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Coastal Marine Ecosystems of Latin America

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15 The Sand Beach Ecosystem of Chile

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15.1 Introduction

The Chilean coast extends for about 4,200 km. South of Chiloé Island the coast (42–56°S) is characterized by archipelagos, fjords, channels, and islands, owing to the sinking of the Chilean longitudinal Central Valley. Exposed sandy beaches of different morphodynamic types alternate with intertidal sand flats at the mouth of rivers in south-central Chile between 38°S and 42°S and with rocky peninsulas in the extreme north (19–30°S; Fig. 15.1). Seasonal cycles of beach sand erosion and accretion are typical. During erosion, beaches have concave profiles with coarser grained sand than during accretion periods, when profiles are convex.

15.2 Environmental Setting

The influence of different ocean currents causes a gradual northward increase of seawater temperatures (Viviani 1979; Brattström and Johanssen 1983). Spring-tide winter and summer water temperatures in the surf zone at Mar Brava (42°S) and Aguila (21°S) range from 12 to 14.5 °C and from 17 to 18.8 °C, respectively (Fig. 15.1). The northern coast (19–30°S) is characteristic of a dry desert climate with low and irregular precipitation (Di Castri and Hajek 1976) and mean monthly air temperatures between 18 and 22 °C in the summer and 12 to 17 °C in the winter. Further south, along a warm-temperate zone (30–38°S), annual precipitation and mean monthly temperature are 110 mm and 15–22 °C at 30°S and 760 mm and 10–13 °C at 38°S (Brattström and Johanssen 1983), respectively. In the rainy Patagonia-Tierra del Fuego zone (38–56°S) mean annual temperatures decrease from 12.5 °C (38°S) to 5.4 °C at Cape Horn (56°S).

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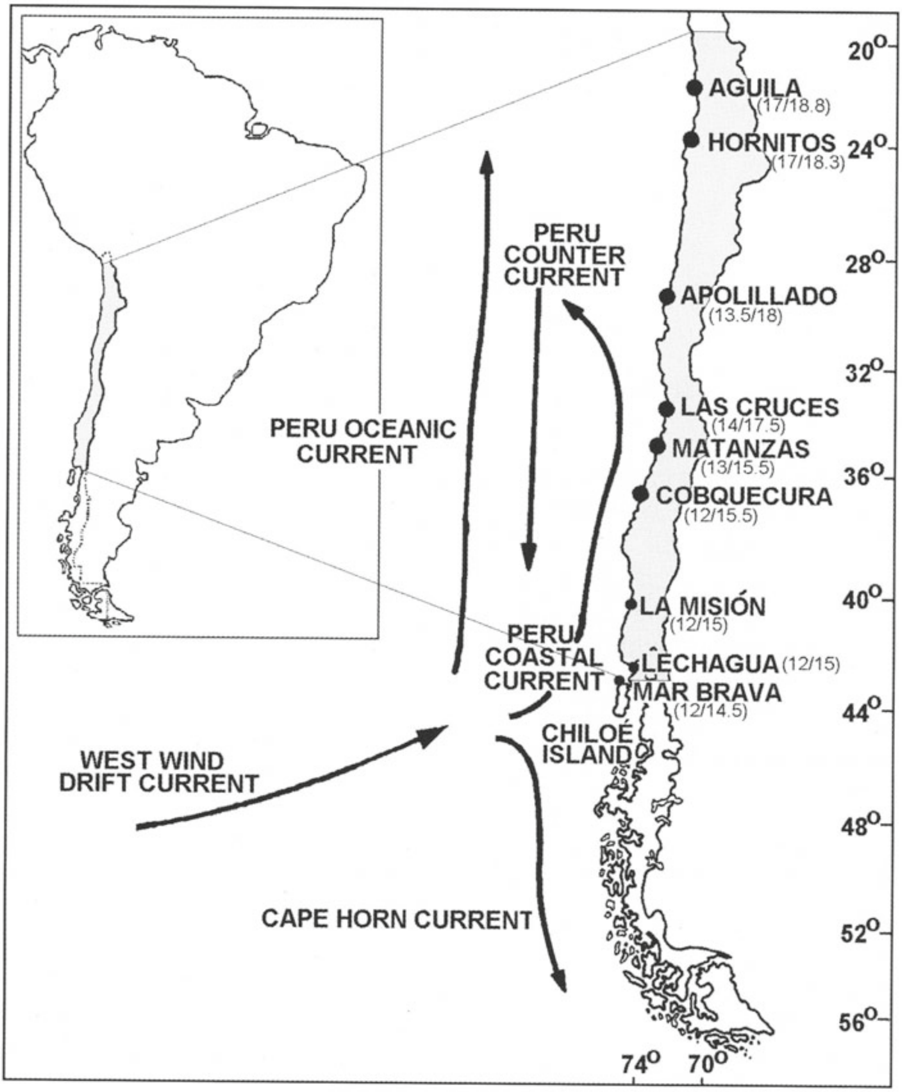

