Distribution of Organisms on the Seashore

7

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Abstract

Marine organisms are found on various types of seashores. The shore features often change gradually according to their degree of exposure to wave action. With decreasing exposure, the substratum changes from rocks in the most exposed/open regions to silts/clays in very sheltered conditions. Some organisms, called ecosystem engineers or foundation species, form biogenic habitats such as mussel beds, oyster reefs, salt marshes, mangrove forests, seagrass meadows, kelp forests, and coral reefs. Marine organisms have latitudinal limits. The climate in Japan ranges from sub-arctic to subtropical, and includes most temperate climatic zones; thus, the distribution of marine organisms depends on the climatic zones present. Biogenic habitats are also influenced by climate; for instance, intertidal salt marsh in a temperate zone is normally replaced by mangrove forest in a subtropical region. Likewise, kelp forest in sub-arctic/temperate zones is replaced by coral reefs in tropical regions. This section briefly describes typical seashore habitats for marine organisms, with a focus on rocky/sediment shores and biogenic habitats, such as kelp forests, salt marshes, mangrove forests, seagrass beds, and coral reefs.

7.1 Rocky Shore

Rocky shores are found on most wave-exposed coastlines where rock predominates (Fig. 7.1). On these shores, solid rock provides an attachment surface for sessile organisms, where epibenthic macrophytes and macrofauna encrust the rock surface, along with mobile fauna. Crevasses or dimples in the rocks create a

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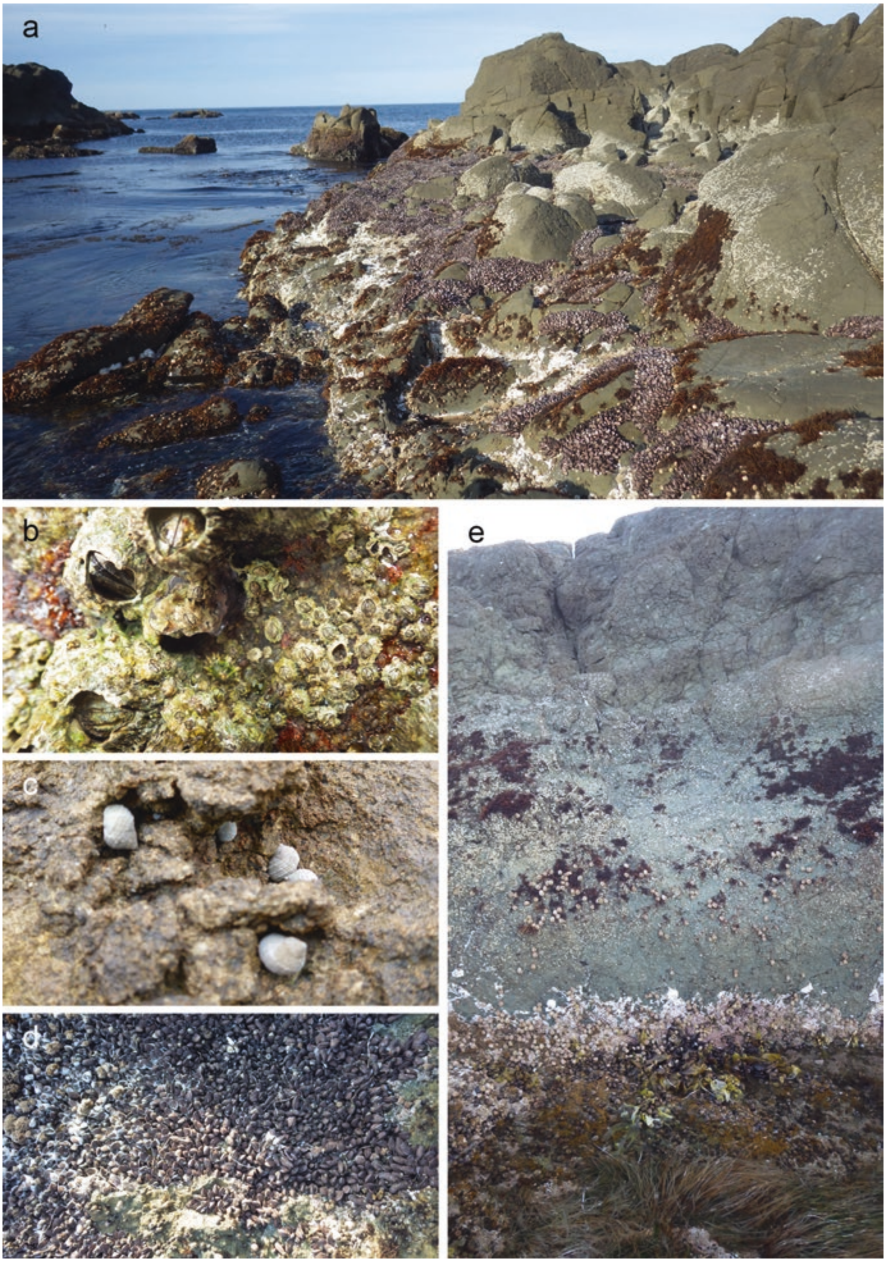

