

## On the Fish Gathering Effect of the Artificial Reefs Ascertained by the Diving Observation - XIX At the Reefs Offshore of Tanegashima, Kagoshima Prefecture

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### Abstract

Five artificial reef sites in the vicinity of Tanegashima were investigated through underwater observation, as to the degree of shoaling, scouring, general condition, and fish gathering patterns. These reefs were located in relatively shallow sandy bottom areas, at depths from 12-28m. The reefs are generally of a single layer construction, with the blocks concentrated into an area with a maximum height of only 3m. The shallow reefs are generally subject to shoaling effects. Regions with sea beds showing sediment transport ripples have the highest shoaling effect. A maximum shoaling rate of 8-9cm/year was calculated for the reefs. Due to the shallow nature of these reefs, schools of the following larval fishes were observed in the shadow of the reefs: *Spratelloides japonicus* (banded blue sprat), *Apogon semilineatus* (bottom perch), *Trachurus japonicus* (Japanese horse mackerel), *Scomber japonicus* (mackerel), and *Lutjanus vitta* (brown striped snapper). Larger fish included *Oplegnathus fasciatus* (striped beak-perch), *Plectorhynchus pictus* (painted sweetlip), and *Prionurus microlepidotus* (surgeon fish), but in limited numbers. In order to form a productive reef, it seems necessary to build a reef in one to two piles, each of a 2-3 peaked type, and of a maximum height.

Key words: Artificial reef, Underwater observation, Fish gathering effect

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## Introduction

The area offshore of Tanegashima lies within the mainstream of the Kuroshio Current. The natural and artificial reefs in this area abound with high densities of resident populations of subtropical species. In particular, artificial reefs (hereafter simply referred to as reefs) built in the neritic zone, near the littoral zone show a high correlation between visibility (water quality), fish assemblages, and reef form (or shape). These factors are prerequisite to an effective reef, and constitute the main aspect of this research.

This research was conducted in the region south of central Tanegashima, in the littoral-offshore region. This paper reports the results of underwater research conducted at five reefs between 1982 and 1989.

## Methods

All of the reported data is based on underwater observation (SCUBA) and photography. Research points were based on shape of the reef structure, species composition, biomass, and position, degree of encrustation (biological), and the state of shoaling (buriedness), or scouring (exposure) of the reef. The reefs were constructed of iron-reinforced concrete blocks (hereafter referred to as blocks). The blocks were square cubic, either  $1\text{m}^3$  or  $1.5\text{m}^3$ . The reef sites which were investigated were 3 sites located off the west coast, and 2 sites off the east coast. These locations, and the scale of the reefs are shown in Figures 1. and 2.

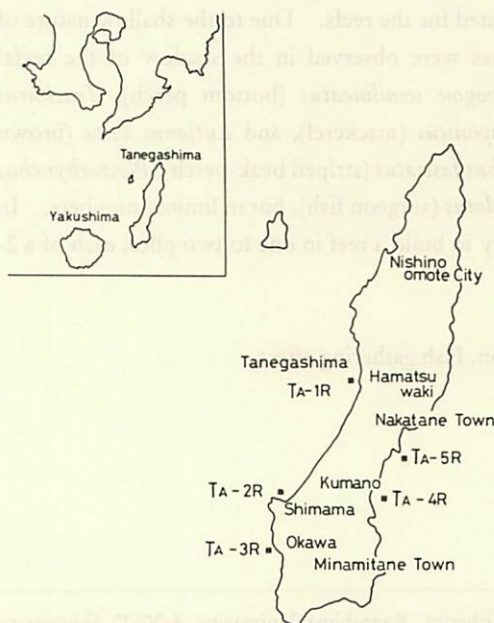


Fig. 1. Map showing reef locations in relation to Tanegashima.

■ reef

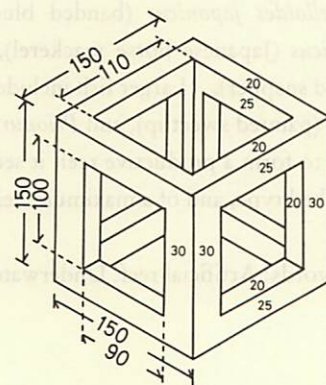


Fig. 2. Schematic of concrete block type of artificial reef. unit: cm

## Results

### TA-1 Reef (Observed on June 22, 1983)

This reef is located offshore of Hamatsuwaki, Nakatane-cho, at a depth of 16-19m. The dates of construction are 1976, and 1979. It is constructed of 226, 1.5m<sup>3</sup> blocks. The reef is arranged in three long and narrow groups, along an east-west axis. The blocks are positioned with a spacing of 3, and 7m, and a maximum length of 65m. The central portion of each group is arranged in a double layer. The sea bottom at the periphery of the reef is mostly flat, with a gravelly substrate. There are wide areas of exposed bedrock visible in the area.

