Appendix 3 Spot Check Method for coral reef monitoring

INTRODUCTION

The Spot Check method is a monitoring method to evaluate the coral reef condition at a number of fixed sites by visual census during 15 minutes of snorkeling. The advantages of this method are; 1) requires only a few manpower (two observers at a time), 2) requires only a short time (15 minutes per each site, and compiling of the data is also easy), 3) does not require special qualification (e.g. scuba skills and knowledge on coral taxonomy), 4) can cover wide area (ca. 2500 m^2 per station), and 5) covers wide range of information (not only corals but also *Acanthaster*, *Drupellas* and other disturbances on coral reef). As this method uses visual assessment, some initial training is required for accurate assessment. Although the variance between experienced observers and beginners can be as much as 20% on coral coverage, this difference can be minimized through training with the skilled person. Averaging data of number of observers can also minimize the deviation. This manual has been developed based on the original procedure of the coral reef monitoring in Sekisei Lagoon (Marine Parks Center of Japan 2001) and introduced new parameters such as the number of juvenile coral colonies and the size range of *Acanthaster* (Okinawa Prefecture 2002).

BACKGROUND

Coral monitoring with spot check method has been developed by Yaeyama Marine Park Research Station, Marine Park Center in 1983 and conducted annually aimed to management of coral reefs in Sekisei Lagoon and effective control of *Acanthaster*. The Ministry of the Environment has had an initiative to continue the monitoring in Sekisei Lagoon since 2002. This method has been introduced to other monitoring programs such as, monitoring around Ishigaki Islands by the Ministry of the Environment since 1999 (Marine Parks Center of Japan 2001, International Coral Reef Research and Monitoring Center 2003), voluntary monitoring called “My Point Check” in Yaeyama waters by Yaeyama Coral Reef Conservation Committee since 1999 (Yaeyama Coral Reef Conservation Committee 1999, 2000, 2001）, rapid survey on *Acanthaster* by Okinawa Prefectural government since 2002 (Okinawa Prefecture 2002).

GENERAL PROCEDURE

The spot check method is used to evaluate annual changes of the coral reef condition in broad area using visual assessment of the site which are selected in a target broad area. Observers assess the reefs in the sites during snorkeling according to the monitoring parameters described below. In addition, bottom sediment can be collected during this survey for SPSS (content of Suspended Particles in Sea Sediment）measurement, which is a rapid assessment of sedimentation developed by the Okinawa Prefectural Institute of Health and Environment.

- The observers (two researchers) reach each site by the boat using GPS.
- At the site, each observer record data of the monitoring parameters using the snorkeling around the area covering approximately 2500 m^2 randomly for 15 minutes individually.
- Underwater photographs are taken as visual records.
- The data of both researchers are averaged or compiled, it is used for the analysis.

PERSONNEL AND EQUIPMENTS

- Two observers / researchers (requires snorkeling skills)
- A small boat with motor for the shallow waters
- Map or a hydrographic chart of the area
- A set of snorkeling equipment
- A GPS
- Data sheets: plastic clip board, underwater paper, and pencil (attached with the board with a string)
- Underwater camera (digital camera is convenient)
- A set of equipment for SPSS (= content of Suspended Particles in Sea Sediment) measurement: 250ml -500ml plastic container with seal (as much as number of points), sieve (ca. 4mm mesh), 2 and 5 ml measuring spoon (× 1, respectively), 500 ml plastic bottle with cap (× 1), a funnel, and 30 cm transparency meter.

MONITORING PARAMETERS TO BE RECORDED

The practical parameters for Spot Check method are listed below. A necessary minimum set of the parameters are; 1, 2, 3, 4 and 5 of biological parameters, 11, 12 and 13 of physical environmental parameters, and 15 and 16 of special remarks. Parameters 6, 7, 8, 9, 10 and 14 are more likely for experienced observers. These parameters can be selected depending on the purpose of the monitoring and the capacity of the observers.

