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Long-term monitoring of the coral reef fish communities around a nuclear power plant

Rong-Quen Jan, Jeng-Ping Chen, Chun-Yu Lin and Kwang-Tsao Shao*
*Institute of Zoology, Academia Sinica, Nankang, Taipei 11529, Taiwan, Republic of China; *Author for correspondence (Fax: +886-2-27858059; E-mail:zoskt@gate.sinica.edu.tw)*

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Abstract

Over the past 21 years (1979–1999) we have observed temporal changes in the fish communities on a coral reef around a nuclear power plant in southern Taiwan. Data used for analyses were collected bimonthly by scuba-diving ichthyologists at four sub-tidal stations (Stations A, B, D, E). The commercial operation of the nuclear power plant was launched in the summer of 1984. During the study period the number of fish species varies, with the coefficient of variation (CV) ranging from 19.0% (Station A) to 25.2% (Station D). Nevertheless, the sequential data on number of species follow a random trend in terms of runs up and down at all four stations. This characteristic persists both before and after the initiation of power plant operation. Dendrograms drawn using UPGMA (unweighted pair-group method using arithmetic averages) on the dissimilarity coefficients between yearly fish occurrences show that the years 1980–1984 are more closely grouped than any other years. This phenomenon prevails at all stations, indicating that wide-scale change occurred between 1984 and 1985. After the power plant began operation, changes in water temperature were minute at these sub-tidal stations. Impacts from other sources such as chlorine release and fish impingement seem remote. We believe temporal variations in the studied fish communities can be better explained as arising from natural fluctuations of environmental factors as well as physical disturbance caused by typhoons. The latter factor is also thought to account for the major faunal change between 1984 and 1985.

Abbreviations: St. – Station A; St. B – Station; St. D – Station D; St. E – Station E.

Introduction

Taiwan Power Company began construction of its Third Nuclear Power Plant at the southern tip of Taiwan in 1979 and commercial operation was launched in 1984. Because this power plant uses seawater from the adjacent Nanwan Bay as a cooling medium, its operation is likely to modify the local coral reef environment by changing some physical, chemical, or biological factors (Odum, 1971; Freedman, 1989). The present monitoring study was thus initiated when the decision to construct the power plant was made. In this study, it has been attempted to use changes in the fish community as an indicator of environmental change.

On coral reefs, fishes are highly diverse in terms of number of species (Ormond & Roberts, 1997). They are the major consumers in the reef's food web (Optiz, 1996). While most species are carnivores, ranging from gobies that feed on minute crustaceans, butterflyfishes that feed on coral polyps, angelfishes of the genera *Holacanthus* and *Pomacanthus* that feed on sponges, to large sharks that feed on fishes, some parrotfishes, surgeonfishes, rabbitfishes, and rudderfishes browse on the fronds of leafy macroalgae (Meyers, 1989; Randall et al., 1990). Fishes are motile, and most can emigrate to safe regions if chronic low levels of pollution occur. However, many of their food sources (i.e., corals, sponges, macroalgae, etc.) are sessile, and will be adversely affected. Accordingly, fishes may not be able to avoid the indirect effects of degradation of the quality of their food caused by pollution. Apart from simply leaving an area, reef fishes may respond more subtly to poor quality of food. Under mild environmental deterioration, food generalists would be expected to change their diets. Therefore emigration of generalist species from a reef might indicate the seriousness of environmental changes (Hourigan et al., 1988).

A community analysis has some advantages in terms of biomonitoring. The fish community consists of species with a range of sensitivities, and therefore is able to provide a multi-species response to any given change in environmental factors. Meanwhile, changes in community structure may reflect long-term integrated conditions as well as catastrophic events. Therefore, information on changes in community, species composition, species diversity, and the relative abundance of those species can be useful in measuring the nature and extent of impacts on a given community (Attrill & Depledge, 1997). Long-term data sets are often required to detect ecological mechanisms which involve slow processes, rare events, and high annual variability. Such data sets are also essential to demonstrate the relative contributions of different factors (Jan et al., 1994). In this study 21 years of local fish and environmental data were used to analyze changes in the fish community with particular concern about the operation of the nuclear power plant. It is hoped for that the information obtained from this study may help to assess the environmental changes associated with the power plant operation.

Materials and methods

The monitoring of fish communities began in July 1979 and continued along with associated monitoring programs until 1994 (Jan & Chang, 1991; Jan et al., 1994; Hung et al., 1998), when study was halted for financial reasons. Data collection was resumed in 1998–1999 to bring the data up to date.

Field trips were undertaken bimonthly to the southern tip of Taiwan, where the power plant is located (120°45′ E, 21°57′ N) (Figure 1). Four sub-tidal stations (namely, Sts. A, B, D, E) on the coral reef area were assigned. Station C was cancelled at the early stage of the study due to successive heavy sedimentation. However, the names of the other stations are retained to allow cross-referencing between collaborative studies. Both Stations A and B are located close to the water discharge canal of the power plant, whereas Station D is located 500 m from the water intake of the plant. Station E is located near the northwest corner of Nanwan Bay and has been included in this study since 1986. Data used in the trend analysis stem mostly from Stations A, B, and D; more detailed information on these three stations is presented in Table 1.

