

Investigation on the Establishment of Coastal Protection Forests and their Relation to Religious Ceremonies carried out on Beaches in Sub-tropical Island Environments

-A case study of Miyako and Tonaki Islands in Okinawa-

Yuei Nakama¹ and Zenfuku Koki²

Abstract: Coastal environments in Okinawa are deeply ingrained in the cultural life, in particular religious ceremonies, of the region's residents. The disaster prevention projects that have been carried out in coastal areas in Okinawa to date have been done so without consideration to the nature and culture of the region. Instead, they have been undertaken with a view to functionality alone. Results of surveys on the relationship between the natural coastal vegetation and the stepped / low-lying upright hollow tide embankments show that the number of plant varieties tends to decrease with the transition from a natural beach environment to these man-made structures. While the number of plant varieties is greater with the low-lying upright hollow embankments, they cut off the beach from the inland areas and thus vegetation continuity is lost. On the other hand, the steps on the stepped tide embankments support vines and creepers that grow out towards the inland areas. The preservation and restoration of the nature and historic culture of these beach environments is a substantial problem confronting disaster protection projects in the coastal regions of Okinawa.

1. Introduction

Approximately 4 million tourists visit Okinawa prefecture each year. In March 2001, a survey was carried out to assess what tourists to Okinawa found most attractive about the islands. When asked the reasons for their visit to the prefecture the most frequent response from a list of possible answers was "the beauty of the coral seas."

Other responses also frequently selected included "the unique culture," and "the sub-tropical forests (mangroves, etc.)." To sum up the types of responses as to why Okinawa is attractive as a tourist destination, it would be safe to say that most were in some way or another related to the beauty of the sea in the prefecture. It is noted that among the attractions unique to Okinawa, the coral reefs, the sandy beaches and the subtropical coastal vegetation proved to be particularly popular among those surveyed (Nakama, 2001).

Today however, this coastal environment is being slowly destroyed by public works designed to protect the coastline. The coast is slowly being transformed into an unattractive mass of concrete. The questions are: In what ways is the coastline being altered and what are the solutions that are being attempted? The purpose of this paper is to investigate ways in which coastal protection forestry measures can be employed, taking into account beaches and people's lifestyles. Up until now, there has been little focus on this issue with regard to folk customs.

Three locations, Karimata Village in Miyako Island, Oogami Island, and Tonaki Island were used as a case study for this paper. The following is a discussion on the problems and current state of administrative policies in

breakwater works and the relationship of the region's inhabitants to the beaches in regard to religious ceremonies of the region (Fig. 1).

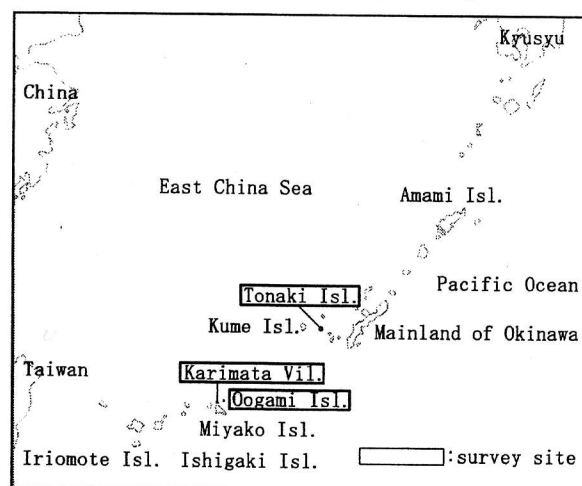


Fig 1: Map of Ryukyu Islands

2. Karimata Village Case Study

2.1 Village background

Karimata Village is located in the north-northeast region of Miyako Island. Ikema Island and Oogami Island can be seen from the village. The village is constructed on a terraced limestone hill. The northeast side of the village is surrounded by hilly forests (original village site). The coastline runs from the north-northeast to the southwest and features sandy beaches and protruding coral reefs.

According to the statistical documents of Taira City, as at November 2002, there were 733 people (286 households) living in the village. Of the 733 residents, 374 were female, 359 were male, and 30% of the total population was over 65 years of age.

Agriculture is the core industry and is carried out on the improved land on the

¹Associate Professor and ²Professor, Faculty of Agriculture, University of the Ryukyus, 1-banchi, Senbaru, Nishihara Town, Okinawa Prefecture, 903-0213, Japan.

southern side of the village. The major crops of the village are sugarcane and leaf tobacco.

2.2 Organization of Religious Ceremonies and Spiritual Leaders

Karimata Village is well known for its secretive religious ceremonies dedicated to ancestors called Uyagam. More than 60 ceremonies are held in the village each year. Karimata Village is one of the few villages in the prefecture that has preserved the traditional aspects of the ceremonies.

There are a number of ancestral shrines in Karimata Village used for religious ceremonies. According to "The History of Taira City" (7th edition), there are eight such shrines in Karimata Village and they are called ① Upugufumutu, ② Na:mamutu, ③ ſ idatimutu, ④ Na:mmimutu, ⑤ Kanja:mutu, ⑥ Mainja:mutu, ⑦ Nis i nuja:mutu, and ⑧ Aragufumutu. The majority of the ceremonies today are carried out at the ① Upugufumutu, ② Na:mamutu, ③ ſ idatimutu, ④ Na:mmimutu shrines. These four shrines are generally referred to as Ju:mutu. The remaining shrines are not used as there is no resident priestess to conduct the ceremonies(Photo.1).



Photo 1: The central place of worship (Upugufumutu Shrine) in Karimata Vil.

The head priestess who carries out ceremonies in Karimata Village is known as "abumma." The abumma's role is as head of the Upugufumutu (the center of the village's religious worship) and is tasked with caring for the god of the island. At present, under the abumma there are also the ju:nunusi and the midz inunusi. The ju:nunusi cares for the harvest god and is the religious head for ③ ſ idatimutu. Midz inunusi cares for the god of water and is the religious head for ④ Na:mmimutu. Supporting the ju:mutu is the uputsukasa (aid to the abumma), the ju:nunusi tsukasa (aid to the ju:nunusi), and the midz inunusi tsukasa (aid to the midz inunusi). Other religious heads include jamatumma, uikanusi, uinupja:, kurumamma, and isinunusi. The uikanusi, uinupja:, kurumamm, and isinunusi have their own respective ibi (small places of worship).

