Benthic Assemblages in South American Intertidal Rocky Shores: Biodiversity, Services, and Threats

Chapter

BENTHIC ASSEMBLAGES IN SOUTH AMERICAN INTERTIDAL ROCKY SHORES: BIODIVERSITY, SERVICES, AND THREATS

Patricia Miloslavich[1,2], Juan José Cruz-Motta,[1,3], Alejandra Hernández[1,4], César Herrera[1], Eduardo Klein[1], Francisco Barros[5], Gregorio Bigatti[6], Maritza Cárdenas[7], Alvar Carranza[8], Augusto Flores[9], Patricia Gil[10], Judith Gobin[11], Jorge Gutiérrez[12], Marcos Krull[5], Juan F. Lazarus[13], Edgardo Londoño[13], Tito Lotufo[9], Erasmo Macaya[14], Elba Mora[15], Sergio Navarrete[16], Gabriela Palomo[17], Mirtala Parragué[16], Franciane Pellizzari[18], Rosana Rocha[19], Leonardo Romero[20], Roberto Retamales[21], Roger Sepúlveda[22], Michelle C. Silva[18] and Sabrina Soria[17]

[1]Universidad Simón Bolívar, Caracas, Venezuela
[2]Australian Institute of Marine Science, Townsville, Australia
[3]University of Puerto Rico, Mayaguez, Puerto Rico
[4]James Cook University, Queensland, Australia
[5]Universidade Federal da Bahia, Salvador, Brazil
[6]Centro Nacional Patagónico, Chubut, Argentina
[7]Bioelite and Universidad de Especialidades Espíritu Santo, Samborondón, Ecuador

[8]Museo Nacional de Historia Natural de Uruguay,
Centro Universitario Regional Este, Uruguay
[9]Universidad de Sao Paulo, Sao Paulo, Brazil
[10]Universidad Nacional Agraria La Molina, Lima, Peru
[11]University of the West Indies, Trinidad and Tobago
[12]Universidad Nacional de Mar del Plata,
Buenos Aires, Argentina
[13]Universidad del Valle, Cali, Colombia
[14]Universidad de Concepción, Chile
[15]Universidad de Guayaquil, Guayaquil, Ecuador
[16]Pontifica Universidad Católica de Chile, Santiago, Chile
[17]Museo Argentino de Ciencias Naturales Bernardo Rivadavia,
Buenos Aires, Argentina
[18]Universidade Estadual do Paraná, Paranavaí, Brazil
[19]Universidade Federal do Paraná, Curitiba, Brazil
[20]Universidad Nacional Mayor de San Marcos, Lima, Peru
[21]Universidad Técnica de Manabí, Portoviejo, Ecuador
[22]Universidad Austral de Chile, Valdivia, Chile

ABSTRACT

Rocky shores are areas of high diversity and productivity providing goods and services. Since humans are altering nature at an unprecedented rate, producing shifts in important parameters for life such as temperature, habitat availability, water quality, among others, it is expected that species will respond by changing their natural distributions and/or abundances. To understand how species will respond to such changes, it is necessary to learn the processes that determine these patterns. The South American Research Group on Coastal Ecosystems was established to assess marine diversity and biomass along both coasts of South America through an international collaboration. The main goals of SARCE are to: (1) Test hypotheses about latitudinal gradients and patterns of local and regional biodiversity, (2) Identify the relationship between biodiversity and ecosystem functioning, (3) Assess the effect of environmental gradients and anthropogenic stressors, (4) Carry out capacity building and training activities aimed to solve environmental problems for the benefit of society. The SARCE network has sampled the coasts of nine countries around South America with a standardized protocol in more than 150 sites (2010-2014), ranging from 11º North to 55º South. This chapter provides a description of the biodiversity of the sites sampled by SARCE, along with a review of the uses and services that these ecosystems provide to human populations and the main threats and impacts these uses have caused.

INTRODUCTION

Biodiversity has been a subject of interest for many decades by scientists and conservationists. More recently, other groups such as managers, government agencies and industries have also been involved in establishing its ecological and economical value, as well as the consequences of its loss. Up to date, an important number of papers have attempted to identify the importance of biodiversity for ecosystem functioning (Loreau et al. 2001, Pachepsky et al. 2001, Cardinale et al. 2002, Pfisterer & Schmidt 2002, Gessner et al. 2004) and the processes by which any diversity loss will be negatively reflected in the number and quality of services that a particular system might provide (Balvanera et al, 2006; Cardinal et al, 2006, O´Connor et al., 2006).

Coastal marine ecosystems have a very high biodiversity (Ray 1996). Within these, the macroalgal habitats rank among the highest along with coral reefs and seagrass communities, due to the fact that they are dominated by bio-engineering organisms that build three-dimensional structures, providing substrate, food and habitat complexity, which ultimately increases species richness (van Oppen et al. 1996, Phillips 1997, Walker & Kendrick 1998, Wysor et al. 2000, Duarte 2000, Engelhardt & Ritchie 2001, Duffy et al. 2001, Sommerfield et al. 2002, Bulleri et al. 2002). On the other hand, due to their particular location (i.e. land-sea interface) these coastal areas are also severely impacted by human activities such as fisheries overexploitation, alteration of the physical environment, pollution, introduction of alien or invasive species and recreational activities, all of which have inevitably impoverished marine biodiversity (Beatley 1991, Norse 1993, Gray et al., 1997, Walker & Kendrick 1998, Cury 1999, Bax et al. 2001, Tilman & Lehman 2001, Piazzi et al. 2001, Barnes 2002).

In this sense, the study of biodiversity is crucial for the sustainable use of coastal resources (Gray 1997), especially in Marine Protected Areas (Ray 1985, Olsen 1999, Ward et al. 1999). Biodiversity has been measured at many different levels and scales and by different methods (France & Rigg 1998). This has made comparisons difficult, so a unified approach to study biodiversity at a global scale was much needed (Rabb & Sullivan 1995, Valero et al. 1998, Mikkelsen & Cracraft 2001). As a response to this need, the NaGISA project (Natural Geography in Shore Areas: www.nagisa.coml.org) of the Census of Marine Life program (CoML: www.coml.org) provided the necessary framework to study biodiversity in rocky shores at a global scale. The NaGISA project was a collaborative effort aimed at inventorying and monitoring habitat specific biodiversity with a standard protocol in coastal marine areas at a global scale (Konar et al. 2010). Thanks to NaGISA (2003-2010), the first global baseline of nearshore biodiversity was initiated [see: Diversity in the Nearshore: The NaGISA Collection (2010) PLoS Collections: http://dx.doi.org/10.1371/issue.pcol.v01.i06], and in South America, it has continued through the South American Research Group on Coastal Ecosystems network (SARCE). This network was established to assess marine diversity and biomass along the Pacific and Atlantic (including the Caribbean) coasts of South America through an international collaboration. The main goals of SARCE are to: (1) Test hypotheses about latitudinal gradients and patterns of local and regional biodiversity, (2) Identify the relationship between biodiversity and ecosystem functioning, (3) Assess the effect of environmental gradients and anthropogenic stressors, (4) Carry out capacity building and training activities aimed to solve environmental problems for societal benefit. The SARCE network includes more than 30 researchers from 9 South American coastal countries and has sampled with a standardized protocol in more than 150 sites around the continent (Figure 1). In this chapter we provide a description of the biodiversity of the sites sampled with the SARCE protocol (http://sarce.cbm.usb.ve/for-scientists/), along with a review of the uses and services that these ecosystems provide to human populations and the main threats and impacts these uses have caused.

Figure 1. Map of South America showing the localities sampled by the SARCE network (South American Research Group in Coastal Ecosystems) in the Caribbean Sea, and in the Atlantic and Pacific oceans.

The intertidal rocky shores in South America: main features and associated biodiversity

THE CARIBBEAN

COLOMBIA

The Caribbean coastline of Colombia has an extension of 1760 km, of which 25% are rocky shores (Posada & Henao 2008), mainly composed by unstable shores highly affected by wave action and coastal erosion. Most of these shores have steep slopes and in the areas where the platform occurs can harbor rich and abundant macro-algal communities (Garcia & Diaz-Pulido 2006). The tide range is 0.5 m due to this is common to find in small areas a mixture of organisms that belongs to different intertidal levels (high, mid and low tide), factors as wave action, substrate type and slope, determine the community composition (Lopez-Victoria et al. 2004). Due to the small tidal range only high and low tide levels can be easily differentiated. According to Lopez-Victoria et al. (2004) the rocky shore can be divided into two types of rocks, cohesive or non-cohesive, each having a particular associated community (algae and macroinvertebrates). The first type of rocks is stable, hard and with low erosion rates, with a high rate of colonization and a well developed community with advanced succession stages. The second type of rocks is unstable, the shores are highly affected by wave action, and therefore, species diversity and richness is lower, and the community cannot reach advanced succession stages. The climate presents two main periods: dry and rainy seasons with a transition season in between. The sea surface temperature and salinity during the dry and rainy seasons vary between 25.5-27.5ºC / 35.6-37 ppt and 27-29.5ºC / 34.5-36.5 ppt respectively. The waves are higher during the dry season (1.5 to 2.5 m) in relation to the rainy season (0.5 to 1.4 m) (Posada & Henao 2008). An upwelling system is present from December to March in the north coast and the sea surface temperature can drop below 20ºC.

In the Colombian Caribbean, the SARCE project sampled in 15 sites within two localities: Santa Marta and Darien. In Santa Marta (Figure 2A), the rocky shore is dominated by cliffs (metamorphic schist rocks), with different size boulders at the base that gives complexity to the shore and offers a variety of habitats that can be exploited by intertidal organisms. The cliffs are part of the Sierra Nevada de Santa Marta system that branches down to the sea. Due to the upwelling, there is a major change in algae composition, species of *Sargassum* can reach a meter in length and other algae species grow and cover most of the rocky substrate. Along the different sites of the Santa Marta bay, the geology varies from cliffs that continue as rocky shores with boulders in the north (Punta Verde) which are highly exposed to wave action, to rocky platforms between 5 to 10 m wide in the south (Playaca). The most abundant invertebrate species in the high intertidal in the north are *Nerita versicolor* and *Littorina* sp, while the low intertidal is dominated by coralline algae, by *Palisada perforata*, *Zoanthus pulchellus* and *Hypnea musciformis*, and the invertebrates *Echinometra lucunter* and *Isognomon bicolor*. In the south, the high intertidal is mostly rock; with some areas with filamentous algae. The most abundant macroinvertebrate species are *Plicopurpura patula*, *I. bicolor* and *Dendropoma* sp. In the low intertidal, dominant species are coralline and filamentous algae along with *Laurencia obtuse, E. lucunter*, *I. bicolor*, *Spirobranchus giganteus* and *Balanus* sp. The low intertidal is also covered by the canopy of large *Sargassum.* The east side of the bay (Playa Grande) is characterized by a rocky platform covered by a thin layer of vermetids. Here, the high intertidal is mostly rock with some areas covered by filamentous algae, the dominant macroinvertebrate species being *N. tesellata* and *Brachidontes domingensis*. In the low intertidal, dominant species are the macroalgae *Acanthophora spicifera*, *Dictyopteris deliculata* and *Neoralfsia expansa* and the invertebrates *Dendropoma* sp. and *I. bicolor*. Other localities sampled in the Santa Marta region were Inka Inka, Puerto Luz, and Aeropuerto. The first two were rocky platforms, while the third was an exposed sandy beach with flat rocks that may be periodically covered by sand due to wave action. In these, the high intertidal was dominated by *N. tesellata*, *P. patula*, *Echinolittorina ziczac* (Inka Inka); *E. ziczac*, *E. angustior* and *P. patula* (Puerto Luz); and *E. interrupta*, *E. angustior* and *Chthamalus sp*. (Aeropuerto). The low intertidal was dominated by coralline algae, vermetids, filamentous algae, *E. lucunter*, *I. bicolor*, *Mitrella ocellata*, *Sargassum* (Inka Inka), *A. spicifera*, *L. obtuse*, filamentous algae, *Dendropoma* sp., *E. lucunter*, *I. bicolor* (Puerto Luz), and *A. spicifera*, *Lyngbya* sp., coralline algae, *Centroceras* sp., *B. domingensis*, *Fissurella nimbosa*, *Stramonita haemastoma* (Aeropuerto).

The locality of Darien is located west of the Uraba Gulf, where mangroves and soft bottoms dominate the landscape; the sediments and nutrients are brought by the Atrato River, one of the largest rivers in the Atlantic basin of Colombia. Tropical rainy forest is the most common type of vegetation; however, grasses for cattle growth have replaced large extensions of this forest. In this region, the volcanic rock shore is located north of the delta of River Atrato, followed by large sandy beaches and abrasion platforms of coralline origin towards the Panama border. This area has little urban development and human settlements are small, there are no roads and the main way of transportation is by boats and most of the settlements are located on the coast. The Darien was sampled in the Trigana area which is located north to the Atrato River delta, with a rocky shore of volcanic origin, interrupted by sandy beaches, and with several small islands in front of the coast. The intertidal in this area is affected by freshwater runoff. The sites ampled were Isla Napú, an islet with a narrow rocky platform that falls to the sea reaching a maximum of 2 m depth in the surrounding areas; Trigana, a platform 10 m wide; Titumate, an islet with a soft slope and shallow sandy bottom (< 1 m) and sea grasses; Capurgana, located in the northwest part of the Uraba Gulf with a rocky shore composed by abrasion platforms of coralline origin; Sapzurro, a bay close to the Panama border, with a soft slope shore and an abrasion platform of coralline origin; and Isla Narza, an islet of volcanic origin in front of Capurgana village, the shore consisting of a cliff in the exposed side and boulders in the sheltered side. In these sites, the high intertidal was dominated by E. angustior, *E. ziczac* and *E. interrupta* (Napu), *E. angustior* and *S. rustica* (Trigana), *E. angustior*, *B. domingensis* and *N. tesellata* (Titumate), and *E. angustior* (Sapzurro and Isla Narza). The low intertidal is dominated by *L. obtusa*, *Pterocladiella capillacea*, *Lyngbia* sp., *Gracilaria domingensis*, *Centroceras* sp., the barnacles *Chthamalus* sp. and *Balanus* sp. which form a complex with vermetids (Napu); filamentous and coralline algae, *S. serratum*, *Centroceras* sp., *L. obtuse*, *G. domingensis*, *Chthamalus sp*., *S. rustica* (Trigana); *S. serratum*, *L. obtuse*, *Centroceras* sp., *Chthamalus* sp., *S. rustica* (Titumate); *L. obtuse*, coralline algae, *E. lucunter*, *Cittarium pica* (Sapzurro), and coralline and filamentous algae, *E. lucunter*, *Ceratozona squalida*, and *Chiton squamosus* (Isla Narza).

VENEZUELA

Rocky shores along the 3964 km of the Venezuelan coastline are very heterogeneous in terms of their geological composition and structure (Miloslavich et al., 2005). Due to small tidal ranges in the southern Caribbean (20-30 centimeters) (Torres and Tsimplis, 2012) Venezuelan rocky shores have been described considering only two levels or strata: high intertidal and low intertidal. The low intertidal is constantly under wave action whereas, the high intertidal is washed rarely by waves, only receiving sea's spray. Consequently, in some Venezuelan rocky shores, gaps openings and/or depressions in the substrate of only few centimeters of depth can generate zones that remain submerged most of the year. These habitats, henceforth called substrates depressions, are located between the high and the low intertidal on platform rocky shores and their species composition is completely different to that found in the high and low intertidal. Given their large extensions, "substrates depressions" are different to rock pools or tide pools.

Characteristics of rocky shores are very heterogeneous and respond to the geomorphology of the different regions of the Venezuelan coast. In the Western coast, from the Paraguana Peninsula to Patanemo, rocky shores are emerging platforms and are composed of limestone rocks (Figure 2B). The Central coast, from Ocumare to Chirimena (Figure 2C), is characterized by narrow rocky stripes formed by sandstones and conglomerates. Sites sampled on the mainland of the Eastern coast, from Santa Fe to La Pared (Figure 2D), had a very steep slope, whereas those sampled in the insular region were emerging horizontal rocky platforms. Nevertheless, all rocky shores in the East are formed by limestone's rocks. Most of the platforms are narrow (3-10 meters), except for San Juan de los Cayos platforms that are between 60 to 120 meters wide. The length of platforms is highly variable. In the western region, they can reach few kilometers, whereas in the central coasts they do not surpass hundreds or tens of meters (Kennedy et al., 2014; Ellenberg, 2010).

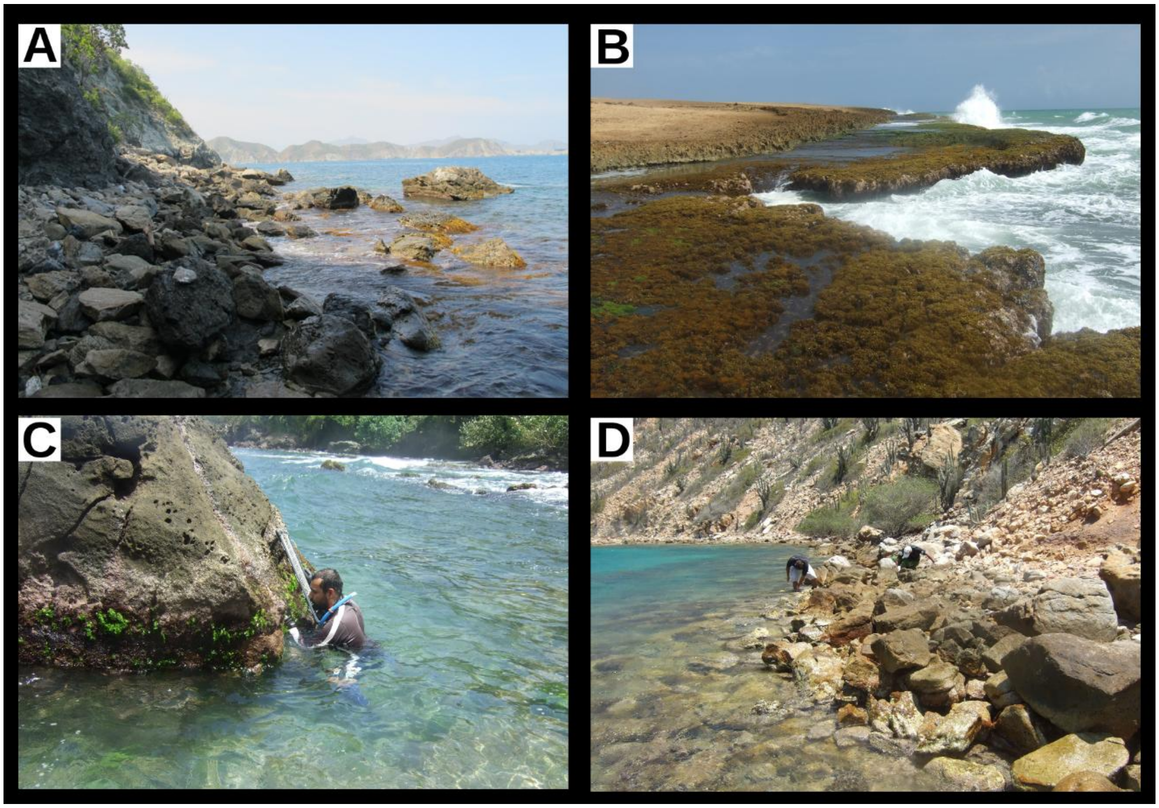

Figure 2. Sampling sites in the Caribbean. A. Colombia – Taganaga, Santa Marta. B. Venezuela - Cabo San Román, West Coast. C. Venezuela – Chuspa, Central Coast. D. Venezuela – Mochima, East Coast.

Estimates of rugosity were moderately high for both strata: 0.809 ± 0.002 and 0.745 ± 0.003 for low and high intertidal, respectively. The rock's irregularities form microhabitats that are used by some organisms like whelks, crabs, limpets and snails that protect them from desiccation and high temperatures during low tides, which in turns contribute to the high diversity reported for the Southern Caribbean. Crevices, scars and holes over the rocky substrate are due to erosion of wind and wave, as well as to the activity of some organism such as the sea urchin *Echinometra* sp. (Bak, 1994).

Despite a small tidal amplitude (Torres and Tsimplis, 2012), desiccation levels can vary significantly due to the effect of wind. Northern Trade winds blow on Venezuelan coasts intensively between December and June, increasing intensity and height wave, and consequently decreasing exposition levels. Besides, trade winds are responsible of annual upwelling, between January and May, in different zones of Venezuelan coast (Castellanos et al., 2002; Muller-Karger, 2004); which has been reported to enhance algae growth and increase the production of herbivores in rocky shores (Wieters, 2005; Bosman et al., 1987). This has not been tested for the Venezuelan Coast, however, the only study done (western region, Peninsula de Paraguna) found no correlation between Sea Surface temperature Changes generated by upwelling and changes in the structure of assemblages associated with rocky shores (Herrera unpublished data).

Like many rocky shores in the continent and the world, assemblages living in Venezuelan rocky shores are mainly composed of seaweeds and small mollusks. The most common seaweeds belong to phylum Rhodophyta, being genera such as *Laurencia* and *Polysiphonia* the most abundant. Also, algae of phylum Chlorophyta (mainly *Ulva* spp.) and Ochrophyta (mainly *Sargassum* spp) can be widely found. The species complex made of crustose coralline algae (commonly named CCA) was present in almost all sampled sites. It is very likely that the species composition of these complexes change among zones, sites, regions and strata; but identification of species of crustose coralline algae in the field is not possible. This complex was present as primary cover usually below corticated, articulated and foliose algae, as well as secondary cover on top of sessile and mobile animals. The most common mollusks living in Venezuelan rocky shores were snails, limpets, whelks, key-hole limpets and chitons.

The dominant functional groups in Venezuela were primary producers (macroalgae), small herbivores (gastropods and chitons), large herbivores (sea urchins and crabs), filter feeders (bivalves and barnacles) and predators (mainly the gastropods *Plicopurpura patula*, *Stramonita* and *Vasula* species; and octopuses). In the southern Caribbean, unlike other rocky shores, the dominant echinoderm was not a sea star but the sea urchin *Echinometra lucunter*. It has been proposed (but not tested) that *E. lucunter* plays a key role in structuring these assemblages due to its high densities, high herbivory rates and bio-erosive activity. Another peculiarity of Venezuelan rocky shores is the low density of barnacles in the intertidal. In Venezuela, they are only present in the central and western coast, usually associated to rock-walls, cliffs and artificial structures.

Continuous monitoring of assemblages associated with rocky shores in Venezuela has shown that they vary importantly at different temporal and spatial scales, and between strata. For example, during the rainy season, conspicuous changes occur due to massive algae cover decrease, and the composition is dominated by opportunistic species such as *Ulva*, *Dictyota*, *Padina* and *Chaetomorpha*. Also, from a spatial point of view and despite large variation at small spatial scales (10s to 100s meters), important differences can be detected among regions (e.g. presence of barnacles only in central and western coast).

Intertidal rocky shores of Venezuela are part of the highly diverse coastal ecosystems of the Southern Caribbean. Using SARCE's protocol, 31 sites across the Venezuelan coast were sampled, detecting a total of 217 species in total: 85 marine algae (40 Rodophyta, 20 Chlorophyta, 18 Ochrophyta, 5 Cyanobacteria, 2 seaweeds not identified), 89 molluscs (66 Gastropoda, 17 Bivalvia, 6 Polyplacophora), 21 cnidarians (17 Anthozoa, 4 Hydrozoa), 8 arthropods (5 Malacostraca, 3 Maxillopoda), 5 echinoderms (2 Echinoidea, 2 Ophiuroidea, 1 Holothuroidea), 5 marine sponges (Demospongie), 3 ascidia (Ascidiacea) and 1 seagrass (Tracheophyta).

