely future changes in the environmental and socio-economic impacts of each of the five concerns on the entire region is assessed according to the most likely scenario which describes the demographic, economic, technological and other relevant changes that might influence the aquatic environment within the region by 2020.

In order to prioritise among GIWA concerns within the region and identify those that will be subjected to causal chain and policy options analysis in the subsequent stages of the GIWA, the present and future scores of the environmental and socio-economic impacts of each concern are tabulated and an overall score calculated. In the example presented in Table 4, the scoping assessment indicated that concern III, Habitat and community modification, was the priority concern in this region. The outcome of this mathematic process was reconciled against the knowledge of experts and the best available information in order to ensure the validity of the conclusion.

In some cases however, this process and the subsequent participatory discussion did not yield consensus among the regional experts regarding the ranking of priorities. As a consequence, further analysis was required. In such cases, expert teams continued by assessing the relative importance of present and potential future impacts and assign weights to each. Afterwards, the teams assign weights indicating the relative contribution made by environmental and socio-economic factors to the overall impacts of the concern. The weighted average score for each concern is then recalculated taking into account

Table 4 Example of comparative environmental and socio-economic impacts of each major concern, presently and likely in year 2020.

Concern	Types of impacts								Overall score
	Environmental score		Economic score		Human health score		Social and community score		
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	1.3	2.3	2.7	2.8	2.6	3.0	1.8	2.2	**2.3**
Pollution	1.5	2.0	2.0	2.3	1.8	2.3	2.0	2.3	**2.0**
Habitat and community modification	2.0	3.0	2.4	3.0	2.4	2.8	2.3	2.7	**2.6**
Unsustainable exploitation of fish and other living resources	1.8	2.2	2.0	2.1	2.0	2.1	2.4	2.5	**2.1**
Global change	0.8	1.0	1.5	1.7	1.5	1.5	1.0	1.0	**1.2**

the relative contributions of both present and future impacts and environmental and socio-economic factors. The outcome of these additional analyses was subjected to further discussion to identify overall priorities for the region.

Finally, the assessment recognises that each of the five GIWA concerns are not discrete but often interact. For example, pollution can destroy aquatic habitats that are essential for fish reproduction which, in turn, can cause declines in fish stocks and subsequent overexploitation. Once teams have ranked each of the concerns and determined the priorities for the region, the links between the concerns are highlighted in order to identify places where strategic interventions could be applied to yield the greatest benefits for the environment and human societies in the region.

Causal chain analysis

Causal Chain Analysis (CCA) traces the cause-effect pathways from the socio-economic and environmental impacts back to their root causes. The GIWA CCA aims to identify the most important causes of each concern prioritised during the scoping assessment in order to direct policy measures at the most appropriate target in order to prevent further degradation of the regional aquatic environment.

Root causes are not always easy to identify because they are often spatially or temporally separated from the actual problems they cause. The GIWA CCA was developed to help identify and understand the root causes of environmental and socio-economic problems in international waters and is conducted by identifying the human activities that cause the problem and then the factors that determine the ways in which these activities are undertaken. However, because there is no universal theory describing how root causes interact to create natural resource management problems and due to the great variation of local circumstances under which the methodology will be applied, the GIWA CCA is not a rigidly structured assessment but should be regarded as a framework to guide the analysis, rather than as a set of detailed instructions. Secondly, in an ideal setting, a causal chain would be produced by a multidisciplinary group of specialists that would statistically examine each successive cause and study its links to the problem and to other causes. However, this approach (even if feasible) would use far more resources and time than those available to GIWA[1]. For this reason, it has been necessary to develop a relatively simple and practical analytical model for gathering information to assemble meaningful causal chains.