Fig. 15.1. Major ocean currents and nine sandy beaches along the Chilean coast with spring-tide winter (1998) and summer (1999) water temperature (°C) in the surf zone

15.3 Biological Components

The most common species of the sandy beach macroinfauna are the cirolanid isopod *Excirolana braziliensis*, the anomuran crab *Emerita analoga*, the insect *Phalerisida maculata*, the bivalve *Mesodesma donacium*, and the polychaete *Nephtys impressa*, all of which occur along the Chilean coast

Table 15.1. Sandy beach fauna from the northern (*N*, 20–23°S), north-central (*NC*, 29–30°S), central (*C*, ca. 33°S), and south-central (*SC*, 40–42°S) coast of Chile. Insecta Coleoptera (*IC*), Crustacea Amphipoda (*CA*), Crustacea Isopoda (*CI*), Crustacea Anomura (*CAN*), Crustacea Brachyura (*CB*), Crustacea Macrura (*CM*), Crustacea Stomatopoda (*CS*), Mollusca Bivalvia (*MB*), Annelida Polychaeta (*AP*) (based on Castilla et al. 1977; Sanchez et al. 1982; Jaramillo 1987b; Jaramillo et al. 1993, 1998; Brazeiro et al. 1998)

Taxa	N	NC	C	SC
Phalerisida maculata Kulser IC	x	x	x	x
Orchestoidea tuberculata Nicolet CA		x	x	x
Bathyporeiapus magellanicus Schellenberg CA			x	x
Phoxocephalopsis mehuinensis Varela CA				x
Huarpe sp. Barnard and Clark CA				x
Lysianassidae Dana CA				x
Tylos spinulosus Dana CI		x		
Excirolana braziliensis Richardson CI	x	x	x	x
Excirolana hirsuticauda Menzies CI		x	x	x
Excirolana monodi Carvacho CI			x	x
Macrochiridothea setifer Menzies CI			x	x
Macrochiridothea mehuinensis Jaramillo CI				x
Macrochiridothea aff. *lilianae* Moreira CI				x
Chaetilia paucidens Menzies CI			x	x
Emerita analoga (Stimpson) CAN	x	x	x	x
Lepidopa chilensis Lenz CAN	x	x	x	x
Blepharipoda spinimana Philippi CAN	x	x	x	x
Ogyrides tarazonai Wicksten and Méndez CM	x			
Ocypode gaudichaudii Milne Edwards CB	x			
Ovalipes punctatus (De Haan) CB				x
Pseudocorystes sicarius (Poeppig) CB				x
Bellia picta Milne Edwards CB		x	x	x
Nannosquilla chilensis Dahl CS				x
Mesodesma donacium (Lamark) MB	x	x	x	x
Donax peruvianus Deshayes MB	x			
Nephtys impressa Baird AP	x	x	x	x
Euzonus heterocirrus Rozbaczylo and Zamorano AP		x	x	x
Scololepis chilensis (Hartmann-Schröder) AP	x		x	
Leitoscoloplos sp. Monro AP	x	x		x
Lumbrinereis sp. Blainville AP	x			x
Spionidae undet. Grube AP		x		
Gliceridae undet. Grube AP	x	x		x
Onuphidae undet. Kinberg AP				x
Nemertina undet.	x	x	x	x

between 20°S and 42°S. Crustaceans (22 taxa), mainly peracarids, with three species of *Excirolana* and the idotheid isopods *Chaetilia paucidens* and *Machrochiridothea* (three species), are the most diverse group followed by polychaetes (eight taxa) (Table 15.1).

