COASTAL ZONE: EXTENT AND CHANGE

Working Definition of **Coastal** Zone

There is no single definition of the **coastal** zone. Some authors have referred to it as "that part of the land most affected by its

marine environments. Examples of su below. *(See Table 1.)*

Such diverse habitats often coexis

proximity to the sea and that part of the ocean most affected by its proximity to the land" (Hinrichsen 1998:2). The PAGE study defined **coastal** regions to be the intertidal and subtidal areas on and above the continental shelf (to a depth of 200 meters)—areas routinely inundated by saltwater—and immediately adjacent lands. This study also included consideration of marine fisheries, because 90 percent of the world capture fisheries come from the marine environment (FAO 1999a:3) and "nearly two-thirds of all fish harvested depend upon **coastal** wetlands, seagrasses, and coral reefs for various stages in their life cycles" (Hinrichsen 1998:18). This study does not include continental slope or deep-sea habitats. Therefore, important oceanic features, such as ocean vents, seamounts, and even the highly diverse faunas currently being described from the ocean benthos, are excluded.

Because the world's **coastal** regions are subdivided by physical rather than biological characteristics, they include a wide array of near-shore terrestrial, intertidal, benthic, and pelagic

tems; therefore, it is difficult to identify
tent, or delineate clear boundaries bet

Table 1

Coastal Environments

Near-shore terrestrial	**Dunes, cliffs, rocky xeromorphic habita agricultural landsca**
Intertidal	**Estuaries, deltas, la mudflats, salt marsl coastal wetlands, p aquaculture beds**
Benthic	**Kelp forests, seagra soft bottom environ continental shelf, a**
Pelagic	**Open waters above freestanding fish fa neuston zone, sea i**

Box 1

Maritime Areas Definitions

The United Nations Convention on the Law of the Sea (UNCLOS) is an international agreement that sets conditions and limits on the use and exploitation of the world's oceans. This convention also rules on how the maritime jurisdictional boundaries of member states are set. UNCLOS defines territorial sea as the 12-nautical-mile zone from the baseline or low-water line along the coast, on which the coastal state has sovereignty. Even though the established maximum limit for a territorial sea is 12 nautical miles, some countries claim larger areas. A country's Exclusive Economic Zone (EEZ), as established by UNCLOS, extends from the baseline out beyond the territorial sea, up to a width of 200 nautical miles. In cases where countries' baselines are within 400 nautical miles of each other, the EEZ boundaries are generally established by treaty, although there are many cases where these are in dispute. Moreover, many states have yet to sign or ratify

claimed, comprise what is defined as t time area of a country—that is, the tota (claimed or unclaimed) within 200 nau coast. The maritime area definition onl areas that are not currently under disp tainties surrounding much of the delin maps and statistics portraying these b to certain limitations and should be tre

In contrast to the territorial sea and tially political boundaries, the coastlin area are delineations based on a natur length is a frequently cited statistic to of coastal zone to a country. However, fraught with difficulty. The main proble surement of an irregular and curving f dent. Maps of individual islands, for ex

UNCLOS, while still others have yet to claim their EEZ. Where claimed and undisputed, a coastal country has certain sovereign rights over the EEZ, namely, rights to exploration, exploitation, conservation, and management of all natural resources of the seabed, its subsoil, and the overlying waters (Baretta-Bekker et al. 1998:118). Some countries have claimed an exclusive fishing zone instead of the more encompassing EEZ. The exclusive fishing zone, in these cases, refers to an area beyond the outer limit of the territorial sea in which the coastal state has the right to fish, subject to any concessions that may be granted to foreign fishermen. The territorial sea and the EEZ or the fishing zone, depending on which has been

great detail, whereas regional maps su lines into a few simple lines. Coastline fected by inclusion or exclusion of co bays, lagoons, and river mouths. More thus, result in longer estimates. For th line lengths were summarized from a g set—the 1:250,000 scale World Vector *2.)* Although the estimates presented h cantly from previously published sour that this is the first time such statistic from a globally consistent source.

E s t i m a t i n g A r e a a n d L e n g t h o f **C o a s t a l** Z o n e

To get a rough indicator and a better understanding of the relative size and distribution of **coastal** areas, this study calculated the spatial extent of **coastal** zone and maritime areas within national jurisdiction (up to 200 nautical miles from the coastline), such as territorial seas and exclusive economic zones. Although these are not ecologically oriented statistics, jurisdiction over resources has significant implications for governance and effective management of **coastal** and marine resources *(see Box 1)*. Furthermore, this analysis presents statistics compiled for the first time from a new, globally consistent source.

Table 2 presents **coastal** zone statistics for selected countries.

C h a r a c t e r i z i n g t h e F e a t u r e s

The habitats and features along the w varied—from the flat, **coastal** plains o grove and coral reef-lined shores of S rocky coastline of Norway. The descri provide baseline information and refe the condition of the ecosystem's good are a major factor in the vulnerability a to a particular pressure. The extent a **habitat** types serve as a proxy conditi the ecosystem services and values th quantify.

