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An Assessment of the Impact of the Solar I Oil Spill on Ichthyoplankton in the Taklong Island National Marine Reserve (TINMAR), Southern Guimaras, Philippines

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Abstract

Data on the abundance, composition and distribution of ichthyoplankton assemblages in the TINMAR from previous investigations (1998-99 and 2000-01) are compared with similar data collected after the oil spill in August 2006 (2006-08). Patterns of variability are described for both sets of data. The overall results of the current monitoring effort do not show any conclusive link between observed egg and larval abundance, distribution and composition on one hand, and the potentially deleterious effects of the oil spill. While some of the observed differences between data from post-spill and earlier surveys may be attributed to an expected impact from the oil spill (e.g., differences in observed densities and the (age) composition of larval assemblages), these cannot be separated from what appears to be natural levels of spatial and or temporal (tidal, diurnal, lunar, month-to-month, and or seasonal) variability. Hence, the focus of future monitoring efforts will shift towards determining an appropriate sampling scheme to systematically address the spatio-temporal and habitat factors having a major influence on ichthyoplankton abundance and distribution in coastal waters.

The immediate impact of oil spills is typically recognizable in intertidal habitats where contaminants are repeatedly brought in and deposited by the tides. The extent of the impact will vary depending on hydrographic and topographic features specific to a given area, and on the kind and amount of oil contaminant. Subtidal habitats (e.g., coral reefs and seagrass beds) may be affected by oil spills if conditions lead to the physical mixing (thru waves) above the shallow subtidal portions or to the settling of deposits formed at the surface.

Not all effects, however, are visible to the naked eye, while others may emerge long after visible contamination has dissipated. Plankton consist of microscopic organism that live in the water column and are among those groups that would be most affected by the oil on and in the water. Larvae of many bottom-dwelling organisms, such as shrimp, crabs and mollusks are planktonic. The eggs and larvae of most fish are likewise planktonic. Any effects on these early life stages would have corresponding effects on their subsequent recruitment. Moreover, any change in their abundance will have effects on organisms that prey on them.

This study focused on the ichthyoplankton (fish eggs and larvae) of waters in the vicinity of the Taklong Island National Marine Reserve (TINMAR) in southern Guimaras to determine and characterize any possible effect(s) of the spilled oil on their abundance, composition and distribution.

Materials and Methods

Ichthyoplankton samples were collected from late August 2006 until May 2008, at roughly 2-month intervals. This report summarizes the overall results of surveys conducted up to January 2008, although information on taxonomic composition is available only up to September 2007. The rest of the samples are still being processed and identified.

Samples were collected during the daytime in all surveys, and from 30 Sep 06 onwards, corresponding night surveys were done as well. During each occasion, ichthyoplankton (fish eggs and larvae) were collected from 13 stations within the reserve (Fig.1) by means of 5 minute surface (within the top 0.5m) tows using a rectangular (0.25m X 0.75m) plankton net with a 2.25m long 300μm mesh bag attached to it. A mechanical flowmeter was attached across the mouth of the net to allow estimates of water volume filtered. All samples were fixed in 10% formalin-seawater in the field and brought back to the lab for processing and identification. Fish eggs were counted and larvae were identified to family or genus level, while larval developmental stages were determined using pre-

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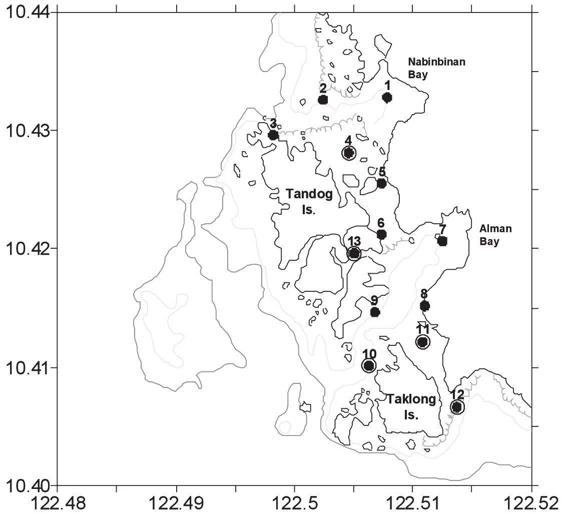

Fig. 1. Location of stations surveyed during ichthyoplankton surveys conducted from Aug 2006 to May 2008 in the Taklong Island National Marine Reserve. Isobaths: Light (10m), Dark (20m). Encircled black dots indicate stations included in both previous (2000-01) and recent (2006-08) surveys.

viously described criteria.

The results are compared with data from similar surveys conducted in 1998[1] and 2000-01[2] using the same field sampling procedures and covering similar (1998) or the same (2000-01) stations within the reserve.

Results and Discussion

Seasonal and Diurnal Abundance

A summary of fish egg and larval densities for all surveys up to January 2008 are presented in Table 1. Mean daytime fish larval densities in the study area varied little between the different surveys, ranging from 19.7 to 68.2 ind./100m^3, with an overall mean of 44.3 larvae/100m^3 across all surveys. Mean densities by survey appeared to decrease from August 2006 to November 2007 (Fig. 2), but increased again in January 2008. There were no recognizable trends within years,

Table 1. Summary of fish egg and larval densities in the Taklong Island National Marine Reserve from day and night surveys conducted from August 2006 to January 2008.