Conceptual model

A causal chain is a series of statements that link the causes of a problem with its effects. Recognising the great diversity of local settings and the resulting difficulty in developing broadly applicable policy strategies, the GIWA CCA focuses on a particular system and then only on those issues that were prioritised during the scoping assessment. The starting point of a particular causal chain is one of the issues selected during the Scaling and Scoping stages and its related environmental and socio-economic impacts. The next element in the GIWA chain is the immediate cause; defined as the physical, biological or chemical variable that produces the GIWA issue. For example, for the issue of eutrophication the immediate causes may be, inter alia:

- Enhanced nutrient inputs;
- Increased recycling/mobilisation;
- Trapping of nutrients (e.g. in river impoundments);
- Run-off and stormwaters

Once the relevant immediate cause(s) for the particular system has (have) been identified, the sectors of human activity that contribute most significantly to the immediate cause have to be determined. Assuming that the most important immediate cause in our example had been increased nutrient concentrations, then it is logical that the most likely sources of those nutrients would be the agricultural, urban or industrial sectors. After identifying the sectors that are primarily

[1] This does not mean that the methodology ignores statistical or quantitative studies; as has already been pointed out, the available evidence that justifies the assumption of causal links should be provided in the assessment.

responsible for the immediate causes, the root causes acting on those sectors must be determined. For example, if agriculture was found to be primarily responsible for the increased nutrient concentrations, the root causes could potentially be:

- Economic (e.g. subsidies to fertilisers and agricultural products);
- Legal (e.g. inadequate regulation);
- Failures in governance (e.g. poor enforcement); or
- Technology or knowledge related (e.g. lack of affordable substitutes for fertilisers or lack of knowledge as to their application).

Once the most relevant root causes have been identified, an explanation, which includes available data and information, of how they are responsible for the primary environmental and socio-economic problems in the region should be provided.

Policy option analysis

Despite considerable effort of many Governments and other organisations to address transboundary water problems, the evidence indicates that there is still much to be done in this endeavour. An important characteristic of GIWA's Policy Option Analysis (POA) is that its recommendations are firmly based on a better understanding of the root causes of the problems. Freshwater scarcity, water pollution, overexploitation of living resources and habitat destruction are very complex phenomena. Policy options that are grounded on a better understanding of these phenomena will contribute to create more effective societal responses to the extremely complex water related transboundary problems. The core of POA in the assessment consists of two tasks:

Construct policy options

Policy options are simply different courses of action, which are not always mutually exclusive, to solve or mitigate environmental and socio-economic problems in the region. Although a multitude of different policy options could be constructed to address each root cause identified in the CCA, only those few policy options that have the greatest likelihood of success were analysed in the GIWA.

Select and apply the criteria on which the policy options will be evaluated

Although there are many criteria that could be used to evaluate any policy option, GIWA focuses on:

- Effectiveness (certainty of result)
- Efficiency (maximisation of net benefits)
- Equity (fairness of distributional impacts)
- Practical criteria (political acceptability, implementation feasibility).

The policy options recommended by the GIWA are only contributions to the larger policy process and, as such, the GIWA methodology developed to test the performance of various options under the different circumstances has been kept simple and broadly applicable.