This study's examination of the wo an exploration of some of the natural c and near-shore areas. The characteriz line is based upon the occurrence of c coral reefs, mangroves, other tidal we

Figure 1

UNEP Regional Seas

Source: Groombridge and Jenkins, 1996; modified at WRI.

Projection: Geographic

estuaries, and sea ice. It also integrates information on continental shelf width and the slope of nearby terrestrial areas. The analysis is implemented at 1-kilometer resolution. The following hierarchical classification scheme is used to simplify the classification of complex ecosystems and overlapping **habitat** types.

1. Areas where sea ice occurs are classified as such.
2. Areas where mangroves are present, areas that are within 10 km of a coral reef, and areas where both **habitat** types overlap are classified as "mangroves/coral reefs".
3. Areas where **coastal** wetlands occur are classified as such.
4. Areas where barrier islands occur are classified as such.
5. Areas including any combination of the following four **habitat** types: freshwater and marine interface, wetlands, barrier islands, and river deltas are classified as Wetland/Estuary/BI Systems.
6. Areas not classified in any of the above classes are classified according to the **coastal** morphology and shelf width categorization from the Land-Ocean Interactions in the **Coastal** Zone (LOICZ). This classification includes categories such as: mountainous narrow shelf, narrow shelf plains, etc.
7. Some areas remain unclassified.

This characterization, presented in Table 3, is admittedly a gross simplification of the highly varied **coastal** environments

of the world and it does not directly ac
or substrate. More complex or detaile
possible and should be explored at na
The hierarchy was determined based
data sets and the importance of these
services examined later in the report.

Table 3 presents summary statisti
characterization for regions of the wor
Regional Seas Program (Groombridg
Figure 1). In this study, UNEP's Regio
slightly by dividing the North Atlantic F
and Greenland, into northeast Atlantic

Map 1 shows a simplified version
ization presented above. The general
ice, wetlands/estuaries/deltas, barrier
(where some **habitat** types may overl
hilly narrow shelf, narrow and wide sh
and mountainous narrow shelf.

As Map 1 shows, the world's coas
terms of physiographical characteristi
row shelf and some estuarine system
nean coastline, coral reefs and mangr
the Middle East and Insular Southeas
has a varied coastline with coral reefs
plains along a narrow shelf.

gross simplification of the highly varied coastal environments ... plains along a narrow shelf.

C o a s t a l E c o s y s t e m s

C o a s t a l Z o n e : E x t e n t a n d C h a n g e

Table 2

Coastal Zone Statistics by Country

	Coastal Length {a} (km)	Area of Continental Shelf (up to 200 m depth) (000 km²)	Territorial Sea (up to 12 nm) (000 km²)	Claimed Exclusive Economic Zone (000 km²)	Exclusive Fishing Zone (000 km²)
WORLD	1,634,701	24,287.1	18,816.9 b	102,108.4	12,885.2
ASIA (EXCL. MIDDLE EAST)	288,459	5,515.4	5,730.9	11,844.2	249.5
Azerbaijan {c}	871	78.0	X	X	X
Bangladesh	3,306	59.6	40.3	39.9	X
Cambodia	1,127	34.6	19.9	X	X
China	30,017	810.4 d	348.1	X	X
Georgia	376	2.7	6.1	18.9	X
India	17,181	372.4	193.8	2,103.4	X
Indonesia	95,181	1,847.7	3,205.7	2,915.0	X
Japan	29,020	304.2	373.8	3,648.4	X
Kazakhstan {c}	4,528	139.1	X	X	X
Korea, Dem People's Rep	4,009	26.3	12.7	72.8	X
Korea, Rep	12,478	226.3	81.1	202.6	X
Malaysia	9,323	335.9	152.4	198.2	X
Myanmar	14,708	216.4	154.8	358.5	X
Pakistan	2,599	43.7	31.4	201.5	X
Philippines	33,900	244.5	679.8	293.8	X
Singapore	268	0.7	0.7	X	0.7
Sri Lanka	2,825	19.2	30.5	500.8	X
Thailand	7,066	185.4	75.9	176.5	X
Turkmenistan {c}	1,289	72.4	X	X	X
Uzbekistan	1,707	26.1	X	X	X
Viet Nam	11,409	352.4	158.6	237.8	X
EUROPE	325,892	6,316.0	2,589.4	11,447.1	1,783.0
Albania	649	6.1 d	6.2	X	6.2
Belgium	76	3.6	1.5	X	2.1
Bosnia and Herzegovina	23	0.0	X	X	X
Bulgaria	457	10.9	6.5	25.7	X
Croatia	5,663	44.9 d	31.7	X	X
Denmark {e}	5,316	102.4	24.8	80.4	X
Estonia	2,956	36.2	24.3	11.6	X
Finland	31,119	82.5 d	55.1	X	55.1
France	7,330	160.7	73.4	706.4	73.4
Germany	3,624	55.5	18.4	37.4	X
Greece	15,147	94.3 d	114.9	X	114.9
Iceland	8,506	108.7	73.0	678.7	X
Ireland	6,437	151.9	39.4	X	358.9
Italy	9,226	110.8 d	155.6	X	155.6
Latvia	565	28.0	12.6	15.6	X
Lithuania	258	5.7	2.0	3.6	X
Netherlands	1,914	64.0	13.2	X	50.3
Norway	53,199	218.5	111.2	1,095.1	X
Poland	1,032	30.0	10.6	19.4	X
Portugal	2,830	20.1	64.1	1,656.4	X
Romania	696	18.6	5.3	18.0	X
Russian Federation {c}	110,310	4,137.0	1,318.1	6,255.8	X
Slovenia	41	0.2	0.2	X	X
Spain	7,268	62.1	115.8	683.2	205.2
Sweden	26,384	153.8	85.3	73.2	X