In the high intertidal of Venezuelan rocky shores, algae presence was uncommon; and when they were, these usually were crustose calcified algae CCA and *Pseudolithoderma extensum*, or filamentous algae such as *Lyngbya* spp. and *Bostrychia tenella*. Mobile species were represented mostly by small herbivores mollusks such as *Nerita versicolor*, *Nerita* peloronta, *Nerita tessellata*, *Echinolittorina ziczac*, *Echinolittorina interrupta*, *Acanthopleura granulata*, *Echinolittorina angustior*, *Cechritis muricatus*, *Tectarius antonii* and *Acmaea* and *Siphonaria* species. Carnivorous mollusks (i.e. *Plicopurpura patula*) were also present but were not as abundant as herbivores species. Assemblages in the high intertidal were highly dominated by few species, especially by Littorinids that commonly had abundances between thousands and tens of thousands of individuals per square meter. Neritidae species were not as abundant, but densities could reach hundreds per square meter. In crevices and gaps, bivalves belonging to genus *Brachidontes* and *Isognomon*, were found in low densities. Sessile mollusks of the family Vermetidae were also occasionally found in very dense patches with abundances ranging between the tens and hundreds of individuals per square meter.

Assemblages in depressions or mid platforms shallow lagoons were dominated by corticated foliose algae such as *Dictyota* and *Padina*, articulated calcareous algae such as *Halimeda opuntia*, foliose calcareous algae such as *Udotea sp* and *Penicillus sp*, and the foliose algae *Ulva* spp. Because these environments are constantly covered by water, cnidarians belonging to genus *Zoanthus* and *Palythoa* were commonly found. Principal mobile organisms in these microhabitats were small fishes belonging to Gobiidae family and hermits crabs. These two groups, however, were not considered in this study. These habitats are constantly submerged by water that is constantly being replaced, but due to their shallow characteristics, temperature is usually few degrees above normal Sea Surface temperature. Consequently, substrate tends to be dominated by one or two of the species mentioned above.

The low intertidal of Venezuelan rocky shores was dominated by macroalgae, mollusks and sea urchins; whereas some cnidarians and other echinoderms (sea cucumbers and brittle stars) were found occasionally. The most abundant and commonly found algae in all sampled sites, were the crustose calcified algae comples CCA and *P. extensum*, the corticated corticated algae *Laurencia obtusa*, *Laurencia papillosa* and *Gelidiella acerosa*, the filamentous algae *Polysiphonia atlantica*, the leathery macrophyte *Sargassum* spp, and filamentous microalgae *Lyngbya* spp. Few species, as the opportunistic green foliose algae *Ulva* spp, the green filamentous algae *Chaetomorpha* spp, and cnidarians *Palythoa* and *Zoanthus* were not commonly seen in all sites; but when they were present, they occupied an important proportion of the primary and secondary substrata. The most abundant mobile species in the low intertidal were herbivores *E. lucunter*, *Chiton squamosus* and *Fissurella* spp, as well as carnivores *Stramonita rustica*, *P. patula* and *Vasula deltoidea*. The carnivore gastropod *P. patula* has its highest densities in the high intertidal (very close to the transition between the high and the mid), however it is present in the low intertidal as well. The sea urchin *E. lucunter* was commonly found in almost all the sites sampled, reaching densities of up to 72 ind/m^2. It is likely that *E. lucunter* plays a key role as the principal herbivorous on Venzuelan rocky shores, but this conceptual model has not yet been tested. Other large herbivores such as the gastropods *Cittarium pica* and *Astraea* spp, are found in low densities and small sizes, very likely due to the pressure of artisanal fishermen.

TRINIDAD & TOBAGO

Trinidad and Tobago is a twin-island state located on the continental shelf of north eastern South America. Trinidad is approximately 12 kilometers from the mainland while Tobago is 30 kilometers North East of Trinidad. Trinidad is the most southerly of the Caribbean islands. The continental origin of the islands is reflected in the similarity of terrestrial fauna and flora. The coastal areas of Trinidad and Tobago are largely comprised of sedimentary rocks. The north coast however is comprised of non-sedimentary rock with low grade metamorphic and small areas of volcanic rock (Georges, 1983). The geomorphology is generally of gently sloping beaches and cliffs. Current flow around Trinidad and Tobago is driven by the South Equatorial current coming north from South America. The current splits with movement to the west entering the Gulf of Paria and to the east moving and merging with the Atlantic Ocean.

Prior to the NAGISA project (2005), the intertidal rocky shores of Trinidad and Tobago had not been studied in any detail. The sites sampled with the SARCE project are on the north-east coast (Saybia, Toco) and the north coast (Maracas Bay). In the north-east coast location (Saybia, Toco there is a fringing reef which offers some protection although there is a strong westerly longshore current. In the north coast (Maracas Bay) area there are generally strong offshore winds and a strong longshore current, although some protection is offered by the headlands. The mean tidal range in Trinidad and Tobago is around 1.2m and is semi-diurnal with a high and low every 12hrs.

The biodiversity associated with the intertidal sites typically included the common groups: macroalgae (green, red, and brown), bivalves (*Isognomon* sp. the most common but only found at Salybia and Toco Bay), gastropods (*Littorina* sp. the most common), polyplacophorans, crustaceans (barnacles found at all sites except Las Cuevas), and tunicates. The red algae, mostly *Heterosiphonia* were the most dominant species, while brown algae were least dominant, and *Chaetomorpha* sp. was the most common green algae (found at Maracas and Blanchisseuse). Coralline algae were well represented at all sites except for Salybia. There were greater numbers of species of soft corals (22) as opposed to soft corals (2), all of which were found in Salybia and Toco Bay, sites nearby to coral reef systems.

THE ATLANTIC

BRAZIL

The Northeast: Ceara

The Ceará state coastline is dominated by long sand beaches, interrupted occasionally by beachrock reefs (Aquasis, 2003). The beachrocks have a more recent origin, and are composed by sand, shell fragments and pebbles cemented by calcium carbonate and iron oxide (Smith and Morais, 1984). These reefs are generally tabular, of variable extension and sloping gently towards the sea. The coastline is more E-W oriented, along typically equatorial latitudes. The climate is typically semi-arid, ruled by the intertropical convergence zone, with 2 seasons characterized by the pluviometry: a rainy season from January to June, and a dry season from July to December (IPECE, 2013). The coast is washed by the North Brazil current, running from E to W, following the strong trade winds that are characteristic for the region (Aquasis, 2003). The North Brazil current water mass is considered oligotrophic, with temperatures varying little around 26ºC and salinity around 36 (NOAA, 2014). The constant trade wind regime blowing from E-SE with 6.4 m.s-1 on average, reaching more than 10 m.s-1 during the dry season (Jimenez et al., 1999). Wind waves are permanently splashing over the reefs, sometimes combined with swell waves, ranging from 1.8 to 3.6 m in height (Aquasis, 2003). The tidal regime is typically semidiurnal, with a mean spring tidal range of 3.3 m, and mean neap tidal range of 1.2 m.

The beachrock reefs of Ceara host a very diverse community which is still poorly studied. The rocky intertidal shows a typical biodiversity zonation from the supralittoral to the subtidal zones. The supralittoral fringe is barely colonized, and the dominant species is *Echinolittorina lineolata*, a small mobile gastropod that fits into minute crevices avoiding extreme desiccation. The same species is also abundant in the high intertidal, but the space is occupied now by barnacles, especially *Chthamalus proteus* and patches of the green algae *Ulva fasciata*. The association of these two species characterizes the whole upper littoral zone, which is considerably poor in terms of species richness. The mid littoral zone is more diverse and the dominant species may vary at different locations. In Caucaia (Figure 3A), near urban capital Fortaleza, there is a belt of the bivalve *Brachidontes exustus* at the higher portion of the upper littoral zone, and a continuum of large colonies of the polychaete *Phragmatopoma caudate* is also present. The dominant algae species are *Chondracanthus acicularis*, *Gelidiella acerosa*, and *Hypnea musciformis*. Other dominant species are *C.*

proteus and *U. fasciata*, which are still abundant in the lower littoral zone. In Trairi, there is not a conspicuous band of *B. exustus*, and the mid littoral zone is then dominated by *U. fasciata*, *Pterocladiella caerulescens* and *Laurencia papillosa*. Large colonies of *P. caudata* are present, and the zoanthid *Palythoa grandiflora* also covers large areas of this zone. The mobile fauna present in the mid littoral zone is mainly composed of crabs, especially *Pachygrapsus transversus*, hermit crabs, such as *Clibanarius antillensis* and *Calcinus tibicen* (Herbst, 1791). The lower littoral zone is the most diverse, and fully dominated by algae. The most abundant species vary by location and site. In Caucaia, the most common species are *Centroceras clavulatum*, *C. acicularis*, and *U. fasciata*, while in Trairi the dominant species are *P. caerulescens*, *Gracillaria* spp., *Amansia multifida*, and crustose coralline algae. The mobile fauna at the lower littoral zone is also more diverse and includes the species mentioned for the mid littoral zone plus the gastropods *Stramonita haemastoma* and *Tegula viridula* (Gmelin, 1791). Recent surveys of the whole littoral zone detected a total of 110 species for Caucaia and 103 for Trairi. Most species are shared by the two locations, but Trairi is considerably more diverse in terms of sessile organisms (both animals and algae), while Caucaia has more motile animals. In terms of composition, the most specious taxa, in decreasing order, were: Rodophyta (45 spp.), Chlorophyta (18 spp.), Mollusca (18 spp.), Ochrophyta (11 spp.), Crustacea (8 spp.), Porifera (7 spp.), Ascidiacea (7 spp.), Cnidaria (5 spp.), Polychaeta (3 spp.) and Echinodermata (2 spp.).

The data collected using the SARCE protocol for large and conspicuous organisms in the intertidal shows that there is a considerable biodiversity along the beachrock reefs in Ceará. There are about 130 species in total, the vast majority of them of algae, especially red and green algae. There is also a tenable difference among locations and sites along this stretch of coast, which highlights also a degree of beta diversity. It is worth mentioning that the protocol favored the algae component of the intertidal community by accounting only for organisms "over" the substrate. Previous surveys aimed at producing inventories had come out with different numbers. For instance, results form the PROBIO initiative in Ceará indicated for the same area 109 species of algae, 53 species of Crustacea, 44 species of Mollusca, 28 species of Ascidiacea, 24 species of Polychaeta, 22 species of Cnidaria, and 9 species of Echinodermata (Matthews-Cascon and Lotufo, 2006). Even these numbers are underestimating the total diversity, because the effort was still punctual.

TheNortheast: Sergipe

Sergipe is the smallest Brazilian State, and the third shortest coast in extension (160 km). Located in the northeastern, it limits with the State of Alagoas in the north, and the State of Bahia in the south. Aracaju, the main city, comprises 25% of the state's population and has two harbor complexes. Sergipe has no real rocky shores, but rather beaches with boulders and rocky outcrops, and few areas with biolithic substrates (*Pragmatopoma caudata*). Beaches are composed by fine sand, and the linear coast is fringed by esturies and mangroves, associated with the rivers Real, Vaza-Barris, Sergipe and São Francisco.

The State has 47.3% of its territory inside of the "Drought Polygon" polígono das secas (FAO). The climate is tropical, with the highest humidity by the coast and in semi-arid backlands. The highest rainfall occurs between January and March.

In Sergipe, the SARCE project sampled, from south to north in three beaches: Praia do Saco, Coroa do Meio, and Praia do Jatobá. A total of 106 taxa were found represented by 34 species of invertebrates, 66 of macroalgae, and 6 species of filamentous cyanobacteria. The supralittoral zone is characterized mostly by bare bolders, which may be colonized by periwinkle gastropods of the complex *Echinolittorina ziczac*, and filamentous cyanobacterias. The high/medium intertidal, not always well zonated, contains a belt of the barnacle *Chthamalus bisinuatus* and the mussel *Brachidontes solisianus*, usually fouled by the red algae *Bostrychia* spp. and other filamentous red and green macroalgae. The low intertidal was the most diverse characterized mainly by barnacles (*Tetraclita stelifera*), oysters (*Crassostrea rhizophorae*), crab (*Aratus pisonii*), *Lottia* (*Collisela*) *subrugosa*, and mussels (*Perna perna*). Regarding macroalgal assemblages, the biomass was dominated in general by filamentous, leathery and terete functional groups. A total of 66 taxa were found: 41 Rhodophyta, 16 Chlorophyta and 9 Phaeophyceae, dominated by Rhodomelaceae (9 species), Ceramiaceae (5 species.), Corallinaceae, Cystocloniaceae, Cladophoraceae and Ulvaceae (4 species). The most conspicuous species were *Gayralia brasiliensis*, *Rhizoclonium riparium*, *Ulva flexuosa*, *Sargassum platycarpum*, *Centroceras clavulatum*, *Gracilaria cervicornis*, *Jania adhaerens*, *Hypnea valentiae*, *Solieria filiformis* and *Pterocladiella capillacea*.

The Northeast: Bahia

In Bahia, rocky substrates are mainly biogenic and sandstone, but some granitic substrate is also found. The SARCE project sampled five locations: Itacaré (Arruda, Corais, Figure 3B, 3C, 3D), Ilhéus (Backdoor, Praia do Sul), Itaparica (Penha, Mar Grande), Salvador (Stella Maris), and Litoral Norte (Guarajuba, Itacimirim), Litoral Norte and Itacaré located within a State marine protected area. Among these, Corais, Penha and Stella Maris are the only sampling sites that are characterized by granitic substrate.

The total number of species found at these sites varied between 29 (Mar Grande) and 58 (Arruda). Macroalgal diversity at all sites was very high and dominated the assemblage. The total number of macroalgal species varied between 18 (Mar Grande) to 46 (Arruda), with red algae being the most speciose group, followed by green and brown algae. In the high intertidal, the most abundant species were *Brachidontes*, *Chthamalus*, *Lyngbya* and *Ulva flexuosa*. The mid intertidal was dominated by *Ulva lactuca*, *Palisada perforata* and *Gelidiela acerosa*, but in general, *P. perforata* and *G. acerosa* were also abundant species in this zone. The low intertidal was dominated by *Sargassum*, but *Bryothamnion triquetrum* and *Amphiroa anastomosans* were also dominant species at Penha and Praia do Sul respectively.

The Southeast: Espírito Santo

Espirito Santo State is bordered by Minas Gerais, Bahia and Rio de Janeiro. Climate is coastal humid tropical. Rainfall is highest during summer (1.000 mm and 1.500 mm/year), and mean air temperatures are around 22°C and 24°C. The south coast is rocky, with sandstone cliffs, and in the central coast, biolithic and granite formations can be found. The south-central coast is very indented with coves and bays sheltered by rocky outcrops. The coast is more indented in the center-south, and open sea to the north. The State comprises the higher seaweed diversity and biomass in Brazil, been influenced by the South Atlantic Central Water upwelling. The SARCE project sampled sites at the localities of Paraty, Ubu (Figure 3E), and Manguinhos.

A total of 183 taxa were found comprised by 48 invertebrate species and 131 macroalgae conspicuos taxa. The supralittoral zone is mostly bare but periwinkle gastropods of the complex *Echinolittorina ziczac*, and the green filamentous algae *Rhizoclonium* may be found. The high/mid intertidal, not always well zonated, contains a belt of the barnacle *Chthamalus* sp., oysters (*Crassostrea rhizophorae*), the mussel *Brachidontes solisianus*, and a complex of the red algae *Bostrychietum*. The low intertidal was more diverse and characterized by the barnacles *Tetraclita stelifera*, and *Lottia (Collisela) subrugosa*, muricid gastropods, and *Palithoa caribeorum*. Regarding macroalgal assemblages, the biomass was dominated in general by foliose, terete and calcareous (crustose and articulated) functional groups. A total of 131 taxa were found: 69 Rhodophyta, 37 Chlorophyta and 25 Phaeophyceae. The most conspicuous species were *Anadyomene stellata*, *Caulerpa* spp. (maily *C. racemosa* and *C. cupressoides*), *Codium* (mainly *C. intertextum* and *C. isthmocladum*), *Valonia aegragopila*, *Canistrocarpus cervicornis*, *Colpomenia sinuosa*, *Dictyopteris delicatula*, *Dictyota menstrualis*, *Neoralfsia expansa*, *Padina gymnospora*, *Sargassum cymosum*, *Arthrocardia flabellata*, *Dichotomaria marginata*, *Gelidium* spp., *Hypnea spinella*, *H. valentiae*, *Jania adhaerens*, *Lithotamnium/Lithophylum* complex, *Ochtodes secundiramea*, and *Palisada flagellifera*.

The Southeast: São Paulo

Nine rocky shores were sampled along 150 km of the coast of São Paulo State, Brazil, within three localities: Baixada Santista (Guaiúba/Guarujá, Ilha Porchat/São Vicente, Itaquitanduva/Praia Grande), São Sebastião (Baleeiro/São Sebastião, Feiticeira/São Sebastião, Itassucê/São Sebastião), and Ubatuba (Enseada/Ubatuba, Itaguá/Ubatuba, Praia Grande/Ubatuba). This coastline faces south - southeast, with variable complexity, from long linear stretches in Bertioga (Figure 3F) and southern São Sebastião, where long sandy beaches prevail, to very intricate coasts in Ubatuba, where small sandy beaches (tens to a few hundred meters) and mangrove forests are interspersed along a general rocky shoreline, forming several small bays and coves (Tessler et al. 2006). This general feature is an outcome of major tectonic dynamics leading to a gradual emergence towards the southwest, leading to the formation of coastal plains and long sandy shorelines, and to submersion towards the northeast, where a sinking mountain range, part of the Serra do Mar system, makes up most of a remarkably convoluted shoreline and coastal islands (Martin & Suguio 1975, Almeida 1976). The rocky intertidal is usually steep, never forming large platforms, and often broken into very large boulders. As in most of the Serra do Mar, rocks are mostly constituted by gneiss and granite (Almeida & Carneiro 1998). The climate regime varies from tropical do humid subtropical (Sant'Anna Neto 1990) within this area. In Ubatuba, where historical climate data are available and have been extensively modeled (e.g. Valentim et al. 2013), temperature is maximum during February [27.8^{o}C air temperature (AT), 28.6^{o}C sea surface temperature (SST)] and minimum during July (21.1^{o}C AT, 21.9 ^{o}C SST). Continuous measurements during the austral summer of 2011, taken at Baleeiro, São Sebastião, showed that temperature at the rock surface in the mid intertidal averaged 28.8 ^{o}C and occasionally exceeded 40^{o}C (Kasten & Flores 2013).

The sampled shores varied from sheltered (Enseada, Itaguá), moderately exposed (Guaiuba, Ilha Porchat, Itaquitanduva, Baleeiro, Feiticeira, Itassucê) and exposed (Praia Grande), within an area where wave height frequencies from 0.5 to 2.0 m sum up 90%, with a wave height interval between 1.0 to 1.5 m making up half the observations (Bomtempo 1991). Wave exposure is apparently related to the midshore height (MH), from the upper limit of the coralline algal turf to the upper limit of the chthamalid barnacle cover. Roughly, the MH is lower than 0.5 m at sheltered shores, betwen 0.5 and 1.0 m at moderately exposed shores, and higher than 1.0 m at exposed shores. In this area, coastal primary production is comparatively low when compared to temperate areas prone to intensive seasonal upwelling (Gianesella et al. 2008). Estimates of nitrate concentration based on SST time series taken in the São Sebastião Channel indicated variation from only 0.2 to 0.7 μM (Flores unpublished data). Local upwelling of South-Atlantic Central Waters (SACW) may take place sporadically, during summer months, but more frequent inputs to the coastal zone take place via remote forcing, mostly during the passage of cold fronts during winter (Ciotti et al. 2010). The tidal regime at this coastline is a semidiurnal one, with the tidal range at spring tides ranging from 1.1 to 1.5 m. There is often a clear intertidal zonation, with the barnacle *Chthamalus bisinuatus* dominating the upper midlittoral (level 1), the mussel *Brachidontes solisianus,* and the volcano barnacle *Tetraclita stalactifera* prevailing in the lower midlittoral zone (level 2), and a coralline algal turf, associated to a very diverse assemblage of other macroalgae, making the most of the infralittoral fringe (level 3). These three levels were the targets of sampling protocols attempting a complete report of species presence and abundance.

Intertidal biological assemblages at the study sites - The upper levels sampled in this survey (levels 1 and 2) showed little variation among localities, but species turnover was very high in the lowest level (level 3), rendering almost shore-specific assemblages. At this lowest level, diversity was very high due to the presence of a large number of small macroalgal species. The most common species at all sites in level 1 in terms of cover were *Chthamalus bisinuatus* and *Brachidontes solisianus*, while *Collisella subrugosa* was one of the most abundant reaching densities of more than 70 ind/m^2. Level 2 was dominated by *Phragmatopoma caudate, Brachidontes solisianus, Tetraclita stalactifera,* and *Chthamalus bisinuatus*. Level 3 showed differences in among the different sites, with *Collisella subrugosa, Fissurella clenchi, Phragmatopoma caudate, Ulva lactuca, Stramonita haemastoma,* and *Caulerpa fastigiata* as some of the most abundant and conspicuous species.

The South: Paraná and Santa Catarina

The rocky coasts along south Brazil are formed by granitic or basaltic rock, resulting from the erosion of the border of the Serra do Mar mountain chain, which lies parallel to the coastline. Biolithic formations are also observed as an important coastal substrate, mainly at Paraná and Santa Catarina States. It is not a continuous ecosystem, but forms more or less extended outcroppings between sandy beaches and around numerous coastal islands. In some beaches there is a large rocky wall with different inclinations, where the intertidal zone is 5 – 6 m wide, but in most cases boulders of different sizes accumulate in front of these walls and the intertidal community covers a band of just 1.5 – 2 m high in each boulder . Usually the tide ranges from -0.2 to 1.8 m and water temperatures range from 17 – 23 ºC but surface water temperatures can reach peaks of 26 – 28ºC. The Paraná comprises the shortest coast in extension in the South and the second shortest in Brazil (98 Km). The area is between two Estuarine Complexes (Paranaguá and Guaratuba Bays), resulting in low transparency and high concentration of dissolved organic matter.

The monitoring of rocky coasts in the Brazilian southern region covered the following beaches from north to south: Morro do Farol (Figure 3G) and Praia Grande (Mel Island), Farol Island (Matinhos), Ferry Boat and Morro do Cristo (Guaratuba), in state of Paraná; First outcrop and Third outcrop (Itapema do Norte, Itapoá), Papagaio Point and Praia de Cima (Palhoça), in state of Santa Catarina; and Praia da Cal and Guarita Park (Torres) in state of Rio Grande do Sul. The northern seven sites listed are close to large estuarine systems (Paranaguá Bay, Guaratuba Bay, Babitonga Bay) and consequently exposed to low salinities (33-34) and high loads of sediment (turbid waters) and high concentration of dissolved organic matter.