Fig. 7.1 A rocky shore at Usujiri, Hokkaido, Japan (**a**). Dominant sessile organisms *Tetraclita japonica* and *Chthamalus challengeri* (**b**). Utilization of rock dimple by *Nodilittorina radiata* (**c**). Mussel beds providing habitats for cryptic animals (**d**). Zonation pattern of an intertidal rocky shore (**e**)

more complex structure, and this creates a three-dimensional habitat for cryptic species. Mussel beds or oyster reefs, which sometimes occupy rock surfaces, also provide complex interstitial spaces between their shells for smaller organisms.

Generally, in intertidal areas, clear zonation patterns are found, showing an obvious vertical distribution pattern of organisms (Rafaelii and Hawkins 1999). According to the universal classification scheme of zonation, the shore is divided into three major zones: the high-shore zone, called the supralittoral fringe; a broad mid-shore area, called the midlittoral zone; and a low-shore zone, referred to as the infralittoral fringe.

7.2 Kelp Forest

Wave-exposed rocky subtidal shores are often occupied by dense macloalga vegetation (Fig. 7.2). In particular, brown seaweeds, in the order Laminariales, form kelp forests throughout temperate and sub-arctic zones. In Japan, most shore habitats are temperate, and thus kelp forests are common along the coast. These

Fig. 7.2 A kelp forest at Oura Bay, Izu Peninsula, Japan (**a**). Animals utilize the seaweed body as refuge site (**b**), or habitat substratum (**c**)

ecosystems have high biological production (Mann 1973), which in turn provide many ecosystem services.

Various marine organisms are found in kelp forests. Seaweeds provide habitat for smaller sessile organisms such as epiphytic diatoms, polyzoans, hydrozoans, and colonial ascidians. Larger mobile fauna, including gastropods and crustaceans, also utilize kelp. Kelp forests provide a complex three-dimensional environment, which functions as a refuge from predators. Kelp also acts as a feeding ground for herbivorous gastropods, echinoids, and fish. Consumption by sea urchins sometimes removes large parts of kelp forests, while consumption by other gastropods and fish has little effect.

7.3 Sediment Shore

Sediment shores are coastal shorelines where sand/mud accumulates (Fig. 7.3). These shores are located in sheltered/closed regions; nevertheless, the degree of wave exposure, which characterizes the beach features, can differ among shores.