The reef is mostly exposed (very little shoaling has occurred), and blocks are encrusted mostly with green and coralline algae. Due to the abundance and diversity of fishes, this can be considered an excellent reef.

The northernmost group of blocks was large in size and had the highest density of schooling fishes associated with it. The fish were distributed at the upper limits of the reef. Species found within the blocks, and in the peripheral areas include *Oplegnathus fasciatus*, *Oplegnathus punctatus*, *Prionurus microlepidotus*, *Calotomis japonicus*, *Zanclus cornutus*, and *Apogon semilineatus*. In the region approximately 5-6m above the reef were schools of larval *Trachurus japonicus* and *Scomber japonicus*. A school of *Elagatis bipinnulata* was seen slightly separated from the reef. *Sarda orientalis* and *Seriola quinqueradiata* were seen circling around at the maximum effective height of the reef.

### TA-2 Reef (Observed on June 23, 1983)

This reef is situated off the breakwater of Shimama Port, Minamitane-cho. It consists of 570, 1m<sup>3</sup> blocks, set over a 3 year period, from 1971-1973. It is located at a depth of 12m, which is extremely unusual for a block reef.

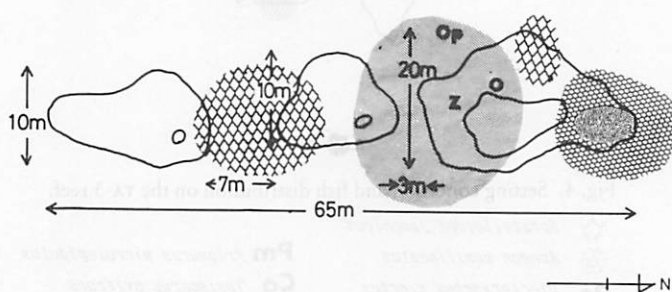


Fig. 3. Setting condition and fish distribution on the TA-2 reef.

-  *Prionurus microlepidotus*
-  *Apogon semilineatus*
-  *Calotomis japonicus*
-  *Trachurus japonicus*
- Op** *Oplegnathus punctatus*
- O** *Oplegnathus fasciatus*
- Z** *Zanclus cornutus*
-  Artificial reef Boundary



The setting condition of the reef is shown in Figure 3. It is basically a long and narrow reef, set on an east-west axis, with a maximum length of about 70m. Patches with two levels of blocks are scattered across the reef. Most of the blocks show partial shoaling, in the range of 30-80cm, or roughly half of the block.

A large school of *Spratelloides japonicus* was visible at the extreme upper functional region of the reef. The periphery contained *Oplegnathus punctatus*, *Oplegnathus fasciatus*, *Prionurus microlepidotus*, and *Plectorhynchus pictus* schools. *Apogon semilineatus*, and *Ypsiscarus ovifrons* were also seen inside the reef.

#### TA-3 Reef (Observed on June 23, 1983)

This reef is located offshore of Okawa River, Minamitane-cho, at a depth of 17m. It was constructed of 362, 1m<sup>3</sup> blocks, over the three year period from 1976-1978. The sea bottom is flat, with large rocks scattered about. There is a natural reef with a relief of approximately 7m located nearby.