The underwater survey of fish assemblages was done using visual counts by scuba-diving ichthyologists. Water temperature was measured with wrist gauges. We originally planned to have regular surveys. However, owing to weather conditions and some unanticipated situations, data from four to seven collections are available for each year. Taxonomic nomenclature for the fish has been carefully updated throughout the monitoring scheme to achieve taxonomic precision.

With the data available, we compared water temperatures before and after the initiation of commercial operation of the power plant. Correlation between water temperatures and numbers of species was analyzed. Numbers of species from sequential observations were tested for randomness using tests of runs (runs above and below the mean, runs up and down) based on the assumption that the sequence is random (Sokal & Rohlf, 1981). To reduce the risks of Type II errors, we also examined the yearly trend using fish species which occurred in each year. Jaccard's similarity coefficient (S) was used to indicate yearly changes of the fish fauna. For each station, the yearly fish faunae were further grouped using cluster analysis to show the faunal distance between years. The result is summarized into a dendrogram drawn using UPGMA (unweighted pair-group method using arithmetic averages, Sneath & Sokal, 1973) based on dissimilarity coefficients (D, = 1- S). We also extracted butterflyfish data from the data set for the yearly trend analysis. For each station, the yearly change of butterflyfish species was compared with the change of the entire fauna by matching similarity indices between years.

Results

During this long-term survey, 87 observations were successfully made at St. A, 88 at St. B, 85 at St. D, and 44 at St. E (Figure 2). The measured water temperatures show two features. First, even though the water temperature at each station fluctuated between 22 and 30 °C along the time axis, it generally followed a yearly trend, that is, the temperature was highest in July and lowest in December–January. Second, slight differences occurred between temperatures measured

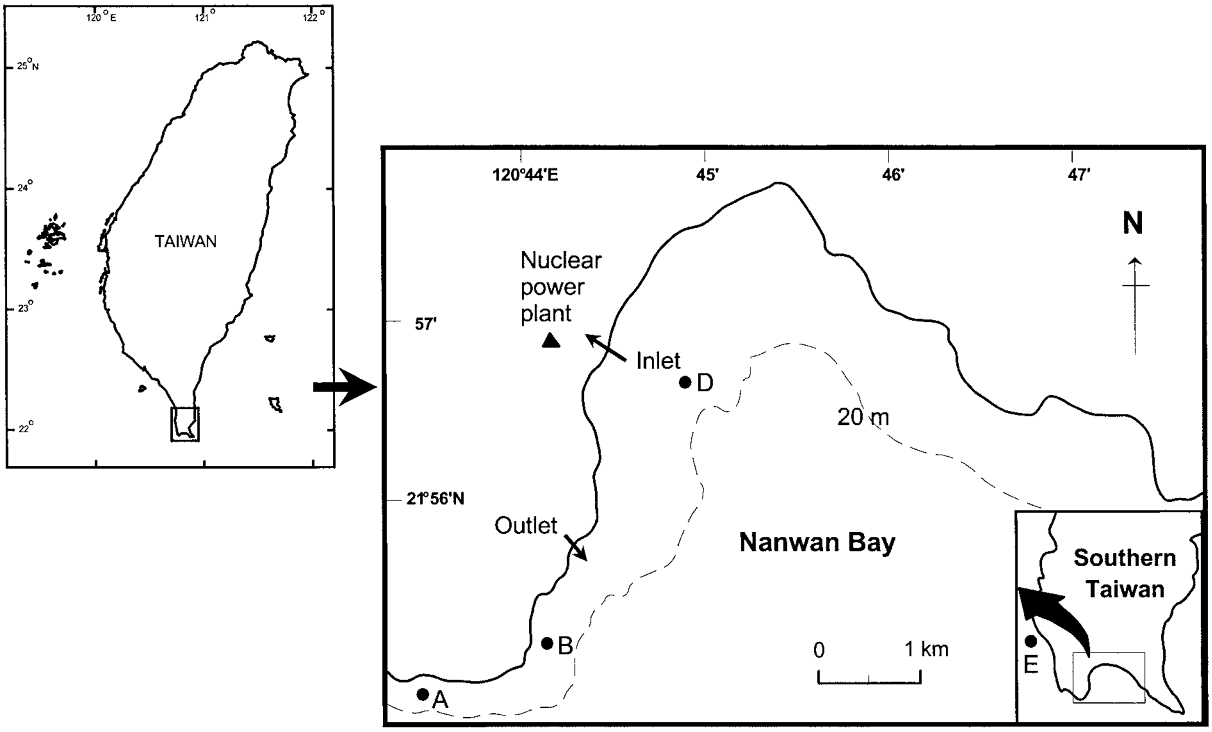

Figure 1. Map showing Nanwan Bay and the study sites. A, B, D and E are sub-tidal stations where monitoring was undertaken; Inlet, inlet of the water intake constructed by the nuclear power plant; Outlet, outlet of the water discharge canal.

Table 1. Characteristics of Stations A, B, D and E

	Major topographic components	Area (m^2)	Water depth (m)	Distance from coast (m)	Distance from discharge canal (m)
Station A	An angular block, 4 m (width) × 8 m (length) × 3 m (height)	150	5–7	25	500
Station B	Limestone terrace, 20 m (width) × 20 m (length) × 6 m (height)	400	6–13	60	100
Station D	Six adjacent rocks; the largest 4 m (width) × 3 m (length) × 2 m (height)	300	10–12	500	1500
Station E	Three isolated reefs; the largest 4 m (width) × 5 m (length) × 2 m (height)	70	10–12	50	8000

Table 2. Results from paired t-tests of significance of the difference of monthly temperatures between periods before and after power plant operation initiation

Station	Averaged monthly temperature difference[a] (°C)	t	Df	p (two-tailed)	Note
A	0.24	1.95	10	0.008**	Data not available for June
B	0.08	0.63	10	0.542	Same as above
D	0.33	1.28	10	0.229	Same as above

[a] (Monthly temperature after July 1984) − (temperature in the same month before June 1984).