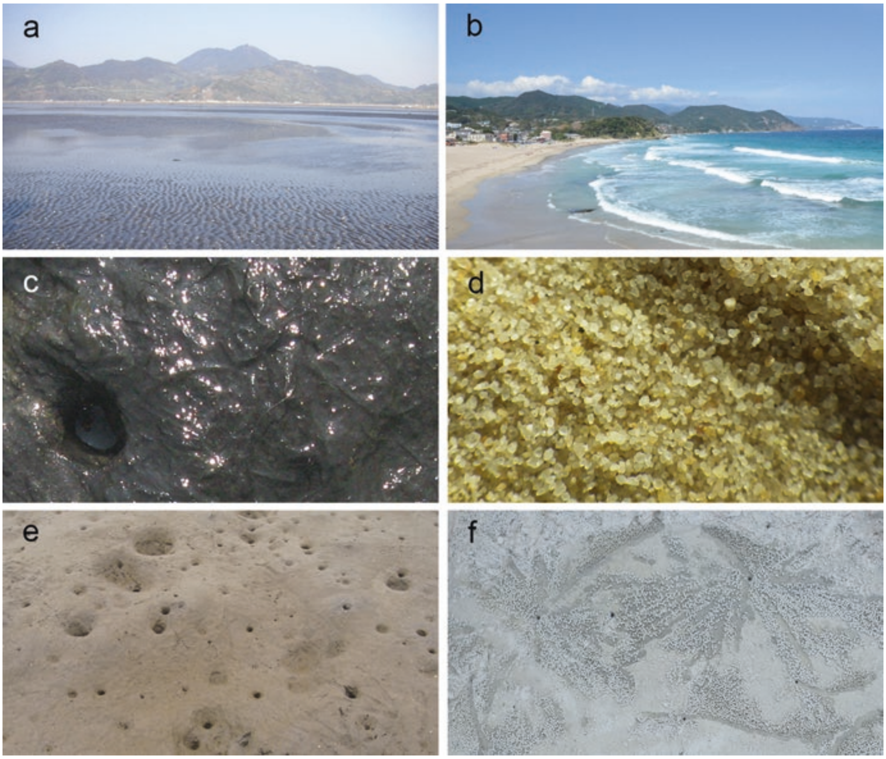

Fig. 7.3 A sheltered shore (mud flat) at Shirakawa estuary in Ariake Bay (**a**), and an exposed shore (sandy beach) at Yumigahama in Izu Peninsula, Japan (**b**). Substratum components of shores (**c**, mud flat; **d**, sandy beach). Burrows of infaunal species on the sediment surface (**e**, mud flat; **f**, sandy beach)

Wave-exposed beaches accumulate larger particles (sand) and are referred to as sandy beaches. The most sheltered/closed beaches, called mud flats, consist of smaller particles (silt/clay).

Organisms are three-dimensionally distributed above and below the sediment on sediment shores. Floral distribution is limited to the surface and/or the thin top-layer and is dominated by benthic microalgae. In contrast, most faunal species are distributed within the substratum, and there are dominant macrofaunal and meiofaunal groups. Generally, the species richness, abundance, and biomass of the macrofaunal community increase from exposed to sheltered shores (Allen and Moore 1987), because most species are unable to cope with the highly unstable habitats caused by wave disturbance.

7.4 Salt Marsh

Intertidal soft sediment is sometimes occupied by salt-tolerant grasses. In the temperate regions of Japan, salt marshes are mainly constituted of reed (*Phragmites australis*) colonies, which are commonly found in brackish areas (Fig. 7.4).

Fig. 7.4 A salt marsh constituted by common reed (*Phragmites australis*) colonies at Shinhamako, Tokyo Bay, Japan (**a**). Epiphytes on common reed stems (**b**). A sesarmid crab utilizing common reed as a food source and refuge site (**c**)

In salt marshes, reed grasses provide a physical structure above the ground (i.e., stems and blades), which is composed of soft sediment. The organisms in this habitat are distributed three-dimensionally from the sediment to the aboveground macrophyte bodies. The grass stems/blades harbor a large number of epiphytic microorganisms (e.g., microalgae). Microorganisms, as well as the detritus from reed grass, support abundant primary consumers, including polychaetes, amphipods, and decapods. Furthermore, the complex structure of reed grass (i.e., dense stems and leaves) provides refuge from predators for various epifaunal species, while underground grass roots support the burrow constructions of some infaunal species (Bertness and Miller 1984).

7.5 Mangrove Forest

In subtropical and tropical zones, intertidal soft sediments are often occupied by mangroves with salt-tolerant trees (Fig. 7.5). Mangrove forests comprise 54–73 plant species worldwide. In Japanese mangroves there are 14 plant species, including some that are non-native (Tropical Coastal Ecosystems Portal 2018). The mangroves in Japan

Fig. 7.5 A mangrove forest in Funaura Bay, Iriomote Island, Okinawa, Japan (**a**). Mangrove roots provide a home for various benthic invertebrates (**b**). *Terebralia palustris* feeding on mangrove leaf litter (**c**)

are the most northerly of the Indo-West Pacific biogeographic region, and accordingly, their distribution is limited to small areas in the south of the country.

Mangrove forests provide unique habitats for both aquatic and terrestrial organisms and achieve a high biological production. Mangrove trees are the largest source of primary production, with macro/microalgae contributing a minor proportion. Various invertebrates (such as polychaetes, bivalves, gastropods, and crustaceans) are distributed widely, from the underground sediment to aboveground macrophyte bodies. Invertebrates benefit from the increased food availability, shelter from predators, physical defense from harsh environments, and habitat provided by mangroves (Nagelkerken et al. 2008).