Emerita analoga and *Excirolana braziliensis* represent 90–99 % of the macroinfauna in sandy beaches at Aguila and Hornitos in northern Chile (20–23°S) while the same crab and *Excirolana hirsuticauda* represent about 72 % of the macroinfauna at Apolillado beach in north-central Chile (29°S). *Emerita analoga*, *Excirolana hirsuticauda*, and the talitrid amphipod *Orchestoidea tuberculata* are the dominant taxa at Cobquecura and Mar Brava beaches in south-central Chile (40–42°S), with a similar abundance of the polychaete *Euzonus heterocirrus* at Mar Brava. Most of these species are recruited during spring/early summer and in the fall (*Emerita analoga*; Osorio et al. 1967; Nuñez et al. 1974; Conan et al. 1975; Contreras et al. 1998) or during summer (*Excirolana braziliensis*, *E. hirsuticauda*, *O. tuberculata*; Zuñiga et al. 1985; Jaramillo 1987a). In general, macroinfaunal abundance varies significantly between seasons (Table 15.2). Low abundance in winter appears to be a result of habitat loss, owing to the erosion of beaches by storms that leads to steep beach-face slopes with coarse-grained sediments (Jaramillo 1987a).

The composition of macroinfauna changes along the shore. The brachyuran crabs *Ocypode gaudichaudii* and *Excirolana braziliensis* are commonly found in the drift line and dry zone of upper shores in northern Chile (20–23°S). The tylid isopod *Tylos spinulosus*, *Orchestoidea tuberculata*, and *Excirolana braziliensis* occupy similar levels in sandy beaches of north-central Chile (29–30°S). In contrast, only *Orchestoidea tuberculata* and *Excirolana braziliensis* are found in the upper shores of central (32–33°S) and south-central Chile (39–42°S; Fig. 15.2), probably due to their high desiccation tolerance (Jaramillo 1987a). Changes in the species composition of the upper shore levels have been related to latitudinal gradients of rainfall and sediment temperature (Jaramillo 1987b). The number of cirolanid isopods occupying the retention zone of mid-shore levels increases from lower to higher latitudes. However, in contrast to *Excirolana braziliensis*, the inter-

Table 15.2. Seasonal variability (1997–1998) of macroinfaunal abundance (ind. m^{-1}) at five sandy beaches of the Chilean coast (see Fig. 15.1 for approximate location of beaches)

Beaches	Spring/summer 1997	Winter 1998
Aguila	597,700	3,730
Hornitos	153,637	6,377
Apolillado	50,124	145,362
Cobquecura	28,660	1,280
Mar Brava	134,225	54,568

