

From the drawing board to the field: an example for establishing an MPA in Penghu, Taiwan

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ABSTRACT

1. In order to promote the establishment of the first marine protected area (MPA) in Taiwan, the conservation values of 12 reef sites in the Penghu Islands were evaluated. The results together with a 6-year surveillance programme revealed that the Chinwan Inner Bay (CIB) possesses the best coral community in the Penghu Islands with the highest coral cover, high species diversity and habitat types, as well as a high conservation value.

2. Utilization of biological resources and socio-economic factors of CIB were investigated by intensive field surveys and a complete visit-and-poll survey respectively. Most of the fishing at CIB is for recreational purposes and is characterized by low investment, low harvest rates, high dependence on weather conditions, and self-consumption.

3. The socio-economic data showed that there was basically no direct conflict of interests with local communities at two neighbouring villages, and most local residents indicated that they would support the MPA proposal.

4. A blueprint for a CIB MPA based on the results of these biological and socio-economic investigations is proposed. Environmental threats including anchor damage and the predation of *Drupella* snails need to be ameliorated and monitored through the implementation of appropriate management. The involvement of local communities is key to the success of this MPA and environmental education is recommended to promote public awareness.

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KEY WORDS: marine protected area; coral community; artisanal fishery; socio-economic value; conservation value

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INTRODUCTION

Over the past 20 years, attention has been given to the need for conservation of marine ecosystems, and the establishment of marine protected areas (MPAs) has been widely recommended as an effective mechanism for protecting marine biological resources (Sumaila, 1998; Stevens, 2002). There is a growing consensus that MPAs can act as an integral component of any marine management plan (Lauck *et al.*, 1998; Alder *et al.*, 2002), and designating a certain portion of the total marine area as MPAs has been suggested in order to maintain sustainable fish stocks (Costanza *et al.*, 1998). Decision makers, managers and scientists are eager to establish quantitative or empirical bases as to the minimum size of MPAs necessary to achieve this goal. A minimum of 20–30% of coral reef habitat as no-take reserve was proposed, based on the precautionary principle as well as empirical and modelling studies of reserves (Bohnsack *et al.*, 2000). Although the rationale of 20–30% was criticized for its narrow extrapolation from very specific localized studies of particular fisheries within particular habitats (Agardy *et al.*, 2003), this criterion was adopted by various advocates of MPAs and fishery managers as a dogmatic standard for no-take reserves (e.g. USCRTF, 2000). A comprehensive marine conservation strategy should involve protection of both representative and distinctive habitats in a network of MPAs (Ballantine, 1997). By protecting marine ecosystems and their populations, no-take reserve networks can reduce risk by providing important insurance for fishery managers against over-exploitation of individual populations (Murray *et al.*, 1999). Such a strategy would require a novel synthesis of relationships between 'species' and 'spaces' approaches to marine conservation by asking how it is possible to take the best advantage of both approaches, rather than seeing them as being in conflict (Roff and Evans, 2002).

In selecting candidate MPAs, the objectives should be to maximize protection of biodiversity, while minimizing economic, cultural and social costs (Roff and Evans, 2002). Thus both ecological and socio-economic issues have to be considered throughout the processes involved in identifying, selecting, and establishing MPAs (Beck and Odaya, 2001; NRC, 2001; Kaiser, 2004). MPAs have the potential to increase and protect fish stocks for spawning, and to export larvae, recruits and exploitable adults to adjacent fishing grounds (McClanahan and Mangi, 2000). Restrictions on traditional access rights to exploit resources can cause misunderstandings and difficulties in promoting spatial protection measures. It is therefore fundamental to respect local fisheries and other extractive activities when designing MPAs (Evans and Birchenough, 2001) as well as other social and cultural considerations. In addition, early continued involvement of and mutual communications with the local communities and stakeholders is crucial for the effectiveness of MPAs. The aims of the MPAs are also key to success and broad acceptance. Employing multiple use MPAs including no-take areas as important tools may help achieve consensus towards the long-term sustainable use and conservation of marine systems (Agardy *et al.*, 2003). If appropriately sited and designed, MPAs may not only protect biodiversity, but may also act as natural fish hatcheries and nurseries leading to the export of juveniles of many species to other areas (Evans and Birchenough, 2001).

There are currently 25 fishery resource conservation areas in Taiwan; however, strictly speaking, none of them can be regarded as an effective MPA (Dai, 1997). The failure of these fishery resource conservation areas is mainly due to lack of support from local fishers and resource users. The lack of convincing data to show the positive effects of setting up fishery resources conservation areas is a major difficulty of promoting MPAs. Owing to the severe degradation of coral reefs and coastal fishery resources (Dai, 1997; Jeng *et al.*, 1999), there is an urgent need to conserve marine resources and a consensus has been reached to establish more effective MPAs (Dai *et al.*, 2002; Kimura *et al.*, 2004).

In 2000, the county government and NGOs in Penghu, Taiwan, planned to set up a model to demonstrate the positive effects of resource management and conservation. Traditionally, fishing has been a major source of revenue in the Penghu Islands, and local people used to declare ownership of the sea or land around their village or island. Thus, there was the potential for serious protests and violent confrontations to occur if no-fishing areas in Penghu were promoted without local support. A less

controversial candidate site for an MPA was urgently needed to demonstrate the advantages and spillover profits that an MPA can bring to local people (Rowley, 1994). In this study, the conservation values (Edinger and Risk, 2000) of 12 reef sites in Penghu Islands were examined and, by considering the results of a long-term reef monitoring programme, the Chinwan Inner Bay (CIB) was selected as the target site for an MPA. Detailed socio-economic and environmental studies to promote the establishment of this MPA were then conducted with the aims of biodiversity conservation in the core zone, and fishery management and public demonstration/ education in the buffer zone as well.