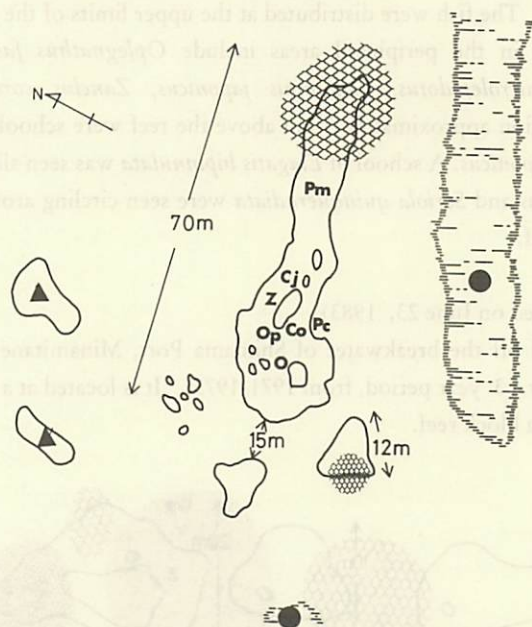
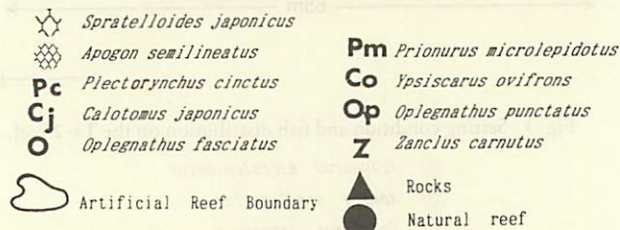


Fig. 4. Setting condition and fish distribution on the TA-3 reef.



The reef consists of two groups of blocks, set about 10m apart. One group consists of two levels of blocks, the other of one layer.

The main species gathered at this reef was a large school of *Microcanthus strigatus*, but *Lutjanus russelli*, *Lutjanus vitta*, *Prionurus microlepidotus*, and *Pseudupeneus chrysopleuron* were

also present.

#### TA-4 Reef (Observed on October 18, 1983)

This reef is located off of Kumano Port, the Pacific coast of Nakatane-cho, at a depth of 24m. It consists of 100, 1m<sup>3</sup> blocks, set in 1960. The surrounding bottom is generally flat and sandy. As shown in Figure 4., the reef was set with a wide range of spacing between the blocks, roughly 5-20m, but slightly more concentrated at the central portion. This stable condition is visible in the photographs (Plate III). The blocks lie in a depression caused by wave action, of about a 5m radius from the block center. The blocks are thus shoaled in this way. An interesting phenomenon is that the blocks only become buried to a depth of about 20-30cm. This seems to possibly be caused by the fact that storm currents (such as caused by typhoons) come from all directions.

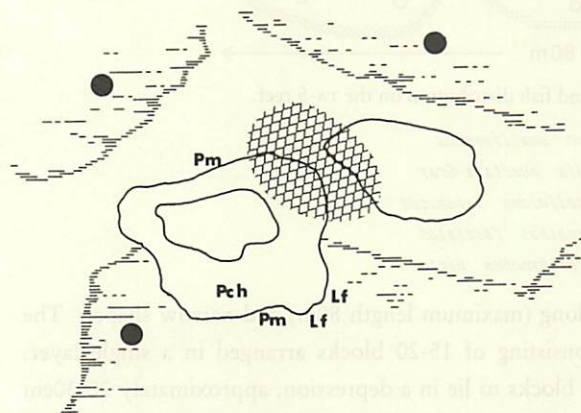


Fig. 5. Setting condition and fish distribution on the TA-3 reef.

- Microcanthus strigatus*
- Pm* *Prionurus microlepidotus*
- Pch* *Upeneus bensasi*
- Lf* *Lutjanus fulvus*
- Natural reef
- Artificial Reef Boundary

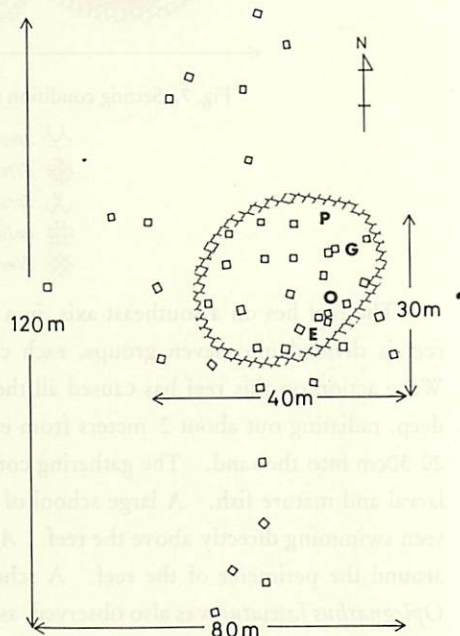


Fig. 6. Setting condition and fish distribution on the TA-4 reef.