Ukraine	4,953	78.0		53.9		86.4	X
United Kingdom	19,717	522.6		168.1		X	753.8
Yugoslavia	X	3.1	d	X		X	X
MIDDLE EAST & N. AFRICA	47,282	786.5		649.7	b	2,016.0	196.0
Algeria	1,557	9.7		27.9		X	60.5
Egypt	5,898	50.1		57.0		185.3	X
Iran, Islamic Rep {c}	5,890	160.2		76.4		129.7	X
Iraq	105	1.0	d	0.7		X	X
Israel	205	3.2	d	4.1		X	X
Jordan	27	0.1		0.1		X	0.1
Kuwait	756	6.5	d	5.4		X	X
Lebanon	294	1.2		4.7		X	X
Libyan Arab Jamahiriya	2,025	63.6	d	38.1	b	222.4	20.9
Morocco	2,008	70.4		37.5		328.4	X
Oman	2,809	46.7		51.8		487.4	X
Saudi Arabia	7,572	95.6	d	82.0		X	X
Syrian Arab Rep	212	0.9	f	3.9	b	X	X
Tunisia	1,927	65.3	d	36.8		X	X
Turkey	8,140	53.3		81.0		176.6	81.0
United Arab Emirates	2,871	51.4		31.0		21.2	X
Yemen	3,149	65.3		82.4		465.0	X

Table 2

Coastal Zone Statistics by Country

	Coastal Length {a} (km)	Area of Continental Shelf (up to 200 m depth) (000 km²)		Territorial Sea (up to 12 nm) (000 km²)		Claimed Exclusive Economic Zone (000 km²)	Exclusive Fishing Zone (000 km²)
SUB-SAHARAN AFRICA	63,124	987.0		871.9	b	7,866.1	3,111.1
Angola	2,252	44.2	f	34.7	b	X	438.0
Benin	153	2.8	f	2.5	b	X	26.8
Cameroon	1,799	13.1	f	8.5	b	10.9	X
Congo	205	7.4	f	3.5	b	X	41.4
Congo, Dem Rep	177	0.8		1.0		X	121.0
Côte d'Ivoire	797	8.6		12.3		157.4	X
Equatorial Guinea	603	8.6		12.9		291.4	X
Eritrea	3,446	47.5	d	39.2		X	X
Gabon	2,019	36.8		19.6		180.7	X
Gambia	503	5.7		2.3		20.5	X
Ghana	758	18.1		11.9		216.9	X
Guinea	1,614	49.7		14.2		97.0	X
Guinea-Bissau	3,176	37.2		19.5		86.7	X
Kenya	1,586	8.5		12.4		104.1	X
Liberia	842	14.9	f	12.7	b	X	239.1
Madagascar	9,935	96.7		124.9		1,079.7	X
Mauritania	1,268	28.4		19.5		141.3	X
Mozambique	6,942	73.3		70.9		493.7	X
Namibia	1,754	95.0		32.7		536.8	X
Nigeria	3,122	41.8		19.3	b	164.1	X
Senegal	1,327	21.0		11.5		147.2	X
Sierra Leone	1,677	23.2	f	11.2	b	X	155.9
Somalia	3,898	40.4		68.8		X	759.3
South Africa	3,751	160.9		74.7		X	1,450.6
Sudan	2,245	15.9		32.6		X	X
Tanzania, United Rep	3,461	17.9		36.6		204.3	X