MATERIALS AND METHODS

Location

The Penghu Islands (the Pescadores) are located in the middle of the Taiwan Strait and extend for a distance of less than 70 km from north to south ($119^{\circ} 20' - 119^{\circ} 50' \text{ E}$; $23^{\circ} 10' - 23^{\circ} 50' \text{ N}$). The marine environment is mainly influenced by water masses from the South China Sea, a branch of the Kuroshio Current, and coastal waters of China (Figure 1). Owing to the effects of underwater geographic barriers (the Formosa Bank in the southern part of the Taiwan Strait and the Chung-Yun Rise in its middle), water circulation in the Strait exhibits obvious seasonal variations (Jan *et al.*, 2002). These currents are also responsible for the dispersal and transportation of larvae and juveniles of various marine organisms

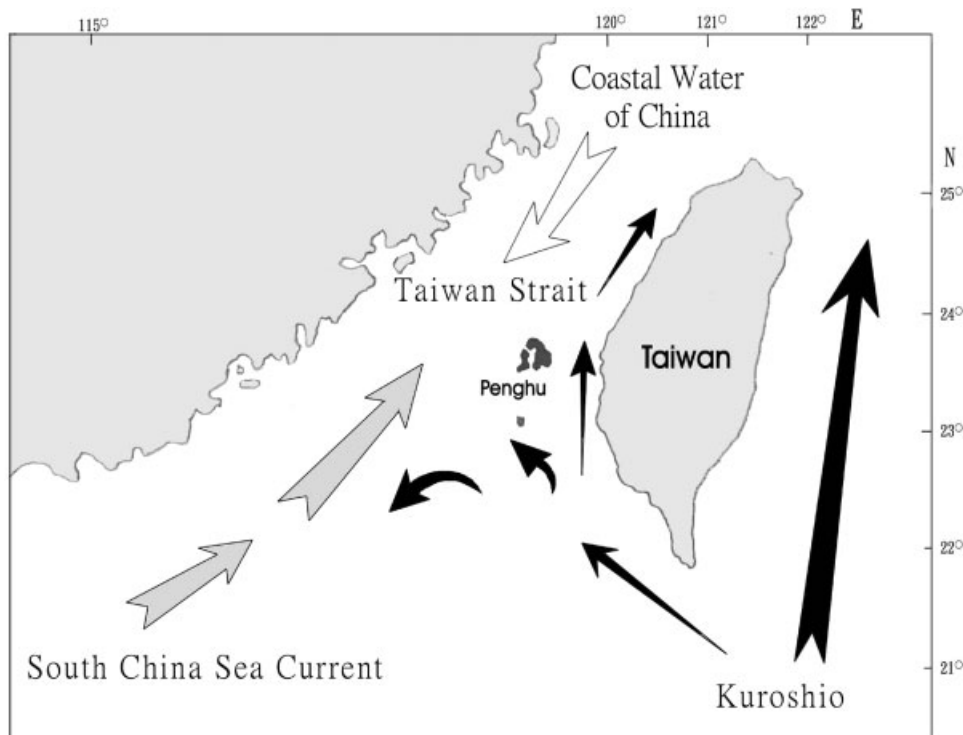


Figure 1. Location of Penghu Islands and the major current systems.

(Chen, 1999). The dominant geology of the Penghu Islands is basalt rocks, which was deposited approximately 10–20 million years ago (Juang and Chen, 1992). CIB is located in an ancient crater to the south of the inner sea of the Penghu Islands (Figure 2).