In times past there were more spiritual roles than there are now. The number of roles has been reduced with the passage of time and the ceremonies in the village today are carried

out by the aforementioned priestesses.

2.3 Coastal Protective Forests on Na:b i da Beach

On the northeast side of the village is a sandy beach the local residents call Na:b i da. It is a beautiful, natural, sandy beach that stretches for more than 400m(Photo.2).



Photo 2: Na:b i da Beach in Karimata Vil.

Along the beach, there is vegetation including *Ipomoea pes-caprae*, *Wedelia biflora*, *Cirsium brevicaule*, *Vitex rotundifolia*, *Hibiscus tiliaceus*, *Macaranga tanarius*, *Pandanus odoratissimus*, *Clerodendron inerme*, *Messerschmidtia argentea*, *Scaevola taccada*, *Euonymus japonicus*, *Diospyros ferrea*, *Garcinia subelliptica*, *Cerbera manghas*, *Flagellaria indica*, *Planchonella obovata*, *Guettarda speciosa*, and *Hernandia nymphaeaefolia*. This plant life exists in harmony with the coral ocean and the beach to form a beautiful natural Okinawan beach environment.

Close to the beach is the Utaki(sacred place for praying) called Isitsu that is covered by a dense forest. Around the ibi, massive *Garcinia subelliptica* tower to provide the area with a sublime atmosphere. At the access point from the beach to the Utaki there is a concrete Shinto shrine gate that has been eroded to the point where it is now on the verge of collapse. There have been calls by the locals to fix the gate, and accordingly, bank protection work was carried out under the name "Coastal Disaster Prevention Forestry Construction."

These bank protection works began on July 1st, 1994 and were completed on January 4th, 1997. The Okinawa Prefecture Miyako Island Branch Office undertook the work at a cost of 1.347 billion yen. The result of the work has seen a total of 207m of concrete tidal breakwaters laid, some 385 *Calophyllum inophyllum* trees planted, and 78 m of metal wind breaks constructed to provide protection for the trees(Photo 3).

The fact that the Shinto shrine gate was in danger of collapsing from erosion was the reason for carrying out the bank protection work. However, the sacrifice of the natural beach vegetation to complete the work was a substantial price to pay for the restoration and protection of a gate. The area is a sacred place where each year Karimata Village carries out

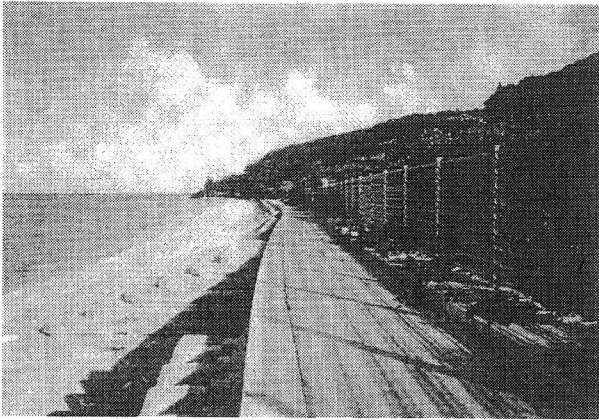


Photo 3: Disaster Protection Forest Project on Na:b^zida beach in Karimata Vil.

the religious ceremony dedicated to the sea god. It is a place where it is said that felling trees and vegetation in the immediate area will result in a curse. While access to the coast has certainly become more convenient, the changes caused to the beach environment have led not only to the destruction of the natural coastal vista, but to the loss of the former sublime atmosphere which the sea god ceremony enjoyed (Nakama, et al., 1998).

2.4 The Sea God (the Palace of the Dragon King) Religious Ceremony

The purpose of this ceremony is to wish for the safety of fishing vessels and a plentiful catch. The ceremony is carried out on the day of the rabbit in February of the lunar calendar on Na:b^zida Beach in front of Isitsu Utaki.

Firstly, the priestesses gather at Upugufumutu Shrine on the morning of the ceremony to offer prayers. They next move on to Na:mamutu (Shrine) where they hold a ceremony dedicated to the sea god and offer more prayers. When these prayers are finished, the priestesses move from the forest behind Na:mamutu Shrine along the cliff to Na:b^zida Beach. The beach provides the main stage for the sea god ceremonial rites.

In the rju:guniga^zi ceremony, the b^zidatsugi: leaf must be used as a plate on which offerings to the gods are presented. The Japanese word for b^zi datsugi: is *Messerschmidtia argentea* "b^zida" is beach and "gi:" is tree and the word represents all the living trees on the beach. The leaves are gathered on the morning of the sea god ceremony by two men known as sadzi and women called tumumma.

The reason why the monpanoki (*Messerschmidtia argentea*) leaf is used is unknown but the priestesses insist that this leaf must be used. While just speculation, the reason may be that the shape of the leaf resembles the shape of a sailboat, and when floated on the sea, the leaf doesn't sink. The tree from which the leaf is taken also grows well along the coast. One of the reasons for the sea god ceremony is to wish for safe passage of sea vessels, and thus, there may well be an analogy being drawn between safe navigation of the seas and the tree whose leaf resembles a sailboat and which grows on the coast.

The priestesses in charge of this ceremony are ① abumma, ② na:mamutu, ③ ju:nunusi, ④ midzīnunusi, ⑤ jamatumma. At present, there is no representative of ② na:mamutu and so the job is taken up by ① abumma. In addition to these priestesses, two men represent a:gu:fu: and pju:īnu:fu:, a further four priestesses in charge of prayers at each of the ibi (areas of worship) and the uputsukasa make up a total of 11 people who carry out the ceremonies.