7.6 Seagrass Bed

Seagrasses are flowering plants (angiosperms) which grow in marine and brackish areas in upper subtidal zones. Seagrasses can develop dense vegetation, referred to as seagrass beds or seagrass meadows. Seagrass beds are found throughout the coast of Japan; *Zostera* spp. are dominant in temperate zones, while various species are found in subtropical zones (Fig. 7.6).

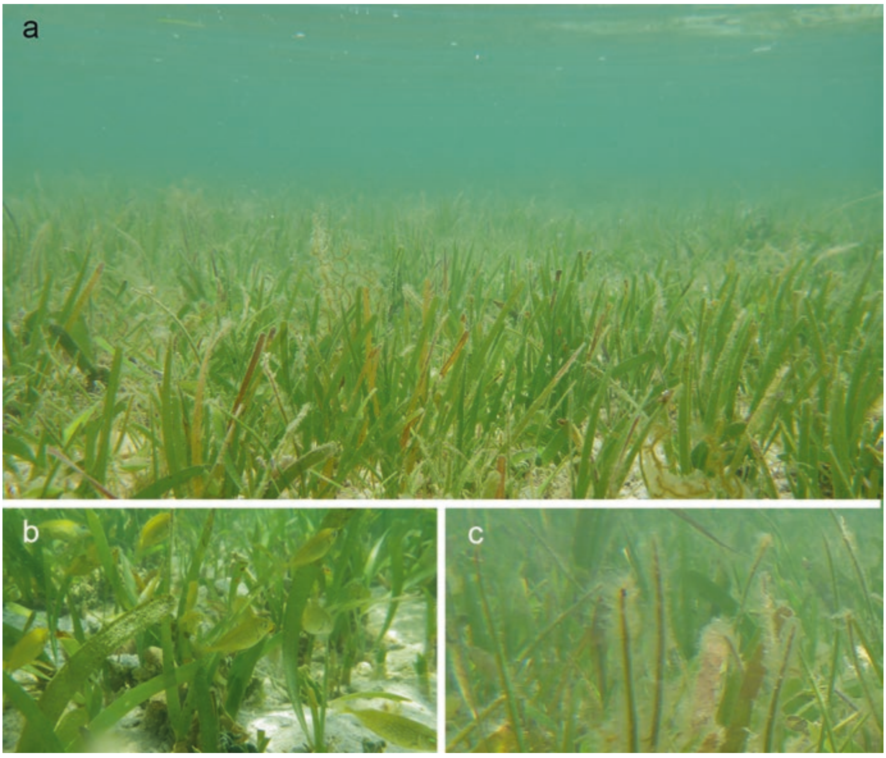

Fig. 7.6 A seagrass bed in Nagura Bay, Ishigaki Island, Okinawa, Japan (**a**). Seagrasses function as nursery grounds and support an abundance of juvenile fish (**b**: photo bay Yamada H). Dense epiphytes on seagrass leaves (**c**)

Seagrass beds harbor various marine organisms; for example, juvenile and adult fish, crustaceans, and gastropods. Epiphytic microalgae are common above the substratum, while polychaetes, bivalves, and nematodes burrow into the sediment. In particular, seagrass meadows support invertebrate larvae and juvenile fish by functioning as nursery grounds. These species stay in seagrass beds during their early life stages, and then move to coral reefs and other ecosystems as they mature. Seagrasses provide refuge from predators, and their leaves allow attachment of epiphytic microorganisms.

7.7 Coral Reef

Coral reefs develop on subtidal shores, normally at greater depths than seagrass beds, in subtropical and tropical zones. Reefs consist of hermatypic coral colonies that have hard carbonate exoskeletons, and their distribution is limited to small areas in southern Japan (Fig. 7.7). However, small patches of coral can be found up to the warm temperate zone (e.g., Boso Peninsula).

Fig. 7.7 A coral reef at Sesoko, Okinawa, Japan (**a**). Corals form a fringing reef along the coastline (**b**). The complex structure of coral branches provides a habitat for various marine organisms (**c**)

Shallow coral reefs form one of the most diverse ecosystems in the world; they provide a habitat for at least 25% of all marine species (Spalding and Grenfell 1997), including sea turtles, fish, cephalopods, gastropods, bivalves, polychaetes, crustaceans, echinoderms, sponges, tunicates, and other cnidarians. Faunal species are widely distributed around the coral exoskeleton structures; they use the interstitial spaces among coral branches as refuge sites, utilize the hard exoskeletons as attachment substrates, and forage around the structures. Although coral reefs sustain a high primary production to support high faunal consumption, conspicuous plants are rare due to significant grazing pressure.

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