Togo	53	0.6		1.0	b	10.8	X
NORTH AMERICA	398,835	5,107.5		3,484.1		11,084.4	X
Canada	265,523	2,877.6		2,687.7		3,006.2	X
United States	133,312	2,229.9		796.4		8,078.2	X
C. AMERICA & CARIBBEAN	73,703	806.6		1,050.0	b	6,489.0	197.2
Belize	1,996	8.7		18.5		12.8	X
Costa Rica	2,069	14.8		24.2		542.1	X
Cuba	14,519	51.0		122.8		222.2	X
Dominican Rep	1,612	5.9		14.0		246.5	X
El Salvador	756	17.7	f	6.6	b	X	87.5
Guatemala	445	13.0		7.7		104.5	X
Haiti	1,977	5.9		40.1		86.4	X
Honduras	1,878	58.8		36.5		201.2	X
Jamaica	895	5.6		16.0		234.8	X
Mexico	23,761	393.3		291.6		2,997.7	X
Nicaragua	1,915	68.6	f	31.6	b	X	94.9
Panama	5,637	44.2	f	57.8	b	274.6	X
Trinidad and Tobago	704	22.6		13.0		60.7	X
SOUTH AMERICA	144,567	2,203.0		1,030.0	b	9,358.8	1,814.1
Argentina	8,397	798.5		142.5		925.4	X
Brazil	33,379	711.5		218.1		3,442.5	X
Chile	78,563	218.9		271.9		3,415.9	X
Colombia	5,874	16.2		44.0		706.1	X
Ecuador	4,597	31.5	f	107.3	b	X	957.0
Guyana	1,154	48.8		10.9		122.0	X
Peru	3,362	84.8	f	59.6	b	X	746.5
Suriname	620	56.9		9.0		119.1	X
Uruguay	1,096	68.8	f	22.5	b	110.5	110.5
Venezuela	6,762	123.6		136.0		385.7	X
OCEANIA	137,772	2,565.0		2,830.4		30,155.0	X
Australia	66,530	2,065.2		773.1		6,664.1	X
Fiji	4,637	19.5		162.2		1,055.0	X
New Zealand	17,209	247.8		176.6		3,887.4	X
Papua New Guinea	20,197	132.4		752.3		1,613.8	X
Solomon Islands	9,880	25.9		212.3		1,377.1	X

Sources: Pruett and Cimino, 2000 unpublished data (maritime areas); CIESIN 2000 (population). Notes: "X" in data column signifies that the data are not available or are not relevant. World totals and regional totals include countries not listed in this table. a. Figures should be interpreted as approximations because of the difficulty of measuring coastline length. Estimates may differ from other published sources. b. Excludes excessive territorial seas claims. For the world, the area of territorial seas in dispute is 2,867,050 km ^{2}. c. No areas claimed in the Caspian Sea have been included. d. Includes continental shelf area of the potential exclusive economic zone even though the country may have not claimed it. e. Excludes Greenland. f. The breadth of the territorial sea is disputed.

Characterizing underwater and benthic ecosystems is even more difficult than describing terrestrial ecosystems. Until the middle of this century, most of our knowledge of continental shelf communities was based on samples dredged or captured by trawls, grab-samples, or even the wax or tallow affixed to the base of plumblines used in hydrographic surveys. The advent of scuba diving, combined with increasing use of manned and remote submersibles, has greatly improved our knowledge base. Unfortunately, this knowledge has expanded in parallel with vastly increased fishing efforts on almost all of the world's continental shelves, including the highly destructive use of benthic trawls. *(See Box 2.)* Thus, we have little knowledge of what pristine environments in the waters just off our shores may have been like even 50 years ago, unless we examine such historic records as the trawl samples taken by early oceanographic cruises and compare them with modern samples.

One of the most fundamental descriptive approaches in terrestrial biogeography at global and regional levels is the identification and description of potential vegetation and the subsequent subdivision of the world into biogeographic ecoregions. Ecoregional mapping combines **habitat** or ecosystem identification with knowledge of physio-chemical parameters and also historical factors of species evolution and distribution. Such work has also been attempted in the marine environment by a number of authors. Biogeographic patterns in the water column are determined most notably by water circulation patterns driven by wind, Coriolis force, and temperature, as well as salinity and nutrient availability. For example, various researchers have studied patterns of pelagic ecosystems and prepared schemes based on ocean currents, temperatures, productivity, or salinity (Hayden et al. 1984; Bailey 1998; Longhurst 1998). Others have looked at patterns in benthic communities (Ekman 1953; Hedgpeth 1957; Briggs 1974), although the availability of data from nonshelf benthos is so poor that they have only described these in general terms.

