



ministerio del ambiente

High-priority Areas Identification and Conservation Gap Analysis of the Marine Biodiversity from Continental Ecuador

Executive Summary

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BACKGROUND

This study is part of the activities aimed at the compliance of the Convention on Biological Diversity (CBD) Program of Work on Protected Areas ratified at the 7th Conference of the Parties, which took place in February 2004. Ecuador, as a signatory of the CBD, is committed to apply the more than 90 activities of the country's Work Program, designed to strengthen its National Protected Areas System (SNAP, from the Spanish Sistema Nacional de Áreas Protegidas). One of the activities contemplated in the Work Program is the System gap analysis, in order to urgently adopt (by 2006) measures addressed at establishing new protected areas or expanding the existing ones, based on the requirement of having a representative protected areas system's that adequately conserve terrestrial, marine, and inland water biodiversity and ecosystems, while at the same time protects highly threatened or highly valued areas.

In order to assist the Ecuadorian government in achieving its commitments to the CBD's Program of Work on Protected Areas, a group of conservation organizations, both national and international, subscribed a Memorandum of Understanding aimed at implementing those actions from the Program of Work that the country has to fulfill by 2006. One of such activities is precisely the Analysis of High-priority Areas for the Conservation of Marine Biodiversity in Continental Ecuador.

Marine and coastal biological research and conservation in the continental coast of Ecuador have been incipient. Systematized information regarding the biodiversity of marine and coastal ecosystems is very limited. Moreover, while most of the terrestrial ecosystems are represented in the protected areas, the marine situation is different. The few existent protected marine areas have been established generally as boundaries' extension of the terrestrial areas nearby. In other cases, protection interests have been placed only in the mangrove ecosystem, considered highly threatened by the shrimp industry.

The main objective of the present study is to identify high-priority areas for the conservation

of marine and coastal biodiversity (ecosystems, communities, and species) in the continental Ecuador, as well as those areas not currently covered by the National Protected Areas System.

Criteria used for prioritizing conservation areas were based exclusively on biological and ecological features. Social, political, economical, and cultural criteria, while very important, should be considered as part of a different process following the identification of biologically important areas. Areas defined in this study constitute a first approach to the creation of a network of marine protected areas in Ecuador, and feasibility studies should be carried out later on.

STUDY AREA

BOUNDARIES

Ecuador is a relatively small country that in spite of its reduced surface hosts a surprisingly high biological diversity, being one of the richest countries in the world in terms of ecosystems, species, and genetic resources. Because of its vast diversity the country has been included in the very short list of those nations designated as "megadiverse", which together comprise 70% of the planet's fauna and flora species.

The Ecuadorian coast is located in the Eastern Pacific and comprises approximately 4.403 km from north to south, including islands, islets, and estuarine borders. The study area comprises from the intertidal zone up to 200 m depth, also including the mangrove areas, and amounts to 3.170.400 ha.

GENERAL DESCRIPTION

The Ecuadorian marine and coastal area constitutes a remarkable transition zone in the Southeastern Pacific, characterized by a significant space and temporal variability of the physical-oceanographic conditions. Ecuador is located in the limit between two major marine ecosystems: the Pacific Central American Coastal and the Humboldtian. Available information indicates the existence of a tropical zone in the Northern area, created by the warm waters of the Panama Stream.

This area has an average annual temperature of 24.5 °C, with a 22 - 27 °C range. A second area, in the central-southern part of Ecuador, is the result of the confluence of warm waters coming from the North and cold waters from the South, which creates a continental front of mixed waters, where the temperature fluctuations and shifting of water masses depend on the time of the year. It is important to mention that Ecuador is periodically affected by the El Niño Southern Oscillation, which has produced important impacts on the marine ecosystems.

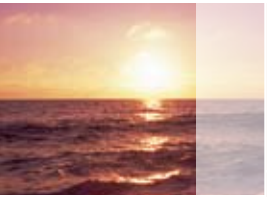
The marine and coastal zone of Ecuador exhibits a vast biological diversity generated by a multiplicity of ecosystems, which are in turn the result of the geographic location, oceanographic conditions, continental contributions, and coast morphology.

A high productivity zone is located in the central-south area of Ecuador. This zone hosts a large number of ecologically important species, which are part of a great diversity generated by the influence of the Guayas River continental contributions. Those contributions have influenced the geomorphologic composition of the Gulf of Guayaquil coast, creating unique ecosystems.

Mangroves are a fundamental part of the estuarine systems because the maintenance of the ecological processes between the marine and freshwater ecosystems, and the surrounding terrestrial ecosystems, rely on them. Ecuador has an important portion of mangroves both in the northern area (San Lorenzo) and the central-south area (Gulf of Guayaquil) of the country.

Despite of the high ecosystem and species diversity that mangroves hold, most of the information regarding marine and coastal species of Ecuador refers exclusively to planktonic and fishing marine resources. Published information on other fauna groups, especially invertebrates, is incipient.

The Ecuadorian coast is a highly populated area. Thirty-nine percent of the national territory is located within the 100 km of coast, and 58% of the Ecuadorian population inhabits there. Threats faced by the marine and coastal systems in Ecuador are mainly due to the effects of anthropic activities in the littoral zone, and also indirectly caused by the inadequate land practices in remote areas, such as river basins that flow into estuarine zones.



METHODOLOGY AND RESULTS ANALYSIS

1 MARINE ECOLOGICAL UNITS

When identifying high-priority conservation areas it is important to take into consideration the spatial distribution of such areas, it means they should be representative of different bio-geographic units. Marine Ecological Units (MEU) are a set of marine and coastal systems that have different temperature, depth, continental contributions, and species' distribution patterns. MEU were used to spatially stratify the country's marine zone, by using environmental variables that determine marine biodiversity patterns and ecological systems characteristics.