Photo 4: The religious ceremony of the Sea God at Na:b^zida Beach in Karimata Vil.

The seating position of representatives of the gods at the beach ceremony is ① abumma, ② na:mamutu, ③ ju:nunusi, ④ midzīnunusi, and ⑤ jamatumma in that order. Because there is no na:mamutu the abumma takes on the combined role. The two men face the ocean and sit behind and to the right of the priestesses. The four priestesses of the ibi, the uputsukasa, and the priestesses below the abumma sit behind and to the left of the male representatives. They support abumma, ju:nunusi, midzīnunusi, and jamatumma.



Photo 5: Use of plants in the religious ceremony of the sea God (*Messerschmidtia argentea*)

The ① abumma, ② na:mamutu, ③ ju:nunusi, ④ midzīnunusi, and ⑤ jamatumma line up in this order, and facing the ocean, they take turns in presenting offerings to the sea god of the Dragon's Palace. The offerings include

salt, uncooked rice, small fish, tofu and rice cakes(Photo 4).

The uncooked rice is placed on a total of 84 monpanoki leaf plates lined up seven deep and 12 wide with 12 plates on the upper left. An additional plate is added and they are offered to the god. The upper left 12 plates represent the 12 points on the sexagenary cycle. The lower plates arranged seven deep and 12 wide represent the seven sea gods of the sea or rather the seven seas. The 12 plates represent 12 directions on the compass. The additional plate that is also added is offered because humans often omit things, and so this extra offering is made should there be something that should have been done but was not(Photo 5).

Around 9 a.m., each representative of the gods arranges her seating position and offerings and they begin with prayers to the god. The point of the prayers to the sea god is for safe navigation of sea vessels and a plentiful catch. The prayers to the god begin at Na:mamutu where the ceremony for the sea god is held.

In the ceremony for the sea god, the men sit behind the priestesses. Small stones are lined up in front, and as they chant ti: (one), ta: (two), mi: (three), the hands are held out at chest level and shaken up and down with the palms facing down. As each prayer is said, 12 stones are taken. This is called misibai.

When the Na:mamutu prayers are finished, the village part of the prayers are begun. The offerings made during this part of the ceremony are virtually the same. In this part of the ceremony, people other than the representatives of the gods also participate for their own personal reasons.

When all the prayers at the beach are finished, the participants divide the offerings and eat before leaving. After all have left, the priestesses return to Upugufumutu and Na:mamutu to report that the ceremony has been completed with no complications. Following this, the abumma and uputsukasa go to Harimidzī Utaki in Taira City where they pray to the sea god there and then close the ceremony(Nakama,et al.,1998).

2.5 Insect Purification Ceremony

This ceremony is to pray for noxious insects of the village and the fields to be taken out to sea and to usher in a plentiful harvest. This is called musiso:dzī in Karimata. It means to get rid of noxious insects and is carried out three times between the day of the Cock and the day of the Ox in February of the lunar calendar(Nakama,et al.,1998).

The 11 priestesses participating in this ceremony include the ju:mutu and jamatumma abumma, ju:nunusi, and midzīnunusi, the uikanusi, uinupja:, kurumamma, isīnunusi who are in charge of the areas of worship, and also the uputsukasa, ju:nunusitsukasa, midzīnunusitsukasa. There is no tsukasa:n priestess, who is in charge of the Na:mamutu, and thus, the tsukasa:n does not participate in the ceremony. In addition, two males also participate. One of the males, the pju:zīnuju:, takes on the role of deciding the schedule for the ceremony. The other male is charged with swimming and taking the imbanari (the boat

with the noxious insects onboard) out to sea. The abumma designates who will swim.

The priestesses gather at Upugufumutu (Shrine) at approximately 6a.m. to pray. They then go round to the Za: (worship site), Idatimutu (Shrine), Na:mmimutu (Shrine), Na:mamutu (Shrine), A:utaki (east Utaki, worship site), Nisiutaki (west Utaki, worship site), Isitsuutaki (worship site) and pray at each site. Finally they arrive at the coast on the western side of the village. The priestesses do not eat or drink throughout the day of the ceremony.

This insect purification ceremony is carried out on the western side of the village with Irabu Island in view to the front of the ceremony site. The rocky area where the ceremony is carried out is called Ta:nubida by the locals.

The area is a mixture of limestone rocky areas and sandy beaches that supports a natural sub-tropical vista with vegetation that includes *Pandanus odoratissimus*, *Messerschmidia argentea*, *Scaevola taccada*, *Hibiscus tiliaceus*, etc.

The boat on which the noxious insects are put is made from the trunk of the *Musa x sapientum* tree and bamboo. The boat is called imbanari or imban and is made by the male representatives. A number of small snails are placed in a bag and tied onto the boat to symbolize noxious insects(Photo 6).

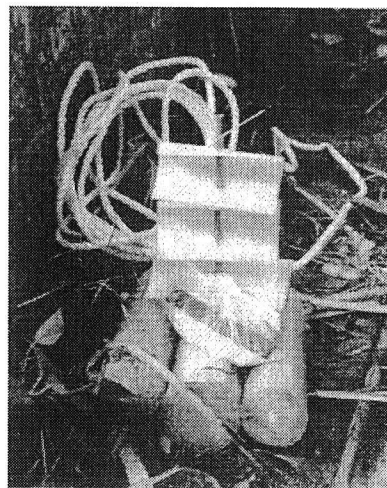


Photo 6: The imban carrying the noxious insects (snails) out to sea

After 9a.m., the 11 priestesses, led by the abumma, arrive at the rocky area on the coast. They face the ocean and place both hands together and begin to pray. One man then pulls the imbanri from the beach and swims out in the direction of the open ocean. While this is being done, the priestesses cover themselves from head to toe with basapani (abaca cloth) and then lie face down on the rocky area not watching the scene until the male has cast the noxious insects into the open sea and returns to the beach. When he returns the priestesses take off their covering robes and stand up. This concludes the ceremony(Photo 7,8).