The classification used by Bailey and Longhurst includes ecological domains, such as the polar/boreal region, westerly drifts, and trade winds. Longhurst further delineated 56 secondary biogeochemical provinces within such domains, including **coastal** waters, and used them to report the pelagic primary production (Longhurst 1995). Sherman (1993) developed Large

sembled for this study. Some of the d
following sections are gathered under
political regions, and reaggregation of

E x t e n t a n d C h a n g e i **C o a s t a l** E c o s y s t e m

The extent and change of **coastal** ec
relative to most other terrestrial **habit**
vidual **coastal** ecosystems, such as w
to cover relatively small areas, detaile
measure extent or change. Until the a
such mapping was beyond the reach
day, high resolution mapping of these
pensive, and has not been attempted

Wetlands are among the most hig
worldwide. **Coastal** wetlands (both tid
destroyed by direct actions (draining,
disposal, and conversion for aquacult
sures (sediment diversion and hydrau
of polluted waters (nonpoint-source p
coastal wetlands, which are already a
sion and development in general. Nat
erosion and subsidence, also contribu
human actions often aggravate these

To provide a global overview of th
diverse **coastal habitat** types, this stu
other **coastal** wetlands, seagrasses, a

MANGROVES

Unlike for most other **coastal** ecosyst
available on the global distribution of
on the **coastal** characterization prese
approximately 8 percent of the world's
estimate by Spalding et al. (1997:20–
groves are distributed along approxim
world's tropical coastlines, covering a
km^2. About 112 countries and territori
their borders. Estimates of current ma
nificantly from one source to another,

Marine Ecosystems (LMEs) as ecological subdivisions of **coastal** waters, which are targeted for ecosystem-based monitoring and management, although the LMEs are incomplete in their global coverage. Such biogeographic regionalization is more ecologically grounded than are political units and provide a better spatial analytical framework in organizing the data collection, assessment, and reporting of ecosystem conditions.

The existing regionalization schemes are useful in characterizing various **coastal** areas; however, no single scheme is either possible or suitable for summarizing all of the data as-

difference in definition, methodology, a tion used *(see Spalding et al. 1997, fo issue)*. Table 4 presents mangrove ar derived from maps and other publishe

No global or even regional map sh bution of mangroves with sufficient res differences between such a distributio area. Scientists are unable to estimate mangroves were before people began ever, based on historical records, it ca

Table 4

Mangrove Area by Country (km²)

Country or REGION	Area	Country or REGION	Area	Country or REGI
THE AMERICAS	49,096	WEST AFRICA	27,995	AUSTRALASIA
Aruba	4.2	Angola	1250	Australia
Bahamas	2,332	Benin	17	Federated States
Belize	719	Togo	26	Fiji
Bermuda	0.1	Cameroon	2,494	Guam
Brazil	13,400	Congo	120	Nauru
Cayman Islands	71	Côte d'Ivoire	644	New Caledonia
Colombia	3,659	Equatorial Guinea	277	New Zealand
Costa Rica	370	Gabon	2500	Solomon Islands
Cuba	7,848	The Gambia	497	Tonga
Dominican Republic	325	Ghana	100	Vanuatu
Haiti	134	Guinea	2,963	Western Samoa
Ecuador	2,469	Guinea-Bissau	2,484	Papua New Guin
El Salvador	268	Liberia	190	
French Guiana	55	Mauritania	1.04	EAST AFRICA/M
Guatemala	161	Nigeria	10,515	Bahrain
Guyana	800	Senegal	1,853	Iran
Honduras	1,458	Sierra Leone	1,838	Oman
Jamaica	106	Zaire	226	Qatar
Anguilla	5.17			United Arab Emi
Antigua and Barbuda	13.16	SOUTH & SOUTHEAST ASIA	75,173	Comoros
Barbados	>0.07	Bangladesh	5,767	Mayotte
British Virgin Islands	4.35	Brunei Darussalam	171	Seychelles
Dominica	1.56	Cambodia	851	Djibouti

Grenada	2.35	China and Taiwan	366	Egypt
Guadeloupe	39.83	Hong Kong	2.82	Eritrea
Martinique	15.87	India	6,700	Saudi Arabia
Montserrat	>0.02	Indonesia	42,550	Somalia
Netherlands Ant. (LW)	10.51	Japan	4	Sudan
Netherlands Ant. (WW)	0.87	Malaysia	6,424	Yemen
St. Kitts and Nevis	>0.71	Myanmar	3,786	Kenya
St Lucia	1.25	Pakistan	1,683	Madagascar
St Vincent	>0.45	The Philippines	1,607	Mozambique
US Virgin Islands	9.78	Singapore	6	South Africa
Mexico	5,315	Sri Lanka	89	Tanzania
Nicaragua	1,718	Thailand	2,641	
Panama	1,814	Vietnam	2,525	
Peru	51			
Puerto Rico	92			
Surinam	1,150			
Trinidad and Tobago	>70			
Turks and Caicos	111			
United States	1,990			
Venezuela	2,500			

Source: Spalding et al. 1997.