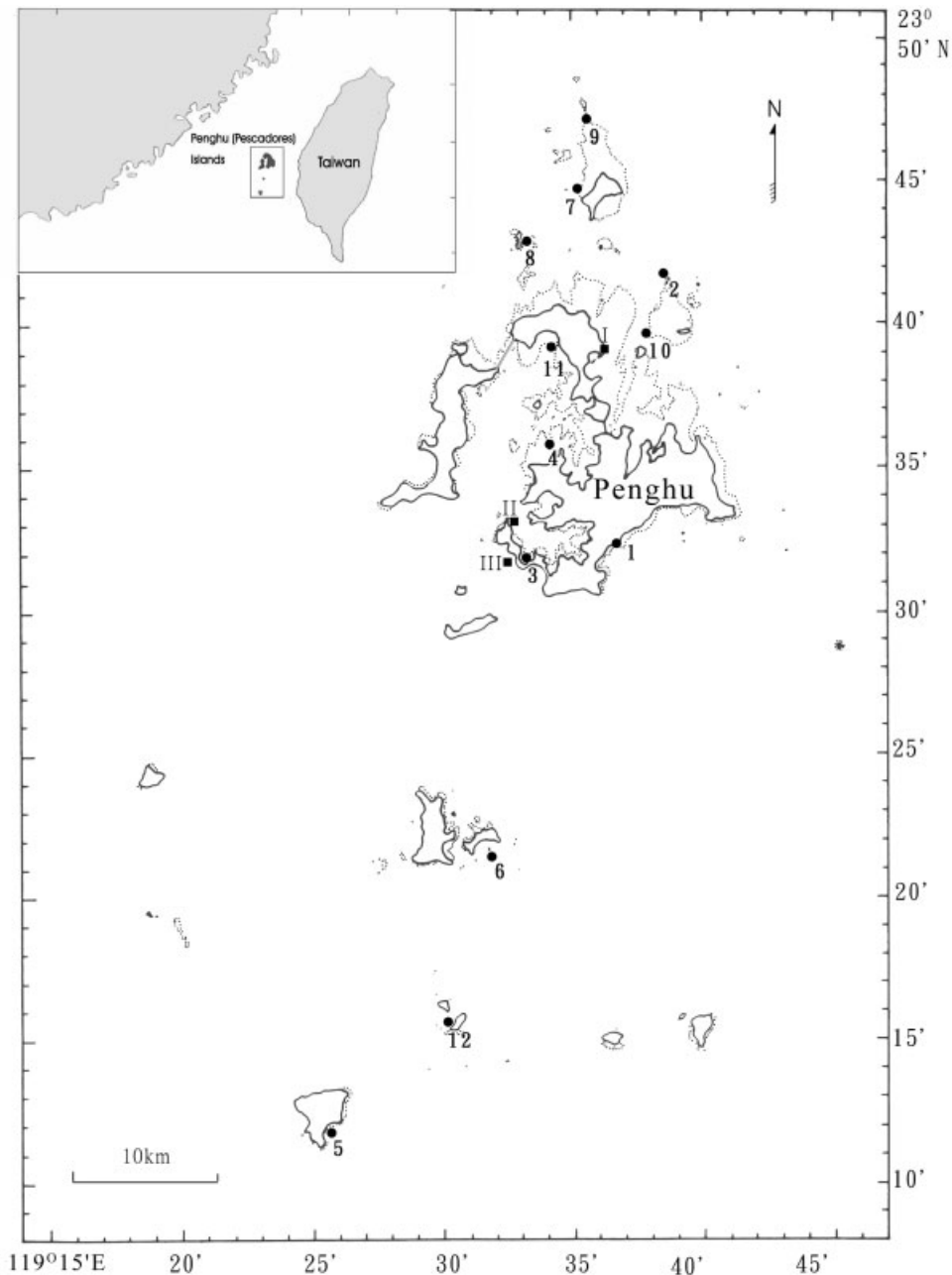


Figure 2. Location of the Penghu Islands (Pescadores) and the 12 survey sites (labelled as '●', 1: AI, Aimen; 2: CD, Chudra; 3: CIB, Chinwan Inner Bay; 4: CK, Chungkwang; 5: CM, Chimei; 6: DW, Dawen; 7: GP, Gipei; 8: GU, Gupo; 9: MD, Mudo; 10: PP, Ponpon; 11: WT, Watung; 12: YP, Yupin) and the other three sites for Reef Check monitoring (labelled as '■', I: Chitou; II: Shertosan; III: Chinwan Outer Bay).

Conservation values

The conservation value, an easy-to-determine and non-taxonomically based idea (Edinger and Risk, 2000), was applied to evaluate and compare the reef conditions at 12 sites which were surveyed in the Penghu Islands (Aimen, Gipei, Mudo, Ponpon, Dawen, Chimei, Chudra, Yupin, Chungkwang, Gupo, CIB and Watung) from 2002 to 2003 (Figure 2). At each site, five 20-m transects were surveyed, and the proportion of coral species with different categories of colony morphologies representing R, K, and S strategists were recorded based on the classification system proposed by Edinger and Risk (2000). Each group represents its own unique ecological characteristics: R comprises weed-like ruderals, K represents competitors, and S consists of stress-tolerators. The composition of each coral community was then plotted on an R–K–S ternary diagram and its position on conservation classes (CC) could be identified (Figure 3(a)). Among them, CC1 represents reefs dominated by stress-tolerators (mainly massive and submassive corals), CC2 represents those dominated by competitors (mainly foliose and branching non-*Acropora* corals), CC3 represents those dominated by ruderals (mainly branching and tabular *Acropora*), and CC4 represents the reefs with mixed coral morphologies or functional groups. It is suggested that reef sites with the highest conservation value (CC4) represent the optimum site for conservation, those with moderate conservation values (CC2 and CC3) are also suitable candidates for conservation, while those with a lower conservation value (CC1) are damaged or stressed communities and not suitable for conservation (Edinger and Risk, 2000). After the 12 sites were plotted on the diagram, priority candidate sites for conservation could be identified.

Live coral cover, zonation and biota of CIB

In addition to the snapshot survey of coral communities, four reef sites in the Penghu Islands, including CIB, Chinwan Outer Bay, Chitou and Shertosan were surveyed annually from 1999 to 2004 by a modified Reef Check protocol (Hodgson, 1999) for documenting long-term variations in coral cover (Figure 2). At each site, one 50-m transect was laid at 3 and 6 m depths respectively, and the categories of benthos or substrate were recorded at 20-cm intervals. The abundance of fish and invertebrate indicators within a 5 m wide belt on the transect was also recorded. After CIB was chosen as a candidate site, an extensive survey of the fauna and flora was conducted by scuba diving in 2003. Habitat types as well as species and relative abundance of corals were recorded.

Status of resource utilization

All fishing and harvesting activities occurring at CIB were recorded from October to December 2002. Various information on fishing activities was recorded including fishing location, operation time, fishing method and harvest rate, together with the species composition of the total catch, species names and other biological parameters (fork length, body weight, sex, gonad weight) of the target species.

Threats to CIB

During the annual Reef Check survey, the occurrences of anchor damage along the 50-m transect were recorded based on evidence of obviously smashed and broken pieces of coral colonies. In 2003, the corallivorous gastropods, *Drupella* snails (*D. cornus*, *D. concatenate*, *D. eburnea*, *D. fragum*, and *D. minuta*) were found in CIB. In order to determine the distribution and density of *Drupella* snails, a transect was laid seaward, perpendicular to the shore, until the edge of reef. Three 1-m² quadrats were surveyed at 10-m intervals. All snails in the quadrat were collected and counted, and their location and host coral species were recorded.