Photo 7: The insect cleaning ceremony at the Ta'nub'ida coast

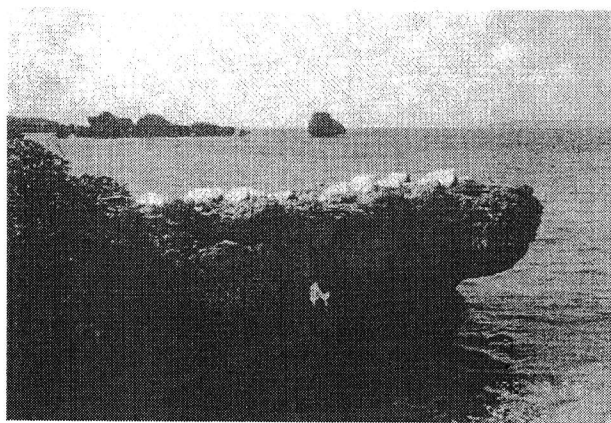


Photo 8: The priestesses lying down and seeing off the imban (boat carrying the noxious insects)

3. Oogami Island Ceremony

3.1 Island Outline

Oogami Island is located to the north-northeast of the main island of Miyako, some 4km from Shimajiri Village. The island perimeter is 2.2km and the area is 0.27km². The highest point on the island, in the form of an elliptical cone-shaped peak, rises to a height of 75m. The island's composition is 90% Oogami sandstone and 10% Ryukyu limestone. Compared to Miyako Island, the relatively high concentration of sandstone is one of the unique characteristics of Oogami Island.

According to Taira City's statistical records, the population of Oogami Island was 50 people as at November, 2002. Of these 50 people, 24 were female and 26 were male. The island supports 21 households and over half of the inhabitants are over 65 years old.

The village is surrounded by cultivable lands that are used by the residents to grow their own food. The residents support themselves by way of fishing and through social welfare.

There are shrines on the eastern and western sides of Oogami Island. These shrines may not be entered by anyone but the island priestess, and it is said that anyone breaking this rule will be cursed. Watching or discussing the religious ceremony Ujagam

(June – October of the lunar calendar) that is held at the shrine is taboo. The contents of the ceremony are shrouded in a veil of secrecy.

The gods rest in the stone and shrines of the island, and thus, the destruction or removal of any part is said to bring forth life-threatening curses.

3.2 Island Vegetation

Plants of the *Miscanthus sinensis* community cover 70% of Oogami Island. In coastal regions, the main vegetation is plants from the *Pandanus odoratissimus* and the *Hibiscus tiliaceus* communities. There are also plants such as the *Scaevola taccada*, *Derris trifoliata*, *Pemphis acidula*, *Macaranga tanarius*, *Ficus microcarpa*, and *Planchonella obovata*. On the southern slope of the hill behind the village is a natural forest of *Persea thunbergii*. Within this forest other types of existing vegetation include *Ficus superba*, var. *japonica*, *Arenga tremula* var. *engleri*, *Ardisia sieboldii*, *Antidesma pentandrum*, *Diospyros maritima*, *Callicarpa japonica*, var. *luxurians*, etc. According to Kawakami (1983), there are some 121 different varieties of plant life on Oogami Island.

3.3 Construction of the Island Perimeter Road

In March 1986, according to Taira City, the "Master Development Plan for Ikema Island / Oogami Island" was formulated. A part of this plan was the construction of a road running around the perimeter of Oogami Island. According to this plan, a 1.5km road running around the island's 75m high observation point in the inner area of the island was to be constructed. In response to calls by locals, breakwater development was also undertaken to counter erosion on the eastern side of the island. In a separate project, construction on a new overland road on the western side of the island was also started.

According to records in the Taira City Fisheries Department, the project to construct the road running around the western side of the island began in fiscal year 1990. Commenced as a part of the fishing port access road maintenance project, the road was constructed over the period spanning March 1991 to March 1996 at a cost of 2.85 billion yen. The completed road was 4 meters wide and was constructed of asphalt and concrete with a total length of 986m (Photo 9,10).

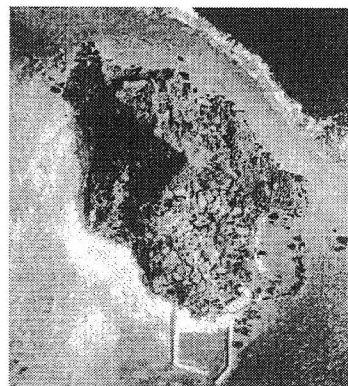


Photo 9: Oogami Island prior to the construction of the coastal road



Photo 10: Oogami Island following the construction of the coastal road



Photo 11: The coastal road on Oogami Island

In the first plan, the proposed circuit road was to link the western side of the island with the village on the eastern side of the island. However, soon after the construction began on the road, it ran into problems after encountering a kamiishi (spirit stone). This caused the project to be halted. In fiscal year 1991, the overland section of the road was changed to a coastal road and construction was recommenced. The road was substantially shortened and ends in the northern side of the island (Photo 11).

The area that caused the problem in the construction of the road is located in the western part of the island where the overland section of the road was to be built. The area is scattered with tombs and places for worship that are designated by kamiishi. When these places were inadvertently destroyed by construction workers, a number of strange happenings occurred. Among the workers, unexplained illnesses began to appear (headaches, nervous breakdowns, nightmares, mental instability etc). The construction was interrupted and the island priestess, yuta (shaman) and construction workers were gathered together to restore the kamiishi to its former site. The path of the road was then changed.

According to the yuta, the gods had been disturbed, and this had resulted in a curse. The priestess and the workers participated in a number of efforts to apologize and soothe the

gods. Finally, it was decided by Taira City to avoid the area in the construction of the road. Permission was sort by way of a resolution from the Fishing Co-op for the landfill of a public water area to construct the road along the coast. The planned road was altered from an overland road to a coastal road and construction was recommenced (Nakama, et al., 1998).