Table 3. Numbers of species in the five major fish families observed at each station. Stations A, B, and D are based on data collected between 1980 and 1999; Station E, between 1986 and 1999

Number of species	Station			
Major family	A	B	D	E
Labridae	71	78	76	67
Pomacentridae	35	36	28	26
Gobiidae	29	26	14	16
Acanthuridae	26	24	23	14
Chaetodontidae	17	14	19	9
Total number of families	47	43	41	41
Total number of species	354	338	331	291

before and after initiation of plant commercial operation. The monthly temperature was 0.08–0.33 °C higher after 1984, but the difference was significant only for St. A (Table 2).

For each of St. A, B, or D, where more than 80 observations were made, around 350 fish species were recorded. These fishes belong to 41–47 families. By contrast, 291 fish species, belonging to 41 families, were recorded for St. E from 44 observations. These fish faunae show one characteristic in common – they are all dominated by a few major families, including Labridae, Pomacentridae, Gobiidae, Acanthuridae, and Chaetodontidae (among them, Labridae was the largest by far). These five major families make up nearly half of the fauna at each station (Table 3).

Analysis of the coefficient of variation (CV) of number of species observed at each station has shown various degrees of temporal and spatial variations in the fish fauna. In general, the CV value for sequential observations of each station was within a range between 19% and 25.2% (Table 4). The CV values were further analyzed by dividing the data from each station into two parts, one including those collected in the period during July 1979 and June 1984 (before operation of the nuclear power plant) and the other collected after July 1984 (with the plant in operation). The results show that at St. A the CV value is higher in the first period, while the situation at St. D was the opposite, i.e., a higher CV in the second period. By contrast, CV values from the two periods are almost identical at St. B.

Analysis of runs-above-and-below-mean of the sequential data shows wide occurrence of departure from randomness of data collected before power plant operation. (This happens at Sts. A, B, and D (Table 5); the survey at St. E was not started yet.). However, such a tendency does not hold in the second period. In contrast, runs-up-and-down occurs randomly at all four stations. This characteristic persists both before and after the initiation of plant operation.

Analysis of the relationship between sequential observations and water temperatures shows that the number of species found at St. A is positively correlated with water temperature ($r = 0.29$, $p = 0.008$). However, at the other two stations (i.e., Sts. B and D) the correlation is not significant.

The above sequential observations provide enough data for an analysis of the yearly occurrence of fishes for 14 years (the yearly data are only applicable in years where more than five observations were made). During 1980–1984 the yearly occurrences of both numbers of fish families and numbers of species are similar for each station. Thereafter these numbers fluctuate, so much so they encompass both the highest and lowest values of the entire study period. The dendrogram based on dissimilarity coefficients between years also shows that the years 1980–1984 are more closely grouped than other years (Figure 3). This phenomenon prevails at all three stations (i.e., Sts. A, B and D), showing a general pattern of changes in the successions of local fish communities. In 1985,