Sea surface temperature, bathymetry, and the continental contributions (freshwater) were considered to establish MEU in the study area. Limits were modeled based on criteria directly related to the distribution of water masses, therefore with the biogeography of the country's marine species. Six MEU were identified at national level (Map 1 : Marine Ecological Units).

CONSERVATION TARGETS

Aiming at having an adequate biodiversity representation of the study area, conservation targets were selected at several geographic and biological organization scales, including marine ecological systems, communities, and species.

ECOLOGICAL SYSTEMS

Two types of marine systems were characterized: intertidal and subtidal. Intertidal systems were identified, classified, and geographically located using geomorphologic informatio n, satellite images, reconnaissance flights, and field samplings. Subtidal system classification was based on the zone's geomorphology (depth, slope, and size), on the substrate composition, structure, heterogeneity and size, and on the presence and representation of the biogenic substrate.

Four intertidal systems were identified in the continental marine and coastal zone of Ecuador: mud beaches, sandy beaches, rocky beaches, and

mangrove; and eight main subtidal systems: soft bottom, rock bottom, grave bottom, coral reef bottom, rock bank and sand bank and freshwater-influenced soft and rock bottoms. These systems were further classified considering their distribution within each MEU. Therefore, this study presents 12 intertidal systems and 27 subtidal systems. All the systems were considered as conservation targets in the study. (Map 2 and 3: Intertidal and Subtidal Marine Systems).

COMMUNITIES

The Ecuadorian coast exhibits a considerable diversity of communities located in small areas. The substrate uniqueness, tide exposure variability, and beach slope allow the presence of an aggregation of communities that are characteristic of every system, if a detailed analysis at smaller scale is carried out.

The level of detail required for marine communities characterization is not concordant with the cartographic scales applied in this study. For this reason, communities are not considered as conservation targets in the present analysis, with the exception of three distinctive ecologic communities: seabirds nesting colonies, beaches visited by migratory shorebirds, and sea turtles nesting beaches.

SPECIES

A preliminary list of the continental marine biodiversity of Ecuador was prepared and used for the identification of potential conservation target species. Later on, species were individually assessed and classified to produce a final list of conservation target species. Criteria applied had different value; the most important factors were related to endemism and current threat level, followed by ecological and biological factors, and then by other criteria (e.g., usefulness as flag-species).

A total of 53 priority species were identified as conservation targets for the continental Ecuador. In some particular cases, species of one family or genera were grouped together and treated as one target, mainly because of the lack of specific information or simply because they were sharing the same habitat. Priority species identified as conservation targets belong to seven large taxonomic groups: fishes, mollusks, sea mammals, corals, crustaceans, birds, and reptiles.

SUITABILITY ANALYSIS

Considering that a detailed analysis of the ecological integrity of each conservation target was not feasible, a geographic suitability assessment was carried out. This index is very effective in setting high-priority conservation areas apart from zones showing greater impacts due to human activities, based on the assumption that the management and conservation of the latter ones would be more costly and that the target species would have less probabilities of enduring on those areas.

A threat analysis was used to assess the areas' suitability for conservation. This step is aimed at identifying those areas that are less impacted by anthropogenic activities, and therefore can be considered as more suitable for conservation. Threats were identified and grouped in five classes: 1) Pollution, 2) Tourism, 3) Extraction, 4) Physical changes, and 5) Population. Each one of the groups was analyzed and processed in several layers of geo-referenced information.

Results from the information gathered regarding threats to marine and coastal environments allowed us to map the distribution and effects of the 17 different threat types that the marine and coastal environments face in Ecuador. Those layers of geo-referenced information are an essential requisite to assess environmental quality, and constitute the basis for the suitability analysis.

In addition to threats, positive factors, which improve the potential suitability of a given area, were also taken into consideration. Those factors were: existence of protected areas (parks, reserves, etc.) and existence of high biodiversity (Map 4: Suitability map).

GOAL SETTING

Conservation goals are established in order to secure the adequate representation of each conservation target (systems, communities, and species) within the high-priority areas identified. Goal setting is focused on the conservation of the total biological diversity and not only on those species of commercial value.

Goals were stratified by Marine Ecologic Units to ensure a good representation of systems and communities in the whole study area; target communities and species were only attributed with global goals.

Goals were calculated as a percentage of the distribution (hectares, meters, or occurrences) of each target, under five categories: *Abundant, Common, Uncommon, Rare, Very Rare* (Table 1). Percentages indicate how much representation each target

should have within the network of high-priority areas identified.

Table 1. Percentages used to calculate conservation goals for systems, communities, and target species.

Qualification	Goal
Abundant	20%
Common	30%
Uncommon	50%
Rare	60%
Very rare	75% or 100%

DESIGNING THE NETWORK OF HIGH-PRIORITY AREAS

Portfolio or the network of priority areas should be designed in such a way that it efficiently achieves the goals defined for each conservation target. An optimization algorithm (SITES) was used for designing the portfolio.

The algorithm aims to minimize the total cost of the portfolio, selecting a set of sites that includes the greater possible amount of targets, clustering the units of analysis in the more efficient way.

Additionally, SITES requires information on the spatial distribution of the conservation targets. To achieve this, units of analysis (hexagons) were intersected with the spatial distribution of each conservation target occurrence. Data may be expressed as polygons (subtidal and mangrove systems), lines (intertidal systems), or points (communities and species). Estimates of the total representation (hectares, meters, or points) of each target within each unit of analysis can be performed in the ArcView software.