Because of this coastal road construction, the natural coastline of the island has been destroyed and replaced by an asphalt and concrete road. The road, 4m wide, is wide enough for two cars to pass in opposite directions. There are however, no cars on the island. The island's perimeter is just 2km and can be covered in few hours on foot. The value of the natural environment destroyed by this construction project carried out without a proper survey and consideration for the environmental effects is immeasurable.

4. Tonaki Island Case Study

4.1 Island Background

Tonaki Island is located 58km northwest of Naha City at a north latitude of 26 degrees 22 minutes and east longitude of 127 degrees 8 minutes. It is a small crescent-shaped island with a perimeter of 12.5km.

The major topographical and geological characteristic of Tonaki Island is that the Ryukyu Limestone layer is in little distribution. Located in the southern area of the island are deposits of Paleozoic crystallized limestone layers, dolomitic limestone, and phyllite. A part of this area has been subject to erosion that has caused the formation of Karst topography. The northern area of the island is formed by tertiary deposits of Cenozoic igneous rock (Tonaki Village Office, 1983).

In the north of the island, Mt Nishimui rises 146m, while the southern area of the island boasts Mt Gichuyama 137m, Uudaki, 179m, Uunda 165m, and Umu 151m. Between these mountainous regions to the north and the south, lies an area of sand dunes upon which the village has been built (Tonaki Village Office, 1983).

Sixty-five percent of the island is made up of forests and wilderness. Only 2% (8ha) of the land area of the island is cultivated farmland (Okinawa Pref. MAFF, 2002), and because of this, the island's economy has traditionally been supported by the fishing industry. The longshore fishing industry is still the mainstay of the island's economy today. The main crops grown on the island are *Panicum miliaceum var. contractum* and carrots.

The total population of the island as at October, 2002 was 417 (249 male, 222 female). Of this number, 40% (188) were aged 65 years or older.

The village is set out in a grid pattern and each of the red tile-roofed houses is surrounded by fukugi trees (homestead forest). Compared to other areas of the prefecture, the village has preserved the traditional village landscape. For this reason, in May 2000, the village was selected by the state as an "important traditional buildings preservation area." Of

the 283 houses on the island as at November 2002, 100 of the structures (89 main dwellings, 11 annexed structures) have been designated for preservation by the state. Tonaki Island is the second island to be awarded such a designation after Taketomi Island in Yaeyama.

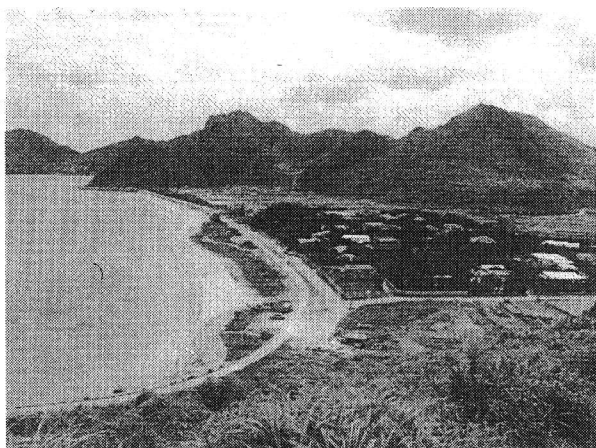


Photo 12: Landscape of premises forest (*Garcinia subelliptica*) in Tonaki Vil.

4.2 Island Vegetation

The island's geology is formed from the Paleozoic Tonaki layer and Tertiary deposits of igneous rock. Combined with the island's steep topography, this has led to a diverse array of vegetation on the island.

According to Tonaki Vil. History (1983), over and above the ferns found on the island, there are some 594 different varieties of vegetation from 124 families. Among these are *Dianthus superbus* var. *longicalycinus* and *Pyrrosia linearifolia* var. *heterolepis*, both of which are native to the island and of great importance to phytogeography.

Coastline vegetation follows the typical pattern found in the Ryukyu Archipelago and includes such plant communities as *Ixeris repens*, *Calystegia soldanella*, *Carex pumila*, *Ipomoea pes-caprae*, *Vigna marina*, *Vitex rotundifolia*, *Spinifex littoreus*, *Scaevola taccada*, *Messerschmidia argentea*, and *Pandanus odoratissimus* (Tonaki Vil. History, 1983).

The lowland vegetation, encompassing the homestead forests surrounding the houses (Photo 12), also includes taller trees such as *Macaranga tanarius*, *Hibiscus tiliaceus*, *Planchonella obovata*, *Ficus microcarpa*, *Morus australis*, *Ehretia acuminata* var. *obovata*, *Litsea japonica*, *Cratava falcata*, *Calophyllum inophyllum*, *Podocarpus macrophyllus*, *Bischofia javanica*, *Melia azedarach*, *Distilium racemosum*, and shrubs such as *Breynia officinalis*, *Murraya paniculata*, *Zanthoxylum beecheyanum*, *Callicarpa japonica* var. *luxurians*, *Antidesma pentandrum*, and *Clerodendron inerme*. Other species include trees from the mantle communities such as *Paederia scandens*, *Clematis meyeniana*, *Clematis grata* var. *ryukyuensis*, *Stephania japonica* var. *australis*, etc. The main

vegetation on farmland on the island includes *Setaria viridis*, *Youngia japonica*, *Oxalis corniculata*, *Digitaria ciliaris*, *Eleusine indica*, *Portulaca oleracea*, *Sonchus oleraceus*, *Dactyloctenium aegyptium*, *Panicum repens*, and *Cenchrus brownii* (Tonaki Vil. History, 1983).

The mountainous areas of the island boast trees from the *Miscanthus sinensis*, *Pleiblastus linearis*, *Cycas revoluta*, and *Pinus luchuensis* communities (Tonaki Vil. History, 1983, Hatsushima and Amano, 1977).

4.3 Coastal Disaster Prevention Forest Projects on Tonaki Island

To date on Tonaki Island, between 1993 and 2002, coastal disaster prevention forest projects have been undertaken at three sites at Anje-ra on the eastern side of the island and two sites at A-garu also located on the eastern side of the island.