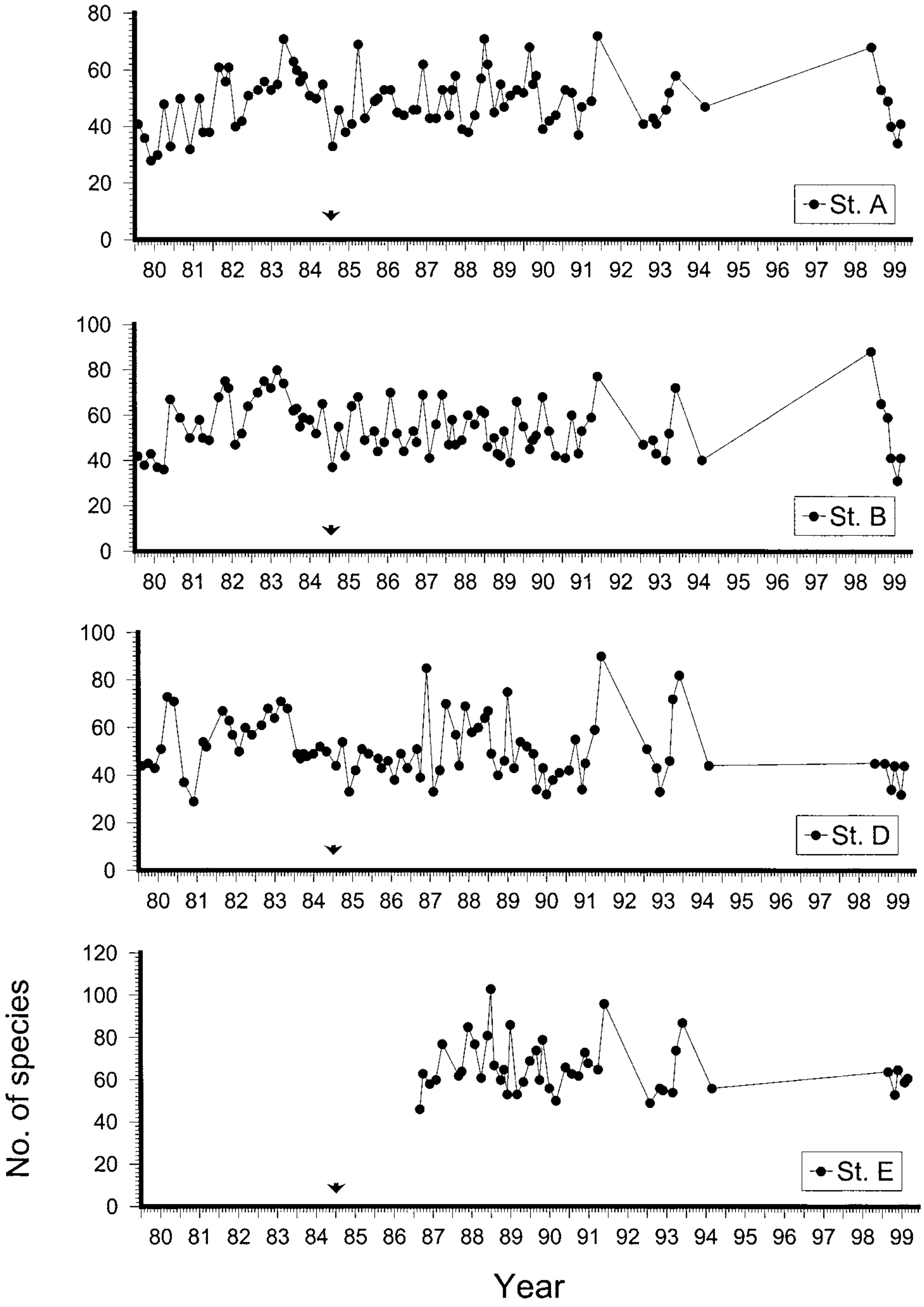

Figure 2. Temporal changes of number of fish species surveyed at four stations. Arrow indicates the time when commercial operation of the power plant was launched.