(1) Biological parameters ●：***minimum*** ○：***options***

●	1. Live coral coverage (%)
●	2. Dominant lifeform categories
●	3. Number of *Acanthaster planci*
●	4. Dominant size of *A. planci*
●	5. Size range of *A. planci*
○	6. Rate of bleached corals (%)
○	7. Number of juvenile coral colonies (in categories)
○	8. Colonial size of large tabulate *Acropora*
○	9. Number of corallivous gastropods (in categories)
○	10. Number of large sized sessile fishes

(2) Physical environmental parameters

●	11. Geographic features
●	12. Benthic features
●	13. Depth range
○	14. Sedimentation level

(3) Special remarks

●	15. Other disturbances on corals
●	16. Peculiar phenomenon or organisms

Details of these parameters are described below.

(1) Biological parameters

(1)-1. Live coral coverage:

The live coral coverage is the percentage of visually estimated, projected area of live corals on a substrate (attachable substrate for corals, excluding mud and sandy bottom). When live coral cover does not reach 10 %, lesser digit (e.g. less than 10 % or less than 5 %) can be applied. Training using schematic representations of percent cover (fig. 1) is useful for accurate estimation. 15-minutes observation can be divided into 3 of 5-minutes observation to record more detailed information.

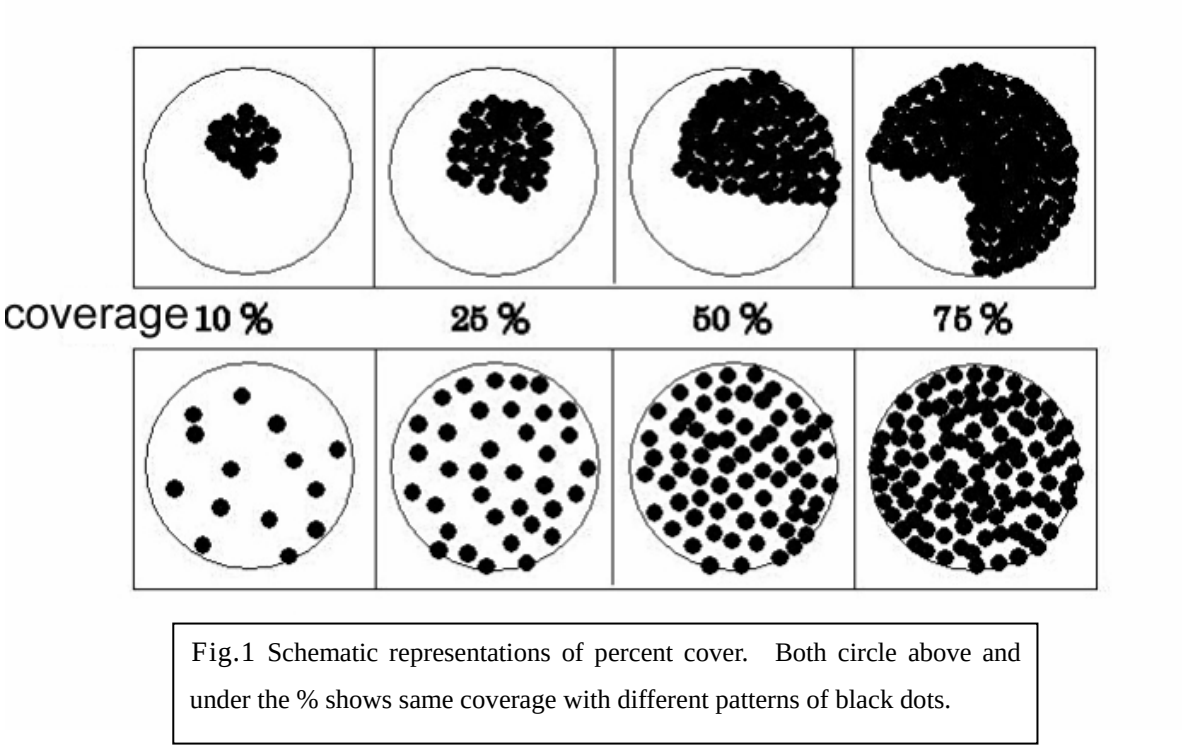

Fig.1 Schematic representations of percent cover. Both circle above and under the % shows same coverage with different patterns of black dots.