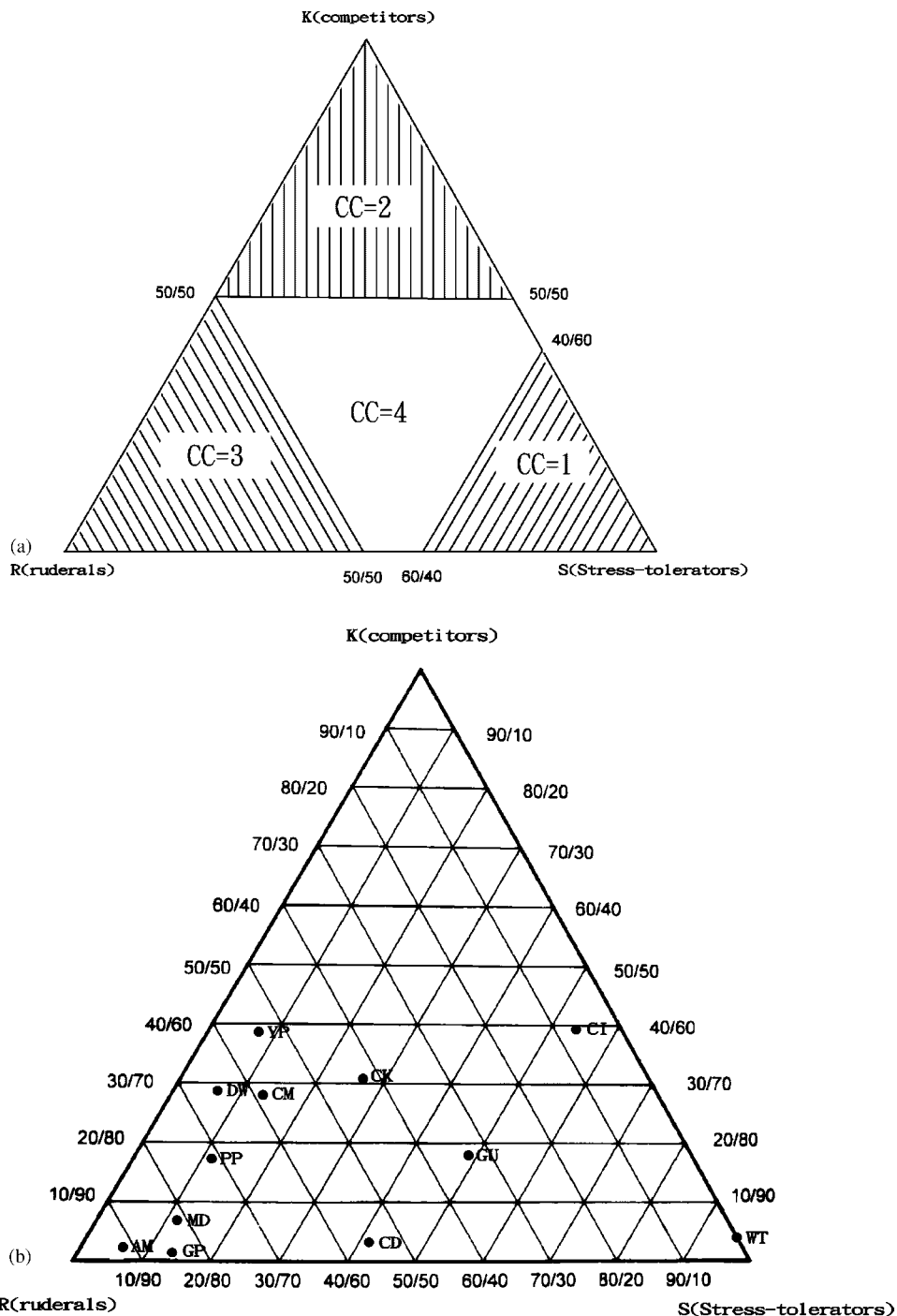


Figure 3. (a) Idealized R-K-S ternary diagram showing the conservation classes (redrawn from Edinger and Risk (2000)). (b) R-K-S ternary diagram of the 12 reef sites in the Penghu Islands (AI: Aimen; CD: Chudra; CIB: Chinwan Inner Bay; CK: Chungkwang; CM: Chime; DW: Dawen; GP: Gipei; GU: Gupo; MD: Mudo; PP: Ponpon; WT: Watung; YP: Yupin).

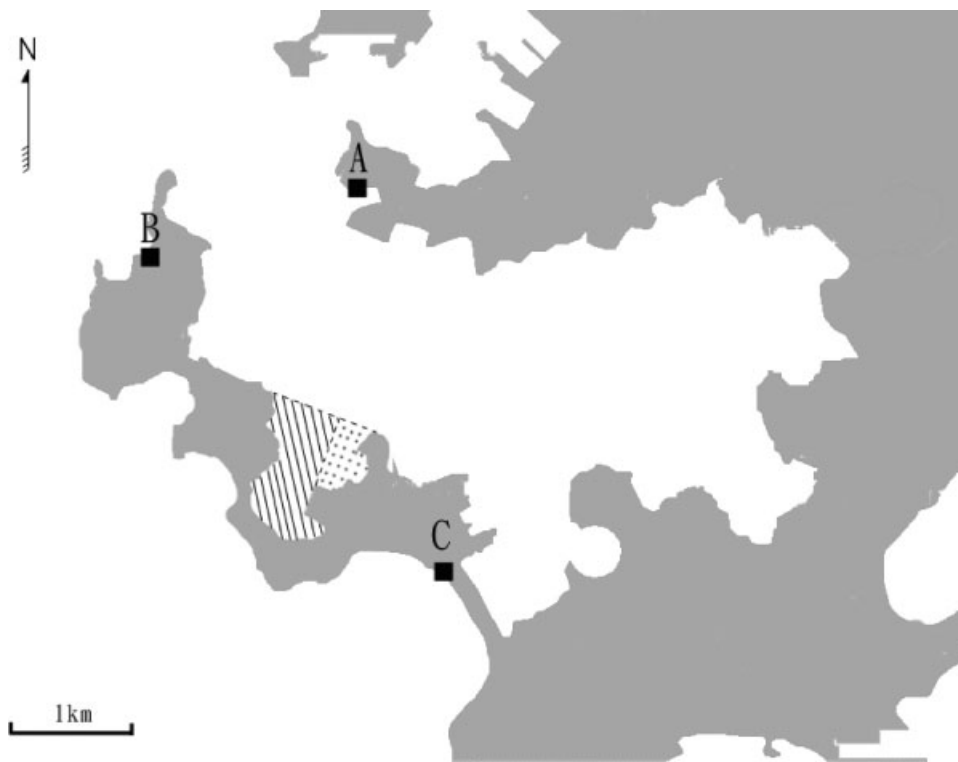


Figure 4. Map of CIB and neighbouring villages (B: Fenguei; C: Shili), the navy base (A), and the boundary of proposed MPA at CIB.

Socio-economic factors

CIB is located between the Shili and Fenguei Villages on the main island of Penghu (Figure 4). Although historically used by local residents for recreation and amateur fishing, this bay has not been claimed and is not owned by either of the two villages. In order to fully understand the attitude of the local communities toward the MPA, a comprehensive survey was conducted. All families in the neighbouring villages (386 at Shili and 430 at Fenguei) were visited in 2002, and a questionnaire concerning their economic information, financial dependence on the CIB, their knowledge about the marine environment, and their attitudes toward the establishment of an MPA was completed (Tables 1–3).

RESULTS

Conservation values

The results of snapshot surveys at 12 sites in the Penghu Islands showed that coral communities at eight sites were classified as CC3 indicating the dominance of branching and tabular *Acropora* in the coral communities, whereas the coral community at Watung was classified as a stress-tolerating community (CC1) (Figure 3(b)). Coral communities at CIB, Gupo and Chungkwang were classified as CC4, indicating that the coral communities were composed of species with diverse morphologies or functional groups. These sites represent the coral communities with higher conservation values and are appropriate candidates for conservation effort (Edinger and Risk, 2000).