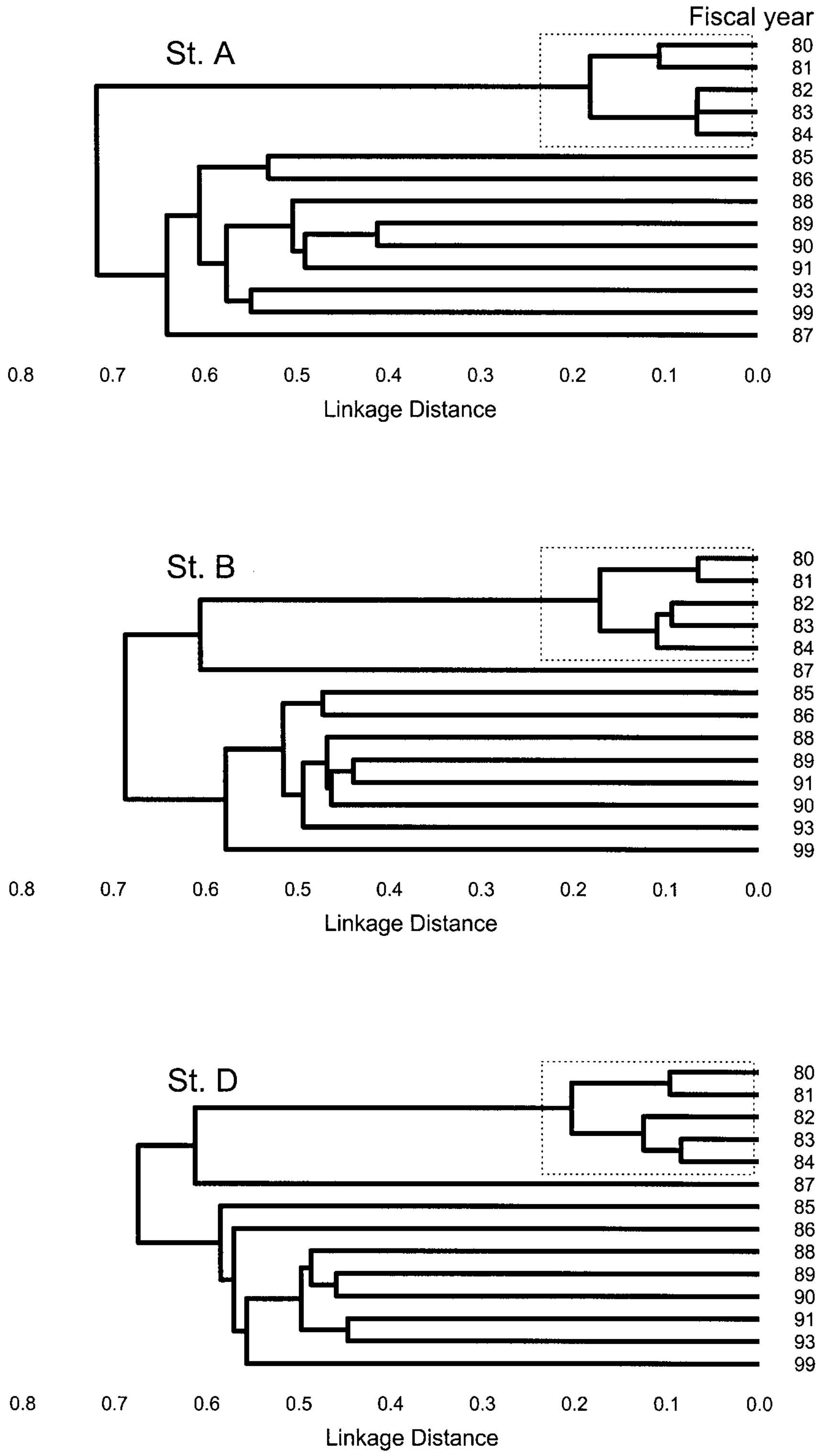

Figure 3. Dendrograms for yearly presence/absence data for fishes occurring at three stations. Groupings are based on dissimilarity coefficients using UPGMA. The year denotes the fiscal year (July–June).

Table 4. Coefficients of variation (CV) of the number of species observed from different stations. NA: data not available

Stage	Station							
	A		B		D		E	
	No. of observ.	CV	No. of observ.	CV	No. of observ.	CV	No. of observ.	CV
Before operation (June 1979–May 1984)	29	22.5	29	21.4	28	19.9	NA	
In operation (June 1984–April 1999)	58	18.6	59	21.2	57	27.2	44	19.0
Total sequence	87	19.8	88	21.8	85	25.2	44	19.0

Table 5. Results of tests for randomness of sequential observations of number of species based on runs above and below mean and runs up and down, where * and ** denote that the sequence of observations do not occur in a random order at the 5% and 1% significant levels, respectively. Data are divided into two parts in this treatment. One includes those collected during July 1979 – June 1984 (before operation of the nuclear power plant.). The other includes those collected after July 1984 (when the plant was in operation)

Stage	Runs tests	Station											
		A			B			D			E		
		No. of observ.	*z*	*p*	No. of observ.	*z*	*p*	No. of observ.	*z*	*p*	No. of observ.	*z*	*p*
Before operation	Above and below mean	29	3.14	<0.01**	29	2.35	0.02	28	2.6	<0.01**	NA		
(June 1979–May 1984)	Up and down	29	0.23	0.82	29	0.23	0.82	28	0	1			
In operation	Above and below mean	58	1.9	0.06	59	0.66	0.51	57	0.13	0.9	44	0.78	0.43
(June 1984–April 1999)	Up and down	58	1.53	0.12	59	0	1	57	0.69	0.49	44	0.55	0.58
Total sequence	Above and below mean	87	2.08	0.04*	88	1.09	0.27	85	2.39	0.02*	44	0.78	0.43
	Up and down	87	1.32	0.18	88	0	1	85	0.74	0.46	44	0.55	0.58

when the exceptional faunal changes occurred, the following 15 fish species were found missing from the faunae from the three stations: *Sargocentron diadema, Parupeneus barberinus, Mulloidichthys vanicolensis, Apogan bandanensis, A. kallopterus, A. cookii, Plectorhynchus flavomaculatus, Cirrhitichthys oxycepphalus, Chaetodon reticulatus, C. punctatofasciatus, C. rafflesii, C. plebeius, Acanthurus pyroferus, Naso brevirostris*, and *Rhinecanthus verrucosus*. By contrast, 20 fish species were newly added, including *Dasyatis kuhlii, Gymnothorax fimbriatus, Saurida gracilis, Parupeneus barberinoides, Fowleria* sp. *Cheilodipterus quinquelineatus, Pseudamia gracilicauda, Cephalopholia rogaa, C. miniata, Epinephelus amblycephalus, F. fario, Monotaxis grandoculis, Aprion virescens, Caesio caerulaurea, Valenciennea strigata, Amblyeleotris wheeleri, Macropharyngodon pardalis, Cheilinus chlorourus, Acanthurus japonicus*, and *Ctenochaetus striatus*.

In the 14 years where yearly data are available, a total of 16 species of butterflyfish occurred at St. A, 14 species at St. B, and 19 species at St. D. Some of these butterflyfishes are residents of the reef. For example, the following species occurred in all 14 years: *Chaetodon citrinellus, C. kleinii*, and *C. speculum* at St. A; *C. argentatus, C. kleinii*, and *C. vagabundus* at St. B; *C. auripes, C. citrinellus*, and *C. kleinii* at St. D. Apparently the proportion of butterflyfish whose occurrence persisted for more than seven years (exclusive) is relatively high, when compared with that of fish meeting the same criterion from the entire fauna (Figure 4). The butterflyfishes were also less temporally variable. This is indicated by higher Jaccard's similarity indices obtained between yearly occurrences (Figure 5).