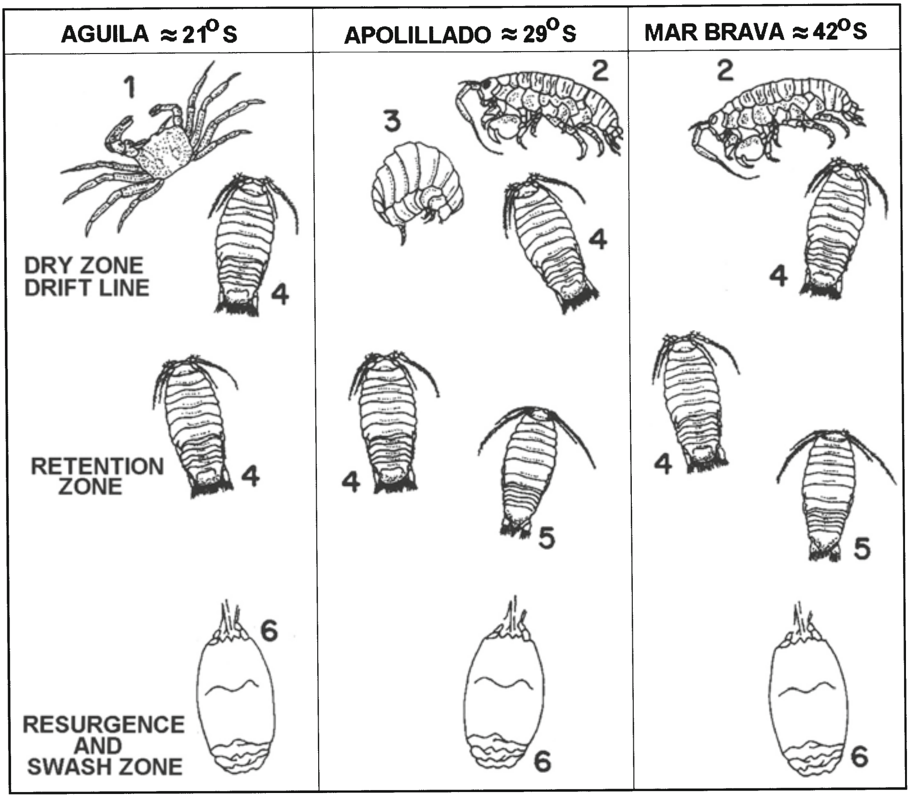

Fig. 15.2. Across-shore zonation of common sandy beach crustaceans at three selected beaches of the Chilean coast. Zonation scheme after Salvat (1969). *Ocypode gaudichaudii* (*1*), *Orchestoidea tuberculata* (*2*), *Tylos spinulosus* (*3*), *Excirolana braziliensis* (*4*), *Excirolana hirsuticauda* (*5*), and *Emerita analoga* (*6*)

tidal distribution of *Excirolana hirsuticauda*, which occupies lower beach levels (resurgence and swash zone), appears to be more affected by wave turbulence during tides (Jaramillo and Fuentealba 1993).

As elsewhere (Defeo et al. 1992), the structure of the macroinfauna community is closely related to different beach types, with richness and abundance tending to increase from reflective to dissipative beaches (McLachlan and Jaramillo 1995; McLachlan et al. 1993, 1996). Over a wide zoogeographic range (20–42°S), however, species number and abundance appear to be highest at beaches with intermediate characteristics (Las Cruces, Apolillado, Matanzas), and intermediate beaches at Matanzas (Dean=3.3) and Hornitos (Dean=3.5) have the same number of species as a dissipative beach at Mar Brava (Dean=10.5; Fig. 15.3). Furthermore, the morphology (presence of bays and horns) of intermediate beaches appears