A total of 160 species were found, around 60 invertebrates and 100 conspicuous macroalgae distributed along the three states, but known species richness in the southern Brazilian coast can reach 220 taxa at Santa Catarina (ca.), 131 taxa in Paraná (Pellizzari et al. 2014) and 85 taxa in Rio Grande do Sul (ca.). Rhodophytes dominated over Chlorophytes and Phaeophycean. The supralittoral zone mostly comprises bare space used by the periwinkle gastropods *Echinolittorina lineolata* (d'Orbigny, 1840), which are the most common and characteristic organisms at the lower part of this zone. Abundances can be as high as 150 individuals per 100 cm2. The high intertidal contains a dense belt of the barnacle *Chthamalus bisinuatus* Pilsbry, 1916, where many *Echilittorina* are still present. The mid intertidal is dominated by the mussel *Brachidontes solisianus*, usually fouled by the algae *Pyropia* (formerly known as *Porphyra*) *suborbiculata*, *Bostrychia* spp., and *Gelidium pusillum* during the winter time. In this zone sand accumulates among the bivalves, sometimes almost covering all the shells, in which a community of vagile invertebrates such as polychaetes and nematodes is found. The community of the low intertidal is more variable among sites. In some beaches, barnacles (*Tetraclita stalactifera*) are very common (Morro do Farol, Morro do Cristo, Ponta do Papagaio), while in others, the mussel *Perna perna* is the dominating species (Ferryboat, Praia de Cima, Praia da Cal, Guarita Park). Below the barnacle and mussels zone, high densities of the sabelariid polychaete *Phragmatopoma caudata* are found forming sand reefs that can extend 50-70 cm away from the substrate. Not all rocks are covered by the sand reefs and macroalgae are also very abundant in this zone. Regarding seaweed assemblages, filamentous, foliose and terete functional groups dominated the biomass. Species with higher coverage in the low intertidal were *Acantophora spicifera, Centroceras clavulatum, Gelidium spp., Gymnogongrus griffthsiae, Hydropuntia caudata, Hypnea musciformis, Pyropia acantophora, Laurencia* spp*., Bryopsis pennata, Cladophora* spp*., Codium taylorii, Gayralia brasiliensis, Ulva lactuca, U. flexuosa, Bachelotia antillarum, Colpomenia sinuosa, Dictyota* sp*., Padina gymnospora and Sargassum* spp. The most important herbivores in the area are sea-urchins and turtles. In some beaches, hydroids are also common in the low intertidal such as *Obelia dichotoma*, *Orthopyxis sargassicola*, and *Acharadria crocea*. The sea anemone *Bunodosoma caissarum* as well as the sponge *Hymeniacidon heliophila* were also frequent. When the tide is very low and the sublittoral fringe gets exposed, a few ascidian species can be found (*Polysyncraton aff. amethysteum*, *Didemnum galacteum*, *Botryllus planus*, and the introduced *Eudistoma carolinense*). Among the grazers, there were five mollusk species and one sea-urchin, while among the predators, *Stramonita braziliensis* was the only ubiquitous and abundant invertebrate species. No sea-stars were found, however, 20 years ago, *Asterina stellifera* was common in the intertidal zone of this region.

Along the Brazilian coast in general, macrofauna does not show significant differences in composition, however seaweed assemblages are strongly marked by latitudinal differences on their composition and biomass. The highest diversity of macroalgae is found between the coasts of Espírito Santo and Bahia States, while the highest biomass is found in the Brazilian Northeastern and also Santa Catarina, in the South, associated probably to the influence of the South Atlantic Central Water (ACAS), distance to large estuaries (affect water transparency), and finally to the availability of hard substrates.

URUGUAY

The Uruguayan marine and estuarine coastlines (ca. 500 km, between 34º and 35ºS) include sandy beaches interrupted by streams and coastal lagoons and rocky (mainly metamorphic and igneous) outcrops forming capes or peninsulae. Since the Uruguayan coast is under the influence of the the Río de la Plata estuary, one of the largest estuaries of South America, a salinity gradient roughly oriented east–west can be identified. Based on salinity, three main regions can be identified: a west region influenced by freshwater (<1ppt), a central region that is influenced by water of variable salinity (1–30 ppt) and an east region open to ocean waters (>30 ppt) (Brazeiro, Borthagaray, and Giménez, 2006; Defeo et al., 2009; Giménez et al., 2010). Diluted waters (i. e. salinity <33.2) dominate shallow coastal area (i.e. depths <50m) and can reach the offshore producing a buoyant fresh water layer during extreme continental discharge that determine variations in coastal water input (Ortega and Martínez, 2007). Upper waters temperature could exceed 20ºC (e.g. Tropical Water) (Thomsen, 1962) at surface. In the boundary between the estuarine and oceanic zone (Punta del Este), water temperature can fluctuate between 10.7ºC in winter and 24.6ºC in summer, (Burone and Bayseé, 1985; Milstein and Juanicó, 1985). The coast experiences a semidiurnal tide (range < 0.5 m) with the water level influenced mainly by wind conditions (direction and speed). Winds blow south-west during winter and north-east during summer. The rocky platforms have variable slopes and are exposed to different degrees of wave action according to their orientation. SARCE sampling sites are located in the east region (Figure 3H).

Across the Uruguayan coast, intertidal species richness of both macroalgae and invertebrates, increased from west to east; this was most notable for sessile fauna and macroalgae (Giménez et al., 2010). In the east region, two to three zones can be identified, following classical zonation schemes: a high intertidal zone dominated by a cyanobacterial film, a middle intertidal zone dominated by barnacles and a low intertidal and shallow subtidal zone characterized by a dense cover of mussels and/or macroalgae. Intertidal mussel beds are thus a conspicuous feature of Uruguayan rocky shores, providing important economic and ecological services (Borthagaray and Carranza, 2007; Riestra and Defeo, 1994; Riestra and Defeo, 2000). Along this gradient, the intertidal mussel beds changes in species composition and structure. Currently, the western region is characterized by the invasive mussel *Limnoperna fortunei*. *Brachidontes darwinianus* and *Mytella charruana* occupy consolidated substrata along the central region (Maytía (Maytia and Scarabino, 1979; Neirotti, 1981; Scarabino et al., 2006), overlapping with *Brachidontes rodriguezii* from the eastern half of the central region and being replaced by this species in the eastern region (e. g. Amaro (Amaro, 1965; Maytia and Scarabino, 1979; Scarabino et al., 2006). *Mytilus edulis*, in turn, is distributed from the eastern half of the central region, being the dominant mussel species in this zone. *Brachidontes rodriguezii* and *Mytilus edulis* originate dense banks in the more saline part of the Río de la Plata, the first being characteristic of the intertidal (also occurring in the Atlantic shores), the second mostly subtidally although some intertidal exposed zones have been observed to be dominated by this species (Borthagaray and Carranza, 2007). The brown mussel *Perna perna* originates large banks in the subtidal of the eastern coast (Rocha) but its presence (in very low abundances) reaches Punta del Este. The Uruguayan coast was massively colonized by this species in the late ´50ths. Since this first colonization, *P. perna* almost disappeared in the late 70s to 1997, when a new process of colonization occurred in the area (Carranza and Borthagaray, 2008; Orensanz et al., 2002). The annotated list of macroalgal species of the Uruguayan coast given by Coll and Oliveira (1999) reported the presence of 69 species sampled from 27 sites located along the central and east sectors of the Uruguayan coast. Conversely, a single site (Cerro Verde) can yield more than 40 invertebrate taxa, including the small mobile (e.g. amphipods, polychaetes), and encrusting (e.g. briozoa, hydrozoa) fauna. Under the SARCE sampling protocol, two sites located in the eastern region showed a combined richness of 20 species, including 9 metazoans (4 Gastropoda, 2 Bivalvia, 2 Cnidaria Anthozoa and 1 Cirripedia), 4 Chlorophyta and 7 Rhodophyta.

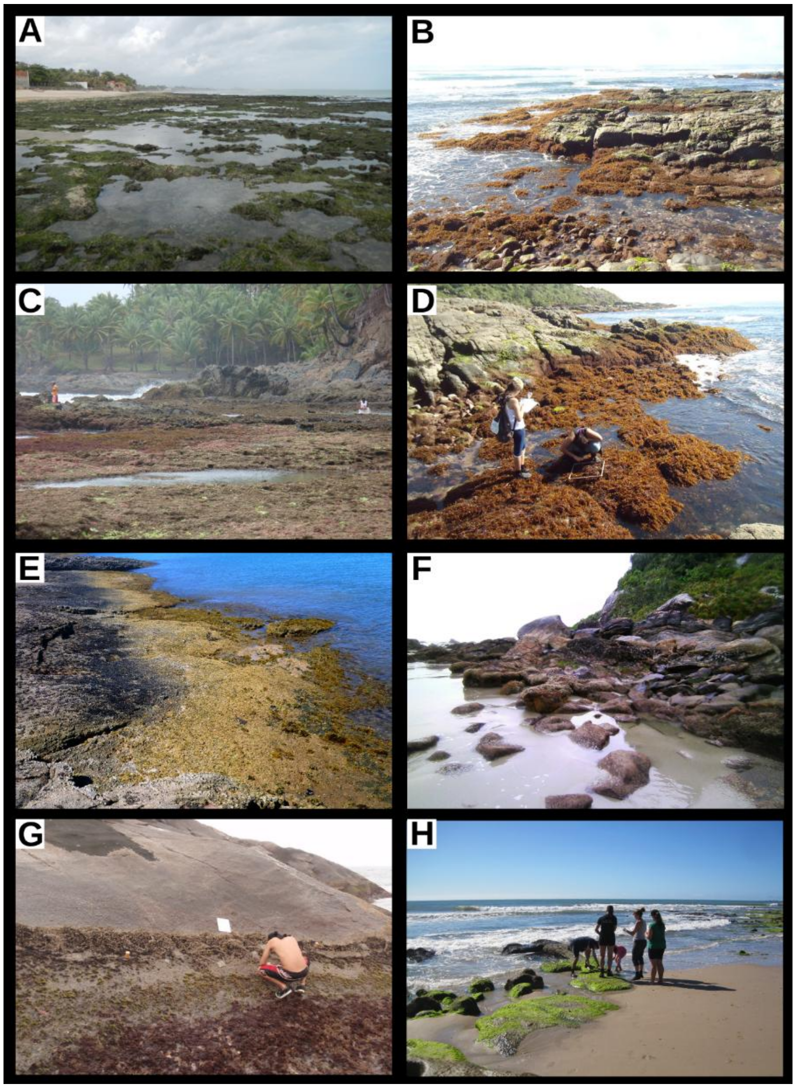

Figure 3. Sampling sites in the Brazilian and Uruguayan Atlantic. A. Northeast Brazil – Caucaia. B. Northeast Brazil – Bahia/Itacaré. C. Northeast Brazil – Bahia/Arruda, octopus fishing. D. Northeast Brazil – Bahia/Itacaré. E. Southeast Brazil – Costao de Ubu/Espirito Santo. F. Southeast Brazil – Sao Lourenco. G. South Brazil – Morro de Farol/Parana. H. Uruguay – Punta del Este.

ARGENTINA

The Argentinean marine coast extends along more than 4700 km and twenty degrees of latitude. It comprises the Argentinean and Magellanic biogeographical provinces, which are delimited by the Valdés Peninsula. The Argentinean Biogeographic Province extends from 36 to 43º S, including the provinces of Buenos Aires and Río Negro, and the north of Chubut province. The Magellanic Biogeographic Province, extends from 43ºS to 56ºS along southern Chubut province as well as Santa Cruz and Tierra del Fuego provinces (the latter includes the Malvinas/Falklands and South Atlantic Islands) (López Gappa et al., 2006, Balech and Ehrlich, 2008). Intertidal rocky platforms in Argentina increase in frequency and extend from North to South. In the northernmost coastal province (Buenos Aires), rocky coastal stretches are markedly discontinuous. They rarely exceed 1 km length and are frequently associated to urban areas. Most intertidal platforms in this province are formed by consolidated sediments (e.g., limestones, sandstones, calcretes) that support both epilithic and endolitic biota (Bagur et al. 2013, 2014). The only exceptions are a handful of metamorphic rock (ortoquartzite) platforms adjoining the city of Mar del Plata (38° S).

SARCE sampled two sites were sampled in the province of Buenos Aires: Playa Chica, an orthoquartzite platform located in the urban zone of Mar del Plata (Figure 4A) and at a calcrete platform located immediately north of the port of Quequén. Both localities are exposed to waves and face the open sea. The tidal regime at these sites is semidiurnal and microtidal (mean and maximum amplitude are 0.83 and 1.65 m respectively). Water temperature varies from a media of 5º C in winter to a media of 18 º C in summer (Servicio Meteorologico Nacional-Argentina, http://www.smn.gov.ar). The next province to the south, Rio Negro, presents intertidal platforms of varying substrate, including sedimentary (e.g., sandstones, limestones) and igneous rock types (e.g., granite, ignimbrites) (Kokot et al. 2004). Tidal regimes are semidiurnal and macrotidal through the whole coastal range. The sampling sites in this province were: El Espigón, La Lobería (Figure 4B), Playa Los Suecos, and Punta Colorada. El Espigón and La Lobería face the open ocean and are characterized by sedimentary rock substrates and maximal tidal amplitude of 4.32 m. Playa Los Suecos and Punta Colorada are located within the San Matías Gulf and show igneous rock substrates and maximal tidal amplitude of 8.72 m (Kokot et al. 2004). Southwards, the rocky shores of Chubut province are exposed to unusually harsh physical conditions, particularly with regard to desiccation (see Bertness et al. 2006). The region is characterized by persistent and intense winds (up to 90 km/h, annual average 16.6 km/h) and low precipitation (mean 235.9 mm/yr (Paruelo et al., 1998, Labraga & De Davies, updated 2013). The tidal regime is semidiurnal and macrotidal. Consolidated sediments are the dominant substrate type across these rocky shores. Sampling sites in Chubut were Puerto Lobos, Punta Este (Figure 4C), and Camarones. Puerto Lobos is located by the Southern end of the San Matías Gulf and its maximal tidal amplitude is about 6 m. Punta Este is located within the Nuevo Gulf, 8 km south from the city of Puerto Madryn. Mean tidal amplitude at this site is 3.8 m (Maximal: 5.7 m). The town of Camarones is located within the homonymous bay. This site is characterized by monthly-averaged wind speeds ranging from 13 to 31 km/h and an average tidal amplitude of 4 m, platforms are characterized by sedimentary rocks although some igneous rock are present. The southernmost continental sampling site was Puerto Deseado (Figure 4D) in Santa Cruz Province. This site is located in the Deseado Massif geological province, and characterized by igneous rock substrates (rhyolites; see Pankhurst and Rapela, 1995; Pankhurst et al., 1998). Climate is also dry and windy with a mean annual precipitation around 200 mm and an average annual air temperature of 8.2 °C (Servicio Meteorologico Nacional-Argentina, http://www.smn.gov.ar). The tidal regime is mesomacrotidal (Isla and Bujalesky, 2008), with amplitudes ranging between 2.5 and 5.5 m. Two additional sites were sampled in Tierra del Fuego Island: Estancia Viamonte (Figure 4E) and Playa Larga (Figure 4F). Estancia Viamonte is located 40 km south of the city of Río Grande and characterized by an extensive limestone abrasion platform (the low tide level is ca. 2 km distant from the high tide line) that faces the open ocean. The tidal regime is macrotidal, with amplitudes ranging between 2.2 and 8.4 m (Bujalevsky 1997, 2007). The area shows a dry and windy climate (340 mm/yr precipitation) with the mean annual temperatures of 5-6 °C and low between-month variations (Bujalevsky 1997, 2007). Playa Larga is located 3.5 km east of the city of Ushuaia in the Beagle Channel. The rocky shore at this site is characterized by methamorphic rocks and a sharp slope. The tidal regime is microtidal (1.1 m mean amplitude). Mean annual temperature and precipitation are 6°C and 500 mm, respectively. This shore faces the dominant SW-W winds and, thus, is exposed to considerable wave splash. The subtidal all along the Beagle channel is characterized by dense forests of *Macrocystis pyrifera* (Figure 4G) down to the channel's mouth to the Atlantic at Estancia Moat, a planned sampling site (Figure 4H).

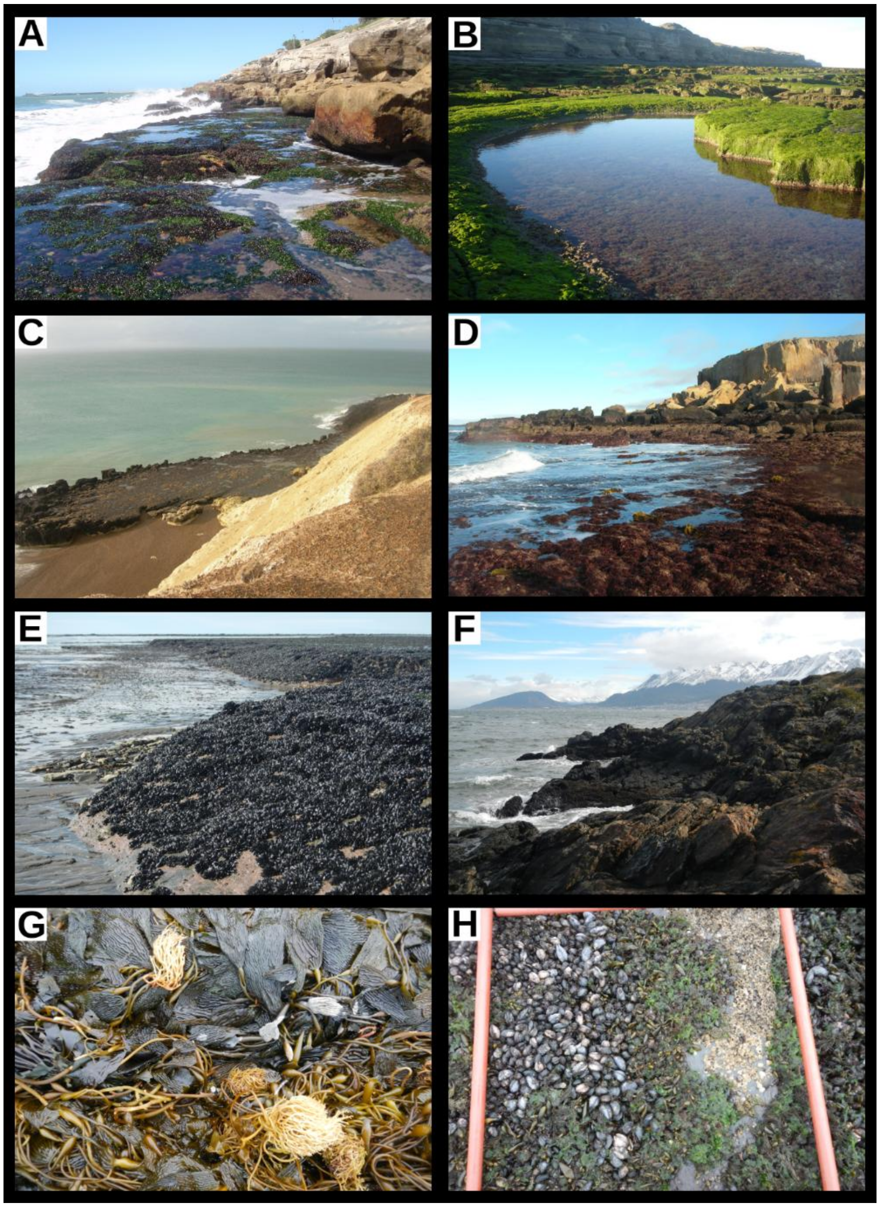

Figure 4. Sampling sites in Argentina. A. Mar del Plata. B. La Lobería. C. Punta Este. D. Puerto Deseado. E. Río Grande. F. Playa Grande. G. Estancia Moat – *Macrocystis pyrifera*. H. Estancia Moat.

The main feature of this extensive coast is the low biodiversity of its rocky intertidal shores, which at the same time involve low biomass (Wieters et al. 2012). From North to South, the two localities in Buenos Aires Province have different geological substrates, and are 120 km apart. Even if both assemblages have the same species composition; the structure and relative abundance of species between localities were different. In Mar del Plata, the locality with quarzitic substrate, the bivalve *Brachidontes rodriguezii*, the limpet *Siphonaria lessoni* and the introduced barnacle *Balanus glandula* are the more abundant species of the high intertidal. In the mid intertidal level, several algae species were added to the assemblages, being *Hildenbrandtia* sp. *Polysiphonia fucoides*, *Ulva* sp. and two non-indigenous red algae *Anfeltiopsis devoniensis* and *Schyzimenia dubyi* the most abundant. In the low intertidal level, the most representative species are *Polysiphonia fucoides* and *Siphonaria lessoni* in Mar del Plata and *Corallina officinalis* and *Balanus glandula* in Quequén. The presence of non-indigenous algae species is limited to Schyzimenia *dubyi*, and in very low coverage.

The Rio Negro Province comprises two localities and also an area of ecotone among two biogeographic regions, the Argentinean and Magellanian provinces. The differences among localities involve not only changes in the species composition but abundance of the ones that are present in both regions. In El Espigón and Loberia, a great variability was found between sites, the high intertidal is inhabited mainly by *Mytilus platensis* in one site and by *Ralfsia expansa* and *Enteromorpha linza* in the other. The mid intertidal level could have up to 98 % coverage of *Brachidontes rodriguezii* in one site and 0 % in the other. *Siphonaria lessoni* is the second more abundant species in this level. In the low intertidal the areas are patchly covered by *E. linza* and *Corallina officinalis* in one site or almost exclusively covered by *C. officinalis* in the other. In Playas Doradas, the most abundant species that inhabits the high intertidal are *Siphonaria lessoni* and *Brachidontes rodriguezii*, but in a very low percentage cover (approximately 12 %). In the mid intertidal, *Brachidontes pupuratus* replaces *B. rodriguezii* and it is the most abundant species followed by *Ralfsia expansa* and *S. lessoni*. For the low intertidal, *C. officinalis* is the most abundant followed by a complex of *Aulacomya actra* and *Mytilus platensis* forming mussel beds. The Chubut Province is characterized by sites with no human settlements. In the north of the province, the biodiversity pattern is similar to the localities in the province of Rio Negro, with *B. purpuratus* being the most abundant species in the high and mid intertidal and *C. officinalis* in the low intertidal. In Puerto Madryn, a site with a local population of 80,000 residents, the pattern is similar but with a greater proportion of the green algae *Ulva* sp. in the mid intertidal, depending on the season. High and mid intertidal are dominated by the mytilid complex of *Brachidontes rodriguezii* and *Brachidontes purpuratus* that produce an heteregenous habitat that facilitates settlement for several species. Also the non-indigenous barnacle *Balanus glandula* is present in high and mid intertidal levels, while the gastropod *Trophon geversianus* is a carnivore specialized on mytilid bivalves. The low intertidal is dominated by the alga *Corallina officinalis* and the herbivore gastropod *Tegula patagonica*. In Camarones, the zonation is similar to Puerto Madryn, presenting zones with 100% of coverage of *Brachidontes purpuratus* dominating the mid intertidal, and the invasive species *Balanus glandula* in the mid and high intertidals. The low interidal is dominated by the calcareous algae *Corallina officinalis*, while *Aulacomya atra* and *Siphonaria lessoni* are abundant in some localities. The gastopod *Trophon geversianus* is less common in this zone, probably due to the harsh physical stress.

Santa Cruz is the last province of the continent and the one with less population, with nearly 10,000 residents on the coast, but with an important port in the sampling locality

Puerto Deseado. Here, even if biodiversity increased slightly, patterns of the most abundant species were kept. The high and mid intertidal were dominated by *Brachidontes purpuratus* and the algae *Bostrichia*, while the in the low tide *Corallina officinalis* and *Chondria* were the most abundant. In the low intertidal level the presence of the non-indigenous red algae *Anotrichium furcellatum* was detected as one of the most abundant. In Tierra del Fuego Island, assemblages are different according to their degree of exposure (open ocean vs Beagle channel). In the open ocean locality, Estancia Viamonte, near Ushuaia (56,000 residents), mussel beds are composed mainly by *Mytilus edulis platensis* and covered from 50 to 87% of the mid and high intertidal. In the low intertidal, the incrusting algae *Corallina* sp. is the more abundant sessile species. The biodiversity of mollusks increased in this site, being *Nacella magellanica*, *Kerguelenella lateralis* and *Trophon geversianus* the most abundant. In the locality in the Beagle Channel, Playa Larga, macroalgal biodiversity increased, being the most conspicuous group in the low and mid intertidal along with *M. edulis platensis*. The limpet *Notochthamalus scabrosus* is the more abundant species in the high intertidal. As observed in the open ocean site, the biodiversity of mobile mollusks increased with *S. lessoni*, *K. lateralis*, *N. magellanica* and *T. gerversianus* the most abundant species in the three intertidal levels.