The project at the Anje-ra was undertaken between 1993 and 1995 at a cost of 1.7046 billion yen while 22.114 million yen was invested on the A-garu project. The result of these projects was the construction of a 262m tide embankment at Anje-ra, and the planting of 0.33ha of trees at A-garu. The work carried out at Anje-ra did not involve any planting but rather breakwater construction for protection against high tides. At the A-garu site *Messerschmidia argentea*, *Cerbera manghas*, *Scaevola taccada*, and *Casuarina equisetifolia* trees were planted (Okinawa pref., 1993-2002).

4.4 The Tide Embankment Construction at Anje-ra and Changes in the Coastal Vegetation

There is tide embankment construction being carried out at anje-ra. The project centers on the construction of stepped concrete tide embankments and upright concrete tide embankments approximately 1 m in height. The upright type tide embankments are made hollow and are then filled with sand from outside (Photo 13,14).

The construction took roughly eight years for completion. A survey was carried out to ascertain how the coastal vegetation changed during this time because of the new construction. The vegetation from the shoreline to inland areas was surveyed at 1m intervals according to the line census method. The survey was carried out in the same area at three different locations: 1) beach, 2) stepped tide embankments, and 3) upright hollow tide embankments. The vegetation that was present in these three environments was compared (Photo 15,16,17).

The results of the survey were: 1) The beach had 20 different types of species from 16 different families, 2) The stepped tide embankments had 14 different species from eight families, and 3) The upright hollow tide embankments had 16 different species from 11 families. The results from the three locations can be summarized as follows:

1) The varieties of vegetation were plentiful in area 1 while there tended to be less in areas 3 and 2 because of the changes made. If there were 100 varieties of vegetation at the natural beach area then there would only be 80 at the

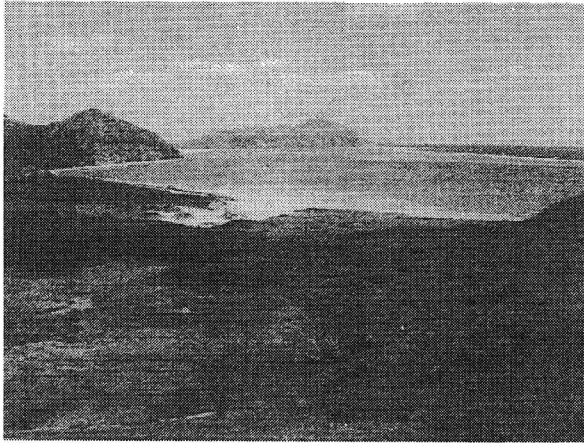


Photo 13: Landscape of Anje-ra beach (Survey area on Tonaki Island)



Photo 14 :Survey areas on Tonaki Island (Anje-ra)

upright hollow tide embankments, and 70 at the stepped tide embankments. The main reason for this decreasing rate is the area taken up by the man-made structures. The stepped tide embankments use several times the area from the shoreline to the inland compared to the upright hollow tide embankments. Because of this, there is a reduced sandy beach environment that is suitable for vegetation growth.

2) Because the stepped tide embankments are constructed in such a way that they slope gently from the inland area where they begin to the shoreline, wind blown sand accumulates on the steps. This sand supports vines such as the *Ipomoea pes-caprae*, and creepers such as the *Vitex rotundifolia*. On the other hand, because the coast and the inland areas at the upright hollow tide embankment site are sharply divided, there is no continuous vegetation growth.

3) The most common type of vegetation that was recorded most frequently at each survey location was varieties of grass. There were four varieties at the beach location, seven varieties at the stepped tide embankment location, and six varieties at the upright hollow tide embankment location. Varieties that

were present at each location include *Spinifex littoreus*, *Zoysia tenuifolia*, and *Miscanthus sinensis*.

4) A survey of the state of vegetation at each respective location showed a combination of mainly grasses and vine-type plants. The most common vines found were the *Ipomoea pes-caprae*, *Vigna marina*, and *Cassytha filiformis*.

5) At the natural beach, the survey confirmed the commonly referred to serial stage from herbaceous to woody plants. Close to the shoreline were *Crinum asiaticum*, *Zoysia tenuifolia*, *Ipomoea pes-caprae*, *Vitex rotundifolia*, and *Thuarea involuta*. These are varieties of creepers that are resistant to damage from salt water and salt-laden breezes. There were fewer varieties of vegetation around the shoreline area. Moving from the shoreline in an inland direction, the number of varieties begins to increase from around the 7m mark. The number of varieties peaks at between 10-16m from the shoreline.

6) Between the shoreline and the inland areas, the most frequently observed vegetation included *Crinum asiaticum*, *Zoysia tenuifolia*, *Ipomoea pes-caprae*, *Spinifex littoreus*, *Pandanus odoratissimus*, *Thuarea involuta*, *Bidens pilosa* var. *radiata*, *Berchemia lineata*, and *Vitex rotundifolia* (Table 1,2,3).

5. Conclusion

To summarize the discussion so far;

1) The coastal environment of Okinawa is not simply a place that supports plant life. On the contrary, it plays a large role in the cultural livelihood of the region's residents. The coast is a source of food, a place for recreation, and also an important place of worship for villages. In some regions especially, the virtuous sanctity of the natural coastal areas is fastidiously preserved for communication between people and the gods.

2) In Okinawa, the disaster prevention projects that have been carried out in coastal regions have been done without considering the nature and culture of the region. It appears that they have been carried out in a uniform manner aiming primarily at functionality. A number of construction techniques have been employed in Okinawa including upright, stepped and upright hollow-type projects. High upright concrete structures effectively divide the beach and the vegetation belts. They also make human access to the sea difficult and thus stepped and low-lying upright hollow-type embankments are becoming more prevalent.