- Apogon semilineatus*, *Lutjanus vitta* and *Zanclus cornutus*
- P* *Plectorhynchus pictus*
- O* *Oplegnathus fasciatus*
- E* *Epinephelus chlorostigma*
- G* *Girella punctata* Gray

The central portion of the reef has the highest production, due to the smaller gaps between the blocks. The photograph (Plate III) shows that within roughly a 5m radius from the center of the block, just above the sea floor there are schools of *Lutjanus vitta*, *Plectorhynchus pictus*, *Oplegnathus fasciatus*, *Epinephelus chlorostigma*, *Girella punctata*, juvenile *Apogon semilineatus* and *Seriola purpurascens*, as well as *Zanclus cornutus*. These schools seemed to occupy well defined regions of the reef. Especially large schools of both *Lutjanus vitta* and *Zanclus cornutus*



were noted to occupy the reef.

#### TA-5 Reef (Observed on September 22, 1989)

This reef is located off the Pacific coast of Nakatane-cho. It was set in April 1988, and consists of 119, 1.5m<sup>3</sup> blocks, set in 26m. The sea bottom surrounding the reef is mostly sandy, with clearly visible ripples.

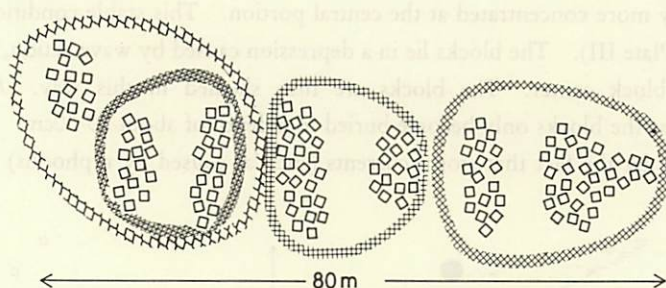







Fig. 7. Setting condition and fish distribution on the TA-5 reef.

-  *Apogon semilineatus*
-  *Girella punctata* Gray
-  *Spratelloides japonicus*
-  *Oplegnathus fasciatus*
-  *Plectorhynchus pictus*

The reef lies on a southeast axis, in a long (maximum length 80m) and narrow shape. The reef is divided into seven groups, each consisting of 15-20 blocks arranged in a single layer. Wave action on this reef has caused all the blocks to lie in a depression, approximately 20-30cm deep, radiating out about 2 meters from each block. The blocks also lie partially buried, about 20-30cm into the sand. The gathering conditions showed distinct separation between schools of larval and mature fish. A large school of larval *Spratelloides japonicus* (5-6cm body length) was seen swimming directly above the reef. *Apogon semilineatus* (1-2cm body length) were observed around the perimeter of the reef. A school of approximately 20 large (40-45cm body length) *Oplegnathus fasciatus* was also observed, as well as *Girella punctata* and *Plectorhynchus pictus*.

### Discussion

All of the reefs studied were of either the 1m<sup>3</sup> or 1.5m<sup>3</sup> cubic concrete blocks. They were typically set in shallow water, ranging from 12 to 26m. Excluding the TA-4 reef, the other reefs were all made by grouping blocks into a low structure, with a maximum height of less than 3m. The TA-4 reef was set with the blocks distributed in a more random pattern. The area of these reefs is often subject to the effects of typhoons, as well as strong northerly winter winds. These conditions result in strong wave action on the reefs. Similarly, the locations near the center of the Kuroshio Current also results in the reefs being exposed to constant, fast currents, resulting in phenomenon such as burial and exposure of the reefs. From this field work, the phenomena of burying is best seen in the TA-2 reef, while exposure is seen in the TA-1 reef.

Around the TA-2 reef, wave ripples in the substrate are visible due to the strong wave action, and the blocks show a very high burial rate, of about 8-9cm/year. The TA-4 reef is constantly subject to fast currents from all directions, and results in the blocks all settling into a small crater that develops around the blocks. This settling rate (resulting in the crater) was shown to be 1m/23years, or 4.4cm/year. Because this type of wave and current action result in burial and exposure of the reefs, the TA-1 and TA-3 reefs were set on a bedrock substrate, or a hard sea bottom.

Table 1. Fishes observed on each artificial reef.