Global International Waters Assessment

Table 5a: Scoring criteria for environmental impacts of Freshwater shortage

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 1: Modification of stream flow "An increase or decrease in the discharge of streams and rivers as a result of human interventions on a local/ regional scale (see Issue 19 for flow alterations resulting from global change) over the last 3-4 decades."	■ No evidence of modification of stream flow.	■ There is a measurably changing trend in annual river discharge at gauging stations in a major river or tributary (basin > 40 000 km^2); or ■ There is a measurable decrease in the area of wetlands (other than as a consequence of conversion or embankment construction); or ■ There is a measurable change in the interannual mean salinity of estuaries or coastal lagoons and/or change in the mean position of estuarine salt wedge or mixing zone; or ■ Change in the occurrence of exceptional discharges (e.g. due to upstream damming.	■ Significant downward or upward trend (more than 20% of the long term mean) in annual discharges in a major river or tributary draining a basin of >250 000 km^2; or ■ Loss of >20% of flood plain or deltaic wetlands through causes other than conversion or artificial embankments; or ■ Significant loss of riparian vegetation (e.g. trees, flood plain vegetation); or ■ Significant saline intrusion into previously freshwater rivers or lagoons.	■ Annual discharge of a river altered by more than 50% of long term mean; or ■ Loss of >50% of riparian or deltaic wetlands over a period of not less than 40 years (through causes other than conversion or artificial embankment); or ■ Significant increased siltation or erosion due to changing in flow regime (other than normal fluctuations in flood plain rivers); or ■ Loss of one or more anadromous or catadromous fish species for reasons other than physical barriers to migration, pollution or overfishing.
Issue 2: Pollution of existing supplies "Pollution of surface and ground fresh waters supplies as a result of point or diffuse sources"	■ No evidence of pollution of surface and ground waters.	■ Any monitored water in the region does not meet WHO or national drinking water criteria, other than for natural reasons; or ■ There have been reports of one or more fish kills in the system due to pollution within the past five years.	■ Water supplies does not meet WHO or national drinking water standards in more than 30% of the region; or ■ There are one or more reports of fish kills due to pollution in any river draining a basin of >250 000 km^2 .	■ River draining more than 10% of the basin have suffered polysaprobic conditions, no longer support fish, or have suffered severe oxygen depletion ■ Severe pollution of other sources of freshwater (e.g. groundwater)
Issue 3: Changes in the water table "Changes in aquifers as a direct or indirect consequence of human activity"	■ No evidence that abstraction of water from aquifers exceeds natural replenishment.	■ Several wells have been deepened because of excessive aquifer draw-down; or ■ Several springs have dried up; or ■ Several wells show some salinisation.	■ Clear evidence of declining base flow in rivers in semi-arid areas; or ■ Loss of plant species in the past decade, that depend on the presence of ground water; or ■ Wells have been deepened over areas of hundreds of km^2;or ■ Salinisation over significant areas of the region.	■ Aquifers are suffering salinisation over regional scale; or ■ Perennial springs have dried up over regionally significant areas; or ■ Some aquifers have become exhausted

Table 5b: Scoring criteria for environmental impacts of Pollution

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 4: Microbiological pollution "The adverse effects of microbial constituents of human sewage released to water bodies."	■ Normal incidence of bacterial related gastroenteric disorders in fisheries product consumers and no fisheries closures or advisories.	■ There is minor increase in incidence of bacterial related gastroenteric disorders in fisheries product consumers but no fisheries closures or advisories.	■ Public health authorities aware of marked increase in the incidence of bacterial related gastroenteric disorders in fisheries product consumers; or ■ There are limited area closures or advisories reducing the exploitation or marketability of fisheries products.	■ There are large closure areas or very restrictive advisories affecting the marketability of fisheries products; or ■ There exists widespread public or tourist awareness of hazards resulting in major reductions in the exploitation or marketability of fisheries products.
Issue 5: Eutrophication "Artificially enhanced primary productivity in receiving water basins related to the increased availability or supply of nutrients, including cultural eutrophication in lakes."	■ No visible effects on the abundance and distributions of natural living resource distributions in the area; and ■ No increased frequency of hypoxia[1] or fish mortality events or harmful algal blooms associated with enhanced primary production; and ■ No evidence of periodically reduced dissolved oxygen or fish and zoobenthos mortality; and ■ No evident abnormality in the frequency of algal blooms.	■ Increased abundance of epiphytic algae; or ■ A statistically significant trend in decreased water transparency associated with algal production as compared with long-term (>20 year) data sets; or ■ Measurable shallowing of the depth range of macrophytes.	■ Increased filamentous algal production resulting in algal mats; or ■ Medium frequency (up to once per year) of large-scale hypoxia and/or fish and zoobenthos mortality events and/or harmful algal blooms.	■ High frequency (>1 event per year), or intensity, or large areas of periodic hypoxic conditions, or high frequencies of fish and zoobenthos mortality events or harmful algal blooms; or ■ Significant changes in the littoral community; or ■ Presence of hydrogen sulphide in historically well oxygenated areas.