THE PACIFIC

COLOMBIA

In general terms, two main regions/features can be recognized on the littoral of the Pacific coast of Colombia: mangrove swamps and muddy flats to the south and rocky shores to the north; with a hybrid zone almost in the middle of the coast: Málaga and Buenaventura Bays. The shoreline is very broken, interrupted by numerous small rivers and creeks characteristic of one of the rainiest and most bio-diverse areas in the World: The Tumbes-Chocó-Magdalena region. Despite this condition or perhaps due to it, most of the coast is unpopulated, with only two relatively large cities: Buenaventura (the most important commercial port in Colombia), located almost in the middle of the coast and Tumaco, a smaller city located at the south, near the border with Ecuador. Although these two are the main cities, there are numerous small towns, such as Guapi and Bahía Solano, among others. The transportation system in the region is precarious. The underdeveloped roads infrastructure is limited to Buenaventura and Tumaco, and all other settlements can only be reached by boat or in few cases by plane, a fact that makes it difficult and expensive to undertake research projects in the Pacific coast of Colombia.

The Pacific coastline has an extension of nearly 1544 km, of which 636 km are exposed rocky shores (Londoño-Cruz et al., 2008, Londoño-Cruz et al., 2014). Despite this exposure, wave action is moderate most of the year round, reaching, on average, wave heights of up to 1 m in most locations (INVEMAR, 2003). Tidal range is relatively large (ca. 4.5 – 5.0) and has a semidiurnal frequency (ca. 6:15 hrs. between high and low tide). Currents, on the other hand, respond to prevalent winds and to the movement of the Intertropical Convergence Zone (ITZC). The most important surface currents are the North Equatorial Current, the North Equatorial Counter-current, the Panama Gulf Current, and the Colombia Current. Although there are hypothesis regarding the existence of upwellings in the Pacific coast of Colombia, these have not been unambiguously confirmed; if they do occur, they happen during the first months of the year and at the northernmost of the Colombian Pacific (Vides and Sierra-Correa 2003). Rocks forming the large extension of rocky shores on the

Colombian Pacific are composed by volcanic rocks from the Secondary or Tertiary periods and by sedimentary rocks from the Quaternary. The volcanic rock characterizes the rocky shores of the northern regions and the Gorgona and Malpelo Islands, while the sedimentary rocks characterize the rocky shores of central (Málaga Bay, Pichidó Isthmus, and Tortuga Gulf) and southern (Gallo Island) regions (INVEMAR, 2004). Due to the relatively large tidal range, the rocky intertidal can be easily divided into three levels, which vary in dimension depending on the slope of the shore. It is very common to find cliffs along the coast, with scattered abrasion platforms and rocky/boulder beaches. Zonation in the intertidal zone is very typical, with periwinkles and *Nerita* spp. occupying the upper intertidal; barnacles, limpets, other snails and bivalves in the middle and a richer arrange of species in the lower. In these rocky shores, the algal coverage is very low as compared to shores in higher latitudes or the Colombian Caribbean; so although species richness in general is high, species abundances are relatively low. It is also important to note that space seems not to be a limiting factor, since there is plenty of free space in almost every rocky shore along the coast. One might hypothesize that the reason for this low abundance is low algal coverage and long exposure periods during low tide, which may bring very high temperatures or very low salinities (during high rainfall).

The localities sampled by SARCE (from North to South) include El Choco (Punta Ardita, Cabo Marzo) (Figure 5A), Málaga Bay (Los Negritos, Isla Palma), and Gorgona Island (La Ventana, La Camaronera, Piedra Redonda) (Figure 5B). Punta Ardita at El Choco is the northernmost locality, near to the border with Panamá, practically undisturbed by human presence. The volcanic rocky shores in this locality are edged by large sandy beaches. The high intertidal is mostly bare rock with *Cladophoropsis* sp., *Nerita scabricosta*, *Echinolittorina conspera*, *Chthamalus panamensis*, *Lottia mesoleuca*, and *Acanthina brevidentata*. The mid intertidal is dominated by *Cladophoropsis* sp., *Acanthina brevidentata*, *Fissurella microtrema*, *Phragmatopoma* sp., *Fissurella microtrema*, and *Lottia mesoleuca*. The most common species in the low intertidal are *Cladophoropsis* sp., *Echinometra vanbrunti*, *Telmatactis* sp., bryozoa, and *Balanus* sp. Cabo Marzo is an isolated locality with no human settlements nearby and practically undisturbed. Rocks, as in the previous locality, are volcanic. There is some coralline formation in this place, waters are very transparent. Wave conditions are relatively rough. Dominant species of Cabo Marzo are *Chthamalus panamensis*, *Echinolittorina conspera*, and *Nerita scabricosta* in the high intertidal, Corallinales, *Fissurella virescens*, and *Siphonaria maura* in the mid intertidal, and Corallinales, *Chiton stokesii*, *Siphonaria maura*, *Nucella melones*, and *Chama frondosa* in the low intertidal.

At Málaga Bay the rocks are sedimentary. This bay is part of a National Natural Park and there is a relatively large human settlement (Juanchaco) at the mouth of the bay, as well as a Navy Base along with several other scattered minor settlements. Seasonal tourism is, perhaps, the main economic income for the inhabitants. The first site, Isla Palma, is an island (uninhabited), while the second site, Los Negritos, is an intertidal rocky reef with both volcanic and sedimentary rocks. Dominant species at Isla Palma were *Chthamalus panamensis*, *Balanus* sp., *Lottia mesoleuca*, *Echinolittorina paytensis*, *Echinolittorina dubiosa*, and *Echinolittorina apicina* in the high intertidal; *Verrucaria* sp., *Lithophyllum* sp., *Nerita funiculata*, *Lottia mesoleuca*, and *Balanus* sp. in the mid intertidal; and *Cladophoropsis* sp., *Bostrychia* sp., *Lithophyllum* sp., *Echinometra vanbrunti*, *Nucella melones*, and *Brachidontes* sp. in the low intertidal.

Gorgona Island is also a National Natural Park. Most of the island's shores are rocky and cliffy. Rocks are volcanic with few exceptions. Basically all sort of rocky shore types can be found in the island. This locality is perhaps, the most sampled area in the entire Pacific coast of Colombia. The main rocky ecosystems sampled (La Ventana, La Camaronera, and Piedra Redonda) are located at the south and western sides of the Island. At La Ventana, the dominant species were *Nerita scabricosta*, *Cladophoropsis* sp., *Echinolittorina conspera*, and *Siphonaria gigas* in the high intertidal, *Nerita funiculate* and *Cladophoropsis* sp. in the mid intertidal, and *Nucella melones* and *Nerita funiculata* in the low intertidal. At La Camaronera, high intertidal is dominated by *Echinolittorina conspera* and *Nerita scabricosta*, the mid intertidal by *Nerita funiculata*, and the low intertidal by *Cladophoropsis* sp., *Nerita funiculata*, and *Tegula pellisserpentis.* At Piedra Redonda, the high intertidal is dominated by *Nerita scabricosta*, the mid intertidal by *Cladophoropsis* sp., *Nerita funiculata*, and *Fissurella virescens*, and the low intertidal by *Cladophoropsis* sp. and *Nucella melons*.

ECUADOR

The coast of Ecuador extends for 4,403 km from north to south and includes several isles, islets and estuaries. The continental platform exceeds 100 km in amplitude mainly at the Gulf of Guayaquil (Sonnenholzner et al, 2013) and a depth of 200 m from the coastline (Mora et al, 2010). About a third of the coast is covered by mangroves, mostly in the north and in the south. The central and part of the north coasts are characterized by large sandy beaches interrupted by a few rocky areas, cliffs, lagoons and rocky reefs (Sonnenholzner et al, 2013; Miloslavich et al, 2011). The rocky shore intertidal has mid to steep slopes formed by stratified rocks within cliffs entering the sea and forming platforms within the sandy beaches. At the base of some of the cliffs, an eroded narrow terrace can be observed, or the beach may be narrow with boulders. Despite the importance of rocky shores, they have been poorly studied in Ecuador, and knowledge on its biodiversity is limited to some taxonomic studies on specific groups such as molluscs (Bonilla 1967; Cruz 1977, 1983, 1992a, b, 1996, 2007 y 2009; Mora and Reinoso 1981; Mora 1989, 1990; Arias 2012), poliychaetes (Villamar 1983, 1986, 1989), echinoderms (Avilés 1984, Sonnenholzner et al. 2013), and macroinvertebrates (Massay et al. 1993; Arroyo and Calderón 2000; Mair et al. 2002; Cruz et al. 2003; Ayala 2010; Mora et al. 2010).

SARCE sampled at two localities at the central and south-west of the coast of Ecuador: Caráquez Bay (Punta Bellaca and Punta Gorda) and at the Santa Elena Peninsula, the localities of Puntilla de Santa Elena (Base Naval and La Lobería) (Figure 5C) and Ballenita (El Barco and El Faro) (Figure 5D) which are located at the provinces of Santa Elena and Manabí. The sites with more human impact were Punta Bellaca and Ballenita, while Punta Gorda and Puntilla de Santa Elena were less impacted.

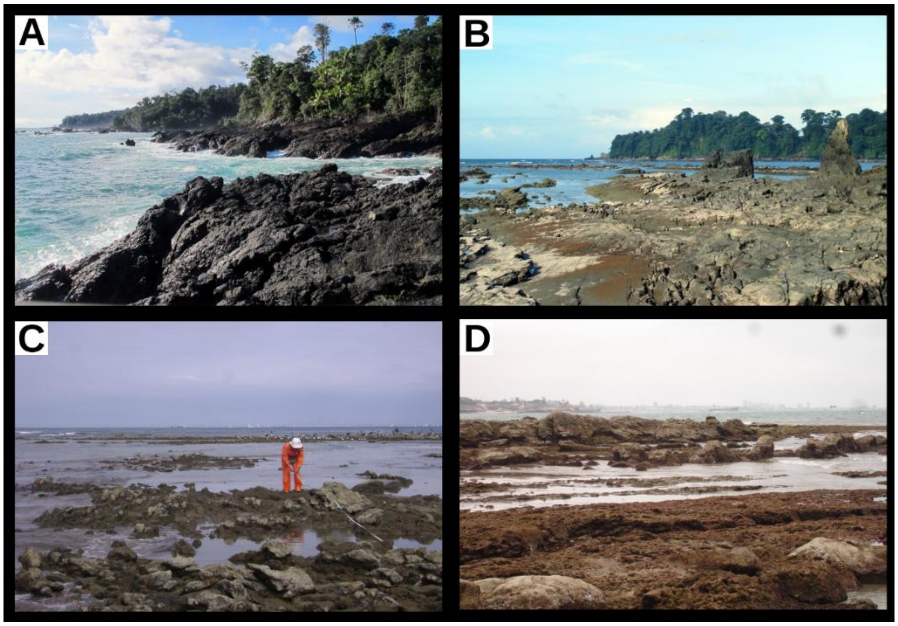

Figure 5. Sampling sites in the Colombian and Ecuadorian Pacific. A. Colombia – Ñuqui/Choco. B. Colombia – La Ventana/Gorgona. C. Ecuador – Puntilla de Santa Elena. D. Ecuador – Ballenita.

Punta Bellaca and Punta Gorda are characterized by almost vertical, high cliffs of up to 100 m interrupted by deep valleys with steep slopes (Ochoa et al, 1987). These cliffs are unstable and landslides are common. The beach is narrow and in some places, eroded rock terraces can be found inserted within sandy beaches (Boothroyd et al, 1994). Weather in this area is tropical dry with an average temperature of 25°C. Rainfall is not uniform due to the complexity of the Oceanic Front, and varies between 200-800 mm (Ochoa et al, 1987). A total of 16 species were found (10 at Punta Bellaca and 4 at Punta Gorda), mostly represented by molluscs (50%), macroalgae (25%), and crustaceans (25%). The most diverse group was the mollusks represented by 7 species of gastropod and one bivalve species. The most abundant species were the gastropods *Nodilittorina aspera*, *Nodilittorina paytensis* and the macroalgae *Enteromorpha* sp. and *Bachelotia* sp..

The high intertidal was mostly represented by bare rock and patches of sand, but some rocks were colonized by the *Brachidontes semilaevis*/*Balanus amphitrite* complex. The most common species in the mid intertidal were *Balanus amphitrite* and *Enteromorpha* sp. and *Bachelotia* sp. in the low intertidal.

At the Santa Elena Peninsula, Ballenita is a public watering place with hotels all along the border of the coast. The weather is tropical with a mean average temperature of 24°C. The intertidal is characterized by short, vertical, and unstable cliffs. The rocky platforms are inserted within the sandy beaches, and have a soft slope (Ochoa et al, 1987). Boothroyd et al. (1994) proposed that the low cliff originated from a system of barrier/littoral plain formed by sand poorly cemented to the carbonates and clay. Wave energy is highest during the rainy season (Brito, 2014). The rainy season occurs in January-April followed by the dry season which extends to November-December (Ochoa et al, 1987). Precipitation varies from 62.5 to 125 mm (Ochoa et al, 1987).

The Puntilla de Santa Elena is within a marine protected area known as "Reserva de Producción de Fauna Marina Costera Puntilla de Santa Elena" or REMACOPSE. The intertidal here is irregular, with low vertical, unstable cliffs that continue at sea, emerged, for a few hundred meters. Between these formations, sandy beaches with coarse sand and steep slopes are found. The base of the cliffs are continuously eroded by wave action (Boothroyd et al, 1994; Soledispa, 2008). From the geological point of view, the most outstanding feature at La Lobería is the Cayo Formation, represented by sandstone, chert and silicified clays (Soledispa, 2008). Wave action is stronger than in the previous site and also highest during the rainy season (Brito, 2014). At the Navy Base, the Beach is characterized by medium size rocks covering a great extension that goes into the sea. According to Soledispa (2008), these lay directly on top of the Cayo Formation where deposits from the quaternary are found and composed by calcarean sandstone and conglomerates with abundant fossils. When the tide is low, numerous intertidal pools can be observed among the sand. Weather in this area is arid, with a mean annual temperature of 24°C, and precipitation, determined by the Humboldt Current, varies between 62.5 and 125 mm (Ochoa et al, 1987).

At these localities, a total of 66 species were found. These were mostly represented by molluscs (39%), macroalgae (24%), crustaceans (14%), cnidarians (9%), bryozoans (5%), echinoderms (5%), sponges (3%), and tunicates (1%). Ballenita had a higher number of species (30 species) in comparison to Puntilla de Santa Elena (19 species). The most diverse group were the mollusks (29 gastropod species plus 2 bivalve species) followed by macroalgae (9 species of rodophytes, 3 of chlorophytes, 3 of phaeophytes plus an unidentified species), and barnacles. The most abundant species were *Balanus amphitrite*, *Brachidontes semilaevis*, *Nodilittorina aspera*, *Nodilittorina paytensis* and one bryozoan. The dominant species in the high intertidal were *Nodilittorina aspera*, *Nodilittorina paytensis*, and the complex *Balanus amphitrite/Brachidontes semilaevis*, while the mid intertidal was dominated by *Pachygrapsus transversus*, *Echninometra vanbrunt*, and *Nerita funiculate;* and the low intertidal by *Nodilittorina aspera*, *Thais brevidentata*, *Padina* sp., and a bryozoan species. The vertical zonation was more evident in the high and mid intertidal which are dominated by littorrinid gastropods, barnacles and mussels (*Nodilittorina aspera*, *Nodilittorina paytensis* and the complex *Balanus Amphitrite*/*Brachidontes semilaevis*) as observed by Cruz (2009) and Brito (2014) at the Santa Elena peninsula. This pattern is dependant on the tide and time of exposure to air (Sibaja-Cordero and Vargas-Zamora, 2006).

PERU

The coastline of Peru extends for 2414 km along the Peruvian Biogeographic Province and is greatly under the influence of the Humboldt Current System, one of the major upwelling systems of the world (Miloslavich et al., 2011). SARCE sampled at seven localities, from north to south: Paita, Huarmey (Figure 6A), Ancón, Paracas (Figure 6B, 6C), Marcona, La Meca, and Punta Colorada (Figure 6D). The geological and physical conditions of these localities are very variable according to their origin and latitude, which ranges from a tropical warm province in the north, to a cold, sub-Antarctic province in the south. These changes are reflected in the composition of the intertidal flora and fauna.

In the north, Paita, located near the border with Ecuador, at the Panamic Province of the Tropical West Pacific is one of the most intense upwelling zones in the coast of Peru and characterized by high productivity (Fahrbach 1981, Huyer 1987, Grados 2002, Graco 2007). It is considered suptropical with very dry weather. Coastal diversity is high at these warm conditions (Ramírez et al., 2003), however, it is temporally affected by ENSO events (Paredes et al. 1998, Paredes et al. 2004), that produce the migration of some vertebrate species and the arrival of larvae or propagules of more tropical species. Sampled areas are relatively small beaches (~100 m in extension), exposed to wave action and located south of the bay of Paita. In this bay, 5 to 9 km from the sampling sites, functions the second largest port of Peru, dedicated mainly to fishing activities and transportation of agriculture products. The coast is characterized by black metamorphic rocks, over which Cretacic rocks can be found, mainly from the quaternary forming sandstones and cliffs of up to 50 m (Palacios Moncayo 1994). Tides are semidiurnal that may reach 1.73 m (HIDRONAV, 2012), and SST varies between 15-29°C (INEI, 2014), with the highest values in summer (February-March) and the lowest in spring (September-October). Paita is also under the influence of of the Peruvian Coastal Current which is characterized by cold Waters but also of tropical ecuatorial surface warm waters (Zuta & Guillen 1970, Cabrera et al. 2005). Very little is known about the biodiversity of these coasts. An abundant species is the barnacle *Pollicipes elegans* which is commercially exploited for exportation (Villena 1995, Oliva 1995, Pinilla 1996). Population density of this barnacle is very high during ENSO events, but after the event, population decreases significantly and is replaced by other invertebrates such as *Semimytilus algosus*, *Austromegabalanus psittacus* and *Balanus* spp (Kameya and Zeballos 1998). As for macroalgae, a total of 35 species were identified in the intertidal zone, of which 22% are considered to be endemic. This diversity is seasonal, decreasing during the winter or during other cold events such as La Niña (Benavente 1994).

In central Peru, the sites sampled at the Bay of Huarmey are exposed to wave action and located at 6.5-11.7 km north of the Port of Huarmey, important for mineral transportation and fishing activities. The rocky shores are part of the Casma Formation, from the late Cretacic, mainly volcanic spills of weathered andesite and inserted sediments. The weather is considered dry, subtropical desert, and tidal amplitude reaches 1.16 m (HIDRONAV, 2012). SST varies between 18-22 °C (Puerto de Chimbote, INEI 2014). Upwelling events are not frequent, but when they occur, SST may decrease to 15 °C (Berru Paz et al 2007). The most common species found in the rocky shores are *Fissurella* spp, *Polyplacophora*, *Pyropia* spp., *Chondrocanthus chamissoi*, which are also commercial species and monitored by IMARPE as artisanal fishing resources (Tam et al. 2007). The sites sampled at Ancón are within the area known as Volcánico de Ancón, which is characterized by pyroclastic rocks and volcanic andesites, typically metamorphic with plagioclases. Also a desert area, it was declared a natural protected area in 2011 along with the islands in front of the coast. The main port of Peru, El Callao, is located 33 km south of Ancón. Sampled sites are protected from wave exposure, tides reach 1.16 m, and SST varies between 14-22°C (Tarazona, unpublished). Upwelling events are frequent and generate hypoxia and even anoxia by the effect of bubbling from the bottom of sulphur compounds and other gases (Tarazona 1984, Tarazona et al. 1988, Tarazona et al. 1996). Biodiversity studies have been carried out since the 1970s (Paredes, 1974), and report 127 invertebrate species. The high intertidal is characterized by barnacles (*Jehlius cirratus* and *Notochthamalus scabrosus*) and littorinid gastropods (*Nodilitorina peruviana* and *Austrolittorina araucana*), the mid intertidal by a zone of mytilids in two bands, the upper band of *Perumytilus purpuratus* and the lower band of *Semimytilus algosus*, among macroalgae, and the low intertidal is characterized by *Austromegabalus psittacus* (Paredes & Tarazona 1980). Other spcies found in the intertidal are *Fissurella* spp., Polyplacophora, *Chondracanthus chamisoii*, and *Patallus mollis.* The locality of Paracas is located within the protected area known as Reserva Nacional de Paracas, the first marine reserve in Peru. The landscape is a coastal cordillera that reaches the sea forming cliffs of 50 to 400 m in height (Palacios et al. 1995). One of the sampling sites is located in the Ambo Formation from the Carboniferous, and the rocks are characterized by carbon sheets, which were formerly exploited. The other site is located on the Paracas Formation from the early Tertiary, characterized by phosphate sandstone and bentonites (Fernandez Dávila 1993). Both sampling sites are protected from wave exposure, tidal range is 1.12 m (HIDRONAV, 2012), and SST varies between 13 a 17 °C, however, at spatial scales of 1 to 2 kilometros, increases of up to 7°C may be observed due to water circulation and wave exposure in the bay (Romero 2000; Quispe et al. 2010, Moron et al. 1998). Intertidal fauna is represented by *Concholepas concholepas*, *Fissurella* spp., *Pyropia* spp., Polyplacophora, *Lessonia nigrecens*, among other species.

In the south of Peru, Marcona is an important area of mineral extraction, but also an area for the conservation of sea lions and pinguins (Punta Marcona). Rocky shores of the sampling sites are characterized by granitic formations from the Coastal Basal Complex, on which sedimentary rocks of the San Juan and Pisco formations have deposited sandstone of calcareous origin (Caldas Vidal 1978). These shores are exposed to wave action, however this is mitigated by a surrounding rocky reef. Tidal amplitude reaches 1.23 m (HIDRONAV, 2012) and SST varies between 12-24°C, with a marked seasonal pattern (Apaza & Figari 1999), and predominance of cold coastal waters. Upwelling events are common in this area (Rojas de Mendiola 1981). The most common species in these shores are the macroalgae *Lessonia* spp., *Macrocystis pyrifera* and *Pyropia* spp., and the invertebrates *Loxoechinus albus* and *Concholepas concholepas* (Galindo et al 1999). La Meca is located near the Wetlands of Ite, which were once heavily polluted by heavy metals from mining. Sampled sites are continuos rocky shores of sedimentary origin with sandstone and some volcanic outcrops from the Chocolate Formation of the coastal cordillera (Acosta Pereira et al. 2012). The sites are exposed to wave action but this is mitigated by rocky reefstidal range reaches 1.38 m (HIDRONAV, 2012) and SST is around 14 °C. This area is visited by artisanal fiherman extracting crabs (*Leptograpsus variegatus*), *Concholepas concholepas*, and macroalgae. The most southern locality is Punta Colorada, also characterized by outcrops of the coastal cordillera and some volcanic Rocks. The shore is exponed but some rocky reefs are also present. Between thes two localities, there are several artisanal fishing ports (Estrella Arellano et al. 1998).

CHILE

The coastline of continental Chile extends over 4200 km (from ca. 18°S to 56°S) encompassing from subtropical to sub-Antarctic waters (Santelices, 2001). The regular and relatively straight coast changes south of Chiloé Island (41°29'S) which is replaced by many gulfs, islands, channels and fjords. The rocky shores in northern and central Chile are mostly exposed to strong wave action (Thiel et al., 2007). Substratum is composed of rock of volcanic, granitic or sedimentary origin. Most of the coastal range consists of Jurassic and Cretaceous volcanic rocks (Fariña et al., 2008). Most of the coastline is influenced by the flowing Humboldt Current System, coastal upwelling and periodic occurrence of El Niño-Southern Oscillation (ENSO) (Thiel et al., 2007).