Table 1. Questionnaire and statistical results of utilization of marine resources in CIB

Question	Shili	Fenguei
Have you ever been to CIB? Yes.	59%	46%
How often do you go to CIB?		
(i) Several times a day	1.0%	0%
(ii) Every day	6.3%	0.5%
(iii) Once every several days	33.7%	3.8%
(iv) Once a week	11.1%	2.9%
(v) Once a month	5.8%	7.2%
(vi) Occasionally	37.5%	71.6%
What is your purpose at CIB?		
(i) Fishing	89%	88%
(ii) Recreation	11%	10%
(iii) Research	0%	2%
(iv) Outdoor education	0%	0%
(v) Others	0%	1%
What kind of fishing method do you use in CIB?		
(i) Gill net	14%	8%
(ii) Angling	14%	30%
(iii) Spear fishing	2%	3%
(iv) Raking clams	28%	18%
(v) Picking snails	36%	22%
(vi) Hook snails	1%	12%
(vii) Scraping seaweed	4%	5%
(viii) Others	1%	1%
How do you use the harvest?		
(i) Self-consumption	90%	72%
(ii) For sale	10%	28%
How much benefit (in NT\$) do you gain from the harvest per year?		
(i) < 5000	61%	100%
(ii) 5000–10 000	26%	0%
(iii) 10 000–15 000	4%	0%
(iv) 15 000–20 000	0%	0%
(v) 20 000–25 000	4%	0%
(vi) 25 000–30 000	4%	0%
(vii) > 30 000	0%	0%

Live coral cover, zonation and biota of CIB

Among the four sites monitored from 1999 to 2004, the live coral cover at CIB remained the highest and relatively stable (Figure 5). Coral cover at the other three sites was lower and more variable, owing to the influences of typhoons and sedimentation (Dai *et al.*, 2002). Forty-one species of scleractinian corals belonging to three families and 10 genera were recorded at CIB, representing *ca* 33% of the total number of coral species found in the Penghu Islands. *Galaxea astreata*, *Montipora cactus* and *Acropora muricata* were among the most abundant species between 3 and 6 m depth, while *Euphyllia paraancora* forms a monospecific carpet between 6 and 8 m depth (Figure 6).

Although the area of CIB is small (less than 80 ha), it contains various habitats and associated biological communities (Figure 6). The intertidal rocky substrates are populated with turbo and littorinid snails, and oysters, whereas the sandy bottom dominated by clams. At 1.5–3.0 m depth, the substrate is covered with seagrass meadows of *Halophila ovalis* (R.Br.) Hook. f., which are important nursery grounds for juvenile fishes and invertebrate larvae. The sea bottom at 3–8 m depth is occupied by well-developed coral

Table 2. Questionnaire and statistical results concerning the present status of CIB

Question	Shili	Fenguei
Do you know the mass spawning of corals occurs every April to May?	Yes 34% No 66%	Yes 19% No 81%
Do you know the living coral coverage percentage in CIB is the highest in the entire county according to results of a 5-year survey conducted by a local NGO?	Yes 8% No 92%	Yes 32% No 68%
Do you know there is a coral, <i>Euphyllia paraancora</i> , which is only found at CIB in Taiwan?	Yes 2% No 98%	Yes 12% No 88%
Do you know there are several kinds of habitats (mudflat, rocky shore, seagrass beds, corals, sandy beach) in CIB?	Yes 58% No 42%	Yes 74% No 26%
What functions do you think CIB has in addition to being a fishery ground?		
(i) Nursery ground	28%	64%
(ii) Tourism	20%	28%
(iii) Ecological value	19%	19%
(iv) Others	38%	18%
What kind of threats do you think CIB suffers from?		
(i) Anchor damage	1%	4%
(ii) Net entanglement of coral	9%	16%
(iii) Poisoning	12%	13%
(iv) Dynamiting	0%	3%
(v) Electric shocking	0%	2%
(vi) <i>Drupella</i> snails	0%	2%
(vii) Bleaching	4%	5%
(viii) Illegal clam collection	7%	23%
(ix) Improper garbage disposal	37%	10%
(x) Others	31%	22%
What kind of problems will these threats cause to CIB?		
(i) Depletion of fishery resources	43%	37%
(ii) Destruction of habitats	30%	36%
(iii) Others	27%	26%

Table 3. Questionnaire and statistical results concerning resource and habitat conservation of CIB

Question	Shili	Fenguei
Do you know what a Marine Protected Area (MPA) is?	Yes 41% No 59%	Yes 86% No 14%
Do you know that not all MPAs are access-denied?	Yes 16% No 84%	Yes 50% No 50%
For the purpose of conservation, are you willing to restrict your own fishing behaviours within a reasonable range, such as restriction on places, period, methods, body lengths of organisms, etc.?	Yes 69% No 31%	Yes 99% No 1%
Will you stop catching organisms during their reproduction seasons?	Yes 70% No 30%	Yes 97% No 3%
If the problems in CIB could be solved by establishing an MPA and your income was not affected, would you support the establishment of an MPA?	Yes 73% No 27%	Yes 98% No 2%
The Penghu County government intends to promote MPA establishment at CIB. If this project will increase the fishery production, will you support it?	Yes 73% No 27%	Yes 98% No 2%

