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Diel patterns in abundance, distribution and composition of ichthyoplankton in shallow reef areas in Southern Guimaras, Central Philippines

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Abstract— Ichthyoplankton samples from 20 reef stations were collected in Southern Guimaras, Central Philippines, during the day and night by means of 5 minute surface horizontal tows using a rectangular plankton net with a 300 μm mesh bag attached to it. Overall mean ichthyoplankton density at night (168 ind/100 m^3) was three times more than that during the day (56 ind/100 m^3), while taxon richness (family level) was 50% higher at night. These results are compared with observed diel patterns in other investigations. Diel differences in overall egg and larval densities and composition are related to the station location, substrate and other factors. The relative similarity in day-night patterns in stations over deep water suggests that the substrates (seagrass beds and coral reefs) serve as shelters from predation during the daytime.

Key words: ichthyoplankton, diel patterns, Philippines

Introduction

Functional marine reserves should allow the rebuilding of fish stocks within their boundaries thereby subsequently enhancing surrounding fisheries by the "spillover" of production or through continuously providing recruits to areas outside (Roberts and Polunin 1991). The latter "recruitment" effect has a longer term and broader effect, because protection of the "source" will ensure a continuous supply of larvae/recruits to downstream "sinks". The idea of sources and sinks highlights the connectivity between reef areas and has important implications on the design of ecologically functional networks of marine reserves.

This study is part of a larger effort to determine the functional role of the Taklong Island National Marine Reserve in the area of Southern Guimaras, Central Philippines. Ichthyoplankton abundance and composition within the reserve were investigated by Campos and Delola (1998), while results of a broader survey covering adjacent reef areas are still being analyzed. The present study was conducted to examine diel differences in the abundance, distribution and composition of fish eggs and larvae in Southern Guimaras on a single occasion, December 2001.

Materials and Methods

The study area is located in Southern Guimaras, Central Philippines bounded by the following coordinates: 10°20.4′ to 10°28.8′N and 122°28.8′ to 122°36.0′E (Fig. 1). The shallow reef habitats are described in Campos et al. (2002).

Ichthyoplankton samples were collected with the use of a 2.5 m 300 μm mesh net attached to a 0.75×0.25 m rectangular steel frame. The net was attached to the boat's outriggers and fished at a fixed layer of 20–40 cm below the water surface. Towing speed was approximately 1–1.5 m/s. A mechanical flowmeter was attached to the mouth of the net to monitor the amount of water filtered by the net. Ichthyoplankton samples were collected between 0800 and 1200 hr (daytime) and 2000–0000 hr (night) at 20 stations located with the aid of a handheld GPS. The mean volume of water filtered from the 40 samples was 44.6 m^3 (sd=8.7; range: 25.3–69.9). All samples were rough-sorted in the field, fixed in 10% seawater-formalin solution, and brought back to the laboratory for sorting and identification to the family level.

Results

A total of 1920 fish larvae, belonging to 53 families, were recorded from combined day and night samples (Table 1). Mean larval fish density at night was three times higher