Table 5

Mangrove Loss for Selected Countries

Region and Country	Current Extent (km²)	Approximate Loss (%)	Peri
Africa			
Angola	*1,100*	50.0	Original exter
Cote d'Ivoire	640	60.0	Original exter
Gabon	*1,150*	50.0	Original exter
Guinea-Bissau	*3,150*	70.0	Original exter
Kenya	*610*	3.9	1971 - 1
Tanzania	*2,120*	60.0	Original exter
Latin America			
Costa Rica	*413*	-5.9 (gain)	1983 - 1

Costa Rica	[illegible]	[illegible] (gain)	[illegible]
El Salvador	*415*	7.8	1983 - 1
Guatemala	161	31.0	1960s -1
Jamaica	106	30.0	Original exter
Mexico	5,315	64.7	1970s - 1
Panama	*1,581*	67.5	1983 - 1
Peru	51	24.5	1982 - 1
Asia			
Brunei	*200*	20.0	Original ext
Indonesia	*24,237*	54.9	Original exter
Malaysia	*2,327*	74.1	Original exter
Myanmar	*4,219*	74.6	Original exter
Pakistan	*1,540*	78.0	Original exter
Philippines	*1,490*	66.7	1918 to 8
Thailand	*1,946*	83.7	Original ext
Vietnam	2,525	36.9	Original ext
Oceania			
Papua New Guinea	*4,627*	8.0	Original exter

Sources: a. World Resources Report 1990; b. UNEP 1997 a; c. Davidson and Gauthier 1993; d. Spalding et al.1997; e. MacKin f. World Bank 1989; g. BAP Planning 1993.

Note: Current extent estimates in italics are not in agreement with the estimates in Table 4, because of differences in year a methodology.

area has declined considerably. Overall, according to one estimate, 50 percent of the world's mangrove forests have been lost (Kelleher et al. 1995:30). Indeed, as Table 5 shows, a number of countries, for which data are available, have lost somewhere between 5 and nearly 85 percent of original mangrove extent. Extensive losses from the original distribution, particularly in the last 50 years, include an estimated 83.7 percent of mangroves in Thailand, and 67 percent in Panama during the 1980s. *(See Table 5.)* Although the net trend is clearly downward, in some regions, mangrove area is actually increasing as a result of plantation forestry and small amounts of natural regeneration (Spalding et al. 1997:24).

NON-MANGROVE **COASTAL** WETL

Unlike mangroves, other wetland type swamps, and peatlands, are less clea is difficult to distinguish ***coastal*** wetla lands. A broad definition of wetlands u on Wetlands, also known as the Rams is internationally accepted, also encor seagrass beds in **coastal** waters (Dav No comprehensive global information able national information, is available seagrass habitats, salt marshes, peat of **coastal** wetlands. Where data do e loss is often dramatic. For example, s Indonesia's peat swamps and as muc are believed to have been lost (Macki

Table 6

Coastal Wetland Extent and Loss for Selected Countries

Country	Habitat Classification	Original Extent (km²)	Current Extent (km²)	Appr
Asia				
Brunei	Peat Swamp	1,643	1,236	
Cambodia	Peat Swamp	15,189	0	
India	Seasonal Salt Marsh	23,524	23,985	
Indonesia	Peat Swamp	196,123	106,136	
Malaysia	Peat Swamp	13,806	5,703	
Pakistan	Seasonal Salt Marsh	8,736	8,736	
Vietnam	Peat Swamp	14,819	230	
Latin America				
Costa Rica	Peat Swamp	X	370	
El Salvador	Peat Swamp	X	90	
Honduras	Peat Swamp	X	4,530	
Nicaragua	Peat Swamp	X	3,710	
Panama	Peat Swamp	X	7,870	
Other				
Brittany, France	Coastal Wetlands	X	X	
US	Coastal Wetlands	X	274,000	

Sources: a. MacKinnon 1997; b. Davidson and Gauthier 1993; c. Dugan 1993; d. Field et al. 1991; e. NOAA 1999.
Note: X signifies that the data are not available.

6 reflects **coastal** wetland extent and loss estimates for a selected number of countries.

SEAGRASSES

As with **coastal** wetlands, information on the extent and loss of seagrass **habitat** is also limited. Historically, most seagrass habitat loss has been the result of degrading water quality primarily caused by high nutrient and sediment loadings. Direct damage from vessels, dredging, and trawling are other activities that have significantly harmed many seagrass beds.

Even though global information on seagrass extent and loss is extremely limited, the magnitude of loss in these ecosystems is thought to be high. Twelve of the 34 responses to the "Global Seagrass Survey," conducted in 1997 and covering 23 countries, report that seagrass area in those countries has declined (Global Seagrass Survey 1999). Given that the survey only represents a fraction of the countries that have seagrass beds within their territory, the results are alarming. In the United States, for example, over 50 percent of the historical seagrass cover has

CORAL REEFS

Information on the extent and distribut ably greater than for any other marine global maps of coral reefs have existe The World Conservation Monitoring C compiled a coarse-scale (1:1,000,000 low coral reefs and more detailed ma tries. Worldwide, there are an estimat low coral reefs, with more than 90 per Indo-Pacific region (Spalding and Gre Table 7 presents two global estimates first column summarizes estimates fro cused on emergent reef crest and ver tems. The second column is from a 19 less detailed approach, but included e areas, that are extremely poorly mapp

In general, coral reef degradation i lem than outright reduction in coral re However, coral reef area has been sig parts of the world through land reclam been lost from Tampa Bay, 76 percent from the Mississippi Sound, and 90 percent from Galveston Bay (NOAA 1999b:19). These losses are partly attributed to population growth and the resulting deterioration in water quality (NOAA 1999b:19).