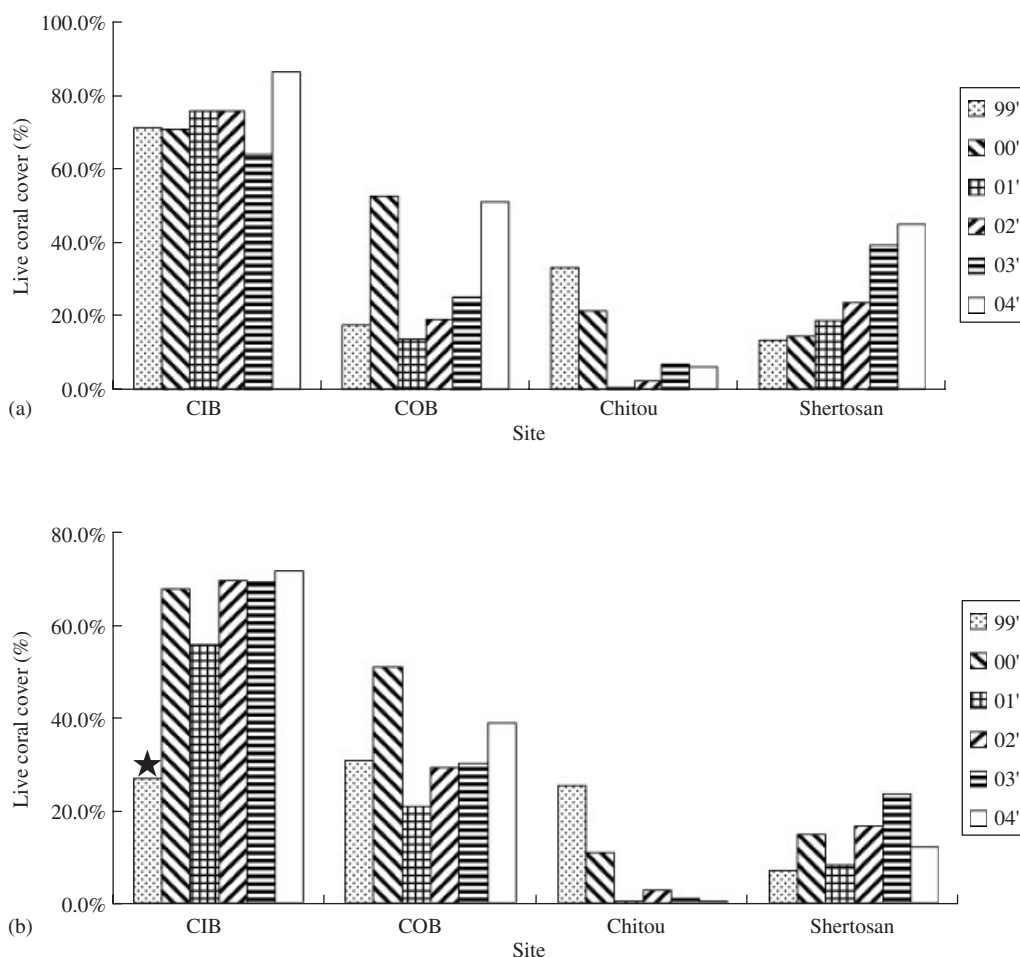


Figure 5. Annual variations of live coral cover at (a) 3 m depth, and (b) 6 m depth at four sites in the Penghu Islands from 1999 to 2004. CIB: Chinwan Inner Bay, COB: Chinwan Outer Bay. The star indicates an underestimated value in 6 m in 1999 due to a misunderstanding of the survey procedure.

communities, where reef fishes such as butterflyfishes, groupers and emperors are common. Below 8 m, there are sand- and mudflats which extend from the edge of the reefs to a deeper slope. This habitat is rich in flounders, goatfishes and common silver biddy fishes.

Status of resource utilization in CIB

Most of the fishing operations carried out at CIB were for recreational purposes. This type of fishing is characterized by low investment, low harvest rates, high dependence on weather conditions, and self-consumption. In October–December 2002, 110 events of boat fishing, 49 of floating raft fishing, 26 of shore fishing, and 36 of intertidal collecting were recorded in 25 days. The other days were too windy or too cold, or the tides were unsuitable for fishery operations.

The 36 intertidal collecting events recorded all occurred during the semidiurnal low tides, in the daytime. The area near the east side of the bay was visited most frequently (Figure 7), and the target organisms were snails and clams. The 61 cases of boat fishing were also concentrated on the east side of CIB (Figure 7).

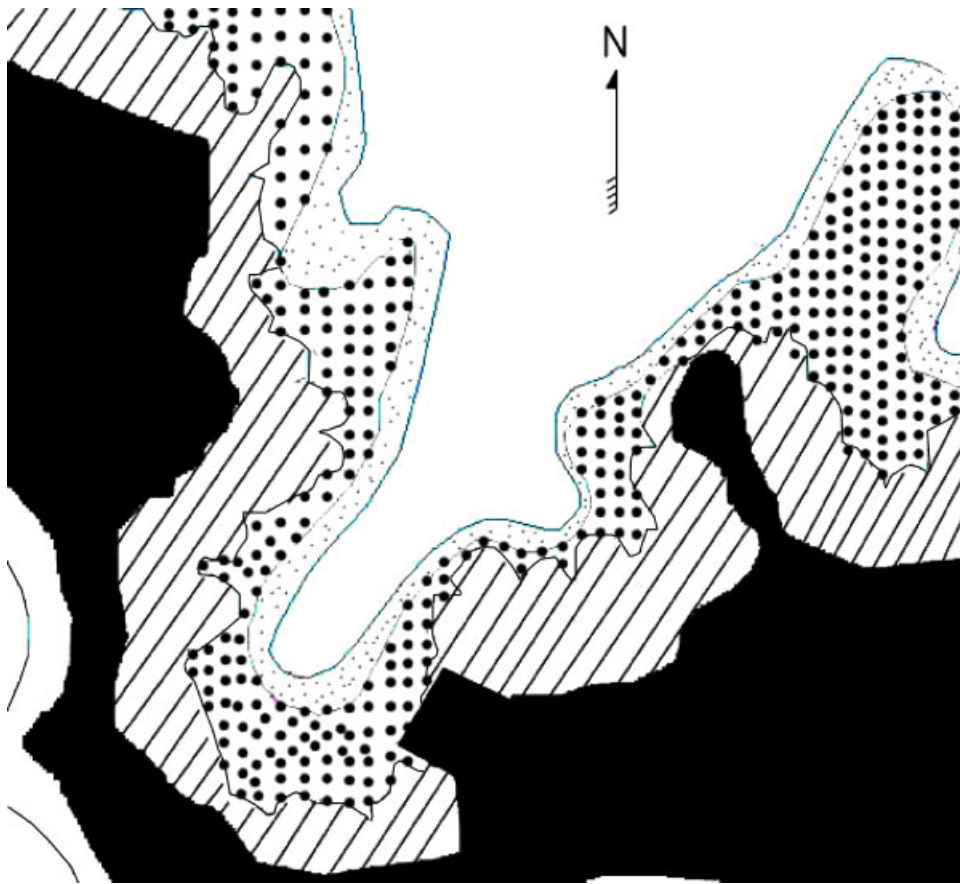


Figure 6. Zonation of habitats and benthic communities at CIB. 'Black area': land mass; 'hatching': intertidal rocky and sandy substrates; 'solid dots': seagrass meadows at 1.5–3.0m depth; 'stippling': coral communities at 3–8m depth; 'blank area': mud flat at >8m depth. This figure is available in colour online at www.interscience.wiley.com/journal/aqc