Issue 6: Chemical pollution "The adverse effects of chemical contaminants released to standing or marine water bodies as a result of human activities. Chemical contaminants are here defined as compounds that are toxic or persistent or bioaccumulating."	■ No known or historical levels of chemical contaminants except background levels of naturally occurring substances; and ■ No fisheries closures or advisories due to chemical pollution; and ■ No incidence of fisheries product tainting; and ■ No unusual fish mortality events. If there is no available data use the following criteria: ■ No use of pesticides; and ■ No sources of dioxins and furans; and ■ No regional use of PCBs; and ■ No bleached kraft pulp mills using chlorine bleaching; and ■ No use or sources of other contaminants.	■ Some chemical contaminants are detectable but below threshold limits defined for the country or region; or ■ Restricted area advisories regarding chemical contamination of fisheries products. If there is no available data use the following criteria: ■ Some use of pesticides in small areas; or ■ Presence of small sources of dioxins or furans (e.g., small incineration plants or bleached kraft/pulp mills using chlorine); or ■ Some previous and existing use of PCBs and limited amounts of PCB-containing wastes but not in amounts invoking local concerns; or ■ Presence of other contaminants.	■ Some chemical contaminants are above threshold limits defined for the country or region; or ■ Large area advisories by public health authorities concerning fisheries product contamination but without associated catch restrictions or closures; or ■ High mortalities of aquatic species near outfalls. If there is no available data use the following criteria: ■ Large-scale use of pesticides in agriculture and forestry; or ■ Presence of major sources of dioxins or furans such as large municipal or industrial incinerators or large bleached kraft pulp mills; or ■ Considerable quantities of waste PCBs in the area with inadequate regulation or has invoked some public concerns; or ■ Presence of considerable quantities of other contaminants.	■ Chemical contaminants are above threshold limits defined for the country or region; and ■ Public health and public awareness of fisheries contamination problems with associated reductions in the marketability of such products either through the imposition of limited advisories or by area closures of fisheries; or ■ Large-scale mortalities of aquatic species. If there is no available data use the following criteria: ■ Indications of health effects resulting from use of pesticides; or ■ Known emissions of dioxins or furans from incinerators or chlorine bleaching of pulp; or ■ Known contamination of the environment or foodstuffs by PCBs; or ■ Known contamination of the environment or foodstuffs by other contaminants.
Issue 7: Suspended solids "The adverse effects of modified rates of release of suspended particulate matter to water bodies resulting from human activities"	■ No visible reduction in water transparency; and ■ No evidence of turbidity plumes or increased siltation; and ■ No evidence of progressive riverbank, beach, other coastal or deltaic erosion.	■ Evidently increased or reduced turbidity in streams and/or receiving riverine and marine environments but without major changes in associated sedimentation or erosion rates, mortality or diversity of flora and fauna; or ■ Some evidence of changes in benthic or pelagic biodiversity in some areas due to sediment blanketing or increased turbidity.	■ Markedly increased or reduced turbidity in small areas of streams and/or receiving riverine and marine environments; or ■ Extensive evidence of changes in sedimentation or erosion rates; or ■ Changes in benthic or pelagic biodiversity in areas due to sediment blanketing or increased turbidity.	■ Major changes in turbidity over wide or ecologically significant areas resulting in markedly changed biodiversity or mortality in benthic species due to excessive sedimentation with or without concomitant changes in the nature of deposited sediments (i.e., grain-size composition/redox); or ■ Major change in pelagic biodiversity or mortality due to excessive turbidity.