Discussion

Many ideas for the biomonitoring of the effects of man-made disturbances to coastal waters are based on the concept of biological succession. In the marine environment, biological succession can vary due to physical and physiological stresses, to biological

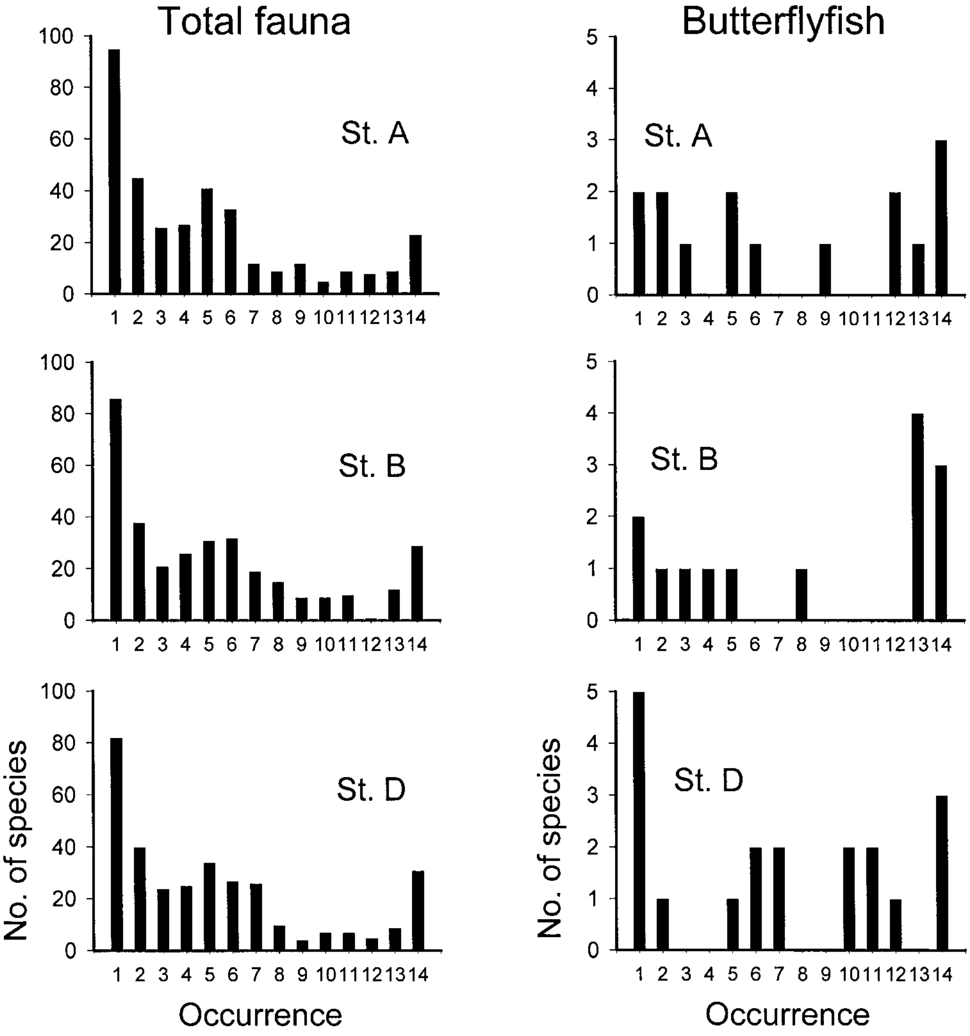

Figure 4. Frequency histogram of yearly fish occurrence in 14 years. Left, all species in the fish fauna; right, butterflyfish species only.

factors (food-web, recruitment, predation, competition, mutualism), and to their integrated effects. In this study structures of fish communities in the past 21 years were found to vary both temporally and spatially, with changes of the community from different stations not following a common trend. The potential change of water temperature constituted the prime issue in this study, because seawater temperature is one of the physical factors most likely to be altered by a thermal discharge, and hence affect the ambient biota. A temperature difference did occur; a slight increase in monthly temperatures appeared after 1984. However, statistical significance of the difference was only found at one of three stations (Table 2). The value was very small: it lied almost beyond the range of accurate readings from a wrist gauge, and was certainly not parallel to the 4–5 °C increase near the water discharge outlet (Hung, 1989). In summer, the temperature of the water 30 m away from the canal outlet could reach as high as 36.5 °C, inevitably causing coral bleaching (Hung, 1989; Hung et al., 1998). However, the observed damage was limited to the area close to the canal outlet, as the effluent was subject to dilution with water movement. Nanwan Bay is an open bay. The tidal regime in this area is semi-diurnal with spring tides alternating regularly with neap tides. The tides influence current patterns of inshore waters of the study area. With the combination of tidal flows and the Kuroshio Current, the current speed in Nanwan Bay is relatively fast (Fan & Yu, 1981). In spite of mass mixing of the water, the warm water still stays in the upper column forming a temperature gradient in shal-