Northern Chile: Iquique, Antofagasta and Copiapó

This area represents one of the driest regions of the world, annual precipitation is extreme low (1 mm to 80 mm) with occasional rainfall episodes during austral summer, but no large differences between winter and summer exist (Schulz et al. 2011) (Figure 6E, 6F).

Species richness at Iquique, Antofagasta and Copiapó intertidal rocky sites was 41, 37 and 52 respectively. The high intertidal communities are dominated by the chthamalid barnacle *Jehlius cirratus* and the periwinkle *Echinolittorina peruviana*, occasionally small limpets *Siphonaria lessoni* and *Scurria variabilis* can be also found. Few macroalgae are present, mostly *Porphyra* sp. and *Pyropia* sp. The middle intertidal is dominated by the anemones *Phymactis papillosa* and *Anemonia alicemartinae*, the purple mussel *Perumytilus purpuratus* and macroalgae such as the ephemeral green alga *Ulva* spp. and the fleshy crustose brown *Ralfsia* sp., particularly in Antofagasta sites the middle and low intertidal are dominated by a dense turf of the red alga *Caulacanthus ustulatus* but in Antofagasta Bay extensive aggregations of the barrel-shaped tunicate *Pyura preaputialis* dominated the middle and low intertidal fringe, this is a non-indigenous species that affect the presence of native organisms (Caro et al. 2011). The low intertidal is dominated by a conspicuous belt of the kelp *Lessonia berteroana*, this brown alga is an ecosystem bioengineers and its holdfast provides habitat for high variety of small invertebrates (Vásquez & Santelices 1984), patches of the red algae *C. ustulatus* and *Corallina officinalis* var. *chilensis* are also present. At several sites the calcareous crusts of *Mesophyllum* sp. and *Lithophyllum* sp. dominates the substrata, over the crusts several individuals of the snail *Tegula atra*, the black sea urchin *Tetrapygus niger*, the edible barnacle *Austromegabalanus psittacus* and the large mollusc *Enoplochiton niger* can be found. At shadow protected places, the sea cucumber *Patallus mollis* and the anemone *Phymactis papillosa* (mostly the blue morph) are quite abundant. Several filamentous algae can be also found at middle and low intertidal, such as *Centroceras clavulatum*, *Polysiphonia* sp. and *Ceramium* spp. In some places the brown algae *Colpomenia sinuosa*, *C. tuberculosa* forms patches of several individuals.

Central-Northern Chile: Coquimbo, Los Vilos and San Antonio

In central Chile, Mediterranean climate is predominant characterized by a winter rainy season and a dry period in summer. The ocean proximity moderates temperatures, averages between 10°C in winter and 17°C in summer can be found. Presence of snow and frost are rare, day-night oscillation is also lower. Species richness at Coquimbo, Los Vilos and San Antonio intertidal rocky sites was 58, 69 and 70, respectively. The chthamaloid barnacle *Jehlius cirratus* dominates the sessile communities at high intertidal. The mobile communities are dominated for *Echinolittorina peruviana* and the small limpet *Siphonaria lessoni*. Mostly fleshy crustose macroalgae are present, such as *Hildenbrandia lecanellieri*, *Ralfsia* spp. and patches of the lichen *Thelidium chilensis*. The middle intertidal is dominated mostly by beds of the purple mussel *Perumytilus purpuratus*, and red algae *Mazzaella laminarioides*, *Hildenbrandia lecanellieri* and the turf-forming alga *Gelidium chilensis*. The mobile organisms in the middle zone are dominated by small limpets such as *Scurria araucana*, *Scurria variabilis* and the pulmonate gastropod *Siphonaria lessoni*. The low intertidal zone is dominated in rocky exposed shores mainly by crustose algae such as *Lithothamnium* spp., *Hildenbrandia lecanellieri* and the articulate calcareous coralline *Corallina officinalis* var. *chilensis*. In lower proportion the mussel *Semimytilus algosus* can be found and a conspicuous belt of the *Lessonia spicata*. The most common mobile organisms in the low intertidal zone were *Scurria araucana, S. scurria* and the key hole-limpets *Fissurella crassa* and *F. costata*. Several species such as *Perumytilus purpuratus*, *Gelidium chilense* and *Corallina officinallis* var. *chilensis* are considered ecosystem bioengineers and it loss can have significant changes in the community structure (Kelaher et al. 2007). On the other hand, is important to mention that in Central Chile a meso-scale eddy activity has been described (around 30ºS) (Hormazábal et al. 2004). Therefore expected differences in the structure of populations across this region can be found (Narváez et al. 2006).

Central-Southern Chile: Concepción and Valdivia

This area represents one of the rainiest regions in Chile, where the annual precipitation is very high, reaching up to 1250 mm (average last 10 years = 847 mm) at Concepción and 2400 mm (average last 10 years = 1800 mm) at Valdivia, with constant rainfall episodes during austral winter (June-September), and also occasionally rainfall during spring, and even during austral summer (December-February) (Figure 6G).

Species richness at Concepción and Valdivia intertidal rocky sites was 48 and 52 respectively, the communities at the high intertidal are dominated principally by the chthamalid barnacle *Jehlius cirratus* and the littorinid snails *Austrolittorina araucana*, occasionally the small limpets *Siphonaria lessoni*, *Scurria scurra* can be also found. The middle intertidal is dominated by dense beds of mussels *Perumytilus purpuratus* and *Semimytilus algosus* covered by the red macroalgae *Mazzaella laminarioides*, and in some sites, the red macroalgae *Mastocarpus latissimus* and *Gelidium pseudointrincatum*. Among mobile species, the limpets *Scurria scurra* and *S. variabilis*, and the snail *Tegula atra* are common inhabitant in the middle zone. The low intertidal is dominated by the red macroalgae *Ahnfeltiopsis furcellata* and patches of *Corallina officinallis* var. *chilensis*. At several sites, the foliose green macroalgae *Ulva* sp. is also found. Over and into primary substrate individuals of the snails *Tegula atra* (in some places assorted with *Prisogaster niger*) and *Acanthina monodon* are very abundant. At shadow protected places, the anemone *Phymactis papillosa* is quite abundant. Others species as the polychaete *Phragmatopoma moerchi*, the solitary ascidian *Pyura chilensis*, and the kelp *Lessonia spicata*, although less important in density, are considered important component on these latitudes because are considered ecosystem bioengineers, which may change significantly the surrounding community structure (Cancino & Santelices 1984, Sepúlveda et al. 2003a, 2003b).

Southern Chile: Punta Arenas

This area represents one of the most austral regions of the world, where annual precipitation is high, reaching up to 640 mm at Punta Arenas, with constant rainfall, snow and hail episodes during all year (Figure 6H). Winds are frequent and often exceed 100 km/h. The minimum temperature during winter can drop up to -2°C approximately (Butorovic 2013). Species richness at Punta Arenas intertidal rocky sites was 48. The communities at high intertidal are dominated by the barnacle *Jehlius cirratus* and the red macroalgae *Porphyra* spp. and *Pyropia* spp., and over the primary substrate the small limpets *Siphonaria lessoni* can be found in medium densities. In the middle intertidal patches of several macroalgae can be found, such as the coarsely branched *Nothogenia fastigiata*, *Mazzaella laminariodes*, the brown alga *Adenocystis utricularis*, *Ulva* sp. and filamentous of several Ceramiales species (e.g. the introduced species *Polysiphonia morrowii*), in this zone *S. lessoni*, and patches of *Perumytilus purpuratus* are also found. The low intertidal is dominated by the brown algae *Caepidium antarcticum* and *Lithophyllum rugosum*, however, the most conspicuous component are the gastropods *Nacella magellanica* and *N. deaurata*, which are found in high densities.

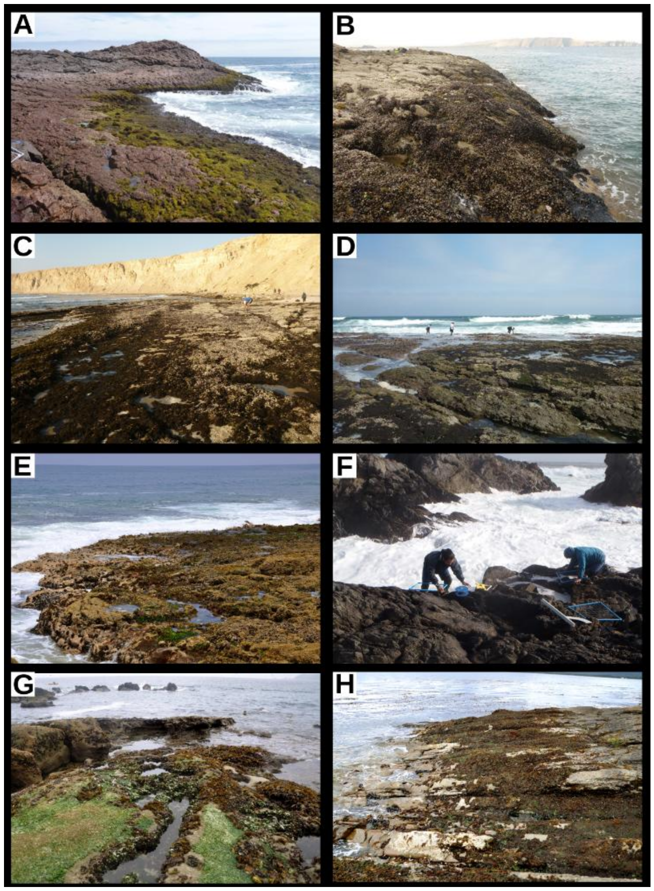

Figure 6. Sampling sites in the Peruvian and Chilean Pacific. A. Peru – Huarmey. B. Peru – Paracas. C. Peru – Paracas. D. Peru – Tacna/Punta Colorada. E. Northern Chile - Huayquique. F. Northern Chile - Copiapo. G. Central-southern Chile – Cocholgue. H. Southern Chile – Fuerte Bulnes.

Uses and threats to the intertidal rocky shores in South America

The intertidal rocky shores around South America represent a valuable resource for local populations in many aspects. The main uses given to these shores along with the threats that such uses produce is summarized in Table 1. In general, localities with dense human settlements face the problems associated to urbanization and sewage discharges along with unregulated tourism, while in less densely populated areas, the uses are basically associated to the extraction of invertebrates and macroalgae for food. Industrialization (e.g. oil and gas extraction, mining) is another issue affecting the services that these ecosystems may provide.

Table. I. Summary of main uses, threats and impacts at intertidal rocky shores in South America.

Country / locality	**Uses**	**Threats / Impacts**
CARIBBEAN		

Colombia	Food (snails, lobster, crab, fish, octopus, chitons) Urbanization, tourism	Decline in species abundance (some under threat categories by IUCN) Pollution, sedimentation
Venezuela	Food (snails, bivalves, sea urchins Tourism, urbanization	Decline in species densities Freshwater runoff, sedimentation, pollution (sewage), oil spills, solid waste
Trinidad & Tobago	Food (fish), tourism, urbanization	Pollution, freshwater runoff, overfishing
ATLANTIC		
Northeast Brazil	Food (artisanal and tramp fisheries of shrimp, crab), tourism, urbanization	Pollution (sewage, petrochemical), freshwater (urban, agriculture) runoff, solid waste, erosion
Southeast Brazil	Tourism, food, urbanization, marinas	Pollution (ore mining, petrochemical, heavy metals, sewage), maritime traffic, sedimentation (dredging navigation channels)
South Brazil	Food (octopus, crabs, oyster, mussel), tourism, urbanization	Pollution (sewage), invasive species, destruction of sand dunes, freshwater runoff, port activities
Uruguay	Food (macroalgae, mussels), tourism,	Invasive species (*Rapana*)
Argentina	Urbanization, food, tourism	Invasive species, pollution (sewage)
PACIFIC		
Colombia	Food (lobsters, fish, snails, shrimp)	Rock removal
Ecuador	Tourism, urbanization, food	Pollution (sewage), sedimentation, gasoline spills
Peru	Food (crabs, snails, macroalgae, chitons, sea urchins) Mining	Pollution (heavy metals from mining)
Chile	Food (macroalgae, snails)	Pollution (sewage), decline in macroalgal density

THE CARIBBEAN

In the Colombian Caribbean, besides populated human settlements, the main economic activity is tourism, so the marine environment is under pressure constantly due to these related activities and waste disposal. Exploitation of some reources also occurs, for example the snail locally known as Burgao or Cigua (*Cittarium pica*), lobsters (*Panulirus* spp.), the Caribbean king crab (*Damithrax spinosissimus*), various fishes (snappers, groupers), octopuses and chitons (Lopez-Victoria et al. 2003). Due to the exploitation, some times exceeding sustainable population limits, several of these species have been allocated in different risk categories of red lists (Ardila et al. 2002, Mejia et al. 2002). In less densely populated areas such as Taganaga, next to the Tayrona Natural National Park, small fishermen villages (ca. 4000 people) have precarious sanitary services polluting the coast with untreated sewage.

In Venezuela, some of the threats to Venezuelan rocky shore's biodiversity are related to freshwater runoff, sedimentation, pollution, tourist pressure, oil spills and urbanization (Miloslavich et al., 2003; Paz-Villaraga et al., 2015). In particular, two of the most important sources of freshwater on the Venezuelan coast are the Tocuyo River, and the Tuy-Carenero Rivers system. The Tocuyo River discharges near Morrocoy National Park (Bastidas et al., 1999), and the sediment plume of Tuy-Carenero system can be large enough to affect the rocky shores of Cabo Codera and Chirimena (Cedeño, 2009). Both rivers are highly polluted, they receive untreated water from a wide array of agricultural and industrial sources, and the discharge from drain sewage from urbanization and rural areas; including untreated waters from Caracas, the capital city of Venezuela. However, no correlations were found between the structure of assemblages associated with rocky shore and their relative distances to these rivers. It is very likely that other factors such as the selective collection, for human consumption, of gastropods, bivalves, and urchins could be affecting these communities. Some populations of invertebrates have shown an alarming decrease of their densities, which might be related to fishermen activities. Some of the gastropods in this situation are *Cittarium pica* and *Astraea tecta,* whose juveniles can be found on the low intertidal (Díaz-Ferguson et al., 2010). *C. pica* is the second gastropod most heavily fished in the Caribbean (Gómez-Gaspar, 1999; Miloslavich and Huck, 2009; Schmidt et al., 2002); however, there are no statistics available for this fishery (Robertson 2003) in the Venezuelan coast. When *C. pica* was present (7 of 31 sites), the diameter sizes ranged between 25mm and 40mm, which represented a clear diminution when compared to values reported in the Archipelago Los Roques National Park on 1987, where maximum size was 115 mm (Castell, 1987; Osorno et al., 2009). Also, this size is classified as small for *C. pica* in the Colombian Caribbean coast, Virgin Island and Puerto Rico (Schmidt et al., 2002; Robertson, 2003; Osorno et al., 2009). Minimum and maximum densities of *C. pica* were 0.4 ind/m^2 and 1.2 ind/m^2, respectively; which is lower than densities reported by Castell in 1987 (5.6 ind/m^2). Finally, despite intertidal rocky shores in Venezuela are not the principal touristic attraction on the coast, some of them (e.g. Peninsula of Paraguaná, Morrocoy and Mochima Nationals Parks, Patanemo, La Sabana and Chirimena) are visited by an important number of tourists, where random collection of shells and invertebrates is a common practice.

In Trinidad & Tobago, the rocky shore areas are very important for shoreline protection and they provide habitats for various species of fish, crustaceans, molluscs and macroalgae. Some rocky areas are very popular for recreational fishing and ecotourism. The main threats to biodiversity and the marine ecosystem in T&T is from land-based activities. These include expanding industrialization and urbanization (eg. land clearing for housing etc), and accompanying pollution and contamination (solid, liquid and gaseous wastes). As with the rest of the region, overfishing and unmanaged coastal development and agricultural practices also exacerbate these problems. More recently, extreme weather conditions reflected in increased rainfall during the wet season and extremely dry seasons (attributed to climate change) continue to result in increased flooding, freshwater runoff and sedimentation. Trinidad and Tobago is a highly industrialized country with 2 very large industrial estates involved in a range of activities dominated by the petrochemical sector. As the largest oil and natural gas producer in the Caribbean, Trinidad and Tobago's also houses one of the largest natural gas processing facilities in the Western Hemisphere. With 11 ammonia plants and seven methanol plants, Trinidad and Tobago is the world's largest exporter of ammonia and the second largest exporter of methanol, according to IHS Global Insight (2013). Trinidad and Tobago's coastal areas contain rich biodiversity reserves including productive and critical habitats- coral reefs, sea grass beds, estuaries, mangrove forests and coastal swamps, beaches and bays. These coastal areas account for approximately 90% of annual fish production. Fishing occurs throughout the marine environment around both islands, in estuaries, nearshore coastal waters and deep oceans. Today, the local fishing industry is largely artisanal, based on resources occurring in the coastal and territorial waters, and is characterized by multi-species, multi-gear and multi-fleet operations (Fisheries Division, 2002). In 2005, the marine fisheries sector contributed $63 million to the Gross Domestic Product (GDP). Other coastal and marine resources include crustaceans (shrimps, lobsters, crabs), cephalopods (squid), cetaceans (marine mammals including whales, dolphins, and porpoises) and sea turtles. Historically, T&T has not been a recognized tourist destination and as recent as 2010 T&T's contribution to the overall Caribbean was only 10.9%. It was estimated that on an annual basis approximately 33% of visitors to Trinidad and Tobago use the coastal resources (Tourism Development Company, 2010). Several beaches in Trinidad and Tobago (Pigeon Point, Maracas, Mayaro etc.) are very popular for recreation and tourism but it is the Buccoo Reef in Tobago which generates the greater tourism income (both local and foreign). The reefs provide livelihoods for a large portion of the local population through both fisheries and tourism (Burke, 2008). In 2006, the value of the reefs to recreation and tourism was estimated to be between US$100 and $130 million, or approximately 45% of Tobago's GDP for that year. At the same time, the value of the reef fisheries was approximately 0.8 to 1 million USD. The coral reef shoreline protection value was calculated at between US$18 and US$33 million in 2006 (WRI 2008). These ecosystem services (coral reef and rocky shores) are important to the island, at the same time they are most vulnerable to erosion and storm damage.

THE ATLANTIC

In the region of Ceará in Brazil, the intertidal reefs are vital for many human populations established along the shore. Most of the small villages depend on the artisanal fisheries and tourism for subsistence, but the aquaculture has also gained importance in the last decades. The reefs play an essential role as nursery habitat for many fish species and also for the spiny lobster, the most important economic resource of the region (Igarashi 2010; Godinho and Lotufo 2010; Cunha et al. 2008). Tourism is a relevant source of income for the state's economy and is present in more or less intensity along the whole coast. In the last three decades, the development of tourism has followed what happened throughout the world, with an increasing number of tourists visiting especially the coastal zone, attracted by the warm water and constantly sunny days of the region (SETUR 2009; Aquasis 2003). The beachrock reefs in Ceará have been strongly impacted by human activities along the shore. The reefs closer to large urban areas, such as Caucaia, receive a large amount of pollutants carried by the rivers that run through farmlands, industrial districts and densely populated cities (Nilin et al. 2007). Locations outside the influence of urban areas are also under stress, because of the exploitation of algae for industrial use, mainly *Gracillaria birdiae* (Plastino and Oliveira 2002). Although not properly evaluated, the impact of algae exploitation is easily noticed when the areas are visited. As an alternative, the cultivation of the algae has been stimulated in different coastal communities, with variable degrees of success. Also, fishermen looking for young lobsters, crabs and especially octopuses, constantly visit these reefs. The strategy used by fishermen for capturing octopus is dislodging the animal with the use of chlorine or large amounts of salt thrown directly on the burrows or tide pools. Aquasis (2003) has presented and discussed extensively the importance of the state's coastal zone, pointing out the conflicts and problems with the management (or absence of management) at both local and regional scales. The main problem is that rocky shores are one of the least studied areas of the Brazilian coast, and the northeast region as a whole is going through an accelerated process of development and increasing pressure over these coastal ecosystems.

At Sergipe, the coastal zone is a contrasting area, in which there are many activities, interests and conflicts, in a scenario that consists of urbanized areas, agricultural (sugar cane, orange and coconut), extractive, industrial and port activities, besides tourism and sale of properties. Moreover, this area is permeated by low density of occupation and occurrence of ecosystems of high environmental significance, but which have been subject of accelerated occupation, a tourism subproduct. This issue generates environmental degradation that hinder the practice of many activities, including tourism. Regarding the disorderly occupation, it noteworthy that 25% of the territory is coastal zone. Sergipe's coastal zone has extensive areas of mangroves associated with estuaries. However, mangroves have been the target of multiple human impacts, mainly shrimp farming and crab catching. In addition, mangroves and dunes are turning into garbage dumps, without any legal or environmental criteria in the area. Petroleum, natural gas, limestone and potassium (largest mine in the Southern Hemisphere) are the main products from mineral extraction, Sergipe is the 6th Brazilian state in oil production, following Rio de Janeiro, Rio Grande do Norte, Amazonas, Bahia and Espirito Santo. Pirambu is a new port area in the State comprising a large off-shore terminal operating primarily with petro and chlorochemical, besides being a vector to expand the economy and the tourism, it is also a potential environmental problem. The most important stressing factors on Sergipe rocky shores are the harbor presence, the trampling effects of tourists and shrimp and crab catching. Other stressing factors are the influence of the petro and chlorochemical industries, sewage pollution, and coastal erosion.

In Bahia, the main use observed at the rocky shores is trampling, especially for fisheries of octopus, sea urchin and fish. However, there is no sign of overfishing in these areas, as there were low numbers of fishermen and most was subsistence fishing by local communities. Even though all sampling sites are considered important touristic areas, there is no evidence of strong pressure in most sampling sites. Itaparica and Litoral Norte are the closest locations to Bahia state capital, Salvador, and thus a popular touristic destination. Tourism in Litoral Norte increased during the past 15 years with the construction of luxurious hotel complexes and the improvement of a state highway. During the holiday season it is common to see people walking on the rock shores. However, considering the number of visitors in that area, it is likely that the rocky shores are affected by trampling and fishing, but this needs further experimental tests. This is especially important in Litoral Norte as it provides feeding and resting habitats for adult and sub-adult green turtles (Jardim et al., 2014). Natural sedimentation is also common in Litoral Norte. Mar Grande (Itaparica location) and Praia do Sul (Ilhéus) are the most threatened sampling sites regarding pollution. Both are located close to urban areas and are subjected to urban runoff, solid waste and domestic sewage discharge. Even though Stella Maris is located in Salvador, it is not a high populated area when compared to the other parts of Salvador and not highly exposed to urban runoff and pollution. Ilhéus is the second largest city, among all sampling sites, with around 220 thousand inhabitants. Itacaré sites are inside an ecological touristic area with a relative low number of visitors. Thus, touristic pressure and water pollution and solid wastes, here, are not a threat.

Espirito Santo, in contrast to the Paraná State where ca. 68% of the territory is preserved by specially protected areas (APA), has only 2% of APA. Furthermore the coastal area of Espirito santo is out of the Conservation Units (UC). The most important stressing factors on Espírito Santo rocky shores, directly or indirectly, are tourism, sewage pollution, industrial complex presence (trading coffee, chocolate, edible oils, citric juices and cellulose), and a harbour complex that handles petrochemical (mainly oil and natural gas, being the second petroleum province in the country). Espirito Santo also encompasses the second largest ore mining dock in the world managed by Vale do Rio Doce Company.