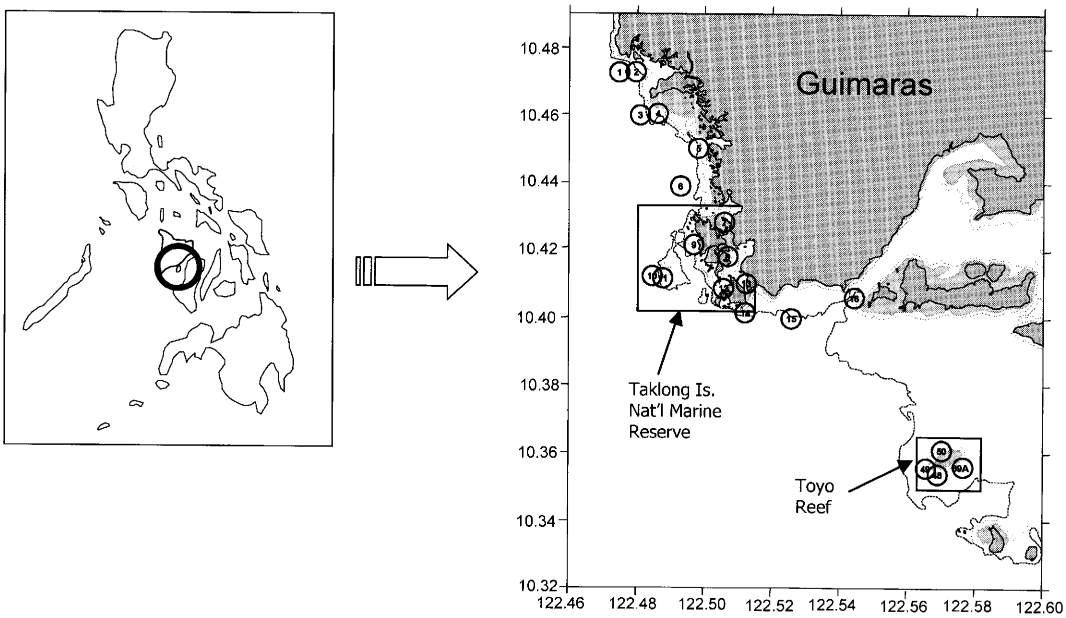

Fig. 1. Map showing the location of the twenty (20) stations sampled in the study area, Southern Guimaras, in December 2001. The approximate boundaries of the Taklong Island National Marine Reserve and the location of Toyo Reef are also shown. Dashed line denotes 10-m isobath.

Table 1. Summary of egg, yolk sac and larval densities, and number of families recorded in 20 stations surveyed in the day and night in Southern Guimaras, Central Philippines in December 2001.

	n	mean	SD	median	min	max
Day						
Larval Density (ind/100m^3)	20	55.6	78.2	38.8	1.7	358.4
Egg Density (no/m^3)	20	8.0	8.4	4.9	0.1	33.3
Yolk sac larvae density (ind/100m^3)	20	2.5	4.7	0.0	0.0	19.4
No. of families	20	7.1	6.2	6.5	1	31
Total no. of families	20	34				
Night						
Larval Density (ind/100m^3)	20	168.5	137.7	129.5	0.0	496.7
Egg Density (no./m^3)	20	2.6	2.7	1.8	0.2	9.4
Yolk sac larvae density (ind/100m^3)	20	8.2	16.8	1.2	0.0	64.1
No. of families	20	13.6	7.1	13.5	0	25
Total no. of families	20	51				

(168.5 ind/100 m^3) than in the daytime (55.6 ind/100 m^3), with significant day-night difference ($t'=3.189$; df$\sim$30; $p=0.0034$). Egg densities, however, showed an opposite trend, with a mean of 8.0 eggs/m^3 in the daytime and 2.6 eggs/m^3 at night. This difference was also significant ($t'=2.725$, df$\sim$23; $p=0.012$).

In terms of families, 34 and 51 families were represented in the day and night samples, respectively (Table 2). During the day, the top 10 families comprised 69.4% of all larvae recorded. At night, the top 10 families represented 74% of the total, with only 6 of the 10 top families being common with those during the daytime. Three of the 10 families were not even within the top 15 families in the daytime. Gobies dominated both day and night samples, representing 20.7% and 45.3% of total larvae, respectively. On the whole, soft bottom demersal groups dominated both day (46.1%) and night (64.5%) with an increase in number of families from 16 to 23 from day to night. Similarly, reef-associated groups also showed a parallel increase in number of families from 8 to 16, although there was little diel change in overall relative abundance of reef-associated fish larvae (Table 2).

Of the total of 53 families, 20 were recorded only at night, including 1/2 of all reef associated families, while only 2 were recorded during the day (Bothidae & Holocentridae). The largest diel differences were shown by demersals and reef associated groups.

The spatial distribution of fish larval densities is shown in Fig. 2A & B. Diel differences in overall larval densities were highest in stations located over shallow water (within the 10 m isobath). This is especially clear for the northern

Table 2. Mean density (ind./100 m³) and relative abundance of the top ten fish larval families recorded in Southern Guimaras, Central Philippines in December 2001.

DAY			NIGHT		
Family	Density	%	Family	Density	%
Gobiidae	11.5	20.7	Gobiidae	76.4	45.3
Clupeidae	8.0	14.4	Pomacentridae	8.0	4.8
Pomacentridae	4.2	7.5	Nemipteridae	7.4	4.4
Scombridae	3.8	6.9	Clupeidae	6.9	4.1
Mullidae	2.4	4.2	Mullidae	6.4	3.8
Nemipteridae	2.1	3.8	Apogonidae	4.6	2.7
Atherinidae	2.0	3.6	Exocoetidae	4.2	2.5
Terapontidae	1.8	3.3	Terapontidae	3.7	2.2
Blenniidae	1.5	2.6	Engraulidae	3.6	2.2
Cynoglossidae	1.3	2.3	Bregmacerotidae	3.3	2.0
	No. fam	%		No. fam	%
demersals	16	46.1	demersals	23	64.5
deep	2	1.8	deep	3	3.0
pelagic	8	28.6	pelagics	9	13.2
reef assoc	8	12.4	reef assoc	16	11.1
others		11.0	others		8.13
Total families	34		Total families	51	

