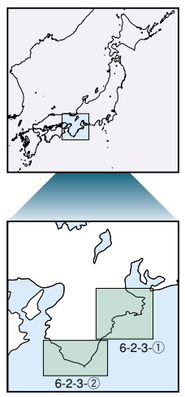
6-2-3 Kii Peninsula
(Map 6-2-3)

Province: Wakayama Pref. at south and west coast, and Mie Pref. at east coast of the peninsula **Location:** The peninsula lies at south of Osaka **Features:** Kii Peninsula is the largest peninsula in Japan, and southern tip of the peninsula (Cape Shiono) is the southernmost part of Honshu **Air temperature:** 17.0˚C (annual average, at Cape Shiono) **Seawater temperature:** 22.0˚C (annual average, at west off Cape Shionomisaki) **Precipitation:** 2,534.4 mm (annual average, at Cape Shiono) **Total area of coral communities:** 113.9 ha **Protected areas:** Ise-Shima National Park: around Shima Peninsula at north of Kumanonada; Yoshino-Kumano National Park: coastal area of southern Kumanonada and around Cape Shionomisaki including Kumanonada Nigijima and Kushimoto Marine Park Zone.

6-2-3-①

＊“号” on this map means “site”.



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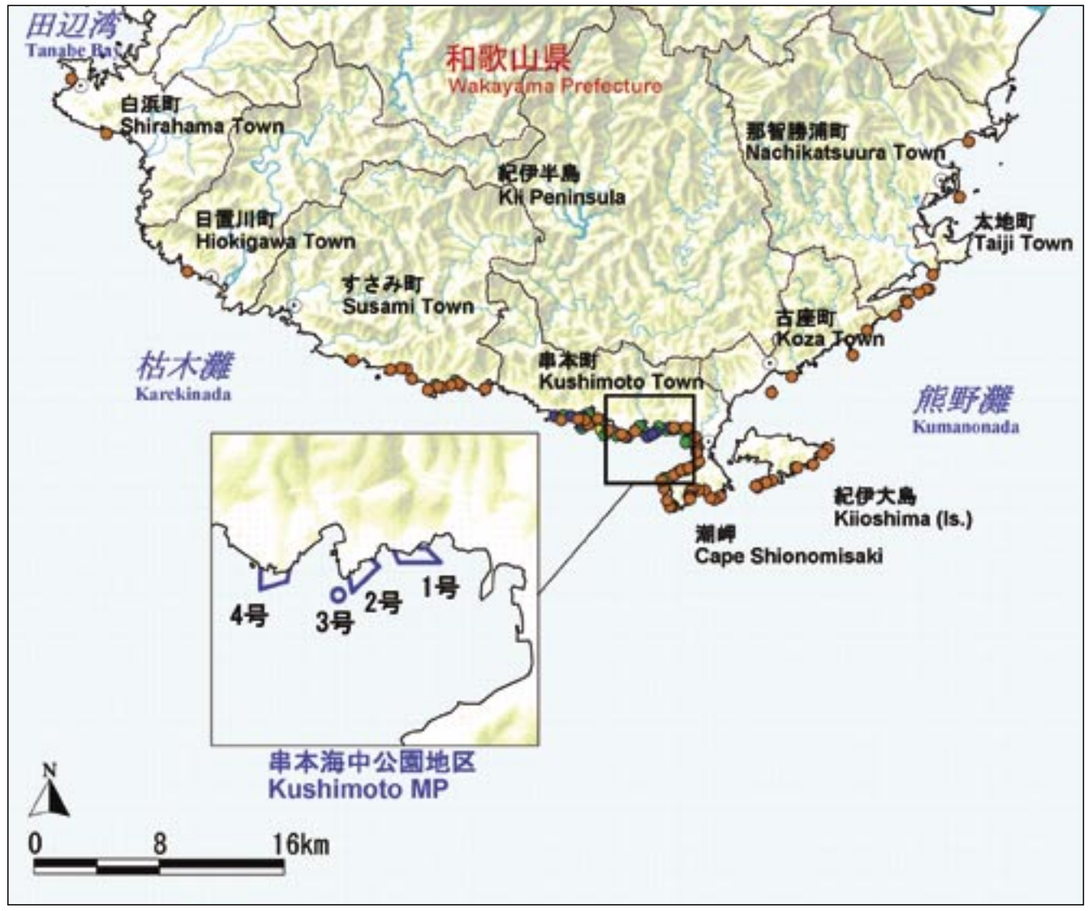

＊“号” on this map means “site”.