In Sao Paulo, coastal land use and human impacts - The Baixada Santista, at the Southern end of the sampled coastline, is a major economic zone within São Paulo State and heavily urbanized area, which includes the cities of Praia Grande, São Vicente, Santos and Guarujá. Together, these cities sum up 1.6 million habitants, imposing severe impacts on the coastal environment. Particularly problematic is the Santos Harbour, the largest in South-America. Apart from a very intense traffic, the channel needs to be frequently dredged to allow the passage of large cargo vessels, further impacting the seafloor and the water column due to excessive siltation and suspended materials, including heavy metals and other major pollutants. Further north, socio-economical activities are leaded by tourism, although there is increasing pressure for the expansion of the São Sebastião Harbour. At the northernmost locality, Ubatuba, the coastal impact is relatively small, although the population has been gradually increasing. Today, the population in Ubatuba is around 85.000 habitants, and domestic sewage is already a major pollution source.

In Parana, the most important stresses on rocky shores communities are the trampling effects of tourists and fisherman, the selective collecting for food, oyster and crabs catching, and mussel seeds for cultures, sewage pollution and bio-invasions. All the sites studied receive a large amount of tourists every summer (from the end of December to the beginning of February) and weekends. Coastal environmental problems in the South also include unplanned occupation nearby the shoreline. Besides the destruction of the frontal dunes, the occupation invades the beach altering the balance of the whole coastal system. Trampling effects on the community have been studied only in one rocky coast at the southeastern region and a negative effect on *Chthamalus bisinuatus* was observed suggesting that the cumulative effect over years is significant (Ferreira & Rosso, 2009). Furthermore, the small towns at the coast double or triple their population during summer months and domestic sewage pollution and consequent eutrophication of coastal areas is certainly occurring, but the consequences to rocky shore communities are not known. The brown mussel (*Perna perna*) is the main item harvested both to be used directly for food, for commercialization or as seeds for cultures. The Brazilian government started a regulation since 2006 forbidding the extraction of this species from natural stocks from September to December each year and also regulating its extraction during the rest of the year. Although the brown mussel was supposedly introduced in Brazil from Africa (Sousa et al. 2004), it is well established in the intertidal community along the southeast and south Brazilian coasts. More recently the brown mussel belt has been invaded by another mussel, *Isognomon bicolor* (Adams, 1845), which forms dense aggregations in some sites in southeastern Brazil displacing *P. perna*, but that have not been so abundant in the Paraná and Santa Catarina coasts. We only found *I. bicolor* in one beach (Praia de Cima) during 2010 surveys and none in 2013 surveys. Also in the south of Brazil, the Paranaguá Harbor is the largest cereal port in Latin America, exporting mainly soybean, and the 3rd largest port of containers from Brazil, following Itajaí, a strategic zone to monitor alien or invasive species. The port area also presents serious problems of waste disposal. The presence of large ports along the south coast (Paranaguá, São Francisco, Itajaí and Imbituba) in addition to the extensive area of bivalve culture in Santa Catarina poses a constant threat of species invasion in this region. During the surveys we found introduced barnacles at most sites visited, being *Megabalanus coccopoma* (Darwin, 1854) the most frequent, but also *Amphibalanus amphitrite* (Darwin, 1854) and *A. reticulatus* (Utinomi, 1967) (Kloh et al. 2013). In the Paranaguá Bay, *Ulva australis* (formerly known as *U. pertusa*) was detected as a free floating thallus. Monitoring is being carried out to confirm the alien species in the area.

In Uruguay, human uses of rocky shores are mainly recreational, although some species e.g. mussels) may be harvested by tourists or by a subsistence, small scale hand-gathering fishery and/or to be sold in local markets (Carranza et al., 2009; Scarabino, 2004). Extraction of the algae *Ulva* spp. may also occur associated to uses in local gastronomy, especially during the summer. Sport fishing (generally unregulated) are frequently observed in these sites, although some rocky shores are included in the National Protected Area System (SNAP). Commercial fisheries are restricted to subtidal mussel beds located at Isla Gorriti (34º57'S 54º58'W) and Isla de Lobos (35º0'S 54º53'W), targeting the blue mussel *Mytilus edulis* (Defeo, 1991; Niggenmayer and Masello, 1992; Riestra and Defeo, 1994). To date, threats to rocky shores biodiversity have not been evaluated at a national level. However, although not occurring in the intertidal, the invasive rapa whelk *Rapana venosa* is a matter of concern since this species preys mainly over mussels in the estuarine-oceanic interphase (Carranza et al., 2010; Carranza, Delgado, and Martinez, 2013). Other exotic species such as *Isognomon bicolor* (Breves et al., 2014) has been detected, but does not seem to have established so far.

In Argentina, the Buenos Aires province coastline is highly urbanized and harbors important ports. Playa Chica is located ca. 1.2 km of Mar del Plata Harbour (the most important fishing port in Argentina) and Quequén is located ca. 2 km m from Quequén Harbour. Both sites are subject to intense recreational use by summer visitors and pollutants associated to maritime traffic and urban runoff, such as policyclic aromatic hydrocarbons (PAHs), trace metals, and Tributyltin (TBT), all of which have been detected in their nearby ports (Marcovecchio et al. 1998, Bigatti et al. 2009, Albano et al. 2013). The Quequén site may also be impacted by a nearby (ca. 5 km) sewage effluent (López-Gappa et al. 1990). Río Negro is not very populated (El Espigón, Punta Colorada) and human settlements are mostly limited to small summer vacationing villages (La Lobería, Playa Los Suecos). Yet, the shipping of iron pellets from a loading dock in Punta Colorada might have contributed with pollutants to this area in spite that the dock in question was intermittently operational over the past two decades. In Chubut Province, Puerto Lobos is an artisanal fishermen place, with no evident contamination, and no ports are present. In Puerto Madryn, the local population is about 80,000 residents but in the summer season this number may duplicate due to the tourism. In this city, the 2nd port in importance regarding fisheries landings in Argentina is settled, as well as different industries in nearby the port. Pollutants such as (PAHs), organochlorinated compounds, trace metals and TBT are present in areas with intense maritime activity in Golfo Nuevo coasts (Commendatore et al., 2000; Esteves et al., 2006; Gil et al., 2006; Commendatore and Esteves, 2007; Massara Paletto et al., 2008; Bigatti et al., 2009; Commendatore et al., 2012). Imposex (masculinization of female gastropods) has been detected in the port zone but at a low frequency in the sampling sites. These are used mainly for tourism at Punta Este during the summer season. In Camarones, the population is around 1300 habitants and the port is used by fishing boats. Near the port, imposex and TBT contamination were detected (Bigatti et al., 2009), while the sampling sites far from this place are imposex free. The sampling site "Algueros" is a place of algae collection for industrial purposes, and the other places are used by tourist for recreation and sport fishing. At Puerto Deseado, near the port, where the maritime traffic is high, TBT contamination has been detected (Bigatti et al., 2009), however, TBT was not detected in the sampling sites.

Recollection of the limpet *Nacella magellanica* is common within the local people. At Tierra del Fuego Island, Playa Larga is likely the most impacted by human activities due to its proximity to Ushuaia. This city is situated in the coast of the Beagle Channel and hosts the southern port of South America, characterized by intense maritime traffic. Contamination by TBT (Bigatti et al., 2009), PAHs (Esteves et al., 2006), metals (Giarratano et al., 2010) and sewage were detected at this area, and up to 100% incidence of imposex was observed in female gastropods.

THE PACIFIC

In the rocky shores of the Colombian Pacific, the main resources exploited are lobsters (*Panulirus gracilis*) and fishes (snappers, groupers), however, some other species such as oysters (families Ostreidae and Pteriidae), and snails (families Littorinidae and Muricidae) are locally exploited. Another source of perturbation is the removal of rocks in the search for shrimps (*Upogebia* spp.) that are used as bait in fishing activities (Lopez-Victoria et al. 2003). The population density on the Pacific coast is very low in comparison to the Caribbean, with most of the shore basically uninhabited. In this way, human disturbance is localized and/or of low impact.

The rocky shores of Ecuador are used for urbanization, fishing, tourism, recreation, and marinas. Punta Gorda is relatively far away from human settlements and therefore, less impacted, but Punta Bellaca, more accessible was once a fishing ground for the lobster *Panulirus gracilis* and it is used sporadically at present by tourism. The main threats detected in the coast of Ecuador are sedimentation, pollution with sewage waters, diesel spills at the marinas, development of vacational complexes and unplanned human settlements.

In Peru, fisheries are a key component of the countries economy. Such fisheries are mostly pelagic resources, however, several species of the coastal zone are also fishing targets. At Paita, the barnacle *Pollicipes elegans* is commercially exploited and exported (Villena 1995, Oliva 1995, Pinilla 1996). Along the coast, there are several benthic species subject to artisanal fisheries in the intertidal including invertebrates and macroalgae: *Fissurella* spp, Polyplacophora, *Pyropia* spp., *Chondrocanthus chamissoi*, *Patallus mollis*, *Concholepas concholepas*, *Lessonia nigrecens*, *Lessonia* spp., *Macrocystis pyrifera*, *Pyropia* spp., and *Loxoechinus albus* among others (INRENA, 2002). At Paracas, subtidal artisanal fisheries also occurs (Mendo & Wolff 2003). Mining has been very intensive in Peru and some areas show pollution associated to mineral exploitation including heavy metals (Jacinto et al. 2001, Jacinto et al. 2003, Jacinto et al. 2008).

In Chile, the impact of human activities on the rocky intertidal has been studied extensively (see Fernández et al. 2000 and references therein). Several types of human impacts clearly affecting nearshore ecosystems can be identified along the coast of Chile, although the intensity, extent, and persistence of these sources vary geographically (Fernández et al. 2000). One of the most important human impacts along the Chilean coast, in terms geographical extent and persistence, are sewage discharges and the harvesting of invertebrates and algae in rocky shores (Gross & Hayek 1998). The removal of several important ecologically species during low tides have a dramatic effect on the structure of the intertidal communities. Historically, intertidal populations were exploited as a food resource but in modern times, flora and fauna are also collected for fish bait, for research, as souvenirs, and for home aquaria uses. A keystone muricid gastropod *Concholepas concholepas*, locally known as “loco” is intensively targeted by food gatherers affecting the functioning of food webs at intertidal rocky shores (Castilla, 1999). The increasing international demand for brown large macroalgae and local requirement as food for abalone aquaculture has caused deterioration of natural kelp populations along the rocky shore in Chile, especially between 18° and 42°S (Vega et al. 2014). Impact of non-indigenous species have been poorly documented, some species have displayed an expansion of their geographical range and increasing of their abundance, such as the anemone *Anemonia alicemartinae* (Hausermann & Forsterra 2001) and the red alga *Mastocarpus* sp. (Macaya et al. 2013). Together with exploitation of marine species, sewage discharges are important in geographical extension and persistence having an impact along the Chilean coast (Fernández et al. 2000).

Gaps in our knowledge and future prospects

Knowledge of the intertidal rocky shore ecosystem is very variable among the different South American countries, and also between different areas within each of the countries. While some countries seem to have a long tradition of research in these ecosystems (e.g. Chile), other are just beginning to study them (e.g. Venezuela). In the Southern Caribbean, rocky shores remain virtually unexplored, despite the high diversity that these ecosystems support (Miloslavich et al., 2010). For example, in Venezuela, most of the research articles on these ecosystems are non-published descriptions or informal inventories about the fauna and algae that inhabit them. Few studies have considered quantitative description of patterns of temporal and across different scales, which would allow proposing underlying mechanisms that drive assemblages associated with intertidal rocky shores (Cruz-Motta, 2007). Furthermore, the total number of scientific publications for this ecosystem is the lowest for coastal and marine ecosystems of Venezuela (Miloslavich et al., 2003). Consequently, describing patterns and determining processes affecting assemblages associated with Caribbean intertidal rocky shores is still a prevailing necessity. Caribbean rocky shores harbor an important biodiversity, however their economic benefits and ecosystem services are still poorly studied and understood. Threats to biodiversity in this ecosystem, and other coastal ecosystems, are imminent; therein lies the importance not only of knowing their biodiversity, but also of monitoring the ecosystem to be able to understand their patterns and processes, their connectivity to other coastal ecosystems, the population dynamics of key species, and finally to have the necessary knowledge to transfer to policy makers so they can take scientifically based informed decisions.

There are several limitations to achieve these goals. The first of them is the funding required to go to the field on a yearly basis, and the commitment to do so, especially at such large geographical scale like the one presented in this chapter. Initiating a long term time series is not an easy task. The second is related to human capacity. The team required to produce quality information is quite complex, with background in marine ecology, biology, taxonomy, genetics, fisheries, and oceanography to mention a few. This expertise is rarely found altogether within a same country, therefore, the importance of establishing and collaborating within the umbrella of an international network. Initiatives like SARCE, and previously NaGISA of the Census of Marine Life, have contributed significantly in the region to increase our understanding of these important but traditionally neglected ecosystems.

Finally, for all the South American region, the use and abuse of the rocky intertidal resources has been intensive during the last years, needing a full re-evaluation of the human impacts along the South American coastline, in order to demonstrate the need for conservation of these ecosystems. The implementation of marine reserves and laws aimed to halt the collection of organisms has proved to be successful in some areas but ultimately depends on the enforcement of the laws and compliance by the public (e.g. Chile). Even, if collecting is stopped through enforcement, other impacts of human use, ranging from local and specific activities such as trampling or overturning of rocks to large scale impact such as pollution and climate change, still persists. Therefore, effective protection of rocky intertidal communities will require an approach that may need to go beyond the singular focus on collecting to reduce the full suite of impacts (Smith et al. 2008).

ACKNOWLEDGEMENTS

SARCE was sponsored by TOTAL Foundation through the project Marine diversity and biomass assessments on coastal ecosystems in South America: Ecosystem function, monitoring, and human impacts. We thank the editor, Rafael Riosmena-Rodríguez, for inviting this chapter to the book.

REFERENCES

Acosta-Pereira, H., Alván de la Cruz, A.A., Cutipa-Cornejo, M., Mamani Huisa, M.I., & Rodriguez-Manrique, J.P. (2012). Geología de los cuadrángulos de La Yarada, Tacna y Huaylillas 37-u, 37-v y 37-x. Serie A: Carta Geológica Nacional. *Boletín N° 145, Instituto Geológico, Minero y Metalúrgico* - *INGEMMET.*

Albano, M. J., da Cunha Lana, P., Bremec, C., Elías, R., Martins, C. C., Venturini, N. & Obenat, S. (2013). Macrobenthos and multi-molecular markers as indicators of environmental contamination in a South American port (Mar del Plata, Southwest Atlantic). *Marine pollution bulletin*, *73*(1), 102-114.

Albano, M. J., Da Cunha Lana, P., Bremec, C., Elias, R., Martins, C. C., Venturini, N., & Obenat, S. (2013). Macrobenthos and multi-molecular markers as indicators of environmental contamination in a South American port (Mar del Plata, Southwest Atlantic). *Marine Pollution Bulletin*, *73*(1), 102-114.

Almeida, F. F. M. (1976) Thesystem of continental rifts bordering the Santos Basin. *An Acad brasil Ciênc 48:* 15-26

Almeida, F. F. M., & Carneiro, C. D. R. (1998). Origem e evolução da Serra do Mar. *Brazilian Journal of Geology*, *28*(2), 135-150.

Amaro, J. A. (1965). La familia Mytilidae en el Uruguay. *Revista del Instituto de Investigaciones Pesqueras 1*, 323-339.

Apaza, M. & Figari, A. (1999). Mortandad de aves marinas duarante “El Niño 1997-98” en el litoral sur de San Juan de Marcona, Ica-Peru. *Revista Peruana de Biologia*: 110-117.

AQUASIS. (2003). *A Zona Costeira do Ceará: diagnóstico para a gestão integrada.* Coordenadores Alberto Alves Campos...[et al.]. Fortaleza: AQUASIS.

Ardila, N., & Navas, G. R. (2002). *Libro rojo de invertebrados marinos de Colombia.* Bogota, Colombia: INVEMAR. Ministerio de Medio Ambiente. La serie Libros rojos de especies amenazadas de Colombia

Arias, E. (2012). *Estado actual de la diversidad de moluscos bivalvos perforadores de madera en la Puntilla de Santa Elena (Salinas)* (Tesis de Grado) Universidad de Guayaquil, Ecuador.

Arroyo, M. F., & Calderón, T. (2000). *Estudio taxonómico de los invertebrados marinos existentes en la zona intermareal de la Isla Santa Clara (Golfo de Guayaquil exterior)*. Convenio interinstitucional entre Universidad de Guayaquil y Energy Development Company, 66 pp.

Avilés, B. (1984). I*dentificación y distribución de los equinodermos en la provincia del Guayas (Tesis Doctoral)* Universidad de Guayaquil, Ecuador.

Ayala, G. (2010). Distribución de la comunidad de macroinvertebrados en la zona intermareal rocosa de Punta Bellaca y P*unta Colorada, Cantón Sucre. Provincia de Manabí Febrero-Julio del 2008* (Tesis de Grado) Sistema Nacional Pontificia Universidad Católica del Ecuador. Manabí, Ecuador.

Bagur, M., Gutiérrez, J. L., Arribas, L. P., & Palomo, M. G. (2014). Endolithic invertebrate communities and bioerosion rates in southwestern Atlantic intertidal consolidated sediments. *Marine Biology*, 1-14.

Bagur, M., Richardson, C. A., Gutiérrez, J. L., Arribas, L. P., Doldan, M. S., & Palomo, M. G. (2013). Age, growth and mortality in four populations of the boring bivalve< i> Lithophaga patagonica</i> from Argentina. *Journal of Sea Research, 81*, 49-56.

Bak, R. P. M. (1994). Sea urchin bioerosion on coral reefs: place in the carbonate budget and relevant variables. *Coral Reefs*, *13*(2), 99-103.

Balech, E., & Ehrlich, M. D. (2008). Esquema biogeográfico del mar Argentino. R*evista de Investigacion y Desarrollo Pesquero 19*, 45-75.

Balvanera, P., Pfisterer, A. B., Buchmann, N., He, J. S., Nakashizuka, T., Raffaelli, D., & Schmid, B. (2006). Quantifying the evidence for biodiversity effects on ecosystem functioning and services. *Ecology letters*, *9*(10), 1146-1156.

Barnes, D. K.A. (2002). Biodiversity: Invasions by marine life on plastic debris. *Nature*, *416* (6883), 808-809.

Bastidas, C., Bone, D., & Garcia, E. M. (1999). Sedimentation rates and metal content of sediments in a Venezuelan coral reef. *Marine Pollution Bulletin*, *38*(1), 16-24.

Bax, N., Carlton, J.T., Mathews-Amos, A., Haedrich, R. L., Howarth, F.G., Purcell, J.E., Rieser, A. & Gray, A. (2001). The Control of Biological Invasions in the World's Oceans. *Conservation Biology*, *15*(5): 1234-1246.

Beatley, T. (1991). Protecting biodiversity in coastal environments: Introduction and overview. *Coastal Management*, *19*, 1-19.

Benavente, M. (1994). *Macroalgas bentonicas de la caleta Yasila-Piura, Perú.* (Tesis de Grado). Facultad de Ciencias Biológicas. Universidad Nacional Mayor de San Marcos. 118 pp.

Berrú-Paz, P., Tresierra-Aguilar, A., & Garcia-Nolazco, V. (2007). Población de la "concha navaja" Ensis macha (Molina, 1782) en el litoral de la Región Ancash, Perú. Inicios del otoño 2006. *Inf. Inst. Mar Perú 34*(2): 165-190

Bertness, M. D., Crain, C. M., Silliman, B. R., Bazterrica, M. C., Reyna, M. V., Hildago, F., & Farina, J. K. (2006). The community structure of western Atlantic Patagonian rocky shores. *Ecological Monographs*, *76*(3), 439-460.

Bigatti, G., Primost, M.A., Cledón, M., Averbuj, A., Theobald, N., Gerwinski, W., Arntz, W., Morriconi, E., & Penchaszadeh, P.E. (2009). Biomonitoring of TBT contamination and imposex incidence along 4700 km of Argentinean shoreline (SW Atlantic: From

38S to 54S). *Marine Pollution Bulletin 58*:695-701.

Bomtempo, V. L (1991) Características hidráulicas e sedimentológicas de trecho do litoral sul do Estado de São Paulo. MSc dissertation, Federal University of Rio de Janeiro.

Bonilla, D. (1967). *Estudio de la familia MYTILIDAE en aguas ecuatorianas.* (Tesis doctoral). Facultad de Ciencias Naturales, Universidad de Guayaquil, 50 pp.

Boothroyd, J. C., Ayón, H., Robadue, D. D., Vasconez, J., & Noboa, R. (1994). Características de la línea costera del Ecuador y recomendaciones para su manejo. *Reporte Técnico 2076. CRC, PMRC y USAID*, 67 pp.

Borthagaray, A. I., & Carranza, A. (2007). Mussels as ecosystem engineers: their contribution to species richness in a rocky littoral community. *Acta Oecologica*, *31*(3), 243-250.

Bosman, A. L., Hockey, P. A. R., & Siegfried, W. R. (1987). The influence of coastal upwelling on the functional structure of rocky intertidal communities. *Oecologia*, *72*(2), 226-232.

Brazeiro, A., Borthagaray, A. I., & Giménez, L. (2006). Patrones geográficos de diversidad bentónica en el litoral rocoso de Uruguay. In R. Menafra, L. Rodríguez-Gallego, Scarabino, F. & Conde, D. (Eds.) *Bases para la conservación y el manejo de la costa uruguaya* (pp. 171-178). Montevideo, Uruguay: VIDA SILVESTRE (Sociedad Uruguaya para la Conservación de la Naturaleza)

Breves, A., Scarabino, F., & Leoni, V. (2014). First records of the non-native bivalve Isognomon bicolor (CB Adams, 1845) rafting to the Uruguayan coast. *Check List*, *10*(3), 684-686.

Brito, M. J. (2014). *Impacto del oleaje en la estructura comunitaria de macro-invertebrados bentónicos marinos en la zona rocosa de Ballenita y Punta Carnero, Península de Santa Elena.* (Tesis de Grado), Facultad de Ciencias Naturales, Universidad de Guayaquil, 50 pp.

Bujalesky, G. (1997). Morfodinámica y evolución histórica de la espiga Punta Popper y la boca de mareas del río Grande, Tierra del Fuego. *Revista de la Asociación Geológica Argentina*, *52*(2), 187-201.

Bujalesky, G. G. (2007). Coastal geomorphology and evolution of Tierra del Fuego (Southern Argentina). *Geologica Acta*, *5*, 337-362.

Bulleri, F., Benedetti-Cecchi, L., Acunto, S., Cinelli, F., & Hawkins, S.J. (2002). The influence of canopy algae on vertical patterns of distribution of low-shore assemblages on rocky coasts in the northwest Mediterranean. *Journal of Experimental Marine Biology and Ecology*, *267*, 89-106.

Burke, L. M., Greenhalgh, S., Prager, D., & Cooper, E. (2008). Coastal Capital - Economic Valuation of Coral Reefs in Tobago. W*orld Resources Institute Report 2008*.

Burone, F., & Bayseé, C. (1985). Diatomeas de la Bahía de Maldonado (Uruguay). II. Bidulphiacae y Chaetoceraceae. *Contribuciones del Departamento de Oceanografía de la Facultad de Humanidades y Ciencias (Montevideo) 2*(1), 1-31.

Butorovic, N. (2013) Resumen meteorológico año 2012 Estación "Jorge C. Schythe" (53°08’S; 70°53’W; 6 m.s.n.m). *Anales Instituto Patagonia 41*: 153-162.

Cabrera-Carranza, C.F., Guadalupe Gómez, E., Maldonado-Dongo, M. (2005). Evaluación ambiental de la bahía de Paita. *Revista del Instituto de Investigación FIGMMG 8*(15):14-18

Caldas-Vidal, J. (1978). Geología de los cuadrángulos de San Juan, Acarí y Yauca: hojas, (31-m, 31-n, 32-n). *Instituto de Geologia y Mineria, 30*

Cancino, J., & Santelices, B. (1984) Importancia ecológica de los discos adhesivos de *Lessonia nigrescens* Bory (Phaeophyta) en Chile central. *Revista Chilena de Historia Natural 57*: 23-33.