3) Results of surveys on the relationship between coastal breakwater projects such as stepped / low-lying upright hollow embankments and the natural coastal vegetation show that moving from a natural beach environment to a low-lying upright hollow or stepped tide embankment tends to cause a reduction in the number of varieties of vegetation. The number of plant varieties showed a tendency to increase around 10-16m from the shoreline along sandy

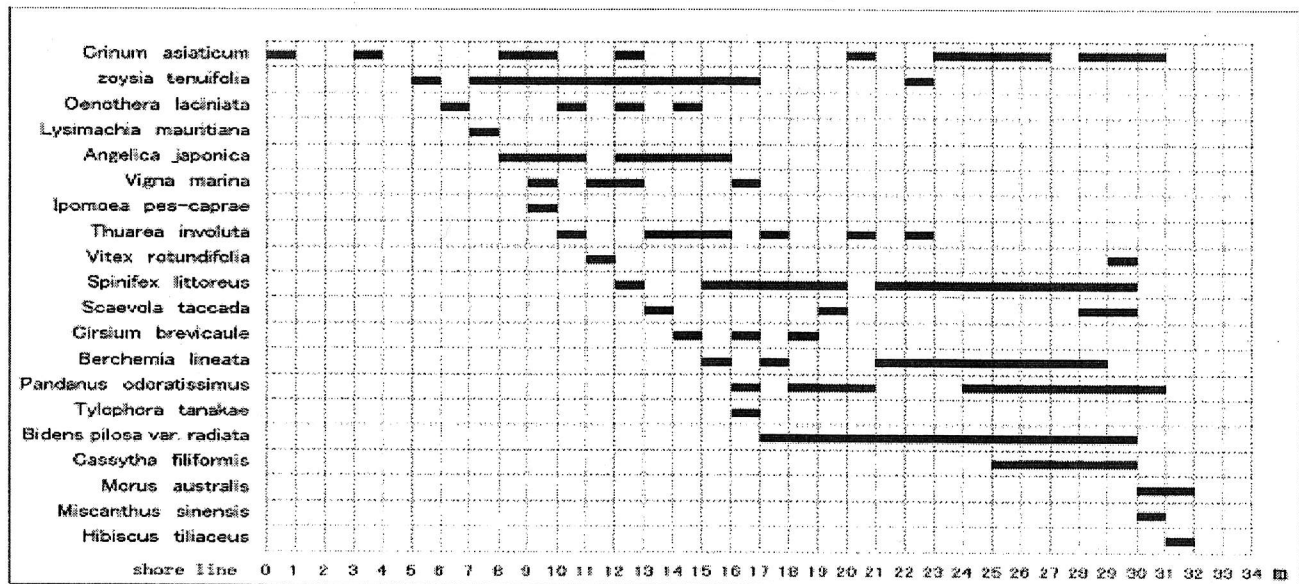
coasts. The reason for fewer varieties of vegetation in stepped embankment locations is thought to be the area needed for the stepped concrete in comparison to other construction methods. Sand that accumulates in the gaps between the steps with this construction method supports vines and creepers.

4) In comparison to stepped embankments, the reduced area needed for the construction of low-lying hollow tide embankments means there are more varieties of vegetation in the beach area. However, because the beach and the inland areas are cut off from each other, the continuity of the vegetation has been lost. On the other hand, despite the fact that the stepped embankments take over the beaches, they do create an environment whereby the vines and creepers can grow towards the inland areas.

The coast is the boundary between the land and the sea, and it is in such areas that sandy beaches, coral reefs, and coastal vegetation are grouped together in a diverse continuous space. The preservation and restoration of the nature and historic culture of these beach environments is a substantial problem confronting disaster protection projects in the coastal regions of Okinawa. This is also linked to the increasing value of such areas as tourism resources.

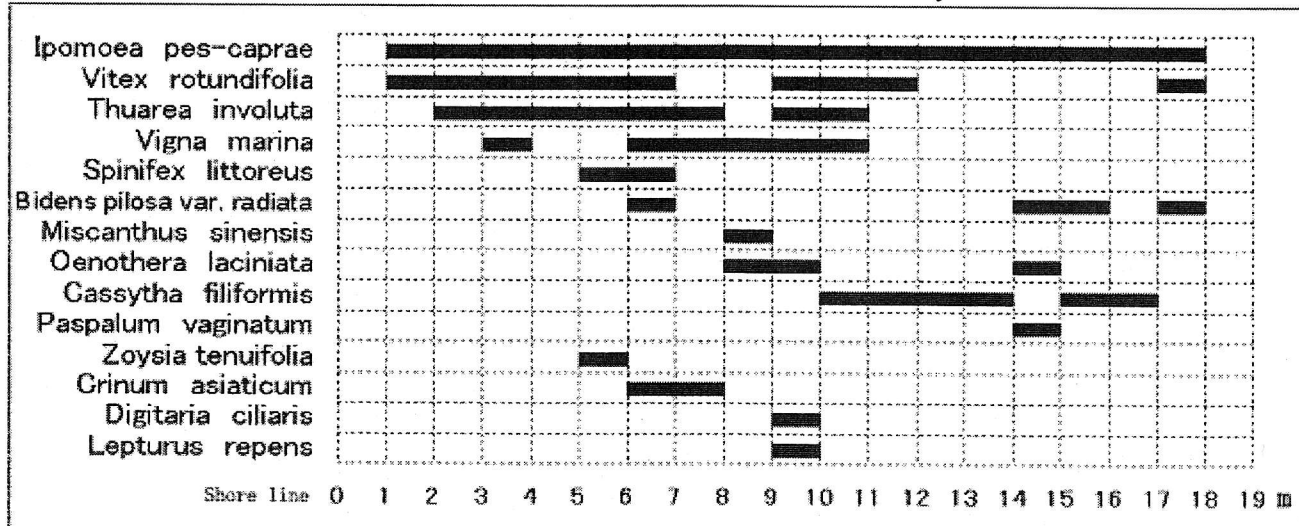
In future, with the employment of a simple assessment beforehand, public opinion on the value of nature can be ascertained, and from that an appraisal of the pros and cons of a project can be made. Moreover, depending on the location, in the case that coastal disaster prevention work is to be carried out, a more nature friendly construction method is needed.