A network of high-priority areas (or portfolio) was obtained by applying the algorithm. The network's total area is 933.450 ha, distributed in 25 blocks. This area constitutes 30% of the total study area, and 35% of the costal line. Blocks are well distributed in the marine ecologic units. The portfolio adequately represents the conservation targets and complies with almost every goal established.

Coherence of the selected portfolio was verified using the SITES sum runs tool to produce a map of the units of analysis most frequently selected. Units that are selected every time might be considered as irreplaceable. There is a good correlation between these units and the final portfolio.

A certain degree of flexibility may exist when choosing the conservation areas for a large part of the subtidal zone, especially in deeper waters and soft bottoms areas because there was little

information available for the model to be able to discriminate those areas more suitable for the portfolio. It is important to mention, however, that despite the difficulty in precisely define important blocks in deeper waters, these systems are important for many planktonic, pelagic, and migratory organisms. Additionally, the diversity of communities associated to soft bottoms is unknown but undoubtedly high.

Sixteen of the blocks proposed in the portfolio are concurrent with proposed protected areas or have been identified as high-priority conservation areas by national, international, public or private groups. Those blocks that have not been included are mostly from deep water and soft bottoms. This portfolio reassures and strengthens the criteria from other parties interested in the conservation of the country's marine and coastal resources.

PORTFOLIO'S PRIORIZATION

There is no official position regarding the marine and coastal ecosystems considered as high conservation priority. The National Biodiversity Strategy raise the need of securing an adequate representation of the marine and coastal ecosystems within the National Protected Areas System (SNAP) but it does not indicate what the conservation priorities are.

It is important to highlight that the prioritization made through this study is based on biological and ecological features. This information should be further analyzed along with socio-economical, cultural and political information with the aim of determining the feasibility of implementing a marine SNAP.

In order to pinpoint priorities, the cost by hectare was compared, which refers to the average block suitability with its biological value. The biological value is an index based on criteria such as size, diversity of systems and communities, unique species, connectivity, and representativeness.

The highest-priority blocks are those of greater suitability, having a high biological value given the size and diversity of systems and communities, as well as for the presence of unique species. Eight blocks were rated as high or very high priority. Those blocks represent 52% of the whole portfolio and 15% of the study area. Altogether, these 8 blocks include at least a minimum representation of 11 of the 13 intertidal target systems, 26 of the 27 subtidal target systems, 5 of the 6 target communities, and the 26 target species that were considered as goals in the analysis (Map 5: Priority Conservation Areas).

Blocks ranked as low priority are not necessarily of minor conservation importance. Rather most of them correspond to soft bottoms of deep water where biological information is very limited. Those blocks should be considered as part of future research activities in order to verify their importance for the regional conservation.

GAP ANALISYS OF THE MARINE AND COASTAL PROTECTED AREAS SYSTEM FROM CONTINETAL ECUADOR

The National Protected Areas System of Ecuador includes 33 conservation areas, just eight of them comprise marine and coastal elements, and from them only two include off-shore marine areas. Areas included in the present analysis were: 1) Manglares Cayapas Mataje Ecological Reserve, 2) Manglares Estuario Río Muisne Wildlife Refuge, 3) Manglares Churute Ecological Reserve, 4) Manglares del Salado Fauna Production Reserve and 5) Ecological Reserve Arenillas, 6) Isla Corazón and Fragatas Wildlife Refuge, 7) Machalilla National Park and 8) Isla Santa Clara Wildlife Reserve.

An analysis of the country's marine and coastal protected areas was carried out based on the presence of the systems and communities selected as conservation target. From the eight areas, six correspond to mangrove zones and estuarine associated systems, whilst the other two (Machalilla National Park and Isla Santa Clara Wildlife Reserve) include a larger diversity of subtidal systems and communities.

The portfolio proposed in this document partially overlaps with 6 of the 8 protected areas. Only two small areas, the Isla Corazón and Fragatas Wildlife Refuge, from the Tropical MEU, and the Manglares del Salado Fauna Production Reserve, from the Mixed MEU, are not included in the portfolio. From the 933.450 hectares of the portfolio, only 8% benefits from some protection status.

Eight systems are not represented within the protected areas of the Mixed MEU. The Tropical MEU does not include any of the subtidal systems, and two of the intertidal systems are not represented either. Most of the systems comprised by the protected areas do not fulfill the conservation goals defined in this document. It is evident that the SNAP does not cover adequately all the marine and coastal ecosystems of the country. (Map 6 : Priority Areas and Protected Areas).

All of the areas are vulnerable to impacts caused by human activities and some of them are located

in high cost places. Costs correspond to the threats that were mapped and valued for each unit of analysis in this study.

Considering only eight of the high and very high priority areas in the portfolio (Priority map): San Lorenzo, Galera-Muisne, Puerto Cayo, Isla de la Plata, Machalilla, Santa Elena, Data de Posorja and Bajoalto, 13% (67.020 ha) is currently part of the SNAP. Three of the five areas ranked as very high priority, and one of the three ranked as high priority partially correspond to the Manglares Cayapas Mataje Ecological Reserve or the Machalilla National Park. From the nine areas ranked as medium priority, two partially overlaps with protected areas, the Manglares Churute Ecological Reserve and the Arenillas Ecological Reserve. The only block ranked as low priority (Isla Santa Clara) corresponds with one protected area, the Isla Santa Clara Wildlife Refuge.

It is important to mention that some of the blocks rated as very high and high priority, like Galera-Muisne, Data de Posorja y Bajoalto, do not receive any protection at this time.