* This survey targets all hermatypic corals including Order Milleporina in Class Hydrozoa, Order Stolonifera and Helioporacea in Subclass Octocorallia, Class Anthozoa, and Subclass Hexacorallia in Class Anthozoa. Although soft corals are not included in the coral cover, when they are abundantly observed in the sites, it is recommended to estimate and record their coverage separately.

Table 1. Index of coral reefs' 'health' from the estimated coverage.

Coverage (%)	Evaluation
0-9	extremely poor
10-24	poor
25-49	rather poor
50-74	rich
75-100	especially rich

(1)-2. Types of coral community

Coral communities of the stations are identified into 6 categories focusing on dominant corals. The categories are; 1) branching *Acropora* dominant type, 2) tabulate *Acropora* (including corymbose) dominant type, 3) branching and tabulate *Acropora* mixed type, 4) specific species dominant type (record the dominant species, aside from *Acropora*), 5) multi-species mixed type (no dominant corals), and 6) soft coral dominant type. The term 'dominant' here means, coverage of which exceeds 60%. 'Soft coral' is defines as

all the species belonging to Order Stolonifera (excluding genus *Tubipora*) and Alcvonacea in Subclass Octocorallia. When the station is categorized as “soft coral dominant type”, coverage and dominant species of soft corals are recommended to be recorded.

(1)-3. Number of *Acanthaster planci*

The number of *A. planci* individuals are counted during 15 minutes snorkeling swim. When the starfish have a large population and too many to be counted (e.g., during intensive outbreak), the period of counting can be reduced. The data should be converted to the number per 15 minutes.

$$\text{Number of } A.\ planci \text{ / 15 minutes} = \frac{\text{Number of } A.\ planci \text{ observed x 15}}{\text{Observation time (minutes)}}$$

The number of starfish has to be counted from sea surface during snorkeling, but not to be searched under the corals or the niches. However, when scars of predation were found but not the starfish itself, observers can search for the starfish for affirmation. Table 3 shows the indication of the outbreak from the number of *A. planci* observed.

Table 3. Indication of *Acanthaster planci* outbreak from counted number of individuals during 15 minutes swim.

Count per 15 min.	State of outbreak
0-1	ordinary
2-4	abundant (warning)
5-9	pre-outbreak
< 10	outbreak

(1)-4. Dominant size of *Acanthaster planci*

The dominant size class of observed *A. planci* are recorded in three categories (< 20 cm, 20-30 cm, and 30 < cm). The approximate diameter (from the tip of the arm to another tip at opposite side) can be roughly estimated using a size of hand, or clipboard. When the size class ranges widely, it can be estimated from taking the average of first 10 encountered individuals.

The size estimation of the starfish will help to understand the approximate age of *A. planci* population. In general, *A. planci* reaches up to 20 cm in diameter in two years and start to be matured. The food consumption reaches to maximum after three years and becomes 30 cm or larger. The outbreak becomes obvious at a size class of 20-30 cm or more than 30 cm.

The forecast of *A. planchi* outbreak based on the distribution of juvenile starfish (Yokochi 1988) is tried in Okinawa, so it is recommended to record it as a special remarks, when numbers of juvenile starfish were observed.

(1)-5. Size range of *A. planci*

Record the minimum and maximum diameter of *A. planci* observed during 15 minutes snorkeling.

(1)-6. Rate of bleached corals

It is the rate of bleached and dead (which were considered to have died due to bleaching) colony among total live coral (including dead but which could be considered alive before bleaching) cover. This parameter is taken only when coral bleaching were observed. It is estimated with the formula below.

$$\text{Rate of bleached corals (\%)} = \frac{\text{bleached corals} + \text{dead corals due to bleaching}}{\text{Live coral} + \text{bleached corals} + \text{dead corals due to bleaching}}$$

(1)-7. Number of juvenile corals

The approximate number of juvenile colonies (5 cm or less in diameter) of *Acropora* species found within 1 m^2 on shallow reef flat or patch reefs will be recorded in a category of the followings: 1) non, 2) 1 or 2, and 3) 3 or more. The juvenile colony of 5 cm or less can be considered to have recruited within past two years. The abundance of *Acropora* recruitment will be useful for the foresight of recovery from the serious disturbance of coral communities.