Issue 8: Solid wastes "Adverse effects associated with the introduction of solid waste materials into water bodies or their environs."	■ No noticeable interference with trawling activities; and ■ No noticeable interference with the recreational use of beaches due to litter; and ■ No reported entanglement of aquatic organisms with debris.	■ Some evidence of marine-derived litter on beaches; or ■ Occasional recovery of solid wastes through trawling activities; but ■ Without noticeable interference with trawling and recreational activities in coastal areas.	■ Widespread litter on beaches giving rise to public concerns regarding the recreational use of beaches; or ■ High frequencies of benthic litter recovery and interference with trawling activities; or ■ Frequent reports of entanglement/ suffocation of species by litter.	■ Incidence of litter on beaches sufficient to deter the public from recreational activities; or ■ Trawling activities untenable because of benthic litter and gear entanglement; or ■ Widespread entanglement and/or suffocation of aquatic species by litter.
Issue 9: Thermal "The adverse effects of the release of aqueous effluents at temperatures exceeding ambient temperature in the receiving water body."	■ No thermal discharges or evidence of thermal effluent effects.	■ Presence of thermal discharges but without noticeable effects beyond the mixing zone and no significant interference with migration of species.	■ Presence of thermal discharges with large mixing zones having reduced productivity or altered biodiversity; or ■ Evidence of reduced migration of species due to thermal plume.	■ Presence of thermal discharges with large mixing zones with associated mortalities, substantially reduced productivity or noticeable changes in biodiversity; or ■ Marked reduction in the migration of species due to thermal plumes.
Issue 10: Radionuclide "The adverse effects of the release of radioactive contaminants and wastes into the aquatic environment from human activities."	■ No radionuclide discharges or nuclear activities in the region.	■ Minor releases or fallout of radionuclides but with well regulated or well-managed conditions complying with the Basic Safety Standards.	■ Minor releases or fallout of radionuclides under poorly regulated conditions that do not provide an adequate basis for public health assurance or the protection of aquatic organisms but without situations or levels likely to warrant large scale intervention by a national or international authority.	■ Substantial releases or fallout of radionuclides resulting in excessive exposures to humans or animals in relation to those recommended under the Basic Safety Standards; or ■ Some indication of situations or exposures warranting intervention by a national or international authority.
Issue 11: Spills "The adverse effects of accidental episodic releases of contaminants and materials to the aquatic environment as a result of human activities."	■ No evidence of present or previous spills of hazardous material; or ■ No evidence of increased aquatic or avian species mortality due to spills.	■ Some evidence of minor spills of hazardous materials in small areas with insignificant small-scale adverse effects one aquatic or avian species.	■ Evidence of widespread contamination by hazardous or aesthetically displeasing materials assumed to be from spillage (e.g. oil slicks) but with limited evidence of widespread adverse effects on resources or amenities; or ■ Some evidence of aquatic or avian species mortality through increased presence of contaminated or poisoned carcasses on beaches.	■ Widespread contamination by hazardous or aesthetically displeasing materials from frequent spills resulting in major interference with aquatic resource exploitation or coastal recreational amenities; or ■ Significant mortality of aquatic or avian species as evidenced by large numbers of contaminated carcasses on beaches.