Table 1. Number of plant varieties found on the natural sandy coast of Anje'ra on Tonaki Isl.



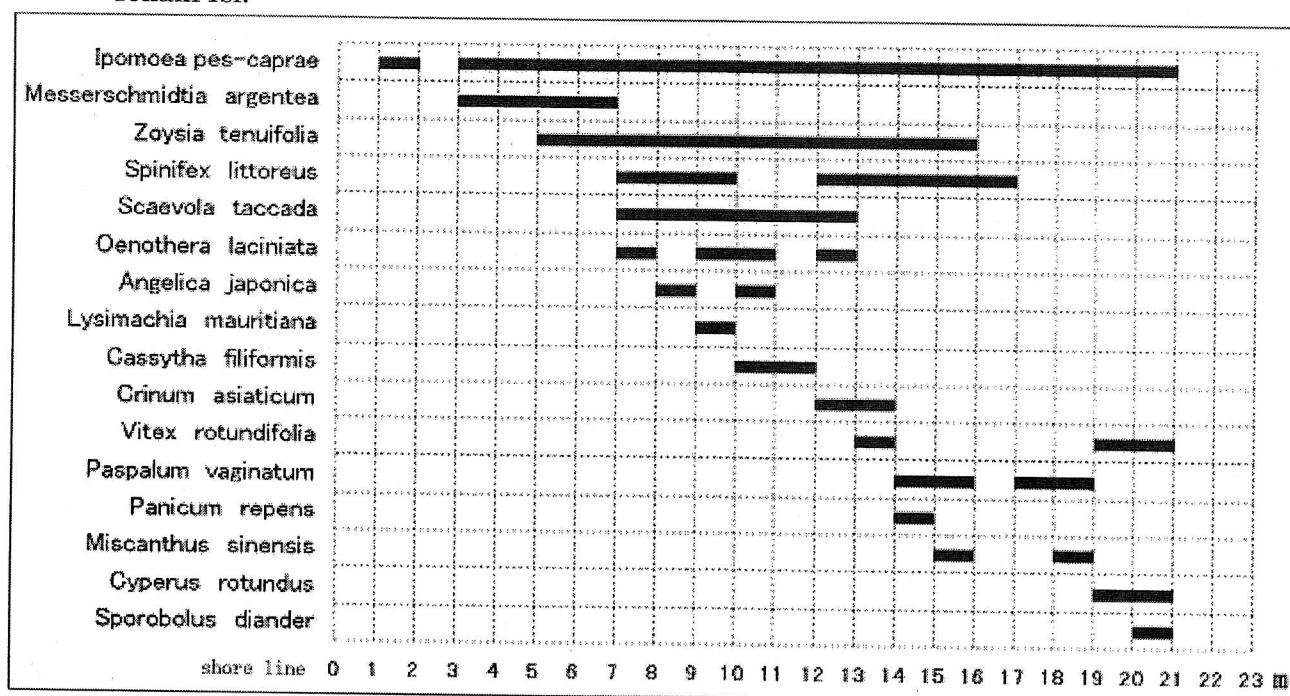
Note: Appearance of plant species from the shore line to the inland (Black line on the Table)

Table 2. Number of plant varieties found on stepped tide embankment beach of Anje'ra on Tonaki Isl.



Note: Appearance of plant species from the shore line to the inland (Black line on the Table).

Table 3. Number of plant varieties found on low-lying upright hollow tide embankment beach of Anje-ra on Tonaki Isl.



Note: Appearance of plant species from the shore line to the inland (Black line on the Table).

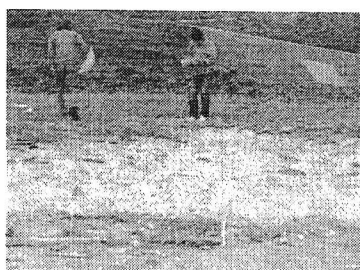


Photo 15. Photo of Table 1 (the natural sandy coast)

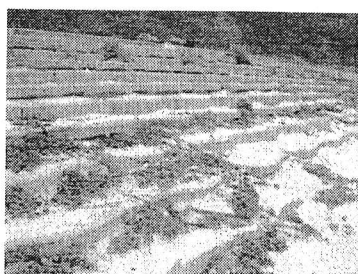


Photo 16. Photo of Table 2 (the stepped tide embankment)

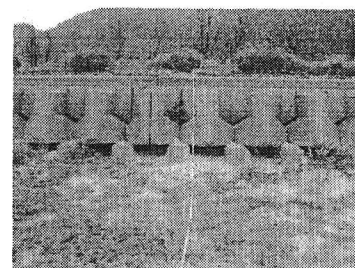


Photo 17. Photo of Table 3 (the low-lying upright hollow tide embankment)

References

- [1] Okinawa Prefecture Ministry of Agriculture, Forestry and Fisheries Green Promotion Section, Outline of Coastal Disaster Prevention Forestry Projects on Tonaki Island (1993-2002).
- [2] Okinawa Prefecture Ministry of Agriculture, Forestry and Fisheries Forestry Section / Green Promotion Section, Okinawa Forests and Forestry (2002), 111.
- [3] Sumihiko Hatsushima, Tetsuo Amano, Ryukyu Plant Catalogue, Deigo Publishing Company (1977).
- [4] Tonaki Village Office, Tonaki Village History, Vol. 1 (1983), 3-34.
- [5] Yui Nakama, The Consciousness of Forest Users, Research Report I on Forest Utilization mainly on the Okinawa Northern Region, Cabinet Office Okinawa General Bureau (2001), 52-60.
- [6] Yui Nakama, Zenfuku Koki, Eiji Nakada, Research of the Preservation of the Coastal Environment and Religious Ceremonies on Miyako Island, The Science Bulletin of the Faculty of Agriculture, University of the Ryukyus, 45 (1998), 109-126.

[Received January 15, 2003, Accepted June 10, 2003]