CONCLUSIONS

In Ecuador, marine research has largely been centered on the Galapagos Islands rather than in the continental coast. The few studies regarding the marine coastal biodiversity have mainly focused on planktonic organisms or important fishery species. Additionally, almost all of those studies refer to the zone comprised between Guayaquil and Manta. In general, there is little information regarding marine ecosystems, environmental conditions, marine physical-chemical parameters, stream patterns, particular species biology, and threats to the marine environment. This lack of updated and geo-referenced information constitutes the main problem faced for the design and management of a network of marine protected areas.

Information about threats is also limited, for example regarding chemical composition of industries' pollutant discharges, their effects on the fauna and flora, and its persistence on the environment; data on marine resources extraction and fisheries are not geo-referenced and, in many cases, they exist only as deck records, or furthermore, data is held confidential by governmental institutions, in order to protect the integrity of key commercial resources. Data regarding human population census are organized by parishes, which makes it difficult to assess its impact and demographic growth trends at specific places. Impacts generated by tourism operations on the marine and coastal environment are not sufficiently studied.

Because of the lack of information, the sites that this portfolio presents should be considered as a first approach. It is important to fill some gaps, particularly those referring to physical oceanographic factors and the spatial distribution of subtidal systems, before a biological/ecological final portfolio is defined.

This portfolio, designed on the basis of biological/ecological criteria, will constitute the basis for the design of a network of marine protected areas with the participation of representatives from the social, economical and political national sectors, and possibly with the participation of international representatives (if it is foreseen that it will be adequate to integrate this network with similar initiatives in the neighboring countries).

Because of the considerable information gaps it is not possible to identify a complete portfolio with certainty. However, it is certain that the blocks identified as very high and high priority are important; it is improbable that the addition of new information would change their classification. Those blocks pointed out as medium and low priority are the ones that require additional information to improve their definition. Similarly, for most of the target species the lack of information prevents the design of conservation programs.

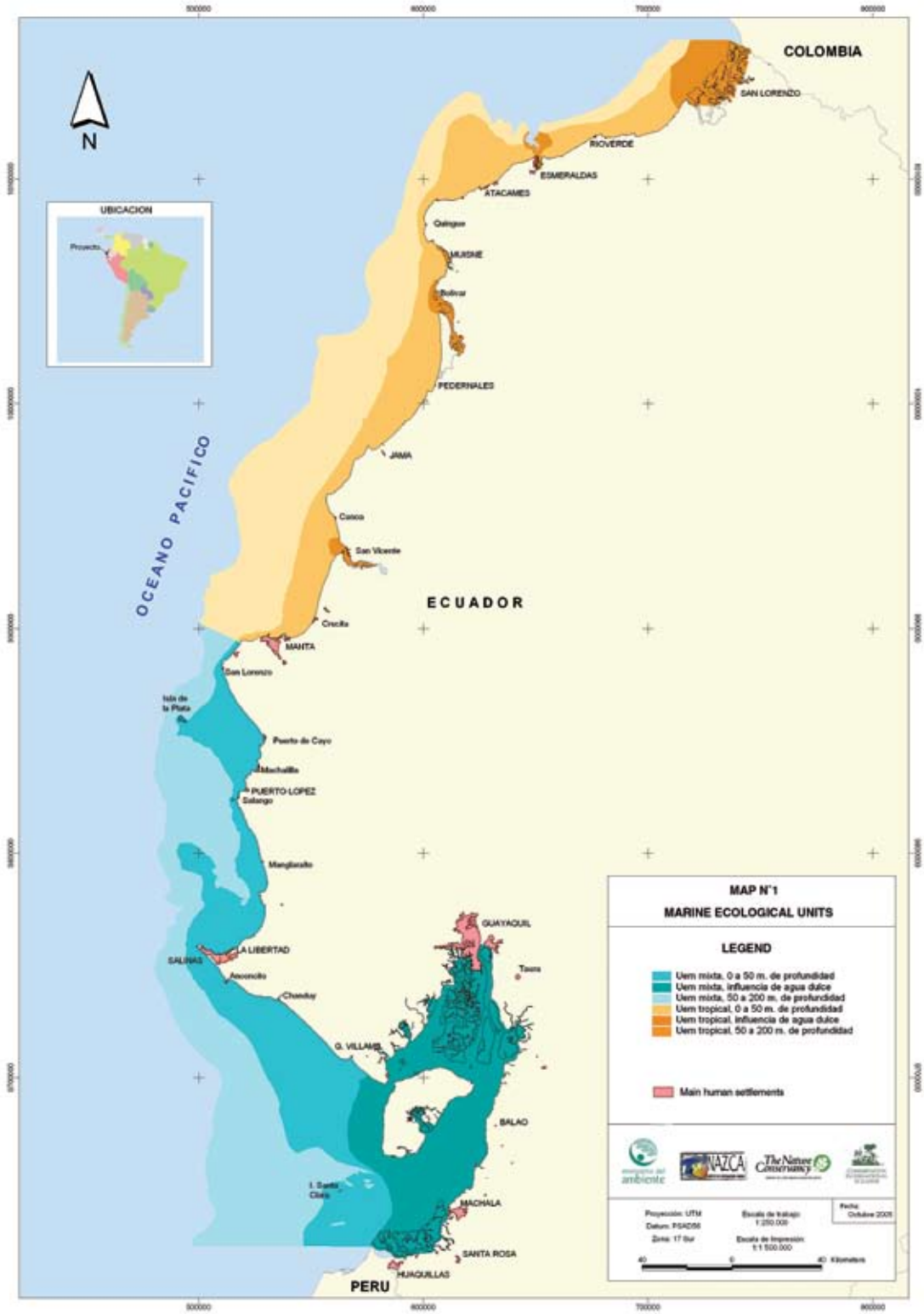
Next steps for establishing of a network of marine and coastal protected areas should include: 1) increasing the quality and quantity of geographic, oceanographic, ecological and biological information of the country's marine and coastal continental zone in or-

der to fill the most relevant gaps, and 2) initiating management processes focused on the conservation of the biodiversity of the blocks rated as very high and high priority, particularly where they overlap with the existing protected areas.