(1)-8. Colonial size of large tabulate *Acropora*

The diameter of 5 largest colonies of tabulate *Acropora* (*Acropora hyacinthus*, *A. solitaryensis*, and *A. cytherea* etc.) will be recorded roughly and will be averaged. The size of tabulate *Acopora* can serve as an indicator on coral reef recovery. Table 2 shows the recovery phase and approximate age of coral community from the size of the largest *Acropora*.

Table 2. Approximate recovery phase and age of coral community from the largest size of tabulate *Acropora* in diameter

Size (cm)	Recovery phase	Approximate age
25 <	initial stage	0-5
25-99	prior stage	5-10
100-199	middle stage	10-15
< 200	later stage	< 15

(1)-9. Number of coral eating gastropods

The number of coral eating gastropod (Genus *Drupella*) will be recorded with the following category:

I) scars of predation are indistinctive,

II) Some small scars of predation can be observed on several corals,

III) Conspicuous scars of predation can be seen on many corals, but large mass of gastropods (more than 100 individuals) has not occurred,

IV) Many coral colonies are dead by the predation and large mass of gastropods can be seen.

The coral eating gastropods especially *Drupella fragum* and *D. concatenata* sometimes cause outbreak and disturbs coral communities considerably as *A. planci*. It occurs predominantly in subtropics areas in the mainland Japan (e.g., Nichinan in Kyushu, Uwakai and Ashizuri in Shikoku, and Kushimoto in Kii Peninsula). *Drupella* can be seen commonly in coral distributed region, but these two species forms a group and acquire mobility, and sometimes forms a mass of several thousands of individuals. When such a group were formed, coral coverage rapidly decreases (Nomura and Tominaga 2001).

(1)-10. Number of large sized sessile fishes

When large sized sessile fishes (e.g. grouper, gilthead, and parrotfish, but excluding migratory fish) of 30 cm or larger were observed, its species name and number of individuals were record. The number of these fishes will indicate fishing pressure around the sites.

(2) Physical environmental parameters

(2)-1. Topographic features

The topographic features of the survey site will be recorded with the following category: moat, patch reef, reef flat, and reef flat (see also Fig. 2). As for non-reefal region, the category can be either; inner bay, outer sea, and offing bank.