portion of the study area, where day-night differences in larval densities outside of the 10 m isobath were negligible. This isobath closely corresponds to the reef margin as well. A similar spatial trend is also shown by the diel difference in number of fish families recorded in the area (Fig. 2C & D). Overall, the most distinct differences were in stations over shallow water, which include seagrass beds and reefs.

The distribution of egg densities, however, do not show a parallel trend. Larger diel differences did not correspond so much with depth than they did with certain locations (Fig. 3A & B), such as the northernmost portion, the Reserve, and Toyo Reef in the south. Similarly, diel differences in yolk sac larvae were more recognizable in these same locations (Fig. 3C & D).

Discussion

The observed day-night differences are likely results of diel vertical migratory behaviour, particularly of epibenthic species, or those closely associated with the substrate, in this case seagrass and reefs. The results are indicative of movement in response to light and is consistent with the classic pattern of larvae being in deeper water during the day and up in shallower water at night (Haney 1988). This has been further clarified with respect to the various layers of the water column. Leis (1991) contends that most studies on vertical distribution show that most of the vertical movement is confined to specific layers rather than across the entire water column. Similarly, the frequency and extent of movement was taxon-specific and not generalized, although there was an overall tendency to avoid the surface layer during the day. Hence, while the classic pattern (Haney 1988) was seldom found, avoidance of the surface was nevertheless common.

The results of the study are in agreement with the above findings. The low overall larval concentrations during the day is consistent with limited vertical movement with most larvae of epibenthic fish avoiding the surface, while the increased concentrations at night is consistent with an increased movement towards the surface where larvae are vulnerable to the plankton net. The latter however is true only for the shallow area, and apparently only for larvae of epibenthic fish. In general, reef fish larval concentrations are usually highest off the reef margin and not over the reefs themselves (Leis 1991), although this may be based primarily on daytime observations. Apparently, this is due to expectedly high predator pressure close to the reef bottom (with typically high juvenile fish densities) (Boehlert 1996). A counter-argument, however, is that habitat complexity (e.g., rugosity), is higher within the reef (bottom), hence more shelter/refugia is available for the larvae. In the present study, larval concentrations were higher in shallower water over reefs and seagrass, particularly at night (Fig. 2B). Kobayashi (1989) showed similar results for gobies, which is also the dominant family in the present study. Leis and Carson-Ewart (2001) mention that the absence of light reflection from the substrate (upwelled light) in deep water may be a major reason why larvae of many epibenthic forms prefer shallow waters. Hence, the observed diel trends in deep and shallow water stations in the present study likely reflect different assemblages on/near the reefs and offshore from them (Kingsford and Choat 1989).