Operating times were not closely related to the tides, and the target organisms were high-valued fishes and crustaceans. Shore fishing was mostly carried out at the abandoned dock to the south of CIB (Figure 7). Floating raft fishing occurred on the west and south sides of CIB where there were sandy and reef bottoms (Figure 7).

In October–November 2002, only two fishing boats constantly operated in CIB. The daily catches of boat fishing and floating raft fishing were 6.52 ± 2.69 kg (mean \pm SD) and 3.48 ± 1.29 kg, respectively. Overall, around 20.4 kg of fish and shellfish were removed daily from CIB; species composition of the catch was highly diverse with 41 fish species in 24 families and 34 genera recorded.

Threats to CIB

Anchor damage

No obvious anchor damage events were observed before 2002. From 2002 to 2004, the occurrences of anchor damage increased rapidly indicating that anchoring was a rising threat to coral reefs at CIB (Figure 8). The incidence of anchor damage in CIB was probably underestimated since only one 50-m



Figure 7. Distribution of all fishing events at CIB from October to December 2002. 'open circle' indicates intertidal collecting; 'solid square' indicates boat fishing; 'solid circle' indicates floating raft fishing; and 'open square' indicates shore fishing. The large star indicates a hotspot with 16 shore fishing events recorded; 'hatching' indicates the abandoned dock.

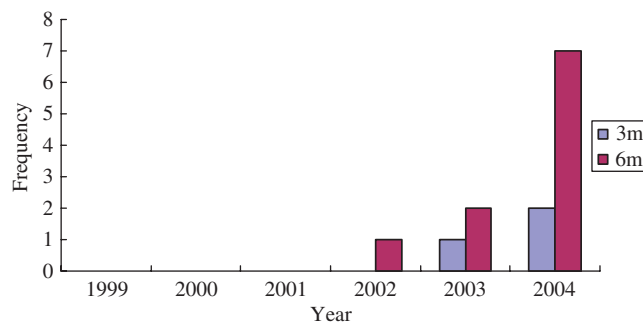


Figure 8. The frequency of anchor damage in the monitoring sites of CIB based on Reef Check data in 1999–2004. This figure is available in colour online at www.interscience.wiley.com/journal/aqc

transect was surveyed at the monitoring site. Judging from the intensive recreational boat fishing and floating raft fishing in CIB, anchor damage could be a significant threat to the coral community.

Drupella snails

Five native species of *Drupella* (*D. cornus*, *D. concatenate*, *D. eburnea*, *D. fragum* and *D. minuta*) were collected at CIB. They co-occurred on the surface of live coral colonies. Among the 27 predated coral

Table 4. Percentages of families at Shili and Fenguei that belong to five categories of annual disposable income in New Taiwan dollars in 2002

Village	Category					
	< 192 000	192 001–384 000	384 001–576 000	576 001–840 000	840 001–1 200 000	> 1 200 001
Shili	34.1%	46.6%	13.6%	5.0%	0.3%	0.3%
Fenguei	25.0%	28.0%	19.0%	16.0%	3.0%	3.0%

In 2002, the average exchange rate was US\$1.00 = NT\$34.62.

colonies observed, 13 were *G. astreata* (48%) and 10 were *M. cactus* (37%). These coral species are the preferred hosts for the snails; other corals that were predated by snails were *Acropora muricata*, *Echinophyllia orpheensis* and *Lithophyllon undulatum*. The average density of *Drupella* snails was 5.5 ind m⁻².

Community awareness and attitudes towards the MPA

In total, 386 completed questionnaires from Shili and 351 from Fenguei were obtained after the entire populations of the villages were visited. The population from Fenguei (pFG) depended less on CIB than did the people at Shili (pSL) (Table 1). The pSL visited CIB more frequently and earned more money from it than did the pFG (Table 1). Both groups mainly utilized CIB for fishing; however, the pSL employed more diverse fishing methods than did the pFG. Most of the fish caught were consumed by the fishers themselves in both villages.

Although about half of the people of both villages visited and used CIB occasionally and directly, fewer than half of them were aware of the results of scientific research conducted there (Table 2). Among the factors causing degradation of the reef at CIB, improper garbage disposal, land construction (in the category 'other'), illegal triple-layered gill nets, illegal clam collection by smashing coral, poisoning, and coral bleaching were better known to the local population.

About 86% of the pFG were familiar with MPAs and half of them understood that not all MPAs are access-denied (Table 3). Almost all (>97%) of the pFG showed a strong intention to support the establishment of the MPA and indicated that they would restrain their fishing activities during reproduction seasons. On the other hand, 41% of the pSL were familiar with MPAs and only 16% understood that not all MPAs are access-denied. When interviewed with the same question, about 31% of the pSL objected to having to halt fishing activities during reproduction seasons.

The disposable income of each family in the two villages was largely classified into the lowest two levels compared to all families in Taiwan (former 40% lower income) (Table 4). The annual disposable income of 80.7% of the families at Shili and 63% at Fenguei was less than NT\$384 000 (approximately US\$11 100). The differences in the economic structures between the two villages may have been the cause of inconsistency in their dependence and their attitude toward the same issues.