Additionally, as increasing numbers o ened from coral bleaching, coral disea mortality is likely to increase. When re reef will eventually erode and as a res coral reef area.

Table 7

Comparison of Two Coral Reef Area Estimates

Region	Coral Reef Area (km²) from Spalding and Grenfell 1997	Coral Reef Area (km²) from Smith 1978
Middle East	20,000	39,000
Atlantic and Caribbean	23,000	97,000
Indian Ocean	36,000	146,000
Southeast Asia	68,000	182,000
Pacific	108,000	153,000
World	255,000	617,000

Note: Spalding and Grenfell estimates focus on shallow and emergent reef areas.

Human Modification of **Coastal** Ecosystems

Humans have modified large areas of the coastline for centuries. Some of the major pressures significantly altering **coastal** ecosystems around the world are land use changes and population growth in the terrestrial communities, and trawling in the benthic communities. The following section presents indicators of the degree of modification of **coastal** ecosystems.

TERRESTRIAL COMMUNITIES

Land Cover

In the absence of detailed estimates of **habitat** conversion, which would be more suitable in directly measuring the human modification of **coastal** ecosystems, this study estimated the overall

Figure 2 summarizes the land cov fication by the UNEP's Regional Seas modification for the North Atlantic as c "natural" vegetation classes are group lands", "other natural", and "snow and

As shown in Map 2, the terrestrial the Black Sea, Mediterranean, and So highest percentage of "altered" lands, the Arctic, Northeast Pacific, South Pa Africa, East Africa, Red Sea and Gulf regions have the highest proportion o

Population Density

As human population increases in **co** sure on **coastal** ecosystems through pollution, and demand for **coastal** res rect human modification of **coastal** ec by looking at the population density w There are many published estimates o population living on the coast, as well for various countries. In most cases, t use of various definitions of **coastal** p on a fixed distance from the coastline others on administrative units adjoinin upon topography, and land areas disc ish or salt water.

In order to measure the direct and lation on **coastal** ecosystems, an idea population" should take into considera ence that this given population would environment. Some of the important fa level of **alteration** in **coastal** ecosystems by using remote sensing to evaluate how much terrestrial **coastal** area remains in natural vegetation, such as forests or grasslands, versus modified habitats, such as urban and agricultural lands. This analysis made use of the 1-kilometer resolution Global Land Cover Characteristics Database (GLCCD 1998) derived from the Advanced Very High-Resolution Radiometer (AVHRR) satellite data covering the period between 1992 to 1993. A classification using 15 different land cover classes (excluding water bodies) was used as the base for this analysis. These were aggregated into "natural," "altered," and "semialtered" classes as shown in Map 2 and Figure 2. Excluding Antarctica, 19 percent of all lands within 100 km of the coast are classified as altered, meaning they are in agricultural or urban use; 10 percent are classified as semialtered, involving a mosaic of natural and altered vegetation; and 71 percent fall within the "natural" or least modified category, meaning that the natural **habitat** remains. This 71 percent includes large uninhabited areas of the world, mostly in northern latitudes.

would include: access or travel time t
provides an estimate of how many pe
presence of rivers or hydrographic bo
sheds, as a means of human access,
transport; topography, such as local s
erosion, etc.; and socioeconomic fact
sumption, because they provide basic
nomic activities the population is eng
impact of these activities on the **coas**
complexity and subjectivity of integrat
as the need to provide a definition of
consistent with previous published es
the level of *direct* human modification
examining the population within 100k
Map 3.) This estimate was calculated
plicit database reflecting global huma
for this project (CIESIN et al. 2000). I
sents population count and percenta
1990 and 1995 for the world, as well
25, 50, and 100 km of the coast. Glob

Figure 2

Natural versus Altered Land Cover Summary

Source: GLCCD, 1998.

living within 100 km of the coast increased from roughly 2 billion in 1990 to 2.2 billion in 1995—39 percent of the world's population. If Map 2 on land cover is compared with Map 3 on population density, one can see that high population density correlates with urban areas classified in Map 2 as "altered" lands. The most uninhabited areas, as is expected, are in northern latitudes, where much of the "natural" land cover remains.