Cardinale, B. J., Srivastava, D. S., Duffy, J. E., Wright, J. P., Downing, A. L., Sankaran, M., & Jouseau, C. (2006). Effects of biodiversity on the functioning of trophic groups and ecosystems. *Nature*, *443*(7114), 989-992.

Cardinale, B.J., Palmer, M.A. & Collins, S.L. (2002). Species diversity enhances ecosystem functioning through interspecific facilitation. *Nature, 415* (6870), 426-429.

Caro, A.U., Guiñez, R., Ortiz, V., & Castilla, J. C (2011) Competition between a native mussel and a non-indigenous invader for primary space on intertidal rocky shores in Chile. *Marine Ecology Progress Series 428:* 177-185.

Carranza, A., & Borthagaray, A. I. (2009). The brown mussel Perna perna in the native mussel beds of Cerro Verde (Uruguay). *Marine Biodiversity Records*, *2*, e76.

Carranza, A., de Mello, C., Ligrone, A., González, S., Píriz, P., & Scarabino, F. (2010). Observations on the invading gastropod Rapana venosa in Punta del Este, Maldonado Bay, Uruguay. *Biological invasions*, *12*(5), 995-998.

Carranza, A., Defeo, O., Beck, M., & Castilla, J. C. (2009). Linking fisheries management and conservation in bioengineering species: the case of South American mussels (Mytilidae). *Reviews in Fish Biology and Fisheries*, *19*(3), 349-366.

Carranza, A., Delgado, E. A., & Martinez, G. (2013). Bases socioecológicas para el desarrollo de una pesquería artesanal de Rapana venosa en Maldonado, Uruguay. In A. Aber, G. Ferrari, J. F. Porcile, E. Rodríguez, and S. Zerbino (Eds.) *Identificación de prioridades para la gestión nacional de las especies exóticas invasoras* (pp. 84-89). Montevideo: UNESCO

Castell, L. (1987). Algunos aspectos de la biología y ecología de Cittarium pica (L.), "Quigua" (Prosobranchia, Trochidae), en el Parque Nacional Archipiélago de los Roques. In *Facultad de Ciencias.* (pp. 135) Caracas: Universidad Central de Venezuela.

Castellanos, P., Varela, R., & Muller-Karger, F. (2002). Descripción de las áreas de surgencia al sur del Mar Caribe examinadas con el sensor infrarrojo AVHRR. *Mem. Fund. La Salle Ci. Nat*, *154*, 55-76.

Castilla, J. C (1999) Coastal marine communities: trends and perspectives from human-exclusion experiments. T*rends in Ecology & Evolution 14:* 280-283.

Cedeño, M.V. Dinámica de las plumas de sedimento de los ríos Tuy y Tocuyo. In *División de Ciencias Biológicas*. Caracas, Venezuela: Universidad Simón Bolívar; 2009; 99.

Ciotti, A. M., Garcia, C. A. E., & Jorge, D. S. F. (2010) Temporal and meridional variability of satellite-estimates of surface chlorophyll concentration over the Brazilian continental shelf. *Pan-Amer J Aquat Sci 5:* 236-253

Coll, J., & Oliveira, E. C. (1999). The benthic marine algae of Uruguay. *Botanica marina*, *42*(2), 129-135.

Commendatore, M. G., & Esteves, J.L. (2007). An assessment of oil pollution in the coastal zone of Patagonia, Argentina. *Environmental Management 40*:814-821.

Commendatore, M.G., Esteves, J.L., Colombo, J.C. (2000). Hydrocarbons in coastal sediments of Patagonia, Argentina: Levels and probable sources. *Marine Pollution Bulletin 40*:989-998.

Commendatore, M.G., Nievas, M.L., Amin, O., & Esteves, J.L. (2012). Sources and distribution of aliphatic and polyaromatic hydrocarbons in coastal sediments from the Ushuaia Bay (Tierra del Fuego, Patagonia, Argentina). *Marine Environmental Research 70*:24-31.

Cruz M. (1992b). Moluscos incrustantes de maderas en el mar ecuatoriano. *Acta Oceanográfica del Pacífico, 7*(1): 69-80.

Cruz-Motta, J. J., Miloslavich, P., Palomo, G., Iken, K., Konar, B., Pohle, G., ... & Shirayama, Y. (2010). Patterns of spatial variation of assemblages associated with intertidal rocky shores: a global perspective. *PloS one*, *5*(12), e14354.

Cruz, M, & Mair, J. (2009). Ecología y distribución de los moluscos bivalvos perforadores de rocas (Familia Mytilidae) en la costa ecuatoriana del 2000 al 2005. *Acta Oceanográfica del Pacífico, 15*(1): 151-164.

Cruz, M, Gabor N, Mora E, Jiménez R, Mair J. (2003). The known and unknown about marine biodiversity in Ecuador (Continental e Insular). Universidad de Concepción, *Revista Gayana, 67*(2): 232-260.

Cruz, M. (1977). Bivalvos de la Plataforma Continental de la Región Norte de Ecuador. *Inocar Cm. Bio, 15, Vol.1* (1): 1- 55.

Cruz, M. (1992a). Estado actual del recurso Malacológico (Bivalvo y Gasterópodo) de la zona infralitoral del Golfo de Guayaquil. *Acta Oceanográfica del Pacífico, 7*(1): 41-68.

Cruz, M. (1996). Pterópodos tecosomados y heterópodos (Gasterópodos) como bioindicadores del evento "El Niño 1992" en la estación fija "La Libertad", Ecuador. Acta Oceanográfica del Pacífico, 8(1): 51-66.

Cruz, M. (1996). Pterópodos tecosomados y heterópodos (Gasterópodos) como bioindicadores del evento "El Niño 1992" en la estación fija "La Libertad", Ecuador. *Acta Oceanográfica del Pacífico, 8*(1): 51-66.

Cruz, M. (2007). Nueva distribución de moluscos meiobentónicos (Gasterópoda: Familia Caecidae) en la costa ecuatoriana. *Acta Oceanográfica del Pacífico, 14*(1): 131-137.

Cruz, M. (2009). Variación de la malacofauna bentónica intermareal y submareal de la bahía de Santa Elena, Ecuador, entre el 2006-2007. *Acta Oceanográfica del Pacífico, 15* (1): 139-150.

Cunha, E. A., Carvalho, R. A., Monteiro-Neto, C., Moraes, L. E. S., & Araújo, M. E. (2008). Comparative analysis of tidepool fish species composition on tropical coastal rocky reefs at State of Ceará, Brazil. *Iheringia. Série Zoologia*, *98*(3), 379-390.

Cury, P. (1999). Marine biodiversity: a fisheries perspective. In: Vidy, G., Albaret, J.J., & Baran, E. (Eds.) *International workshop on status of the freshwater/coastal/marine living resources with particular emphasis on threats and options in coastal areas.* Montpellier, Fance: IRD.

Defeo, O. (1991). *El recurso mejillón Mytilus edulis platensis de Uruguay: situación actual y perspectivas*. Tech Report INAPE, p 71.

Defeo, O., Horta, S., Carranza, A., Lercari, D., De Álava, A., Gómez, J. & Celentano, E. (2009). Hacia un manejo ecosistémico de pesquerías. Áreas marinas protegidas en Uruguay. Facultad de Ciencias-DINARA, Montevideo.

Díaz-Ferguson, E., Haney, R., Wares, J., & Silliman, B. (2010). Population genetics of a Trochid gastropod broadens picture of Caribbean Sea connectivity. *PloS one*, *5*(9), e12675.

Duarte, C. M. (2000). Marine biodiversity and ecosystem services: an elusive link. *Journal of Experimental Marine Biology and Ecology*, *250*, 117-131.

Duffy, J.E., Macdonald, K. S., Rhode, J. M. & Parker, J. D. (2001). Grazer diversity, functional redundancy, and productivity in seagrass beds: an experimental test. *Ecology*, *82*, 2417-2434.

Ellenberg, L., Venezuela. In: Bird,E.F. *Encyclopedia of the World's Coastal Landforms.* Springer Netherlands; 2010; 249-257.

Engelhardt, K. A. M. & Ritchie, M. E. (2001). Effects of macrophyte species richness on wetland ecosystem functioning and services. *Nature*, *411* (6838), 687-689.

Esteves, J. L., Commendatore, M., Nievas, M.L., Paletto, V.M., & Amín, O. (2006). Hydrocarbon pollution in coastal sediments of Tierra del Fuego Islands, Patagonia Argentina. *Marine Pollution Bulletin 52*:582-590.

Estrella-Arellano, C., Guevara-Carrasco, R., & Palacios León, J. (1998). Informe estadístico de los recursos hidrobiológicos de la pesca artesanal por especies, artes, caletas y meses durante el primer semestre de 1998. *Inf. Inst. Mar Perú 139*(1):229 pp.

Fahrbach, E., Brockmann, C., Lostaunau, N. & Urquizo, W. (1981). The Northern Peruvian upwelling system during the ESACAN experiment. Coastal Upwelling, *Coastal and Estuarine Sciences 1* , pp. 134-145 .

Fariña, J. M., Palma, A.T., & Ojeda, F. P (2008) Subtidal kelp associated communities off the temperate Chilean coast. In: McClanahan, T. R., & Branch, G. M (Eds). *Food webs and trophic dynamics of marine benthic ecosystems.* (pp 79-102): Oxford University Press.

Fernadez-Dávila, M. (1993). Geología de los cuadrángulos de Pisco, Guadalupe, Punta Grande, Ica y Cordova. Serie A: Carta Geológica Nacional. *Instituto Geológico, Minero y Metalúrgico – INGEMMET, 47.*

Fernandez, M., Jaramillo, E., Marquet, P. A., Moreno, C. A., Navarrete, S. A., Ojeda, F. P., Valdovinos, C. R., & Vasquez, J. A. (2000) Diversity, dynamics and biogeography of Chilean benthic nearshore ecosystems: an overview and guidelines for conservation. *Revista Chilena de Historia Natural 73*: 797-83.

Ferreira, M. N., & Rosso, S. (2009). Effects of human trampling on a rocky shore fauna on the Sao Paulo coast, southeastern Brazil. *Brazilian Journal of Biology*, *69*(4), 993-999.

Fisheries Division. (2002). *Atlas Marine Fisheries Atlas of Trinidad and Tobago Part 1, Fisheries and Information series 10.* Ministry of Agriculture Land and Marine Resources.

Flores, A. A., Christofoletti, R. A., Peres, A. L. F., Ciotti, A. M., & Navarrete, S. A. (2015). Interactive effects of grazing and environmental stress on macroalgal biomass in subtropical rocky shores: Modulation of bottom-up inputs by wave action. *Journal of Experimental Marine Biology and Ecology*, *463*, 39-48.

France, R., & Rigg, C. (1998). Examination of the "founder effect" in biodiversity research: patterns and imbalances in the published literature. *Diversity and Distributions*, *4*, 77-86.

Galindo, F.O., Segura-Zamudio, M. (1999). Prospección del recurso Chanque Concholepas concholepas en Pisco, San Juan de Marcona y Lomas, 1998 y enero 1999. *IMARPE. Informe Progresivo, 111*:15-26

Garcia, C.B. & Diaz-Pulido, G. (2006). Dynamics of a macroalgal rocky intertidal community in the Colombian Caribbean. *Boletín de Investigaciones Marinas y Costeras. 35*:7-18.

Gessner, M.O., Inchausti, P., Persson, L., Raffaelli, D. G & Giller, P. S. (2004). Biodiversity effects on ecosystem functioning: insights from aquatic systems. *Oikos*, *104*, 419-422.

Gianesella, S. M. F, Saldanha-Corrêa P (2008) Características Químicas. In Pires-Vanin, AMS (Ed.), *Oceanografia de um ecossistema subtropical: Plataforma de São Sebastião* (pp. 183–203). São Paulo: Editora da Universidade de São Paulo

Giarratano, E., Duarte, C. A., & Amin, O. A. (2010). Biomarkers and heavy metal bioaccumulation in mussels transplanted to coastal waters of the Beagle Channel. *Ecotoxicology and Environmental Safety 73*:270-279.

Gil, M. N., Torres, A., Harvey, M., & Esteves, J. L. (2006). Metales pesados en organismos marinos de la zona costera de la Patagonia argentina continental *Revista de Biología Marina y Oceanografía 41*:167-176.

Giménez, L., Borthagaray, A. I., Rodríguez, M., Brazeiro, A., & Carranza, A. (2010). Rocky intertidal macrobenthic communities across a large-scale estuarine gradient. *Scientia Marina*, *74*(1), 87-100.

Godinho, W. O., & Lotufo, T. M. C. (2010). Local v. microhabitat influences on the fish fauna of tidal pools in north-east Brazil. *Journal of fish biology*, *76*(3), 487-501.

Gómez, A. (1999). Los recursos marinos renovables del Estado Nueva Esparta , Venezuela. Biología y pesca de las especies comerciales . In *Invertebrados y algas.* (pp. 208) Margarita, Venezuela: Fundación Museo del Mar

Graco, M. I., Ledesma, J., Flores, G., & Girón, M. (2007). Nutrientes, oxígeno y procesos biogeoquímicos en el sistema de surgencias de la corriente de Humboldt frente a Perú. *Revista peruana de biología*, *14*(1), 117-128.

Grados, C., Vásquez, L., Gutiérrez, D. (2002). Impact of ENSO on Near-Shore Dynamics of two Peruvian Upwelling Centres between 1993 - 2001. *Investigaciones Marinas 30* (1): 141-43

Gray, J. S. (1997). Marine biodiversity: Patterns, threats and conservation needs. *Biodiversity and Conservation, 6,* 153-175.

Gray, J.S., Poore, G.C.B., Ugland, K.I., Wilson, R.S., Olsgard, F., & Johannessen, O.E. (1997). Coastal and deep-sea benthic diversities compared. *Marine Ecology Progress Series, 159,* 97-103.

Gross, P., & Hajek, E. (1998) Indicadores de calidad y gestión ambiental, *Alfabeta Artes Gráficas, Santiago,* 221 pp.

HIDRONAV (Dirección De Hidrografía y Navegación). (2012). T*abla de mareas 2013, puertos de la costa del Perú. Marina de guerra del Perú - Dirección de Hidrografía y navegación*. Callao - Perú. 147pp.

Hormazabal, S., Shaffer, G., & Leth, O. (2004) Coastal transition zone off Chile. *Journal of Geophysical Research-Oceans 109:* C01021.

Huyer, A., Smith, R.L. & Paluszkiewicz, T. (1987). Coastal Upwelling off Peru during Normal and El Niño Times, 1981–1984. *Journal of Geophysical Research 92* (C13): 14297.

Igarashi, M. A. (2010). Nota sobre registro fotográfico e observações preliminares de puerulus a juvenil de Panulirus argus após o assentamento em macroalgas Amansia sp. no Brasil. *Semina: Ciências Agrárias, 31*(3), 767-772.

INEI (Instituto Nacional de Estadística e Informática). (2014). P*erú: Anuario de Estadísticas Ambientales 2013.* Lima: Instituto Nacional de Estadística e Informática, 639pp.

INVEMAR. (2005) Informe del Estado de los Ambientes Marinos y Costeros en Colombia: Año 2004. *Panamericana Formas e Impresos (Serie de publicaciones periódicas/INVEMAR; No.8),* 210.

IPECE. (2013). *Anuário Estatístico Do Ceará*. Fortaleza.

Isla, F. I. & Bujaleski, G.G (2008).Coastal geology and morphology of Patagonia and the Fuegian Archipelago. *Late Cenozoic of Patagonia and Tierra del Fuego*, 227-239.

Jacinto, M.E., Cabello, R & Orozco, R. (2008). Calidad ambiental en el área marino costera de Huarmey, Perú-Marzo 2002. *Inf. Inst. Mar Perú 35* (1): 49-58.

Jacinto, M.E., Dominguez, N., & Orozco, R. (2003). Bahía de Huarmey, Ancash, Perú-Evaluación ambiental en abril 2003. *Inf. Inst. Mar Perú 35*(1): 59-64.

Jacinto, M.E., Salazar, C.M., Velazco, I & Pizarro, L. (2001). Condiciones ambientales y biologico-pesqueras en la bahía de Huarmey, diciembre 2000. *IMARPE. Informe Progresivo, 148,* 24 pp.

Jardim, A., López-Mendilaharsu, M., Barros, F. (2014) Demography and foraging ecology of Chelonia mydas on tropical shallow reefs in Bahia, Brazil. *Journal of the Marine Biological Association*.

Jimenez, J. A, Maia, L. P, Serra, J. & Morais, J. (1999). Aeolian Dune Migration along the Ceará Coast, North-Eastern Brazil. *Sedimentology 46: 689–701.*

Kameya, A., & Zeballos, J. (1998). Distribución y densidad de Percebes Pollicipes elegans (Crustacea: Cirripedia) en el mediolitoral peruano (Yasila, Paita; Chilca, Lima). *Boletín 12*(1), 1988, 20 pp.

Kasten, P., & Flores, A. A. (2013). Disruption of endogenous tidal rhythms of larval release linked to food supply and heat stress in an intertidal barnacle. *MARINE ECOLOGY-PROGRESS SERIES*, *472*, 185.

Kelaher, B. P., Castilla, J. C., & Prado, L. (2007) Is there redundancy in bioengineering for molluscan assemblages on the rocky shores of central Chile? *Revista Chilena de Historia Natural 80:* 173-186.

Kennedy, D.M., Stephenson, W.J., Naylor, L.A. (2014) Rock Coast Geomorphology: A Global Synthesis. *Geological Society Publishing House.*

Klôh, A. D. S., Farrapeira, C. M. R., Rigo, A. P. R., & Rocha, R. M. (2013). Intertidal native and introduced barnacles in Brazil: distribution and abundance. *Marine Biodiversity Records*, *6*, e102.

Kokot, R. R., Codignotto, J. O., & Elissondo, M. (2004). Vulnerabilidad al ascenso del nivel del mar en la costa de la provincia de Río Negro. *Revista de la Asociación Geológica Argentina*, *59*(3), 477-487.

Konar, B., Iken, K., Pohle, G., Miloslavich, P., Cruz-Motta, J.J., Benedetti-Cecchi, L., Kimani, E., Knowlton, A., Trott, T., Iseto, T. & Shirayama. Y. (2010a). Surveying Nearshore Biodiversity. In: McIntyre, A. (Ed). *Life in the World's Oceans: Diversity, Distribution and Abundance.* Oxford: Blackwell Publishing Ltd.

Laboy-Nieves, E. N., Klein, E., Conde, J. E., Losada, F., Cruz, J. J., & Bone, D. (2001). Mass mortality of tropical marine communities in Morrocoy, Venezuela. *Bulletin of Marine Science*, *68*(2), 163-179.

Labraga, J.C. and De Davies E.C. (updated 2013) Datos de la estación meteorológica del Centro Nacional Patagónico (CONICET), Puerto Madryn (42°46'S; 65°02'W) [online]. 2013. Available from: URL: http://www.cenpat.edu.ar/fisicambien/climaPM.htm.

Ley 29767. Congreso de la República. (2011). Ley que declara la intangibilidad del balneario de Ancón. Lima 26 de julio de 2011. El Peruano, Normas Legales: 447239-447240.

López Gappa, J. J., Tablado, A., & Magaldi, N. H. (1990). Influence of sewage pollution on a rocky intertidal community dominated by the mytilid Brachidontes rodriguezi. *Marine Ecology Progress Series*, *63*, 163-175.

López Gappa, J. J., Tablado, A., & Magaldi, N. H. (1990). Influence of sewage pollution on a rocky intertidal community dominated by the mytilid Brachidontes rodriguezi. *Marine Ecology Progress Series*, *63*, 163-175.

López Gappa, J., Alonso, G. M., & Landoni, N. A. (2006). Biodiversity of benthic Amphipoda (Crustacea: Peracarida) in the Southwest Atlantic between 35 S and 56 S. *Zootaxa*, *1342*, 1-66.

López-Victoria, M., Cantera, JR., Díaz, JM., Rozo, D., Posada-Posada, BO. & Osorno, A. (2003) Estado de los litorales rocosos en Colombia, acantilados y playas rocosas. In: I*nforme del estado de los Ambientes Marinos y Costeros en Colombia.* (pp. 329) Santa Marta, Colombia, INVEMAR. Serie de Publicaciones Periódicas Nº 8

Loreau, M., Naeem, S., Inchausti, P., Bengtsson, J., Grime, J.P., Hector, A., Hooper, D. U., Huston, M.A., Raffaelli, D., Schmid, B., Tilman, D., & Wardle, D.A. (2001).

Biodiversity and ecosystem functioning: Current knowledge and future challenges. *Science*, *294* (5543), 804-808.

Macaya, E. C., Pacheco, S., Caceres, A., Musleh, S. (2013) Range extension of the non-indigenous alga *Mastocarpus* sp along the Southeastern Pacific coast. *Revista de Biología Marina y Oceanografia 48*: 661-665

Maguiña-Agüero, A., Valle-Basto, D., Untama-Martínez, J. (2002). Reserva Nacional de Paracas - Plan Maestro 2003-2007 Lima – Perú. *WWF, Pro Naturaleza*, 192.

Mair, J., Mora, E., Cruz, M., Arroyo, M., González, K., & Merino, D. (2002). Manual de Campo de los Invertebrados Bentónicos Marinos: Moluscos, Crustáceos y Equinodermos de la zona litoral ecuatoriana. Proyecto Iniciativa Darwin, *Universidad de Guayaquil y Heriot-Watt University.* 108.

Marcovecchio, J. E., Ferrer, L. D., Barral, A. O., Scagliola, M. O., & Pucci, A. E. (1998). A model for geochemical partitioning of heavy metals in the Mar del Plata coastal ecosystem, Argentina. In *Environmental Geochemistry in the Tropics* (pp. 139-148). Springer Berlin Heidelberg.

Marcovecchio, J. E., Ferrer, L. D., Barral, A. O., Scagliola, M. O., & Pucci, A. E. (1998). A model for geochemical partitioning of heavy metals in the Mar del Plata coastal ecosystem, Argentina. In: *Environmental Geochemistry in the Tropics* (pp. 139-148). Springer Berlin Heidelberg.

Martin, L., & Suguio, K. (1975) The State of São Paulo coastal marine quaternary geology. *An Acad brasil Ciênc 47 (suppl.)*: 249-263

Massara-Paletto, V., Commendatore, M.G., Esteves, J.L. (2008). Hydrocarbon levels in sediments and bivalve mollusks from Bahía Nueva (Patagonia, Argentina): An assessment of probable origin and bioaccumulation factors. *Marine Pollution Bulletin 56*:2082-2105.

Massay, Sh., Correa, J., Mora, E. (1993). Catálogo de Peces, Crustáceos y Moluscos de mayor importancia comercial en Ecuador. *Inst. Nac. Pesca*: 1-122.

Matthews-Cascon, H., & da Cruz Lotufo, T. M. (2006). *Biota marinha da costa oeste do Ceará.* Ministério do Meio Ambiente.

Maytía, S., & Scarabino, V. (1979). Las comunidades del litoral rocoso del Uruguay: zonación, distribución local y consideraciones biogeográficas. *Memorias del Seminario de Ecología Bentónica y Sedimentación en la Plataforma Continental del Atlántico Sur. UNESCO. Montevideo, Uruguay*, 149-160.

Mejía, L.S. y A. Acero. (2002). L*ibro rojo de peces marinos de Colombia*. Bogotá, Colombia: INVEMAR, Instituto deCiencias Naturales-Universidad Nacional de Colombia, Ministerio de Medio Ambiente. La serie Libros rojos de especies amenazadas de Colombia.

Mendo, J. & Wolff, M. (2003). El impacto de El Niño sobre la producción de concha de abanico *(Argopecten purpuratus)* en bahía Independencia, Pisco, Perú. *Ecología Aplicada 2*(1): 51-57.