Kii Peninsula

(Maps 6-2-3-①, ②)

Keiichi Nomura

1 Corals and coral reefs

1. Geographical features

The Kii Peninsula is located at the southern end of the mainland Japan (Lat: 34° N, Lon: 136° E), and straddles Osaka, Wakayama, Nara, and Mie prefectures (Fig. 1). The length of the coastline totals 1,956 km (223 km in Osaka, 628 km in Wakayama, and 1,105 km in Mie). There are 486 islands (none in Osaka, 253 in Wakayama, and 233 in Mie). Except in Osaka, the natural coastline is generally undisturbed, showing distinctive topographical features such as coastal erosion cliffs, coastal terraces, and ria coasts. Ria coasts are especially well developed from Shima to Owase, along the east coast of the Kii Peninsula. The coasts are generally steep, with the depth contour of 100 m closely following the coastline from Gobo, in Wakayama Prefecture, to Daiozaki on the Shima Peninsula, in Mie Prefecture. The area is mainly based on igneous rock, except for the area west of Cape Shionomisaki (southern edge of the Kii Peninsula), which incorporates mudstone strata.

Fig. 1. Schematic diagram of the Kii Peninsula and distribution of corals of the Kii Peninsula. The red arrow indicates Kuroshio Current and its branch current.

Coral reefs are regarded not to form in this region. However, coral reef-like features (bedrock of coralline origin) distribute at Sabiura coast and west coast of the Cape Shionomisaki (Nojima 1990; Uchida 1994; Nomura *et al.* 2003a). Cape Shionomisaki is an island that is connected to the mainland by a coastal terrace. East coast from the Cape is called the Kumanonada Sea, and west of that is the Karekinada Sea.

The Kinan Branch Current, divided from the main Kuroshio Current, flows westward along the west coast of the Kii Peninsula (Fig. 1). The Kuroshio Current and the Kinan Branch Current supply the Karekinada coast with warm clear seawater from the south, along with abundant eggs and larvae of tropical organisms. In consequence, coral reef organisms are remarkably abundant around Kushimoto, and a subtropical biological community has formed in which tropical features are joined with temperate ones. East of Cape Shionomisaki, however, the coasts are influenced by water that flows into the Kumanonada. These waters have lower temperatures and lower salinity than those of the southern Karekinada, and this region shows temperate biological communities. The following meteorological observations were made at Sabiura in Kushimoto (Nomura *et al.* 2003a), where strongly influenced by the Kuroshio Current. The annual average sea surface water temperature was 21.1°C, with a low of 16.3°C in winter (February), and a high of 27.2 °C in summer (August). The average annual air temperature was 17.5°C, with a low of 8.7°C in winter (January), and a high of 26.7°C in summer (August). The annual average salinity was 35.0 PSU and the annual average underwater transparency was 14.7 m.

2. Coral distribution

Around the Kii Peninsula, hermatypic corals occur between south of Takashima in Hirokawa (Wakayama Prefecture) and south of Wagu in Shima (Mie Prefecture). The number of observed species in each place in the Kii Peninsula is as follows. Karekinada coast; Kushimoto (109 species), Shirahama (77 species), Tenjinzaki in Tanabe (12 species), Gobo and Mihama (21 species) and Takashima (3 species), and Kumanonada coast; Myougajima of Kushimoto (12 species), Miminohana in Nachikatsuura (16 species), around Nigishima in Kumano (10 species), Kiinagashima

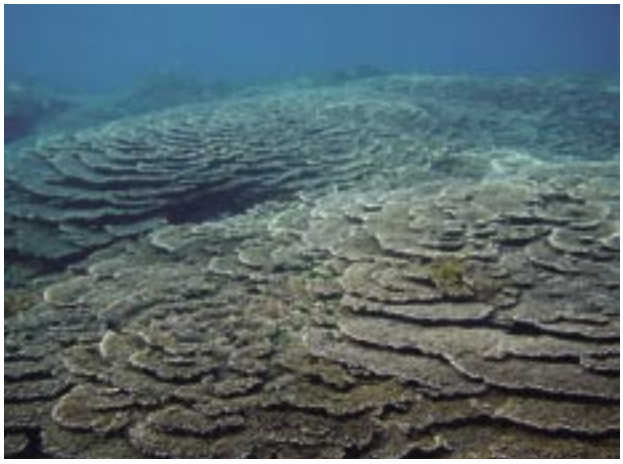

Photo. 1. Monospecific community of *Acropora hyacinthus* (Sabiura, Kushimoto).