When thinking about the marine and coastal protected areas, it is necessary to consider the interactions between estuarine and intertidal systems with the adjacent subtidal systems. This is one of the reasons for considering that the coastal protected areas already established should be extended from the intertidal zone to comprise deeper water systems. On the other hand, such expansion would contribute to improve the representation of some of the systems that are currently subrepresented in the SNAP, without the need of increasing the number of protected areas.

High-priority Areas Identification and Conservation Gap Analysis of the Marine Biodiversity from Continental Ecuador

Maps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Galera
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Crucita
MANTA
San Lorenzo
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PUERTO LOPEZ
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MAP N°1
MARINE ECOLOGICAL UNITS
LEGEND
Uem mixta, 0 a 50 m. de profundidad
Uem mixta, influencia de agua dulce
Uem mixta, 50 a 200 m. de profundidad
Uem tropical, 0 a 50 m. de profundidad
Uem tropical, influencia de agua dulce
Uem tropical, 50 a 200 m. de profundidad
Main human settlements
NAZCA
The Nature Conservancy
Proyección: UTM
Datum: PSAD56
Zona: 17 Sur
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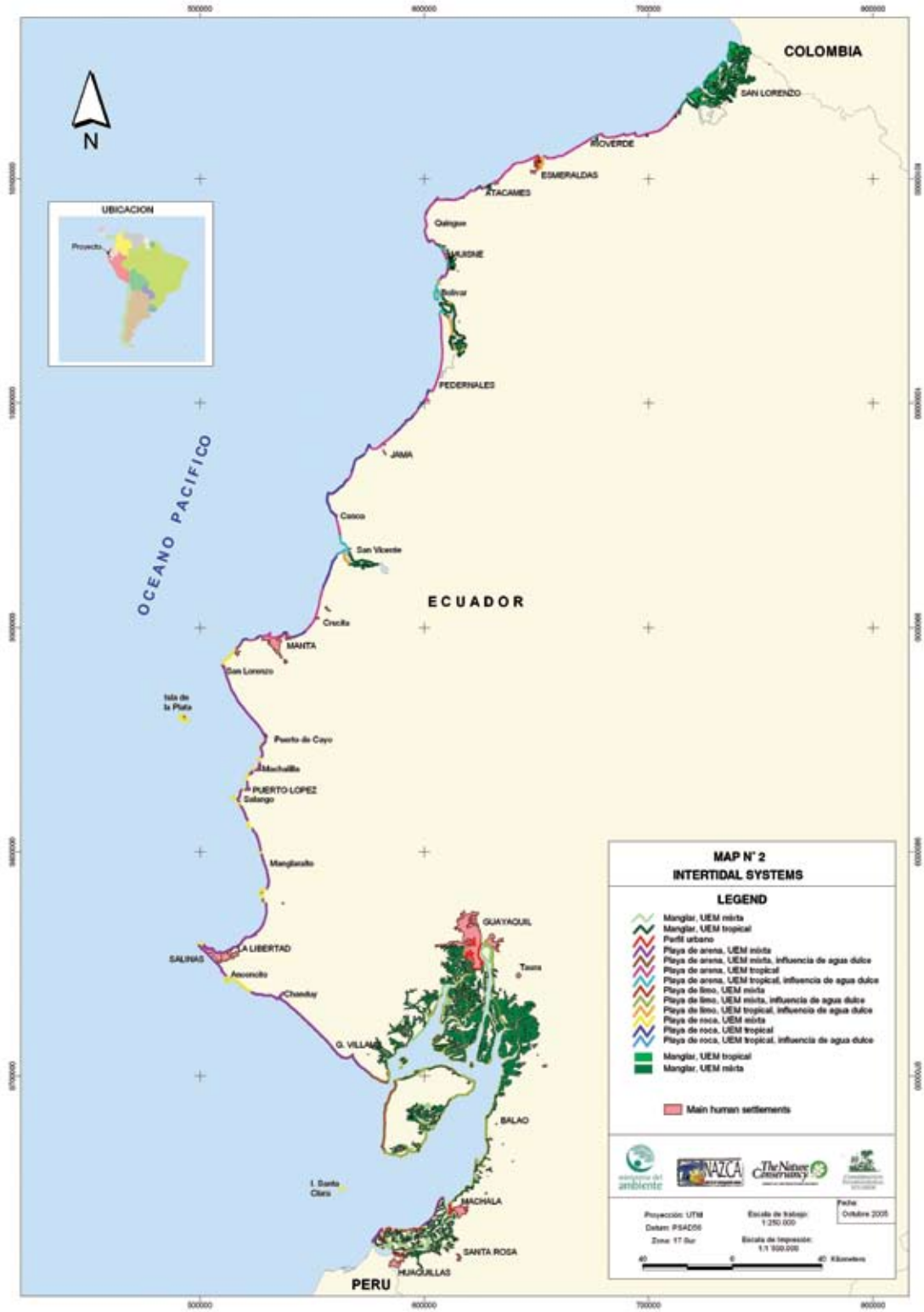
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MAP N° 2
INTERTIDAL SYSTEMS
LEGEND
Manglar, UEM mixta
Manglar, UEM tropical
Perfil urbano
Playa de arena, UEM mixta
Playa de arena, UEM mixta, influencia de agua dulce
Playa de arena, UEM tropical
Playa de arena, UEM tropical, influencia de agua dulce