Mikkelsen, P.M. & Cracraft, J. (2001). Marine biodiversity and the need for systematic inventories. *Bulletin of Marine Science, 69*, 525-534.

Miloslavich, P. & Huck, E. (2009) Comunidades de moluscos asociadas a praderas de fanerógamas marinas y litorales rocosos con macroalgas en Venezuela:

implementación del Protocolo NaGISA. *Memoria de la Fundación La Salle de Ciencias Naturales, 69*(171): 81-98.

Miloslavich, P., Díaz, J. M., Klein, E., Alvarado, J. J., Díaz, C., Gobin, J… & Ortiz, M. (2010). Marine biodiversity in the Caribbean: regional estimates and distribution patterns. *PloS one, 5*(8), e11916.

Miloslavich, P., et al., (2005). Venezuela. In Miloslavich, P., & Klein, E. (Eds.), Caribbean marine biodiversity: The known and the unknown. (pp. 109-136). Lancaster, Pennsylvania. USA: DEStech Publications.

Miloslavich, P., Klein, E., Díaz, J. M., Hernandez, C. E., Bigatti, G., Campos, L…. & Martín, A. (2011). Marine biodiversity in the Atlantic and Pacific coasts of South America: knowledge and gaps. *PloS one*, *6*(1), e14631.

Miloslavich, P., Klein, E., Yerena, E., & Martin, A. (2003). Marine biodiversity in Venezuela: status and perspectives Biodiversidad marina en Venezuela: Estado actual y perspectivas. *Gayana*, *67*(2), 275-301.

Milstein, A., & Juanico, M. (1985). Zooplankton dynamics in Maldonado Bay (Uruguay). *Hydrobiologia, 126*(2), 155-164.

Mora, E, Jurado V, Mendívez W. (2010). Diversidad de Macroinvertebrados en la Plataforma Continental de Ecuador. *Revista de Ciencias del Mar y Limnología, V.4* (2): 1-14.

Mora, E. (1989). Moluscos de importancia comercial en el Ecuador: Estado Actual y su perspectiva. Comisión Permanente del Pacífico Sur (CPPS). *Rev. Pacifico Sur (Número Especial).*

Mora, E. (1990). Catálogo de Bivalvos Marinos del Ecuador. Instituto Nacional de Pesca. Guayaquil, Ecuador. *Boletín Científico y Técnico, 10* (1): 1-136.

Mora, E., & Reinoso, B. (1981). Investigaciones preliminares sobre el estado actual de las poblaciones de ostiones en tres zonas del Estuario Interior del Golfo de Guayaquil. *Revista de Ciencias del Mar y Limnología, V.1* (1).

Morón, O., Lostanau, N., & Escudero, L. 1(988). Parámetros oceanográficos en Bahía Independencia, Perú, entre mayo de 1985 y julio de 1987. *Bol.Inst. Mar Perú - Callao Vol. Extraodinario*.: 25-34.

Muller-Karger, F., Varela, R., Thunell, R., Astor, Y., Zhang, H., Luerssen, R., & Hu, C. (2004). Processes of coastal upwelling and carbon flux in the Cariaco Basin. *Deep Sea Research Part II: Topical Studies in Oceanography*, *51*(10), 927-943.

Narváez, D. A., Navarrete, S. A., Largier, J., & Vargas, C. A. (2006) Onshore advection of warm water, larval invertebrate settlement, and relaxation of upwelling off central Chile. *Marine Ecology Progress Series 309*: 159-173.

Neirotti, E. (1981). Estudio comparativo del supralitoral y mesolitoral rocoso en diferentes localidades del estuario del Río de la Plata. *Comunicaciones de la Sociedad Malacológica del Uruguay*, *5*(40), 347-370.

Niggemeyer, F., & Masello, A. (1992). La pesquería del mejillón (Mytilus edulis platensis): análisis de los desembarques en el puerto de Punta del Este (Maldonado, Uruguay). *Publicaciones de la Comisión Técnica Mixta del Frente Marítimo (Uruguay) A*, *12*, 83-88.

Nilin, J., Castro, C. B., Pimentel, M. F., Franklin-Junior, W., Matos, R. F. G., Lotufo, T. M. C. & Costa-Lotufo, L. V. (2007). Water Toxicity Assessment of the Ceará River Estuary (Brazil). *Journal of the Brazilian Society of Ecotoxicology 2* (2): 107–113.

NOAA. (2014). National Oceanographic Data Center. www.nodc.noaa.gov.

Norse, E. A. (1993). *Global marine biological diversity: a strategy for building conservation into decision making.* Washington, DC: Contribution to the Global Biodiversity Strategy, Island Press, 383p.

O'Connor, N. E., & Crowe, T. P.(2005). Biodiversity loss and ecosystem functioning: Distinguishing between number and identity of species. *Ecology 86*: 1783–1796.

Ochoa, E., Macías, W., & Marcos, J. (1987). Ecuador Perfil de sus Recursos Costeros. Visión Global. Fundación Pedro Vicente Maldonado. *Programa de Manejo de Recursos Costeros (PMRC)*, 267 pp.

Oliva, J. (1995). *Ecología y dinámica poblacional del "percebe" Pollicipes elegans Bahía Yacila - Paita (Perú) Mayo 1994 -Febrero 1995.* Tesis de maestría. Universidad Nacional de Trujillo.

Olsen, J.L. (1999). Earth is a marine habitat and marine biodiversity matters. *Third European marine science and technology conference (MAST conference), Conference proceedings,* 319-328.

Orensanz, J. M. L., Schwindt, E., Pastorino, G., Bortolus, A., Casas, G., Darrigran, G., ... & Vallarino, E. A. (2002). No longer the pristine confines of the world ocean: a survey of exotic marine species in the southwestern Atlantic. *Biological Invasions*, *4*(1-2), 115-143.

Ortega, L., & Martínez, A. (2007). Multiannual and seasonal variability of water masses and fronts over the Uruguayan shelf. *Journal of Coastal Research 23*(3), 681-629.

Osorno-Arango, A., Gil-Agudelo, D.L. & Gomez-Lemos, L.A. (2009) Plan de Investigación para la Conservación de Cittarium pica (Linnaeus, 1758). I*nstituto De Investigaciones Marinas Y Costeras Invemar, 72.*

Pachepsky, E., Crawford, J. W., Bown, J. L., & Squire, G. (2001). Towards a general theory of biodiversity. *Nature*, *410* (6831), 923-926.

Palacios-Moncayo, O. (1994). Geología de los cuadrángulos de Paita, Piura, Talara, Sullana, Lobitos, Quebrada Seca, Zorritos, Tumbes y Zarumilla 11-a, 11-b, 10-a, 10-b, 9-a, 9-b, 8-b, 8-c, 7-c . *Instituto Geológico, Minero y Metalúrgico - INGEMMET. A-54*

Palacios, O., Caldas, J., & Vela, C. (1992). Geología de los Cuadrángulos de Lima, Lurín Chancay y Chosica. Serie A: Carta Geológica Nacional. *Instituto Geológico, Minero y Metalúrgico – INGEMMET, Boletín 43.*

Palacios, O., Sanchez, A., Herrera, F. (1995) GEOLOGIA DEL PERU, *Instituto Geológico minero y metalurgico, Serie A: Carta Geológica Nacional, primera edición. Boletin 55*. 143 pp

Pankhurst, R. J., Rapela, C. W., Saavedra, J., Baldo, E., Dahlquist, J., Pascua, I., & Fanning, C. M. (1998). The Famatinian magmatic arc in the central Sierras Pampeanas: an Early to Mid-Ordovician continental arc on the Gondwana margin.*Geological Society, London, Special Publications*, *142*, 343-367.

Paredes C., Cardoso, F., & Tarazona, J. (2004). Distribución temporal de moluscos y crustáceos tropicales en la Provincia Peruana y su relación con los eventos El Niño. *Revista Peruana de Biología 11* (2): 213-18.

Paredes, C. (1974). El modelo de zonación en la orilla rocosa del Departamento de Lima. *Revista Peruana de Biología 1*(2): 169-191.

Paredes, C., & Tarazona, J. (1980). Las comunidades de mitílidos del mediolitoral rocoso del Departamento de Lima. *Rev. Per. Biol. 2*(1): 59-71.

Paredes, C., Tarazona, J., Canahuire, E., Romero, L., Cornejo, O., & Cardoso, F. (1998). Presencia de moluscos tropicales de la provincia panameña en la costa central del Perú y su relación con los eventos "El Niño". *Rev. Perú. Biol. 5*(2): 123-128.

Paruelo, J. M., Beltran, A., Jobbagy, E., Sala, O. E., & Golluscio, R. A. (1998). The climate of Patagonia: general patterns and controls on biotic.Ecologia *Austral 8*, 85-101.

Paz-Villarraga, C. A., Castro, Í. B., Miloslavich, P., & Fillmann, G. (2015). Venezuelan Caribbean Sea under the threat of TBT. *Chemosphere*, *119*, 704-710.

Pellizzari, F. M., Bernardi, J., Silva, E. M., Silva, M. C., & Yokoya, N. S. (2014). Benthic marine algae from the insular areas of Paraná, Brazil: new database to support the conservation of marine ecosystems. *Biota Neotropica*, *14*(2), 1-12.

Pfisterer, A. B., & Schmidt, B. (2002). Diversity-dependent production can decrease the stability of ecosystem functioning. *Nature*, *416* (6876), 84-86.

Phillips, J.A. (1997). Marine conservation initiatives in Australia: Their relevance to the conservation of macroalgae. *Botanica Marina*, *41*, 95-103.

Piazzi, L., Ceccherelli, G., & Cinelli, F. (2001). Threat to macroalgal diversity: Effects of the introduced green alga *Caulerpa racemosa* in the Mediterranean. *Marine Ecology Progress Series*, *210*, 149-159.

Pinilla-García, F.R. (1996). *Variación temporal de la densidad y biomasa de la población del percebe Pollícipes elegans de la zona de Lobitos, Piura*. (Tesis de Grado). Perú, Facultad de Ciencias, Universidad Nacional Agraria La Molina.

Plastino, E M., & Oliveira, E. C. (2002). Gracilaria Birdiae (Gracilariales, Rhodophyta), a New Species from the Tropical South American Atlantic with a Terete Frond and Deep Spermatangial Conceptacles. *Phycologia 41* (4): 389–396.

Posada, BO. & Henao, W. (2008). *Diagnóstico de la erosión en la zona costera del Caribe colombiano*. Santa Marta, Colombia: INVEMAR, Serie Publicaciones Especiales No. 13*;* 200

Quispe, D., Graco, M., Correa, D., Tam, J., Gutiérrez, D., Morón, O., Flores, G. & Yamashiro, C. (2010). Variabilidad espacio-temporal de condiciones hidrofísicas en Bahía Independencia, Pisco – Perú. *Ecología Aplicada (Lima) 9* (1):9-18.

Rabb, G. B. & Sullivan, T. A. (1995). Coordinating conservation: Global networking for species survival. *Biodiversity and Conservation*, *4*, 536-543.

Ramírez, R., Paredes, C., & Arenas, J. (2003). Moluscos del Perú. *Rev. Biol. Trop. 51* (Suppl. 3): 225-284

Ray, G.C. (1985). Man and the sea – the ecological challenge. *American Zoologist*, *25*, 451-468.

Ray, G.C. (1996). Coastal-marine discontinuities and synergisms: Implications for biodiversity conservation. *Biodiversity and Conservation*, *5*, 1095-1108.

Riestra, G., & Defeo, O. (1994). Aspectos de la dinámica poblacional y estructura de la comunidad del mejillón *Mytilus edulis* platensis en la costa atlántica uruguaya. *Publicaciones de la Comisión Técnica Mixta del Frente Marítimo (Uruguay)*, *7*(66-67).

Riestra, G., & Defeo, O. (2000). La comunidad macrobentónica asociada al mejillon *Mytilus edulis* platensis en costas del departamento de Maldonado: variación espacio-temporal e incidencia del impacto pesquero. In Rey, M. (ed.) *Recursos pesqueros no tradicionales: moluscos bentónicos marinos* (pp. 17-57.) Montevideo: Proyecto URU/92/003. INAPE-PNUD

Robertson, R. (2003). The edible West Indian “whelk” Cittarium pica (Gastropoda: Trochidae): Natural history with new observations. *Proceedings of the Academy of Natural Sciences of Philadelphia*, *153*(1), 27-47.

Rojas de Mendiola, B. (1981). Seasonal phytoplankton distribution along the Peruvian coast. In: Richards, F. (Ed.). *Coastal Upwelling*. (pp: 348-356) Washington D.C.: AGU.

Romero, L. (2000). *Indicadores para el monitoreo de biodiversidad en comunidades de ambiente intermareal en la Reserva Nacional de Paracas. Proyecto WWF: QK23, Proyecto CSI: 91001042.* Facultad de Ciencias Biológicas Universidad Nacional Mayor de San Marcos. Lima.

Rueda-Roa, D. T., & Muller-Karger, F. E. (2013). The southern Caribbean upwelling system: Sea surface temperature, wind forcing and chlorophyll concentration patterns. *Deep Sea Research Part I: Oceanographic Research Papers*, *78*, 102-114.

Sant'Anna-Neto, J. L (1990) Ritmo climático e gênese das chuvas na zona costeira paulista. MSc dissertation, University of São Paulo.

Santelices, B. (2001) Littoral and sublittoral communities of continental Chile. In: Mathieson, AC, Nienhuis, PH. (Eds) *Ecosystems of the World.* (pp 347-369) Amsterdam: Elsevier Science Publishers.

Scarabino, F. (2004). Conservación de la malacofauna uruguaya. *Comunicaciones de la Sociedad Malacológica del Uruguay*, *8*(82-83), 267-273.

Scarabino, F., Zaffaroni, J. C., Clavijo, C., Carranza , A., & Nin, M. (2006). Bivalvos marinos y estuarinos de la costa uruguaya: faunística, distribución, taxonomía y conservación. In Menafra, R., Rodríguez-Gallego, L., Scarabino, F. & Conde, D. (Eds). *Bases para la conservación y el manejo de la costa uruguaya* (pp. 157-169). Montecideo: VIDA SILVESTRE (Sociedad Uruguaya para la Conservación de la Naturaleza)

Schmidt, S., Wolff, M., & Vargas, J. A. (2002). Population ecology and fishery of Cittarium pica (Gastropoda: Trochidae) on the Caribbean coast of Costa Rica. *Revista de biología tropical*, *50*(3-4), 1079-1090.

Schulz, N., Boisier, J. P., & Aceituno, P. (2012) Climate change along the arid coast of northern Chile. *International Journal of Climatology 32:* 1803-1814.

Sepúlveda, R. D., Cancino, J. M., & Thiel, M. (2003b) The peracarid epifauna associated with the ascidian *Pyura chilensis* (Molina, 1782) (Ascidiacea: Pyuridae). *Journal of Natural History 37:* 1555-1569.

Sepúlveda, R. D., Moreno, R. A., & Carrasco, F. D. (2003a) Diversidad de macroinvertebrados asociados a arrecifes de *Phragmatopoma moerchi* Kinberg, 1867 (Polychaeta: Sabellariidae) en el intermareal rocoso de Cocholgüe, Chile. *Gayana 67:* 45-54.

Servicio de Hidrografía Naval, Secretaría Marina, (1962). *Masas de agua características del Océano Atlántico (parte Sudoeste).* Thomsen, H. Publ H632.

SETUR. (2009). *Estudos Turísticos Da SETUR: Evolução Do Turismo No Ceará.* Fortaleza.

Sibaja-Cordero, J. A., & Vargas-Zamora, J. A. (2006). Zonación vertical de epifauna y algas en litorales rocosos del Golfo de Nicoya, Costa Rica. *Rev. Biol. Trop. Vol. 54* (suppl. 1): 49-67.

Smith, A. J, & Morais, J. O. (1984). Estudos Preliminares Sobre a Geologia Ambiental Costeira Do Estado Do Ceará, Nordeste Do Brasil. *Arquivo de Ciências Do Mar 23*: 85–96.

Smith, J. R., Fong, P., & Ambrose, R. F. (2008). The impacts of human visitation on mussel bed communities along the California coast: are regulatory marine reserves effective in protecting these communities? *Environmental Management 41*:599-61

Soledispa, P. (2008). Características geomorfológicas y sedimentológicas de la Bahía de Santa Elena. *Instituto Oceanográfico de la Armada, INOCAR,* 18 pp.

Somerfield, P.J., Yodnarasi, S., & Aryuthaka, C. (2002). Relationships between seagrass biodiversity and infaunal communities: implications for studies of biodiversity effects. *Marine Ecology Progress Series, 237,* 97-109.

Sonnenholzner, J., Brandt, M., Francisco, V., Hearn, A., Luzuriaga, M., Guarderas, P., & Navarro, J. C. (2013). Echinoderms of Ecuador. In: Alvarado, J.J. & Solís-Marín, F.A. (eds.) *Echinoderm Research and Diversity in Latin America.* Chapter 6. (pp 183-233).

Souza, R.C.C.L., Fernandes, F.C., & Silva, E.P. (2004) Distribuição atual do mexilhão Perna perna no mundo: um caso recente de bioinvasão. In Silva J.S.V. and Souza R.C.C.L. (eds) *Água de lastro e bioinvasão.* (pp. 157–172) Rio de Janeiro: Interciência

Tam, J., Ganoza, F. & Orozco, R. (2007). Prospección biológico-pesquera y calidad del ambiente marino en Huarmey, Ancach. Otoño 2000. I*nf. Inst. Mar Perú 34*(3): 255-268.

Tarazona, J. (1984). Modificaciones de la infauna bentónica de una bahía con deficiencia de oxígeno durante "El Niño" 1982-83. *Rev. Com. Perm. Pacífico Sur 15:* 223-238.

Tarazona, J., Arntz, W., & Canahuire, E. (1996). Impact of two "El Niño" events of different intensity on the hypoxic soft bottom macrobenthos off the central Peruvian coast. *Marine Ecology 17*(1-3): 425-446.

Tarazona, J., Salzwedel, H., & Arntz, W. (1988). Positive effects of "El Niño" on macrozoobenthos inhabiting hypoxic areas of Peruvian upwelling system. *Oecologia 76:*184-190.

Tessler, M. G., Cazzioli y Goya, S., Yoshikawa, P. S., & Hurtado, S. N. (2006) São Paulo. In: Muehe M, (Ed) (pp. 476). MMA, Brasília: Erosão e progradação do litoral brasileiro

Thiel, M., Macaya, E. C., Acuña, E., Arntz, W. E., Bastias, H., Brokordt, K., Camus, P. A., Castilla, J. C., Castro, L. A., Cortés, M., Dumont, C. P., Escribano, R. E., Fernandez, M., Gajardo, J. A., Gaymer, C., Gomez, I., González, A. E., González, H. E., Haye, P.

A., Illanes, J. E., Iriarte, J. L., Lancellotti, D. A., Luna-Jorquera, G., Luxoro, C., Manriquez, P. H., Marín, V., Muñoz, P., Navarrete, S. A., Perez, E., Poulin, E., Sellanes, J., Sepúlveda, H. H., Stotz, W,. Tala, F., Thomas, A., Vargas, C. A., Vasquez, J. A., Vega, A. (2007) The Humboldt current system of northern-central Chile: Oceanographic processes, ecological interactions and socioeconomic feedback. *Oceanography and Marine Biology Annual Review*: 195-344.

Tilman, D., & Lehman, C. (2001). Human-caused environmental change: Impacts on plant diversity and evolution. *Proceedings of the National Academy of Sciences USA*, *98*, 5433-5440.

Torres, R.R., & Tsimplis, M.N., (2012). Seasonal sea level cycle in the Caribbean Sea. *Journal of Geophysical Research-Oceans*, *117*, 1-18.

Valentim, S. S., Bernardes, M. E. C., Dottori, M., & Cortezi, M. (2013). Low-frequency physical variations in the coastal zone of Ubatuba, northern coast of São Paulo State, Brazil. *Brazilian Journal of Oceanography*, *61*(3), 187-193.

Valero M., Gliddon, C., Aberg, P., Kloareg, B., Sosa, P. A., Olsen, J. L., Billot, C., Bouza, N., Cabrera, H., Destombe, C., Engel, C., Gaggiotti, O., Lindgren, A., & Morchen, M. (1998). Biodiversity and genetics of algal populations (BIOGAP). *Third European Marine Science and Technology Conference (MAST Conference), Project Synopses Vol. 1: Marine Systems*, 153-167.

Van-Oppen, M. J. H., Klerk, H., Olsen, J. L., & Stam, W. T. (1996). Hidden diversity in marine algae: Some examples of genetic variation below the species level. *Journal of the Marine Biological Association of the UK*, *76*, 239-242.

Vásquez, J. A., Santelices, B. (1984) Comunidades de macroinvertebrados en discos adhesivos de *Lessonia nigrescens* Bory (Phaeophyta) en Chile central. *Revista Chilena de Historia Natural 57:* 131-154.

Vega, J. M. A., Broitman, B. R., & Vasquez, J. A. (2014) Monitoring the sustainability of *Lessonia nigrescens* (Laminariales, Phaeophyceae) in northern Chile under strong harvest pressure. *Journal of Applied Phycology 26:* 791-801.

Vides, M.P. & Sierra-Correa, P.C. (2003). Atlas de Paisajes Costeros de Colombia. Instituto de Investigaciones Marinas y Costeras -INVEMAR- y Corporación Autónoma Regional y de Desarrollo Sostenible del Archipiélago de San Andrés, Providencia y Santa Catalina -CORALINA-. *Serie Documentos Generales de INVEMAR*, *16*, 132

Villamar, F. (1983). Poliquetos bentónicos del Golfo de Guayaquil. *Acta Oceanográfica del Pacífico*, *2*(2): 659 – 733.

Villamar, F. (1986). Distribución de los poliquetos bentónicos en el Golfo de Guayaquil: Acta Oceanográfica del Pacífico, *Inst. Ocean. de la Armada del Ecuador, 3* (1): 121-131.

Villamar, F. (1989). Estudio de los poliquetos bentónicos en el Golfo de Guayaquil, Exterior (Canal del Morro y Jambelí). *Acta Oceanográfica del Pacífico, 5* (1): 34-40.

Villena, G. (1995). *Aspectos reproductivos del percebes Pollicipes elegans de la zona de Yacila, Paita, Perú.* (Tesis de Grado). Facultad de Pesquería, Universidad Nacional Agraria La Molina.

Walker, D. I., & Kendrick, G. A. (1998). Threats to macroalgal diversity: Marine habitat destruction and fragmentation, pollution and introduced species. *Botanica Marina*, *41*, 105-112.

Ward, T. J., Vanderklift, M. A., Nicholls, A. O., & Kenchington, R. A. (1999). Selecting marine reserves using habitats and species assemblages as surrogates for biological diversity. *Ecological Applications*, *9*, 691-698.

Wieters, E. A. (2005). Upwelling control of positive interactions over mesoscales: a new link between bottom-up and top-down processes on rocky shores. *Marine Ecology Progress Series*, *301*, 43-54.

Wieters, E. A., McQuaid, C., Palomo, G., Pappalardo, P., & Navarrete, S. A. (2012).Biogeographical boundaries, functional group structure and diversity of Rocky Shore communities along the Argentinean coast. *PLOS ONE*, *7*, e49725.

World Resources Institute (WRI) in collaboration with United Nations- World Resources (2008). Roots of Resilience—Growing the Wealth of the Poor.

Wysor, B., Kooistra, W. H., & Frederico, S. (2000). Marine macroalgal diversity in the republic of Panama. *Journal of Phycology*, *36*, 72.

Zuta, S. & Guillén, O. (1970). Oceanografía de las Aguas Costera del Perú. Bol. *Inst. Mar Perú Callao*, *2*: 157-324.

KD