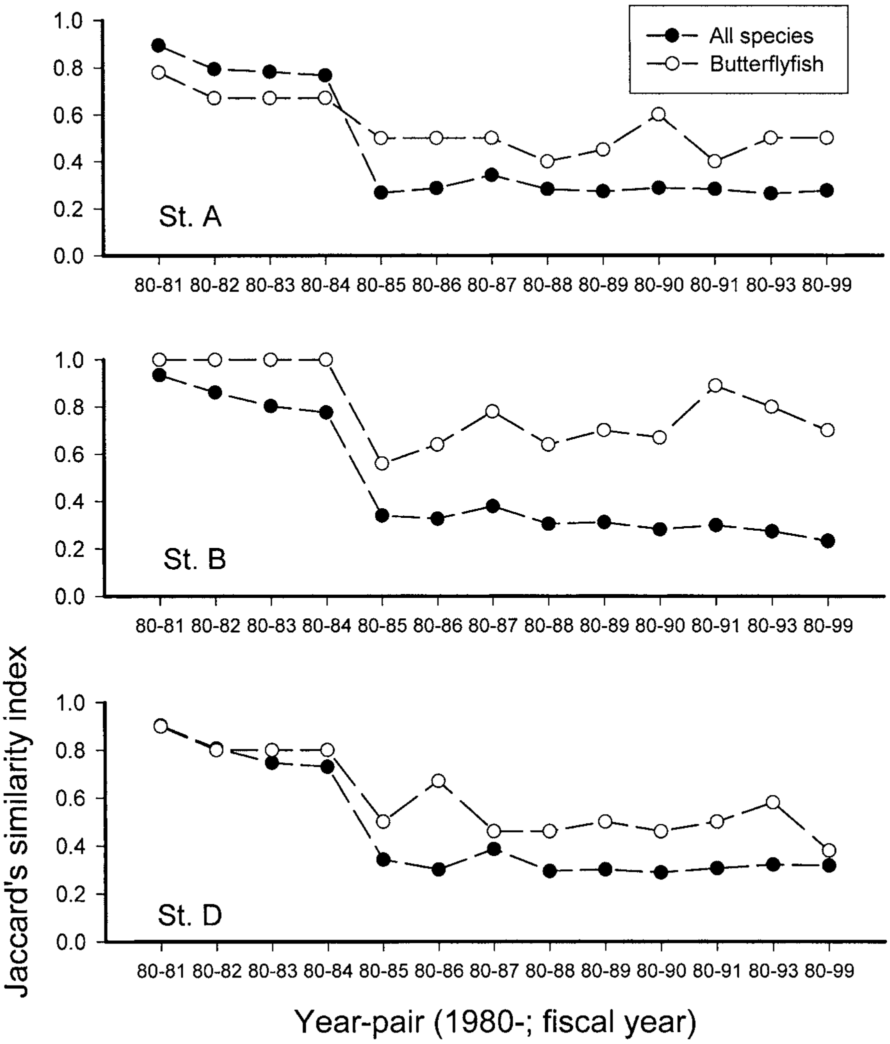

Figure 5. Jaccard's similarity indices between fish faunae from various year-pairs. The index was obtained separately from (a) all the species in the fauna, and (b) butterflyfish species only. The year denotes the fiscal year (July–June).

low waters (Hung et al., 1998). In the present study, the stations were located at depths within a range between 5 m and 13 m (Table 1). Serious temperature increases at our sampling stations may have not occurred due to the given distances from the canal outlet and the water depths.

The power plant used chlorine as a biocide to kill fouling organisms. The dilution effect of the seawater seems to have applied to the chlorine discharged together with the heated effluent. In fact, the contents of residual chlorine at our sampling stations have been very small, mostly less than 0.01 mg l^{-1} and hence undetectable by the DPD method (Su et al., 1988; Hung et al., 1998).

Apparently the change of water temperature and the release of chlorine could hardly explain the difference between the data collected before and after initiation of plant operation, as indicated by results from the test of runs above and below mean (Table 5). Neither can it explain the formation of the extraordinary distance between the 1984–1985 data in the yearly dendrogram (Figure 3). For the latter case, drastic changes seem to have occurred in the short period between the two yearly surveys (Figures 5 and 6), as minor changes would not have caused such an overwhelming faunal difference. Upon retrospection, we found two instances occurring in the 1984–1985 period which require further scrutiny. Power plant op-

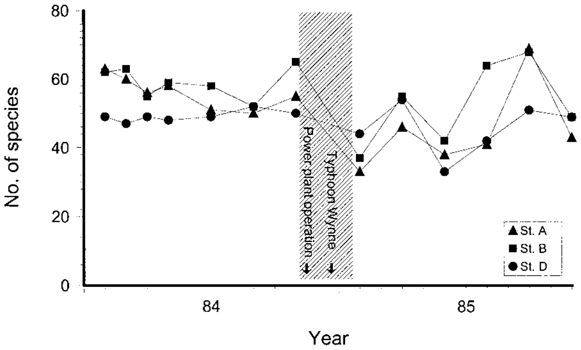

Figure 6. Graph showing the period (as a hatched column) where events were most likely to have caused notable faunal differences between the fiscal years of 1984–1985. The launch of the nuclear power plant operation and the occurrence of Typhoon Wynne are assigned as two major events in this period.

eration was tested on 9 May 1984, and commercial operation was launched in July. The use of cooling water by the power plant caused impingement of fish. The quantity of impinged fish was estimated to be 192 kg in 1988 (Su et al., 1988). With such a small amount, it is also unlikely that fish impingement could have caused the notable 1984–1985 faunal difference.

The other instance is the prevalence of typhoons. In June 1984, typhoon Wynne hit the Nanwan Bay, which suffered serious damage (CWB, 1986), followed by typhoons Alex (July), Freda (August), Gerald (August), and June (August). It is widely reported that a typhoon strike might result in removing juveniles from the reef, causing re-distribution of sub-adult individuals, as well as damaging the habitat and associated food source (Kaufman, 1983; Lassig, 1983; Walsh, 1983; Williams, 1984; Mah & Stern, 1986; Fenner, 1991; Moring, 1996). In addition, a typhoon might influence recruitment patterns, which also play an important role in the variation of local populations (Letourneur, 1996; Ault & Johnson, 1998). The typhoon prevalence mentioned above is therefore more than likely to have been the main cause for the exceptional differences in the fish faunae between 1984 and 1985.