Higher egg densities during the day suggest that egg

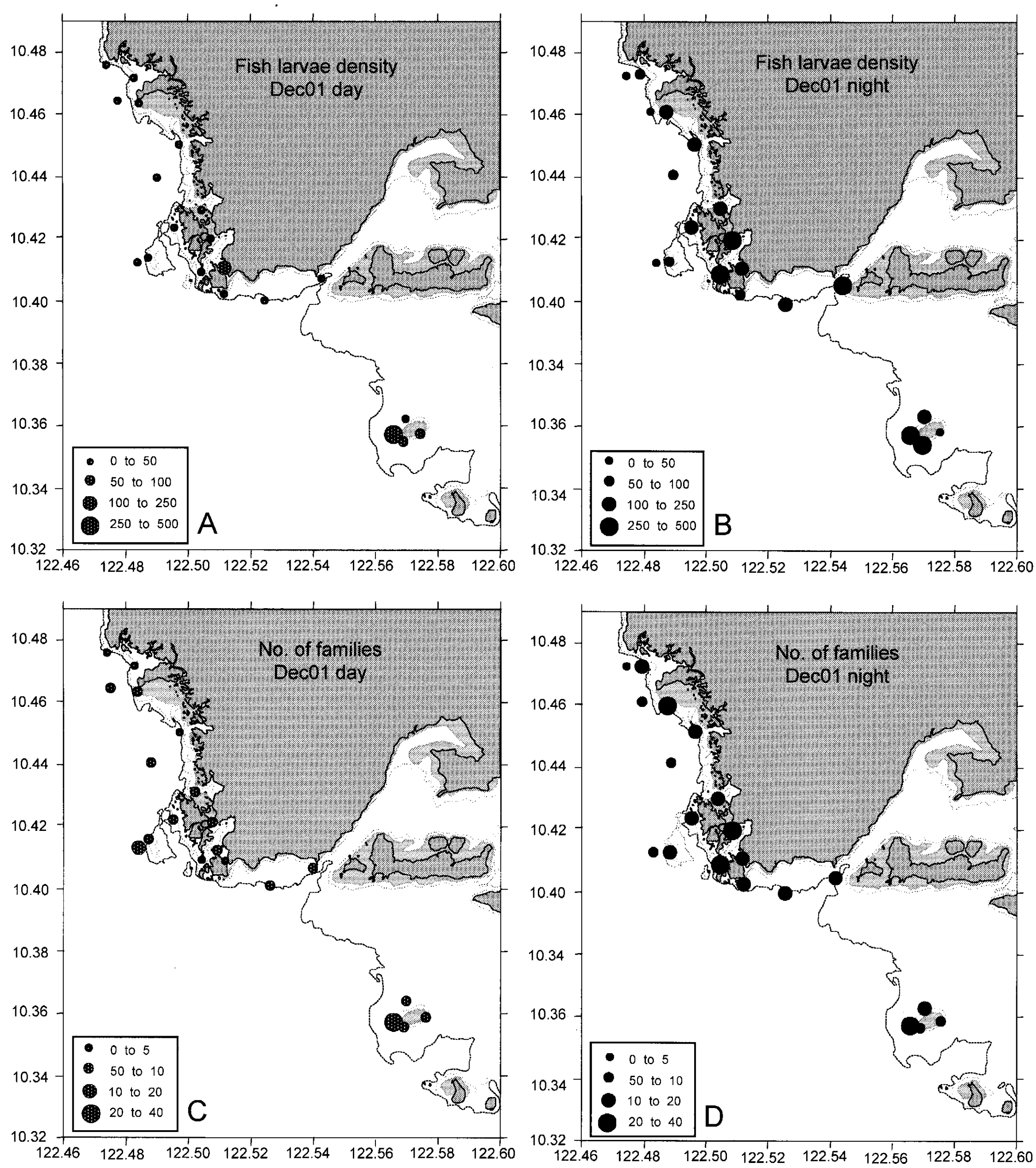

Fig. 2. The distribution of fish larvae density (ind./100 m^3) during the day (A) and night (B), and the distribution of fish larvae diversity (no. of families) during the day (C) and night (D) in the study area in December 2001.

concentrations in the area are dispersed within a tidal cycle, which is about half a day in the study area where semi-diurnal tides dominate. The tidal regime in Southern Guimaras in December shows a much larger tidal range at night, with the ebb phase beginning after midnight. Since spawning during the ebb tides would facilitate dispersal and minimize predation on eggs as they are carried downstream (Johannes 1978), it is likely that spawning occurred during the hours immediately prior (i.e., dawn) to daytime sampling. Low egg concentrations one tidal cycle after (evening) would then be consistent with such a scenario.

There are, however, other factors affecting diel spawning patterns in reef fish. Much of the literature deals with the timing of spawning in response to predation risk of both propagules and spawners themselves (Robertson 1991). Crepuscular periods, dusk or dawn, might be favored because of reduced risks from predators which are generally less active during such portions of the day (Thresher 1984). Similarly, spawning at dawn would also result in less interruption of feeding in nocturnally active fish, especially those that move between reefs and seagrass beds (Robertson 1983). Whatever the true reasons are, conditions in Southern Guimaras in December seem to favor spawning at dawn.