(8 species) and Wagu (1 species). Areas of over 1 % coral coverage occur between south of Gongenzaki at Shirahama in the Karekinada, and south of Miminohana at Nachikatsuura in the Kumanonada. Areas of high density coral cover (> 50 %) are distributed from Azumame to Tago in Kushimoto (Fig. 1). Coral communities with 5 % coverage are found in Kumano and Kiinagashima, but their distribution is local and restricted (Hiraga and Koda, unpublished data; Hiraga 1994; Miyawaki 1994; Nishihira and Veron 1995; Nomura *et al.* 2003a; Nomura and Hirotsuji 2001; Nomura and Fukuda 2000; Uchida 1994). Coral distribution in the Kii Peninsula is centered on the western region of Cape Shionomisaki in Kushimoto. As distance from this point increases along the coastlines, both the number of coral species and the coverage decreases, especially on the Kumanonada side.

Tabulate *Acropora hyacinthus* dominates shallow water (< 10 m in depth) in Kushimoto; large-scale communities of this species are seen in Azumame (Kushimoto Marine Park Site 1), Sabiura (Kushimoto Marine Park Site 2, Photo. 1), Najikasaki (Kushimoto Marine Park Site 4), Soshima, and around Tako.

Especially in Azumame, a monospecific community, of about 100 m × 20 m (0.2 ha), forms a beautiful seascape. Other dominant species in the shallow water include *Acropora* aff. *gemmifera*, *Cyphastrea serailia*, *Montastrea valenciennesi*, *Goniastrea australensis*, *Platygyra contorta*, *Favites flexuosa*, *G. aspera*, and *Acropora solitaryensis*. In deeper zones (10–20 m depth), *Echinophyllia aspera* (Photo. 2) dominates. Peculiar communities of the following species are seen in the following places: inner bay area (*Acropora tumida*; Photo. 3 and *Lithorhyllon undulatum*; Photo. 4), the northern coast of Soshima (*Goniopora* sp.; Photo. 5), Najikazaki (*Acropora microphthalma*; Photo. 6), Sambira (*Acropora formosa*), Kamiura to Andonohana (*Pavona decussata*; Photo. 7), Andonohana (*Catalaphyllia jardinei*; Photo. 8), north of Sumisaki (*Astreopora incrustans*, *Pavona cactus*, and *Merulina ampliata*), and Sumisaki (*Acropora cuneata*). Huge, massive coral colonies (3–5 m along the major axis) of *Porites lutea*, *Coscinaraea columna* and *Turbinaria peltata* are seen scattered in the inner bay area. However, most of these *P. lutea* colonies are now dead (Nomura 2001, 2002, 2003, 2004; Nomura and Fukuda 2000, 2001, 2002; Nomura *et al.* 2003a).

The coral fauna becomes monotonous with the rise in the latitude from Cape Shionomisaki, the frequency of *Acropora* gradually decreases and, simultaneously, the frequency of species such as *Porites heronensis*, *Psammocora profundacera*, *Hydnophora exesa*, *Cyphastrea serailia*, *Montastrea valenciennesi*, or *Plesiastrea versipora* increases. The northern limit of coral distribution on the Karekinada side is at Takashima in Hirokawa, and the species that occur here are *Acanthastrea* sp., *Favia speciosa*, and *Cyphastrea serailia*. On the Kumanonada side, the northern limit is at Wagu in Shima, and the only species that occurs there is *Hydnophora exesa* (Fukuda, unpublished data; Hiraga and Koda unpublished data; Nomura and Hirotsuji 2001; Uchida 1994). The northernmost point at which a coral community with over

Photo. 2. *Echinophyllia aspera*

Photo. 3. *Acropora tumida*

Photo. 4. *Lithophyllon undulatum*


Photo. 5. *Goniopora* sp.