Table 5c: Scoring criteria for environmental impacts of Habitat and community modification

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 12: Loss of ecosystems or ecotones "The complete destruction of aquatic habitats. For the purpose of GIWA methodology, recent loss will be measured as a loss of pre-defined habitats over the last 2-3 decades."	■ There is no evidence of loss of ecosystems or habitats.	■ There are indications of fragmentation of at least one of the habitats.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by up to 30 % during the last 2-3 decades.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.
Issue 13: Modification of ecosystems or ecotones, including community structure and/or species composition "Modification of pre-defined habitats in terms of extinction of native species, occurrence of introduced species and changing in ecosystem function and services over the last 2-3 decades."	■ No evidence of change in species complement due to species extinction or introduction; and ■ No changing in ecosystem function and services.	■ Evidence of change in species complement due to species extinction or introduction	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure; and ■ Evidence of change in ecosystem services[2].

[2] Constanza, R. et al. (1997). The value of the world ecosystem services and natural capital, Nature 387:253-260.

Table 5d: Scoring criteria for environmental impacts of Unsustainable exploitation of fish and other living resources

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 14: Overexploitation "The capture of fish, shellfish or marine invertebrates at a level that exceeds the maximum sustainable yield of the stock."	■ No harvesting exists catching fish (with commercial gear for sale or subsistence).	■ Commercial harvesting exists but there is no evidence of over-exploitation.	■ One stock is exploited beyond MSY (maximum sustainable yield) or is outside safe biological limits.	■ More than one stock is exploited beyond MSY or is outside safe biological limits.
Issue 15: Excessive by-catch and discards "By-catch refers to the incidental capture of fish or other animals that are not the target of the fisheries. Discards refers to dead fish or other animals that are returned to the sea."	■ Current harvesting practices show no evidence of excessive by-catch and/or discards.	■ Up to 30% of the fisheries yield (by weight) consists of by-catch and/or discards.	■ 30-60% of the fisheries yield consists of by-catch and/or discards.	■ Over 60% of the fisheries yield is by-catch and/or discards; or ■ Noticeable incidence of capture of endangered species.
Issue 16: Destructive fishing practices "Fishing practices that are deemed to produce significant harm to marine, lacustrine or coastal habitats and communities."	■ No evidence of habitat destruction due to fisheries practices.	■ Habitat destruction resulting in changes in distribution of fish or shellfish stocks; or ■ Trawling of any one area of the seabed is occurring less than once per year.	■ Habitat destruction resulting in moderate reduction of stocks or moderate changes of the environment; or ■ Trawling of any one area of the seabed is occurring 1-10 times per year; or ■ Incidental use of explosives or poisons for fishing.	■ Habitat destruction resulting in complete collapse of a stock or far reaching changes in the environment; or ■ Trawling of any one area of the seabed is occurring more than 10 times per year; or ■ Widespread use of explosives or poisons for fishing.
Issue 17: Decreased viability of stocks through contamination and disease "Contamination or diseases of feral (wild) stocks of fish or invertebrates that are a direct or indirect consequence of human action."	■ No evidence of increased incidence of fish or shellfish diseases.	■ Increased reports of diseases without major impacts on the stock.	■ Declining populations of one or more species as a result of diseases or contamination.	■ Collapse of stocks as a result of diseases or contamination.
Issue 18: Impact on biological and genetic diversity "Changes in genetic and species diversity of aquatic environments resulting from the introduction of alien or genetically modified species as an intentional or unintentional result of human activities including aquaculture and restocking."	■ No evidence of deliberate or accidental introductions of alien species; and ■ No evidence of deliberate or accidental introductions of alien stocks; and ■ No evidence of deliberate or accidental introductions of genetically modified species.	■ Alien species introduced intentionally or accidentally without major changes in the community structure; or ■ Alien stocks introduced intentionally or accidentally without major changes in the community structure; or ■ Genetically modified species introduced intentionally or accidentally without major changes in the community structure.	■ Measurable decline in the population of native species or local stocks as a result of introductions (intentional or accidental); or ■ Some changes in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).	■ Extinction of native species or local stocks as a result of introductions (intentional or accidental); or ■ Major changes (>20%) in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).