Playa de limo, UEM mixta
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Playa de roca, UEM tropical
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Manglar, UEM tropical
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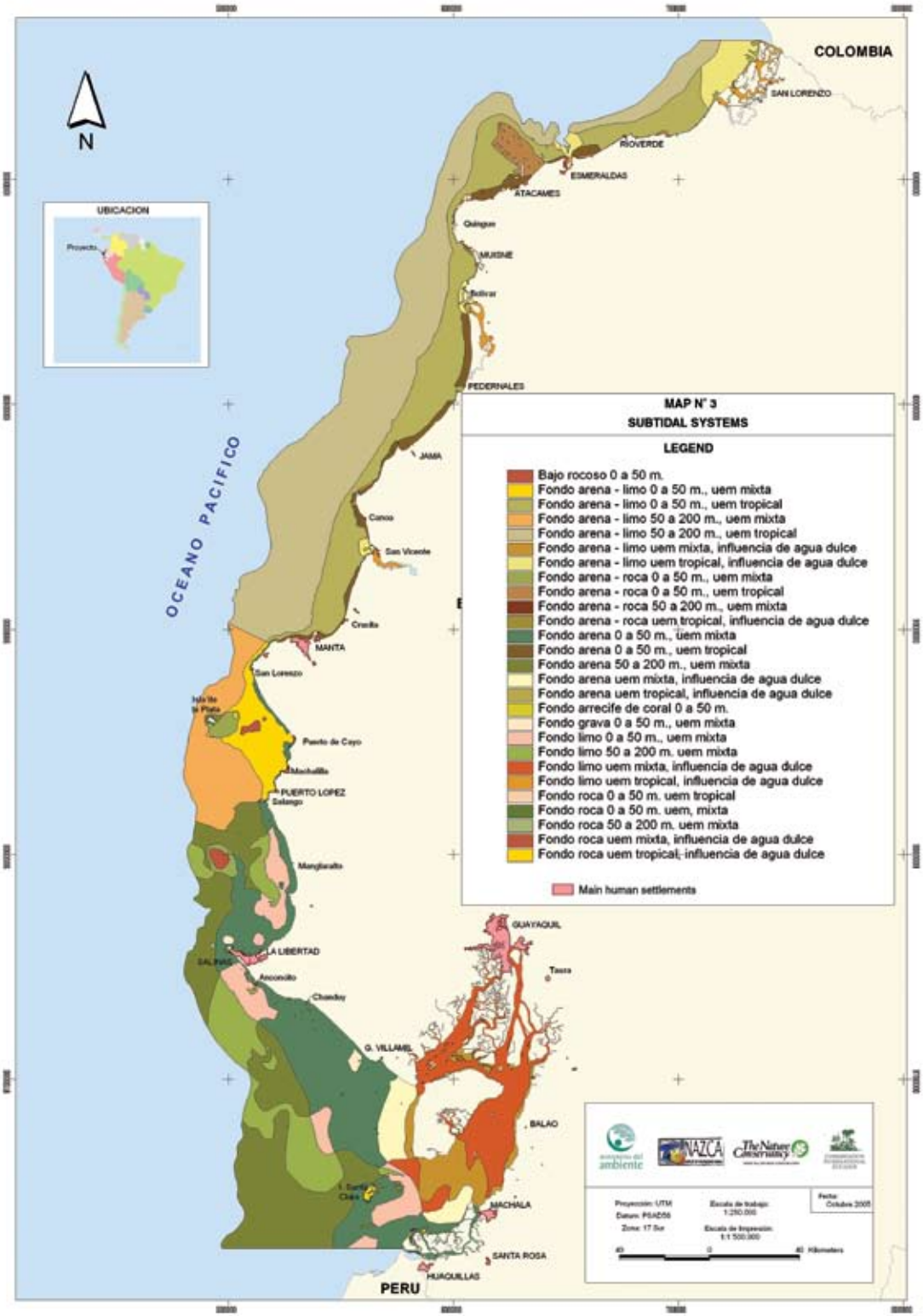
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SUBTIDAL SYSTEMS
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Fondo arena - roca uem tropical, influencia de agua dulce
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Fondo arena 0 a 50 m., uem tropical
Fondo arena 50 a 200 m., uem mixta
Fondo arena uem mixta, influencia de agua dulce
Fondo arena uem tropical, influencia de agua dulce
Fondo arrecife de coral 0 a 50 m.
Fondo grava 0 a 50 m., uem mixta
Fondo limo 0 a 50 m., uem mixta
Fondo limo 50 a 200 m. uem mixta
Fondo limo uem mixta, influencia de agua dulce