DISCUSSION

CIB as the priority site of the establishment of an MPA

The high conservation value, high coral cover and species diversity in CIB suggests that it is a site with good potential for the conservation of biodiversity of coral reefs in the Penghu Islands. In addition, various types of habitats including the intertidal basalt rocky shore, a subtidal coral community, seagrass beds, and sandy/muddy substrates exist within the bay (Hsieh *et al.*, 2001). A diverse biota can also be found in

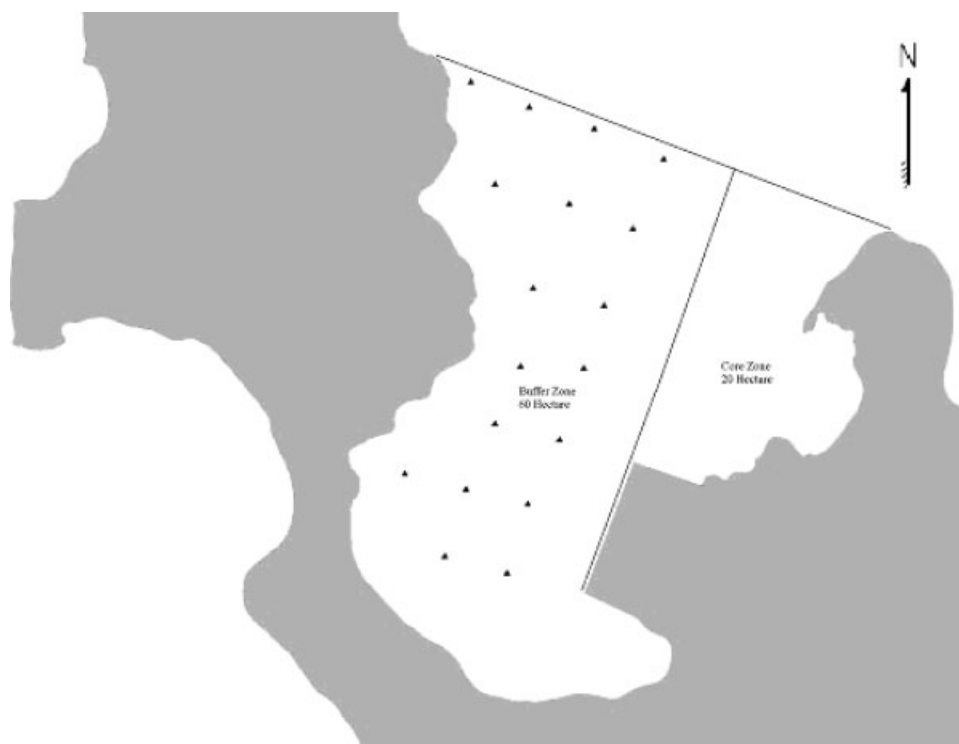


Figure 9. Recommended zoning plan for the MPA at CIB. Solid triangles are proposed sites for anchor buoys.

various habitats of the bay. Thus the establishment of CIB MPA is likely to be beneficial both for the conservation of biodiversity and to the conservation of commercial fish species in the Penghu Islands.

Coral communities at CIB are well-developed compared to other places in Penghu Islands possibly because it is protected from waves and illegal fishing practices by the surveillance of a nearby navy base (Hsieh *et al.*, 2002). However, this bay is nevertheless facing anthropogenic and ecological stresses including anchor damage and the proliferation of corallivorous gastropods. Anchor damage to coral reefs and communities has long been reported as one of the major factors in reef destruction (Davis, 1977; Dinsdale and Harriott, 2004). Using anchor buoys instead of regular anchors has been recommended to avoid causing mechanical destruction to coral colonies. After evaluating the damage, practical anchor buoys were designed, and areas for their deployment were recommended according to distribution patterns of coral and fishing activities (Figure 9).

Blueprint for the MPA at CIB

Studies have shown that 'no-take areas' of MPAs can effectively increase population densities of animals including fishes and improve the catch per unit effort (Polunin and Roberts, 1993; McClanahan and Kaunda-Arara, 1996; Kamukuru *et al.*, 2004). Even small reserves (0.4 km^2) can successfully enhance local fish stocks, especially those territorial and non-migratory species such as snappers and parrotfishes (Roberts and Hawkins, 1997). Fishers and local inhabitants can benefit from the spillover and sustained propagation from the no-take area. Based on the results of both ecological and socio-economic studies, a blueprint for the designation of CIB as the first MPA in Taiwan is presented.

An area of approximately 20 ha on the east side of the bay that includes various habitat types and supports high species diversity is proposed as the 'core zone' (Figure 9) or 'no-take area'. All activities here would be strictly prohibited except scientific research with permission from the administrating authority (the Penghu Agriculture and Fishery Bureau). The other 60 ha of subtidal area on the west side is recommended as a 'buffer zone' to reduce the impact to traditional resources utilization of the neighbouring villages. Traditional fishery operations would be allowed here under adequate regulations such as bans on use of gill nets, bottom trawling, light traps, poisoning, dynamiting and electric shock fishing. To prevent anchor damage to corals, 18 anchor buoys will be deployed evenly within the buffer zone for boat and floating raft fishing operations. Regulations on body length, fishing period, fishing methods and total allowable catch for target species will be implemented in the future with the aim of conserving the fishery resources.

Although the recommended MPA at CIB is small, it is an important first step and has the potential to be effective not only in enhancing biodiversity conservation but also in illustrating the benefits to activities such as fishing. The creation of MPAs within fishing grounds can be beneficial to the fishery by providing a refuge for part of the stock and thus, possibly increasing overall production (Roberts *et al.*, 2001). The success of this MPA at CIB may provide a model for a network of sites that could deliver better conservation of marine resources and biodiversity in Taiwan.

The future of the MPA at CIB, whether expressed in human or environmental terms, is dependent on effective and responsible management. Such management practices, in general, would benefit from increased community involvement. This would require renewed emphasis on feelings of ownership and increased knowledge of the environment by the general public (Evans and Birchenough, 2001). Although most of the people in local villages support the establishment of the MPA at CIB, some controversies still exist among stakeholders. Apparently, more efforts should be made to promote public awareness toward the establishment of an MPA at CIB, not only for people in the two villages but also for people throughout Penghu Islands. Environmental education is recommended to bring about the changes in public perceptions and attitudes. Unless a common understanding and interpretation of the significance of MPA is achieved among multiple stakeholders its management will continue to be filled with tension and threaten community solidarity. There is, therefore, an urgent need for initiatives in environmental education, which operate outside the formal system and address all ages and sections of society.

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