Since the day and night surveys in this study were done on only a single occasion (i.e., December 2001), it may be argued that the data are too initial to allow extraction of

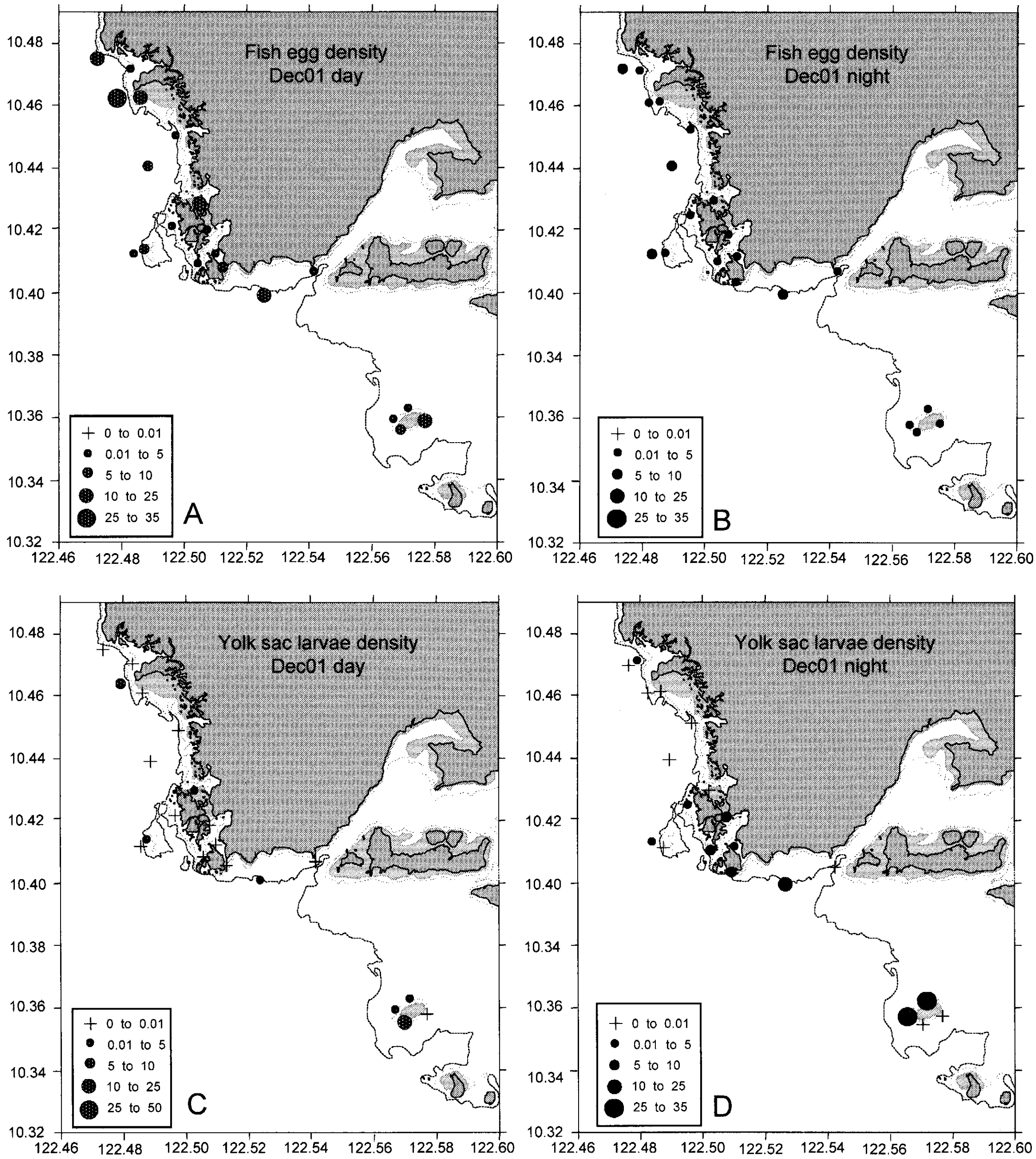

Fig. 3. The distribution of fish egg density (no./m^3) during the day (A) and night (B) and the distribution of yolk sac larvae (ind./100 m^3) during the day (C) and night (D) in the study area in December 2001.

trends. However, the spatially coherent results among shallow stations and their consistent difference with stations in deeper water (Figs. 2A & B) are strong arguments against the lack of a general pattern, as implied by Leis and McCormick (2001).

Because the increase in epibenthic diversity occurred over shallow water (Fig. 2C & D), it is tempting to attribute the observed pattern to the potential role of the substrate. The absence of large diel differences among pelagic groups (Fig. 2A & B also) reflects their independence of the substrate, while the recognizable diel pattern for soft demersals and reef associated groups reflects their eventual shift to an epibenthic habit. During the daytime, larvae of epibenthic fish avoid the surface where they are most visible to predation by planktivores. While they may still be visible on the bottom, the physical habitat structure of seagrass beds and coral reefs in the shallow portion of the study area may serve as shelter and protection from potentially high predation by epibenthic fish and other organisms. In contrast, the barren sandy substrate in the deeper open water area offers little protective habitat structure. Hence it is likely that larvae of most epibenthic fish are absent in the deeper area, resulting in apparently limited vertical movement. This may explain the weak diel differences in the deepwater stations of the study.