BENTHIC COMMUNITIES

Our lack of knowledge of sea bottom habitats and species distribution on the world's continental shelves precludes most direct measures of changes in these environments. There have been only site-specific studies of geophysical characterization or mapping of near-shore benthic **habitat**. One way of inferring

the level of human modification to the
the areas where destructive activities
most direct and globally pervasive thr
ment benthic communities on contine
world is bottom trawling. The PAGE s
bal analysis on the extent of benthic tr
compiled and mapped for trawling gro
taining 41 percent of the world's conti
the areas captured by this analysis, tr
percent of the total continental shelf a
sented in Box 2 and Map 4, show tha
vast majority of the world's continenta
extent.

Table 8

Coastal Population Estimates for 1990 and 1995

Box 2

Global Distribution of Known Trawlir

Proximity to Coastline	Population in 1990 (millions)	Population in 1995 (millions)	Percentage of total population in 1995
Within 25 km	1,070	1,144	20%
Within 50 km	1,544	1,646	29%
Within 100 km	2,075	2,213	39%
Global population total	5,267	5,667	100%

Source: CIESIN 2000.
Note: Figures are expressed in cumulative totals and calculated from a GIS database with the grid resolution of approximately 5km by 5km, and thus, may differ from other published estimates.

I n f o r m a t i o n S t a t u s a n d N e e d s

Information on the location and extent of **coastal** features and ecosystems types often provides the basis for subsequent analyses of condition of the ecosystem, relationships between different habitats, and overall trends. Yet, despite this fundamental importance, such information is incomplete and inconsistent at the global level. Benthic ecosystem mapping, for example, has only been performed for a limited number of habitats and over certain portions of the globe. Data on the distribution of important and restricted habitats, such as kelp beds and seagrasses, are not available at the global level.

The data sets presented in this study made use of the best information currently available at the global scale. UNEP-WCMC has attempted to develop base maps of coral reefs, mangroves, and wetlands for the world by harmonizing and integrating available sources. These are the best base maps currently available for these **habitat** types, still, they reflect the uneven quality of the original data sources. Differences in definitions as well as variations in resolution and interpretation further complicate the numerical measurement of **habitat** extent from global maps. There is an urgent need for better global classifications and data sets characterizing the world's coasts, particularly the distribution of sandy and rocky shores, salt marshes, tidal mudflats, and lagoons.

Much data could be gathered from existing maps, chart series, aerial photographs, and high- resolution satellite imagery. Priority should be given to amalgamating and harmonizing available data into global data sets, from which gaps in knowledge could be more directly assessed. Once assembled, it is important that these data sets be freely and publicly available.

Historical data describing previous extent of habitats, against which we might hope to measure change, is highly limited. No comprehensive global assessments of changes in the extent of **coastal** habitats have been carried out. The tables presented

Grounds

Benthic trawling is a significant sour biodiversity of coastal and benthic e ers are powerful and effective fish-lc machines. Habitats in trawl-swept ar which a trawl has passed—may be li fects lasting only a few weeks or int some impacts on corals, sponges, a species lasting decades or even cen ing is taking place beyond the contin depths up to 400m, and in some plac 1500m.

Trawling grounds are areas of th cial trawling, legal or illegal, is preva may be repeatedly swept each year, bally, an estimated 14.8 million km by trawling gear (the "trawl swept ar 1998:1190). For this study, the distri (both swept and unswept) for 24 cou cient data were available was mappe resent about 41 percent of the world *(See Map 4.)* Trawling grounds in th 8.8 million km², of which about 5.2 m on the continental shelves, or some continental shelf area of these coun

different **habitat** classification scheme time periods. Therefore, they reflect th lection. Where no historical data exist dictive mapping should be considered oceanographic, biogeographic, and to

Remote sensing, particularly the u ellite imagery, can play an important r improved information on current **habi** imagery and processing continue to d evaluation of change in **habitat** area c changes in extent of various **habitat** t multiscale approaches and should inc measurements to improve accuracy a ellite data, at the required spatial and yet to be assembled and interpreted f coarse-scale satellite sensors focused environments, we have relatively goo sea surface temperature (SST), sea le ductivity (from ocean color), and ocea tries have performed **habitat** inventor is more the exception than the rule. M vary by country. The United States, fo above are a compilation of recorded **habitat** loss measured by

vary by country. The United States, fo

sess a detailed base map of all coral r

waters, but has performed detailed mapping of all major estuaries by salinity zone.

Although the extent and change data presented above are an important basis for assessing the condition of other ecosystem goods and services—and are referred to as such throughout this report—these are mere proxies for measuring the condition of the ecosystems. Data with higher resolution and accuracy are needed to sufficiently capture the level of human modification in the complex and narrow **coastal** zone. We do not have a good understanding of the overall impacts on **coastal** ecosys-

tems caused by human modification o

anthropogenic disturbances, such as

These changes and disturbances influ

ture of these ecosystems, which may

as **habitat** loss. We need better quant

change in the extent of various habita

goods and services that are derived fr

the degree of degradation suggested

tion reinforces the need for precaution