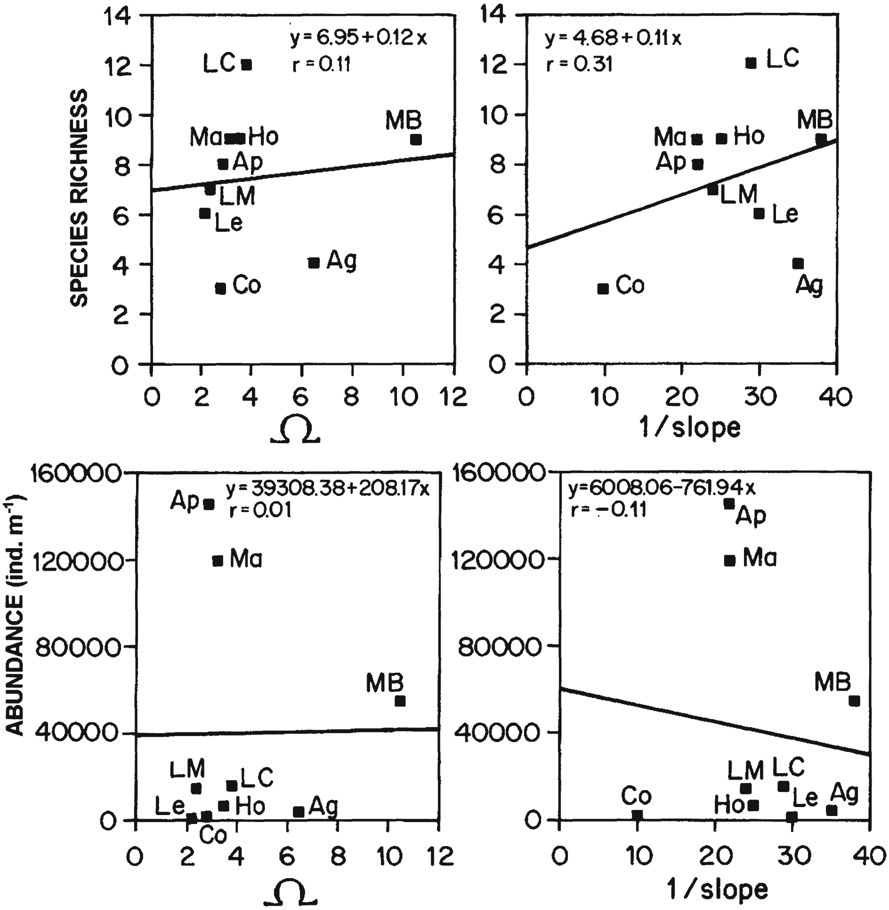

Fig. 15.3. Species richness and macrofaunal abundance in nine beaches of the Chilean coast in relation to Dean's parameter (Ω=wave height (cm)/wave period (s) × sand fall velocity; Short and Wright 1983) and beach face slope. Aguila (*Ag*), Hornitos (*Ho*), Apolillado (*Ap*), Las Cruces (*LC*), Matanzas (*Ma*), Cobquecura (*Co*), La Misión (*LM*), Lechagua (*Le*), and Mar Brava (*MB*)

to influence macroinfaunal abundance and zonation in central Chile (Brazeiro et al. 1998). It therefore seems that abundance is more affected by beach sand dynamics than by a single physical factor like mean particle size (Jaramillo 1987a). Physical factors related to El Niño events and large-scale oceanographic processes such as upwelling do not appear to induce differences in the macroinfaunal community structure of Chilean sand beaches (Jaramillo et al. 1998).

Competitive interactions affect the macrofaunal community organization elsewhere (Croker and Hatfield 1980); however, they appear to be absent from Chilean sandy beaches, even between closely related species like *Excirolana braziliensis* and *E. hirsuticauda* (Jaramillo 1987a). Fishes (*Eleginops maclovinus*) and birds, like the whimbrels (*Numenius phaeopus*) and sanderlings (*Calidris* spp.), prey on *Emerita analoga* in the swash zone of exposed beaches (Pequeño 1979), though predation does not appear to regulate the abundance of the population. The adults of upper shore species like *O. tuberculata* and the tenebrionid beetle *Phalerisida maculata* display similar patterns of nocturnal surface locomotor activity (Jaramillo et al. 1980), probably to escape predation by visually feeding shorebirds as well as to avoid desiccation at high temperatures and low humidity during daylight. The slope and water content of the sandy substrate probably influence daily migrations between different beach zones (Kennedy 1997).

15.4 Human Impacts

The surf clam *Mesodesma donacium* is the only invertebrate species widely harvested in the surf zone and the shallow subtidal area of exposed sandy beaches between 19°S and 42°S (Tarifeño 1980). In some areas clams ("machas") are collected by divers behind the surf zone. However, clams are mostly harvested during low tide by the fishermen ("macheros") who use their feet and body weight to excavate the sand until clams come up to the sediment-water interface. In north-central Chile (30°S), surf clams reach commercial size (70 mm) after 4–5 years. The maximum size of 109 mm at an age of 15 years decreases to 86 mm from north-central Chile to southern beaches at 37–38°S (Alarcón 1979; Tarifeño 1980, 1984). Landing data suggest a significant decrease in clam fisheries from 12,000–17,000 tons in 1987/89 to about 6,000 tons during 1995–1997 due to overexploitation.

The disposal of liquid and solid wastes along the Chilean coast has increased over the years. Accidental oil spills and the deposition of mine tailings have changed the zonation patterns of the intertidal macroinfauna and caused a decrease in macroinfaunal species richness and abundance (Castilla et al. 1977; Castilla 1983). Furthermore, Chilean sand beaches represent an important recreational resource due to their proximity to major urban centers. The mechanical disturbance of sands in the intertidal area by beach visitors is common during the summer holiday season, though it seems to have little effect on intertidal macroinfauna (Jaramillo et al. 1996).

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