Reef No.	Species	Fork length (cm)	Number
TA-1	<i>Prionurus microlepidotus</i>	40	50
	<i>Apogon semilineatus</i>	3~4	School
	<i>Calotomus japonicus</i>	25	10
	<i>Trachurus japonicus</i>	15~20	School
	<i>Oplegnathus punctatus</i>	50	Several
	<i>Oplegnathus fasciatus</i>	38~45	Several
	<i>Zanclus cornutus</i>	40	20
	<i>Sarda orientalis</i>	40~45	School
	<i>Seriola quinqueradiata</i>	45~50	School
TA-2	<i>Spratelloides japonicus</i>	—	Large school
	<i>Apogon semilineatus</i>	3~4	School
	<i>Prionurus microlepidotus</i>	35	5~6
	<i>Plectorhynchus cinctus</i>	40	5~6
	<i>Callyodon ovifrons</i>	80	1
	<i>Calotomus japonicus</i>	40	5~6
	<i>Oplegnathus punctatus</i>	45	1
	<i>Oplegnathus fasciatus</i>	45	2
	<i>Zanclus cornutus</i>	20~30	10
TA-3	<i>Microcanthus strigatus</i>	—	Large school
	<i>Prionurus microlepidotus</i>	35	Small school
	<i>Upeneus bensasi</i>	25	10
	<i>Lutjanus vitta</i>	35	School
TA-4	<i>Lutjanus vitta</i>	7	Large School
	<i>Plectorhynchus pictus</i>	45	20
	<i>Oplegnathus fasciatus</i>	40	Several
	<i>Epinephelus chlorostigma</i>	40	Several
	<i>Girella punctata</i> Gray	—	—
	<i>Apogon semilineatus</i>	1~2	School
	<i>Seriola purpurascens</i>	5	Large school
	<i>Zanclus cornutus</i>	40	Large school
TA-5	<i>Apogon semilineatus</i>	1~2	Large school
	<i>Spratelloides japonicus</i>	5~6	Large school
	<i>Plectorhynchus pictus</i>	45	Several
	<i>Oplegnathus fasciatus</i>	40	20
	<i>Girella punctata</i> Gray	40	Several
	<i>Lutjanus sebae</i>	30	School
	<i>Platax orbicularis</i>	20	School

In terms of the fish gathering on the reefs, the most prevalent were schools of small fish, such as *Spratelloides japonicus*, and *Apogon semilineatus*. Schools of juvenile *Seriola purpurascens* were also commonly seen. Schools of larger fish, such as *Oplegnathus fasciatus*, *Oplegnathus punctatus*, *Plectorhynchus pictus*, *Prionurus microlepidotus*, and *Lutjanus vitta* often gathered around the reefs.

Generally speaking, fish tend to school over the regions where the blocks are piled to some height. For this reason, it seems that reefs should generally be constructed from either one or two piles of blocks, gathered to a height of 3-4m, and generally in a double or triple mountain (peak) design.

### Acknowledgement

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A



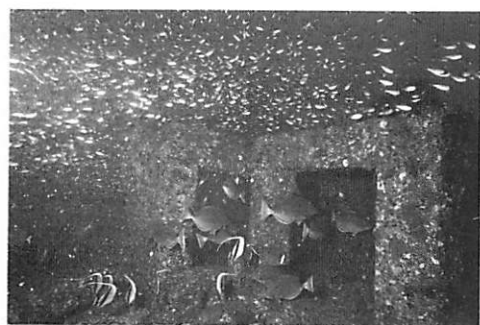
D



B



E



C



F

Plate I. A-C : TA-1 reef D-F: TA-2 reef



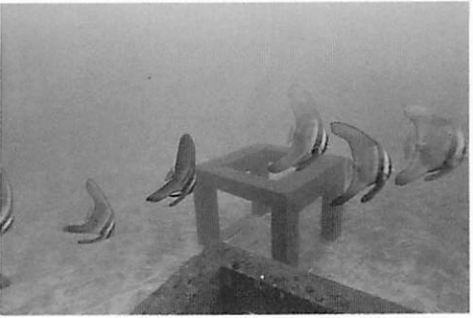
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D



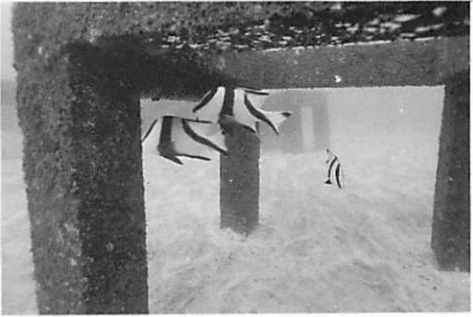
B



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F

Plate II. A-C : TA-3 reef D-F: TA-5 reef



Plate III. TA-4 reef

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