Many butterflyfish species are suggested to be excellent candidates for indicators of changes in conditions of the coral reef (Hourigan et al., 1988). The present study found that the butterflyfish are not immune from the stresses that caused 1984–1985 faunal changes. However, they were as a whole less temporally variable than was the fish fauna to which they belong (Figure 5), indicating their possible suitability as use as a bioindicator. Furthermore the Klein's butterflyfish, *Chaetodon kleinii*, was observed each year at all three stations. Since this butterflyfish feeds mainly on soft corals, its appearance probably reflects the well-being of the co-inhabiting soft corals.

Conclusion

The long-term data collected in this monitoring scheme have shown some inconsistency in the temporal variations of the local fish communities. Because changes in water temperature are minor at underwater stations, such temporal variations are better explained as arising from natural fluctuations of environmental factors as well as physical disturbances caused by typhoons. This finding, for the most part, parallels to that obtained from a monitoring study on marine sessile macro-organisms undertaken at the same underwater stations (Jan & Chang, 1991), and is essential for the elucidation of the long-term effect of the power plant operation.

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References

Attrill MJ and Depledge MH (1997) Community and population indicators of ecosystem health: targeting links between levels of biological organisation. Aquat Toxicol 38: 183–197

Ault TR and Johnson CR (1998) Spatially and temporally predictable fish communities on coral reefs. Ecol Monogr 68: 25–50

CWB (1986) Report on Typhoons in the Western North Pacific in 1984. Central Weather Bureau, Taipei

Fan KL and Yu CY (1981) A study of water masses in the seas of southernmost Taiwan. Acta Oceanograph Taiwanica 12: 94–111

Fenner DP (1991) Effects of Hurricane Gilbert on coral reefs, fishes and sponges at Cozumel, Mexico. Bull Mar Sci 48: 719–730

Freedman B (1989) Environmental Ecology. Academic Press, New York

Hourigan TF, Tricas C and Reese ES (1988) Coral reef fishes as indicators of environmental stress in coral reefs. In: Soule DF and Kleppel GS (eds.), Marine Organisms as Indicators. Springer-Verlag, New York, pp. 107–135

Hung TC (1989) The preliminary report for the assessment of ecological impact of the operation of the third nuclear power plant on the Nanwan Bay. National Scientific Committee on Problems of the Environment, Academia Sinica, Taipei (in Chinese)

Hung TC, Huang CC and Shao KT (1998) Ecological survey of coastal water adjacent to nuclear power plants in Taiwan. Chem Ecol 15: 129–142

Jan RQ and Chang KH (1991) A monitoring study of the succession on marine sessile macro-organisms five years before and after the operation of a nuclear power plant. In: Jeffrey DW and Madden B (eds.), Bioindicators and Environmental Management. Academic Press, London, pp. 21–35

Jan RQ, Dai CF and Chang KH (1994) Monitoring of hard substrate communities. In: Kramer KJM (ed.), Biomonitoring of Coastal Waters and Estuaries. CRC Press, Boca Raton FL, pp. 285–310

Kaufman LS (1983) Effect of Hurricane Allen on reef fish assemblages near Discovery Bay, Jamaica. Coral Reefs 2: 43–47

Lassig BR (1983) The effect of a cyclone on coral reef fish assemblages. Env Biol Fish 9: 55–63

Letourneur Y (1996) Dynamics of fish communities on Reunion fringing reefs, Indian Ocean. II. Patterns of temporal fluctuations. J Exp Mar Biol Ecol 195: 31–52

Mah AJ and Stern CW (1986) The effect of Hurricane Allen on the Bellairs fringing reef, Barbados (West Indies). Coral Reefs 4: 169–176

Meyers RF (1989) Micronesian Reef Fishes. Coral Graphics, Guam

Moring JR (1996) Short-term changes in tidepools following two hurricanes. Hydrobiologia 328: 155–160

Odum EP (1971) Fundamentals of Ecology. WB Saunders, Philadelphia and London

Opitz S (1996) Trophic interactions in Caribbean coral reefs. ICLARM Tech. Rep. 43, 341 pp

Ormond RFG and Roberts CM (1997) The diversity of coral reef fishes. In: Ormond RFG, Gage JD and Angel MV (eds.), Marine Diversity: Patterns and Processes. Cambridge University Press, Cambridge, pp. 216–257

Randall JE, Allen GR and Steene RC (1990) Fishes of the Great Barrier Reef and Coral Sea. University of Hawaii Press, Honolulu

Sneath PHA and Sokal RR (1973) Numerical Taxonomy. WH Freeman, San Francisco

Sokal RR and Rohlf FJ (1981) Biometry. 2nd ed. WH Freeman, New York

Su JC, Hung TC, Chiang YM, Tan TH, Chang KH, Shao KT, Huang PP, Lee KT, Huang CY, Fan KL and Yeh SY (1988) An ecological survey on the waters adjacent to the nuclear power plant in southern Taiwan. IX. The progress report of the ninth year study (1987–1988) and the preliminary report for the assessment of ecological impact of the operation of the power plant (July 1979–June 1988). Special Publication No. 59. National Scientific Committee on the Problems of Environment, Academia Sinica, Taipei (in Chinese)

Walsh WJ (1983) Stability of a coral reef fish community following a catastrophic storm. Coral Reefs 2: 49–63

Williams AH (1984) The effects of Hurricane Allen in back reef populations of Discovery Bay, Jamaica. J Exp Mar Biol Ecol 75: 233–243