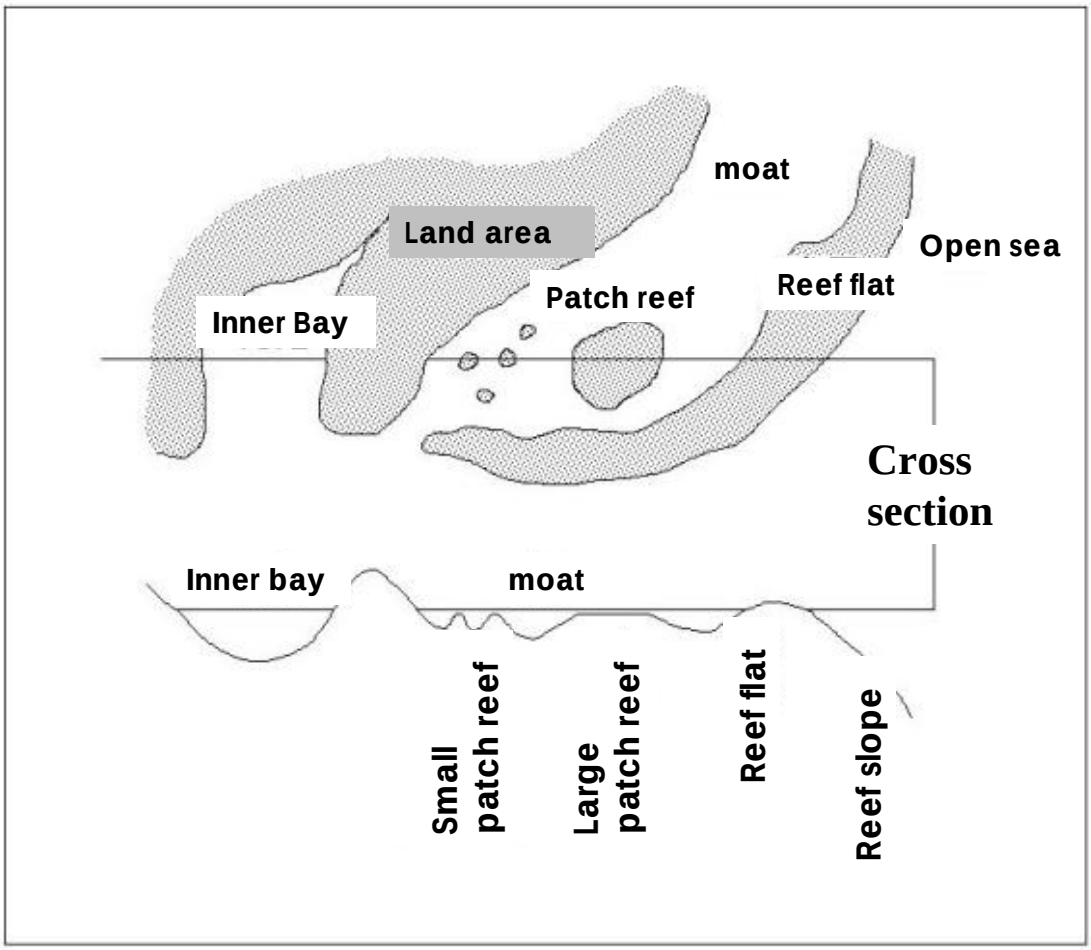

Fig. 2 Topography of the coral reef area

(2)-2. Substrate

The benthic features of the survey site will be recorded with the following category: carbonate, rubble, sand/rubble, sand, and mud.

(2)-3. Depth range

The approximate depth range of the surveyed sites by visual estimation will be recorded.

(2)-4. Level of sedimentation (SPSS measurement)**

Sediment samples is collected at the surface layer of sea bottom of the sites for SPSS. The method was developed by the Okinawa Prefectural Institute of Health and the Environment to monitor red soil pollution in 1985 (Omija 2001; Omija in press). It is also applicable to monitor the sedimentation level of terrestrial soil run-off in mainland as well.

(3) Special remarks

(3)-1. Other coral disturbing factors:

When other coral disturbing factors was recognized, record its factor and extent of the damage. The correspond factors are; eg., Coral bleaching event, *Acanthaster planci*, coral eating gastropods, accumulation of silts, drainage discharges, anchoring damages, and

typhoon destruction.

(3)-2. Peculiar phenomenon or organisms:

Record the encountered peculiar phenomenon (e.g. spawning behavior) or rare species when observed. Special remarks' column can be utilized for such personal notes. When large sized sessile fishes ((1)-10) were observed, record in this column.

COMMENTS

a. Site selection:

Sites are selected based on the fallowing information: A) where high coral coverage or important communities exist, B) where such communities had been recorded, C) where it had been utilized as study sites for other survey and their data are available, and D) where were considered important for long term monitoring. The sites should be selected for long term monitoring, but not a temporary show off the abundance of corals at the sites. Moreover, the location and the number of sites should be selected considering the repeatability for long term, meaning that it can be undertaken once a year without any difficulty. The minimum area is approximately 5 km^2 and less than 10 points per day.

b. Target Area:

The target of this monitoring is basically the area that can be observed during 15 minutes snorkeling and it is estimated about 50m $\times$ 50m (2,500 m^2). Although the area does not need to be a square shape, geographical features and approximate scale of the sites should be noted with GPS data to ensure monitoring of he same area. If specific colonies or communities are selected for the monitoring, the approximate area should be recorded every year to and Surrounding area of the target site can be selected as another monitoring site.

c. Timing of the survey:

It is recommended that the survey be conducted during late summer to fall to assess the impact of coral bleaching by high water temperature during the summer. Although the survey is possibly done in other season, it should be fixed in certain time annually to evaluate the change and trend

d. Period of observation:

Observation should be done in 15 minutes basically. To observe larger or smaller area, period of observation could be changed, but the number of *Acanthaster* counted should be calculated into 15 minutes to compare with other sites .

c. Visual record:

Underwater photograph is important data to overview the site and it provides more useful information if the photograph takes the same view of the site from fixed angle of the camera. It is recommended to select an area, which geographically or ecologically represents the site.

d. Use of SCUBA:

Spot check method has been developed for a snorkel survey. When the stations are deeper than 10 m in depth or in turbid water, it is difficult to observe the coral condition with snorkeling from the sea surface. SCUBA could be used for the survey in those conditions. However, there is a difference on the scope between snorkeling and SCUBA survey and the quality of the data also

possibly have difference between these two methods. It should be noted on the data sheet which method was used for the survey.

e. Measurement of water temperature

Since coral bleaching has been occurred frequently, monitoring of water temperature is an important task for prediction of the impact. There are some reasonable automatic temperature measurement devices, called data logger, has been developed for underwater use. To detect the trend of water temperature, it is recommended to use these devices.

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****PROCEDURE OF SPSS (content of Suspended Particles in Sea Sediment) MEASUREMENT.**

(cited from website of Okinawa Prefectural Institute of Health and the Environment in Japanese, http://www.eikanken-okinawa.jp/suiaka/akatuti/akahp/Spss.htm)

1: Collect the sediments from the surface layer of sandy bottom where it is though to represent the benthic feature of the target site. Fill up the 250 ml measurable container with the sediments, seal it tight, and bring up on the boat. The sediment samples will be collected by two divers respectively on each site, and brought back to the lab.

2: Leave the container still to precipitate fine particles and discard the supernatant water. Sieve the taken sediments through 4 mm mesh and exclude shells and pebbles. Each set of particles received after sieving and some mixture will serve as the analytical sample.

3: Measure out 5 ml of the analytical sample with the 5 ml measuring spoon (use the 2 ml one when it is abound with silts). Pour the sample with clean fresh water into the 500 ml plastic bottle with cap(commercially available 500 ml plastic bottle for drinking water) and mess-up to 500 ml. Shake the bottle intensely to extricate the sediments in water.

4: Leave the container still for one minute. The supernatant fluid will be the test water.

5: Pour the liquid into the 30 cm transparency meter and measure the transparency. When transparency was greater than 30 cm or less than 5 cm, adjustment is necessary.

6: Evaluate the rate of SPSS using below formula.

SPSS = (1.718 / transparency – 17.8) × dilution rate / amount of the sample

The required time for the above procedure is approximately 10 minutes for one sample. It can be done in about 5 minutes when skilled. An adjustment of dilution rate is often necessary when measuring with the transparency meter. The below table (Table 1) shows the correspondent state of the benthic feature with the SPSS level. It is considered that the area is under the red soil pollution caused by anthropogenic factor when the rank was greater than 6. SPSS often show seasonal fluctuations where it tends to be high during and after rainy season and adversely low during typhoon and monsoon seasons due to re-suspension of sediments by the waves. Therefore, such seasonality should be taken into consideration in order to understand the state of the red soil pollution.

Table 1. Relationship between SPSS value and visually observed benthic properties

Rank	SPSS (kg/m^3)	Benthic properties
1	0.0-0.4	Extremely clean and clear
2	0.4-1.0	Fine particles are not easily suspended even when bottom sediment is stirred.
3	1-5	Fine particles can be suspended by stirring the bottom sediment.
4	5-10	Water becomes little turbid when bottom sediment was stirred.
5	10-30	Fine particles can be observed on the surface of bottom sediment by careful observation.
6	30-50	Dust-like fine particles cover the sediment surface.
7	50-200	Sediments such as red soil can be seen at glance. Obvious pollution.
8	200-400	Sedimentation of red soil is remarkable, but sand can still be seen. Obvious pollution.
	400 <	Feet get bogged in mud. Sands can rarely be observed.

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