Table 5e: Scoring criteria for environmental impacts of Global change

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 19: Changes in hydrological cycle and ocean circulation "Changes in the local/regional water balance and changes in ocean and coastal circulation or current regime over the last 2-3 decades arising from the wider problem of global change including ENSO."	■ No evidence of changes in hydrological cycle and ocean/coastal current due to global change.	■ Change in hydrological cycles due to global change causing changes in the distribution and density of riparian terrestrial or aquatic plants without influencing overall levels of productivity; or ■ Some evidence of changes in ocean or coastal currents due to global change but without a strong effect on ecosystem diversity or productivity.	■ Significant trend in changing terrestrial or sea ice cover (by comparison with a long-term time series) without major downstream effects on river/ocean circulation or biological diversity; or ■ Extreme events such as flood and drought are increasing; or ■ Aquatic productivity has been altered as a result of global phenomena such as ENSO events.	■ Loss of an entire habitat through desiccation or submergence as a result of global change; or ■ Change in the tree or lichen lines; or ■ Major impacts on habitats or biodiversity as the result of increasing frequency of extreme events; or ■ Changing in ocean or coastal currents or upwelling regimes such that plant or animal populations are unable to recover to their historical or stable levels; or ■ Significant changes in thermohaline circulation.
Issue 20: Sea level change "Changes in the last 2-3 decades in the annual/seasonal mean sea level as a result of global change."	■ No evidence of sea level change.	■ Some evidences of sea level change without major loss of populations of organisms.	■ Changed pattern of coastal erosion due to sea level rise has became evident; or ■ Increase in coastal flooding events partly attributed to sea-level rise or changing prevailing atmospheric forcing such as atmospheric pressure or wind field (other than storm surges).	■ Major loss of coastal land areas due to sea-level change or sea-level induced erosion; or ■ Major loss of coastal or intertidal populations due to sea-level change or sea level induced erosion.
Issue 21: Increased UV-B radiation as a result of ozone depletion "Increased UV-B flux as a result polar ozone depletion over the last 2-3 decades."	■ No evidence of increasing effects of UV/B radiation on marine or freshwater organisms.	■ Some measurable effects of UV/B radiation on behavior or appearance of some aquatic species without affecting the viability of the population.	■ Aquatic community structure is measurably altered as a consequence of UV/B radiation; or ■ One or more aquatic populations are declining.	■ Measured/assessed effects of UV/B irradiation are leading to massive loss of aquatic communities or a significant change in biological diversity.
Issue 22: Changes in ocean CO_2 source/sink function "Changes in the capacity of aquatic systems, ocean as well as freshwater, to generate or absorb atmospheric CO_2 as a direct or indirect consequence of global change over the last 2-3 decades."	■ No measurable or assessed changes in CO_2 source/sink function of aquatic system.	■ Some reasonable suspicions that current global change is impacting the aquatic system sufficiently to alter its source/sink function for CO_2.	■ Some evidences that the impacts of global change have altered the source/sink function for CO_2 of aquatic systems in the region by at least 10%.	■ Evidences that the changes in source/sink function of the aquatic systems in the region are sufficient to cause measurable change in global CO_2 balance.

The Global International Waters Assessment (GIWA) is a holistic, globally comparable assessment of all the world's transboundary waters that recognises the inextricable links between freshwater and coastal marine environment and integrates environmental and socio-economic information to determine the impacts of a broad suite of influences on the world's aquatic environment.

Broad Transboundary Approach

The GIWA not only assesses the problems caused by human activities manifested by the physical movement of transboundary waters, but also the impacts of other non-hydrological influences that determine how humans use transboundary waters.

Regional Assessment - Global Perspective

The GIWA provides a global perspective of the world's transboundary waters by assessing 66 regions that encompass all major drainage basins and adjacent large marine ecosystems. The GIWA Assessment of each region incorporates information and expertise from all countries sharing the transboundary water resources.

Global Comparability

In each region, the assessment focuses on 5 broad concerns that are comprised of 22 specific water related issues.

Integration of Information and Ecosystems

The GIWA recognises the inextricable links between freshwater and coastal marine environment and assesses them together as one integrated unit.

The GIWA recognises that the integration of socio-economic and environmental information and expertise is essential to obtain a holistic picture of the interactions between the environmental and societal aspects of transboundary waters.

Priorities, Root Causes and Options for the Future

The GIWA indicates priority concerns in each region, determines their societal root causes and develops options to mitigate the impacts of those concerns in the future.

This Report

This report presents the GIWA assessment of the Indonesian Seas region, which comprises some 18 000 islands, is geologically and topographically diverse, and lies at the global centre of tropical marine biodiversity. The region supports a rapidly growing coastal population, and has rapidly deteriorating marine ecosystems with the likely imminent collapse of many of its coral reef-associated and pelagic fish populations. Unsustainable exploitation of living resources has caused severe environmental and socio-economic impacts across much of the region, and the major transboundary influence of the live food fish and aquarium trades, particularly poison fishing using cyanide, are further discussed. The causal chain analysis discusses the root causes of destructive fishing practices by investigating the cause-effect pathways of the issue. Policy options are analysed in order to enhance the management and improve the environmental quality of the region's aquatic environment.

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