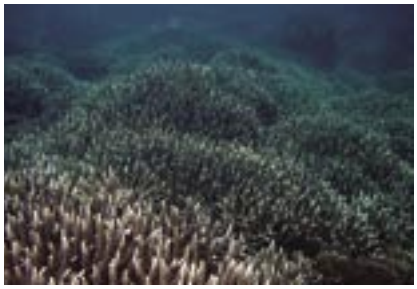
Photo. 6. *Acropora microphthalma*


Photo. 7. *Pavona decussata*

50 % coverage was known to occur at Esumi in Susami (Miyawaki 1994) but, recently, the existence of a high density, large scale communities of *A. hyacinthus* was confirmed in Okinose (Fukabae), Tanabe Bay (Akagi 2003).

There are two coral species (*Acropora hyacinthus* and *Catalaphyllia jardinei*) of particular note in the Kii Peninsula. *A. hyacinthus* (Photo. 1) not only forms high density communities in the southern peninsula, to the point that it becomes the main constituent of the marine landscape, but it is also highly important as a species resource and as an ecological base. *C. jardinei* (Photo. 2) is very rare species in Japanese waters, and forms the domestic large-scale community in Kushimoto.

Taxonomical study of corals in the mainland Japan has not been sufficient, and many unidentified or undescribed species are recognized. As taxonomical knowledge increases, it is expected that further important species will be added.


Photo. 8. *Catalaphyllia jardinei*

2 Situation of usages

1. Tourism

Major marine tourisms in the Kii Peninsula are sea bathing (especially Shirarahama in Shirahama), SCUBA diving (especially southern part of the Peninsula), and recreational fishing (all coastal areas).

2. Fisheries

Fisheries are prosperous in the Kii Peninsula. Typical fishing methods include line fishing (skipjack, tuna, red sea bream, horse mackerel, pigfish and squid), buoy gill net fishing (saury and flying fish), bottom gill net fishing (flatfish, lobster, and top shell), coastal dragline fishing (coastal fish), fixed net fishing (coastal fishes), towed net fisheries (anchovy, sand eel, and halfbeak), trawling (hairtail, red sea bream, prawn), stick-held dip net fishing (sardine, banded blue-sprat, horse mackerel, mackerel, and saury), net fishing (sardine, horse mackerel, and mackerel), drive-in fishery (small whales), and dive fishing (ear-shell and top shells). And also aquaculture is prosperous: main species are sea bream, yellowtail, flatfish, bluefin tuna, prawns, noble scallops, and pearls (Nakajima *et al.* 1985).

3 Threats and disturbances

The major disturbances for the coral communities of the Kii Peninsula are discussed below.

1. Typhoon waves

Although strong typhoons approach the Kii Peninsula once in about 10 years, the accompanying big waves can cause damage to coral communities. Such a situation could chiefly cause damage to the seascape of *Acropora hyacinthus* communities in Kushimoto. However, areas

that have been affected thus far have been able to recover to their previous state within a few years (Nomura *et al.* 2003a).

2. Abnormal water temperature

Abnormally high and low water temperatures have caused bleaching and the subsequent death of corals such as *Acropora hyacinthus* around Kushimoto. Coral bleaching by the low water temperatures has been confirmed three times (1980, 1982, and 1984) since 1971; in terms of damage, 1984 was the most severe event. On this occasion up to 50 % of *A. hyacinthus* died in general, and suffered catastrophic damage in some places. This severity was probably due to a long period of under 14 ˚C water temperatures (20 days or more). Since 1971, coral bleaching during episodes of high water temperatures has been observed four times (1984, 1994, 1998 and 2001) in Kushimoto. Bleaching was also recorded in infralittoral zones (except in 2001) but, in each case, the death rate was insignificant. The 2001 bleaching event was limited to corals growing in intertidal pools, where the death rate was > 50 %, particularly for the dominant species *Cyphastrea serailia* (Nomura *et al.* 2003a).