Fondo limo uem tropical, influencia de agua dulce
Fondo roca 0 a 50 m. uem tropical
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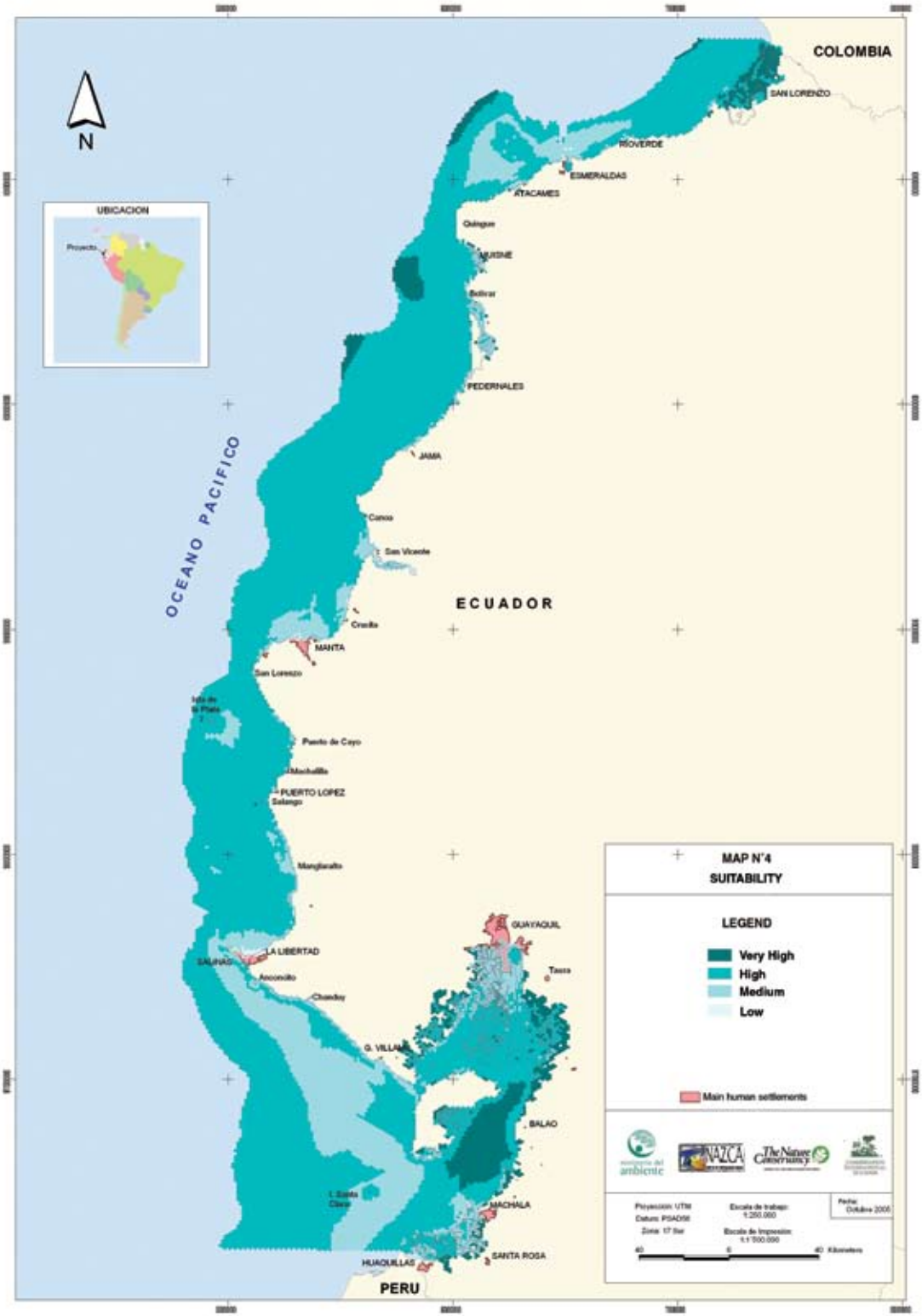
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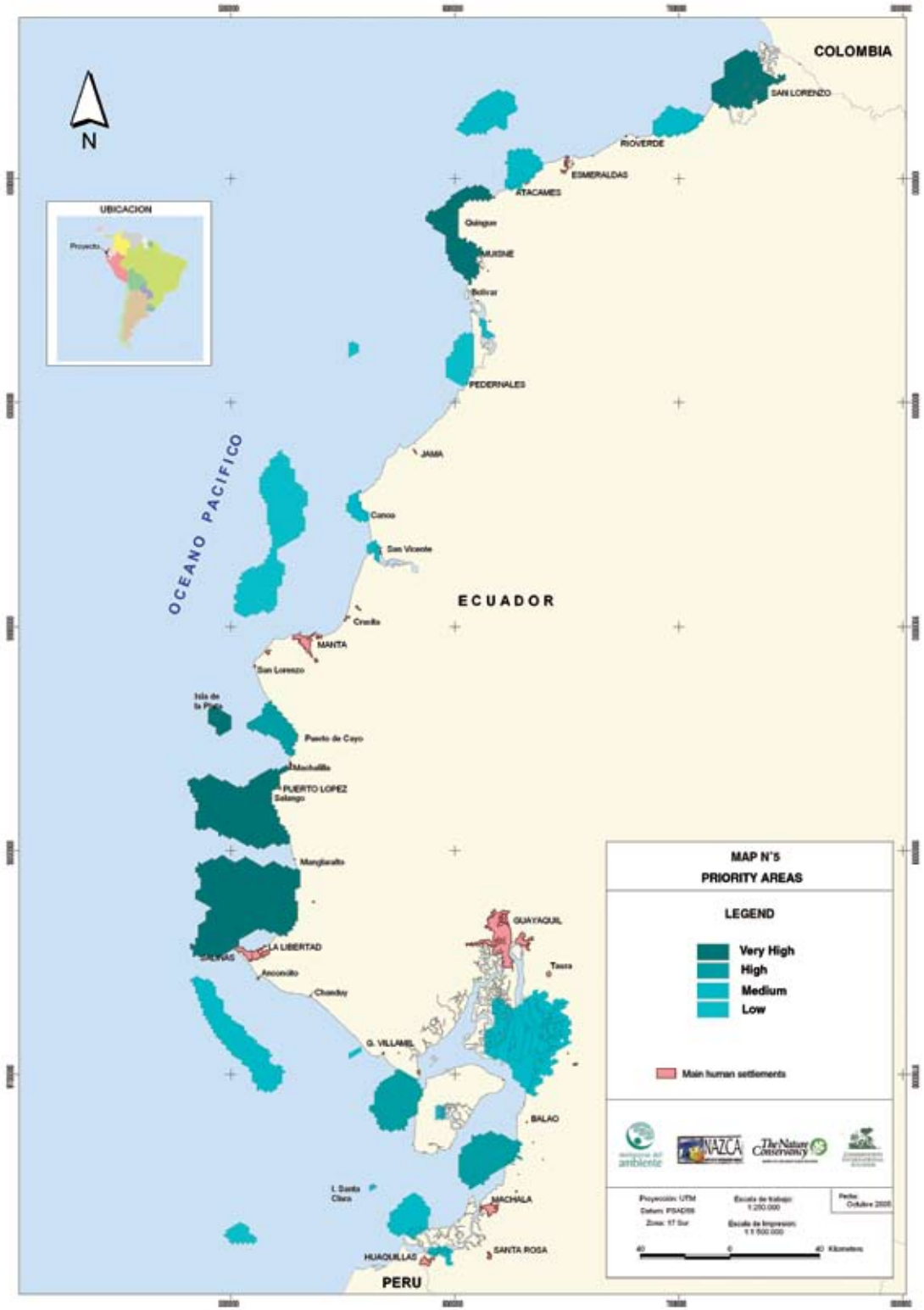
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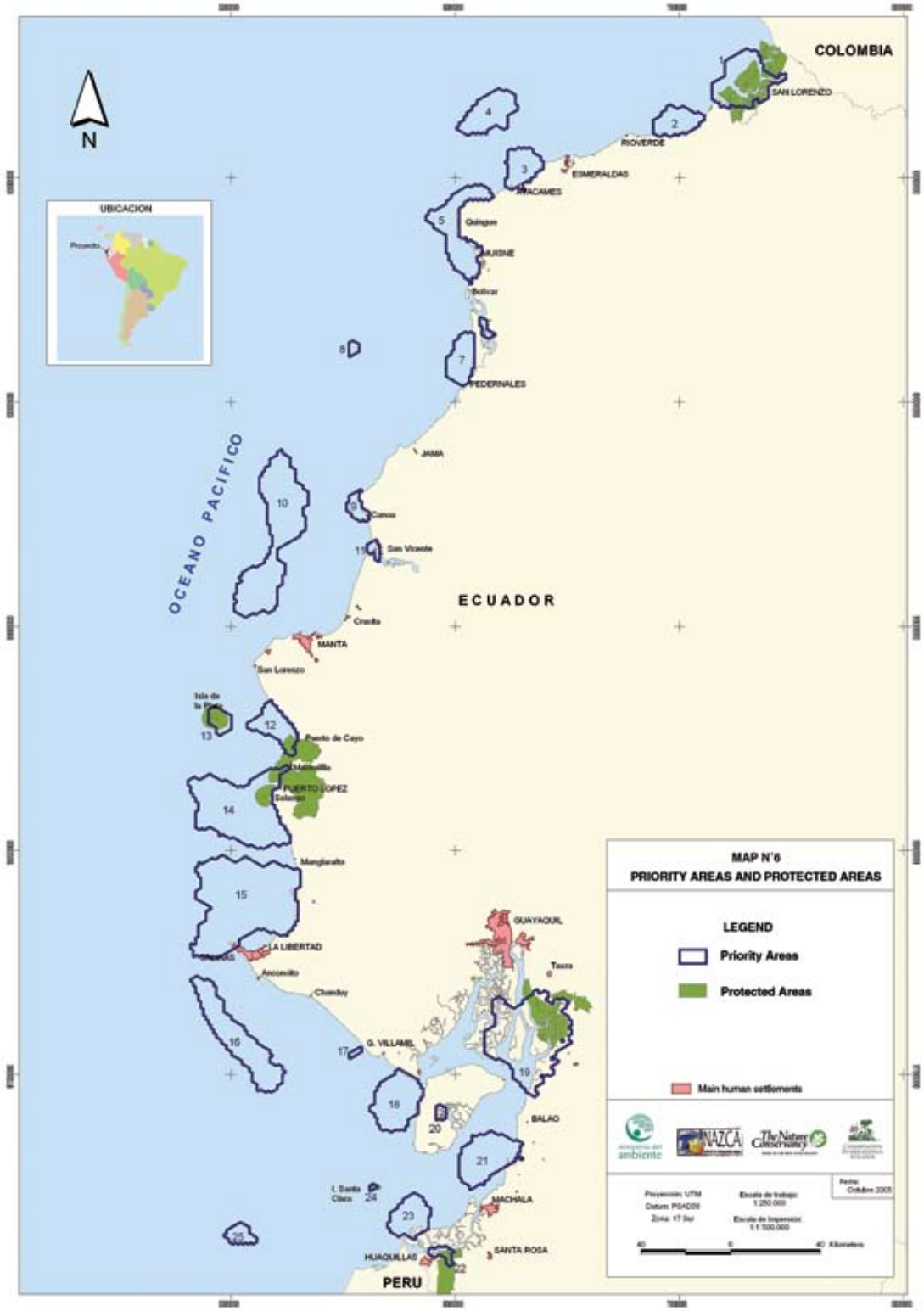
COLOMBIA
SAN LORENZO
RIOVERDE
ESMERALDAS
MUISNE
Bolivar
PEDERNALES
JAMA
Canoa
San Vicente
Crucita
MANTA
San Lorenzo
Puerto de Cayo
PUERTO LOPEZ
Salango
Manglaralto
LA LIBERTAD
Anconcito
Chanduy
G. VILLAMIL
GUAYAQUIL
Taura
BALAO
MACHALA
SANTA ROSA
HUAQUILLAS
PERU
ECUADOR
OCEANO PACIFICO
UBICACION
Proyecto
N
MAP N°6
PRIORITY AREAS AND PROTECTED AREAS
LEGEND
Priority Areas
Protected Areas
Main human settlements

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