Reef fish larvae are believed to possess higher sensory competence than other fish larvae of the same size (Leis 1991). While habitat discrimination begins while still in the pelagic stages (Doherty and Carleton 1997), it is believed that only the late stage larvae appear to be capable of perceiving substrate suitability before settling (Boehlert 1996). Unfortunately, we were unable to stage or age specimens in the samples, but to our recollection there were no outstanding differences in the relative age composition of larvae caught during the day than at night. In fact yolk sac larvae were more abundant at night, particularly around Toyo Reef (Fig. 3D), but this is related more to the timing of hatching than to behavioral vertical movement.

If the observed nocturnal increase in abundance and diversity of epibenthic larvae can be truly attributed to use of bottom habitat structure as shelter from predation during the daytime, then it is likely that a large portion of these larvae are in their late developmental stages. The abundance of both yolk sac and late developmental stage larvae in Southern Guimaras suggests that reef fish populations in the area are recruited locally (Leis and McCormick 2001).

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References

Boehlert, G. W. 1996. Larval dispersal and survival in tropical reef fishes. *In* Reef Fisheries. Polunin, N. V. C. and Roberts, C. M. (eds.), pp. 61–112, Chapman and Hall, London.

Campos, W. L. and Delola, A. P. 1998. Occurrence and distribution of fish larvae in Taklong Island National Marine Reserve, Guimaras. UPV J. Nat. Sci. 3(2): 109–123.

Campos, W. L., Evano N. P., Beldia, P. D. II, and Santillan, A. S. 2002. Prospects from improved protection in marine reserves: An initial analysis of reef fish abundance, fishing effort and habitat complexity in southern Guimaras. UPV J. Nat Sci. 7: 146–157.

Doherty, P. J. and Carleton, J. H. 1997. The distribution and abundance of pelagic juvenile fish near Grub Reef, Central Great Barrier Reef. Proc. 8th Int. Coral Reef Symp. 2: 1155–1160.

Haney, J. F. 1988. Diel patterns of zooplankton behaviour. Bull. Mar. Sci. 43: 583–603

Johannes, R. E. 1978. Reproductive strategies of coastal marine fishes in the tropics. Environ. Biol. Fishes 3: 65–84.

Kingsford, M. J. and Choat, J. H. 1989. Horizontal distribution patterns of presettlement reef fish: Are they influenced by the proximity of reefs? Mar. Biol. 101: 285–297.

Kobayashi, D. R. 1989. Fine-scale distribution of larval fishes: Patterns and processes adjacent to coral reefs in Kaneohe Bay, Hawaii. Mar. Biol. 100: 285–293.

Leis, J. M. 1991. The pelagic stage of reef fishes: The larval biology of coral reef fishes. *In* The Ecology of Fishes on Coral Reefs. Sale, P. F. (ed.). pp. 183–230, Academic Press, Inc., California.

Leis, J. M. and Carson-Ewart, B. M. 2001. Behaviour of pelagic larvae of four coral reef fish species in the ocean and an atoll lagoon. Coral Reefs 19: 247–257.

Leis, J. M. and McCormick, M. I. 2001. The biology, behaviour, and ecology of the pelagic, larval stage of coral reef fishes. *In* Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem, Sale, P. F. (ed.), pp. 171–199, Academic Press, California.

Roberts, C. M. and Polunin, N. V. C. 1991. Are marine reserves effective in management of reef fisheries? Rev. Biol. Fish. 1: 65–91.

Robertson, D. R. 1983. On the spawniong behavior and spawning cycles of eight surgeonfishes (Acanthuridae) from the Indo-Pacific. Environ. Biol. Fishes 9: 192–223.

Robertson, D. R. 1991. The role of adult biology in the timing of spawning of tropical reef fishes. *In* The ecology of fishes on coral reefs. Sale, P. F. (ed.), pp. 356–398, Academic Press Inc., San Diego, CA.

Thresher, R. E. 1984. Reproduction in reef fishes. TFH Publ., Neptune City, New Jersey.