3. Damage by other organisms

Abnormal proliferation of crown-of-thorns starfish (*Acanthaster planci*) or coral-eating gastropods can cause massive coral damage and death. A proliferation of *A. planci* was identified around Cape Shionomisaki in the 1970s, but this group of starfish had disappeared by the 1980s without causing serious damage to coral communities. Totally 1,400 individuals were removed during this period. At present, several individuals of starfish can always be observed on submerged rocky reefs off Kushimoto, but the distribution density remains low. However, it is possible that this population spread to coastal areas, and thus monitoring is required (Nomura *et al.* 2003b).

The coral-eating gastropod *Drupella fragum* has proliferated abnormally for about five years around Kushimoto, causing damage to *Acropora hyacinthus* and other *Acropora* species. Systematic removing projects were commenced in this area soon after their increased numbers were noted, but this proliferation is probably a chronic problem. A large-scale monospecific community of *A. hyacinthus* disappeared from marine park Site 4, where *Drupella* had initially caused a lot of damage, but colonial regeneration has been observed taking place (Nomura *et al.* 2003a). High predation pressure by another coral-eating gastropod, *Coralliophila costularis*, is occurring in coral communities from Gobo to Mihama.

Damage to coral communities during a red tide has also been observed. In 1984 *Gymnodinium nagasakiense*, a species of dinoflagellate, proliferated in large quantities in the Kumanonada, over an extended period (June–July). This species forms a vast red tide, causing extensive damage to coastal organisms. Corals in the area are assumed to have received catastrophic damage at this time, and the present inhabitants probably developed after this occurrence (Hiraga 1994).

4. Anthropogenic disturbances

Inner bay coral communities have been disturbed, to varying degrees, by the reclamation and construction that have accompanied harbor improvements, limited water exchange, and sedimentation of silts and mud, among other things. Healthy colonies of *Porites lutea*, which are popular in particular to inner bay areas, are now very rare in the sea near Kushimoto. These anthropogenic disturbances (along with *Drupella*-induced damage) have caused many *Acropora tumida* communities, which were also once distinctive inner bay areas, to decrease altogether. Coral communities at the mouth of Arita Bay at Kushimoto (including colonis of *Catalaphyllia jardinei*) appear to have been largely destroyed by repeated anchoring of a harbor maintenance ship (Nomura 2001, 2002, 2003, 2004; Nomura and Fukuda 2000, 2001, 2003). Although no reliable data exist, it is suspected that aquarists are illegally collecting invertebrates, including corals and coral rubble (live rock), together with fish.

4 Monitoring and conservation

Several national parks along the coast of the Kii Peninsula have been designated, and are conserved by the Natural Parks Law. They are: Setonaikai National Park (near Kada in Wakayama), Yoshino-Kumano National Park (from Kushimoto to Owase), and Iseshima National Park (on the Shima Peninsula). In Yoshino-Kumano National Park, two marine park zones have been designated at Nigishima (two sites, totaling 14.4 ha), and at Kushimoto (four sites totalling 39.2 ha); in these zones, construction works and the collection of marine organisms are restricted (Nature Conservation Bureau, Environment Agency 1999c). Moreover, the fishery adjustment law formulated in each municipality generally

restricts the collection of marine organisms.

It is probable that important marine biological communities are disappearing without our notice, because of the difficulty in looking around the features in the sea. This disappearance seems to increase concomitantly with the environmental pressures imposed by human activities. The trend is particularly noticeable in inner bay areas, where anthropogenic influences are strong. In the southern Kii Peninsula, coral communities, composed mainly of *Acropora tumida*, *Lithophyllon undulatum* and *Pectinia aylen*, occur inner bays, but their continued existence could be difficult because of the environmental degradation. Occurrence of a huge earthquake named the Nankai or the Tonankai Earthquake is predicted in the near future, and Kii Peninsula is forecasted to suffer tsunami damage. Consequently, plans for construction of breakwaters to protect vulnerable coastal villages are now rapidly in progress with little or no reference to the fact that their construction will cause further damage to inner bay coral communities.

To prevent important biological communities from disappearing, it is essential to first understand their nature and distribution. However, it isn't attained satisfactorily in the Kii Peninsula. As a necessary first step towards conservation, more surveys of these communities should be undertaken, and appropriate protective measures must be implemented when the importance of the communities were detected and ascertained.