DAY	Larvae Density (ind./00m^3)									
	26-Aug 06	3-Sep 06	1-Oct 06	24-Nov 06	21-Feb 07	28-Aug 07	11-Sep 07	7-Nov 07	10-Jan 08	Overall mean
n	12	12	13	13	13	13	13	13	13	13
mean	68.2	47.9	43.1	32.4	42.3	35.1	44.0	19.7	62.3	44.3
sd	64.4	31.4	38.5	24.3	44.3	44.0	71.2	21.8	67.1	21.0
median	32.7	39	34.9	24.9	23.8	23.7	23.4	12.2	39.5	40.9
min	6.4	7.5	5.9	2.7	0.0	0.0	0.0	0.0	11.0	16.4
max	189.5	97.6	138.8	85.8	129.0	167.5	270.1	76.5	222.0	84.2
	Egg Density (no./m^3)									
n	12	12	13	13	13	13	13	13	13	13
mean	5.0	17.7	9.5	1.4	3.0	14.4	29.4	18.8	10.9	12.1
sd	5.4	33.1	9.7	1.9	4.8	24.1	49.8	31.9	24.0	10.7
median	2.7	5.5	6.3	0.6	1.5	2.3	7.6	11.5	0.5	9.2
min	0.3	0.5	0.5	0.0	0.1	0.3	2.0	0.5	0.0	1.9
max	18.1	120.3	36.9	6.9	16.0	81.3	176.2	121.9	67.3	41.2
NIGHT	Larvae Density (ind./100m^3)									
			30-Sep-06	23-Nov-06	21-Feb-07	28-Aug-07	10-Sep-07	7-Nov-07	10-Jan-08	Overall mean
n			10	13	13	13	13	13	13	13
mean			657.8	401.4	917.3	845.0	1709.9	3670.1	629.7	1276.1
sd			620.1	302.4	629.2	764.0	1429.2	3450.4	418.6	667.8
med			496.6	341.0	768.3	537.4	873.5	2315.1	563.1	1075.6
min			80.6	16.8	161.1	85.5	149.6	228.1	159.1	220.5
max			1981.8	990.8	2159.0	2565.9	3864.8	11652.4	1629.8	2543.1
	Egg Density (no./m^3)									
n			10	13	13	13	13	13	13	13
mean			6.8	6.5	3.7	5.0	19.2	21.2	7.6	10.1
sd			4.1	6.4	4.6	4.6	19.5	20.0	10.2	6.8
med			7.1	2.5	2.2	2.8	11.6	14.2	4.6	8.2
min			0.9	0.7	0.3	0.9	0.8	3.0	0.1	2.5
max			16.5	18.3	15.1	15.7	60.1	58.1	35.2	21.8

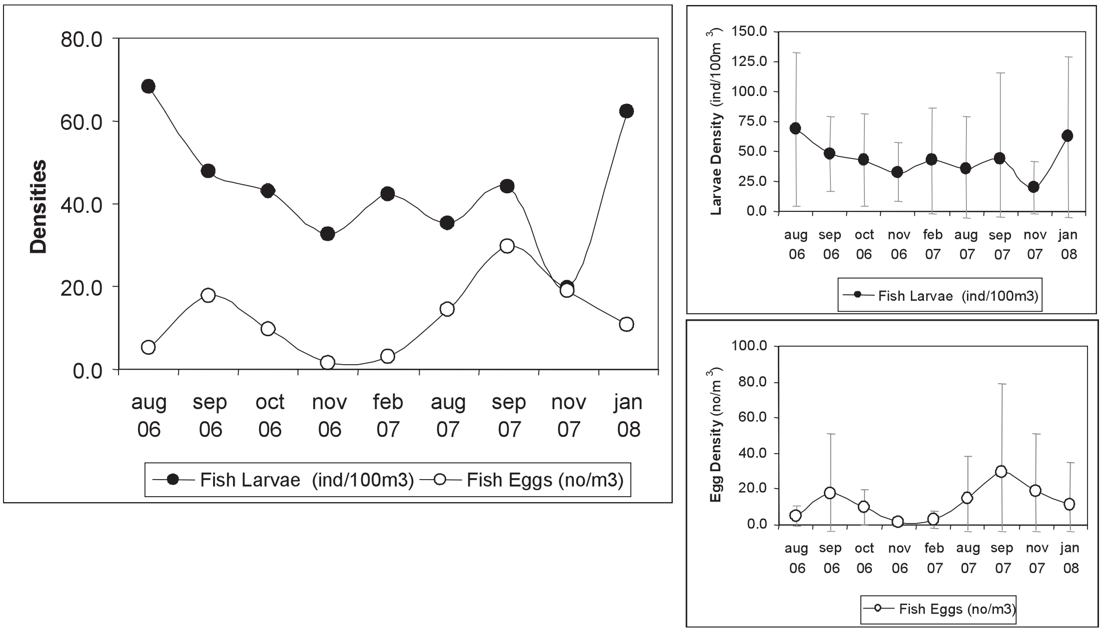

Fig. 2. Mean daytime egg and larval densities recorded in the study area during each survey. The figures on the right show mean density +/- sd (error bars).

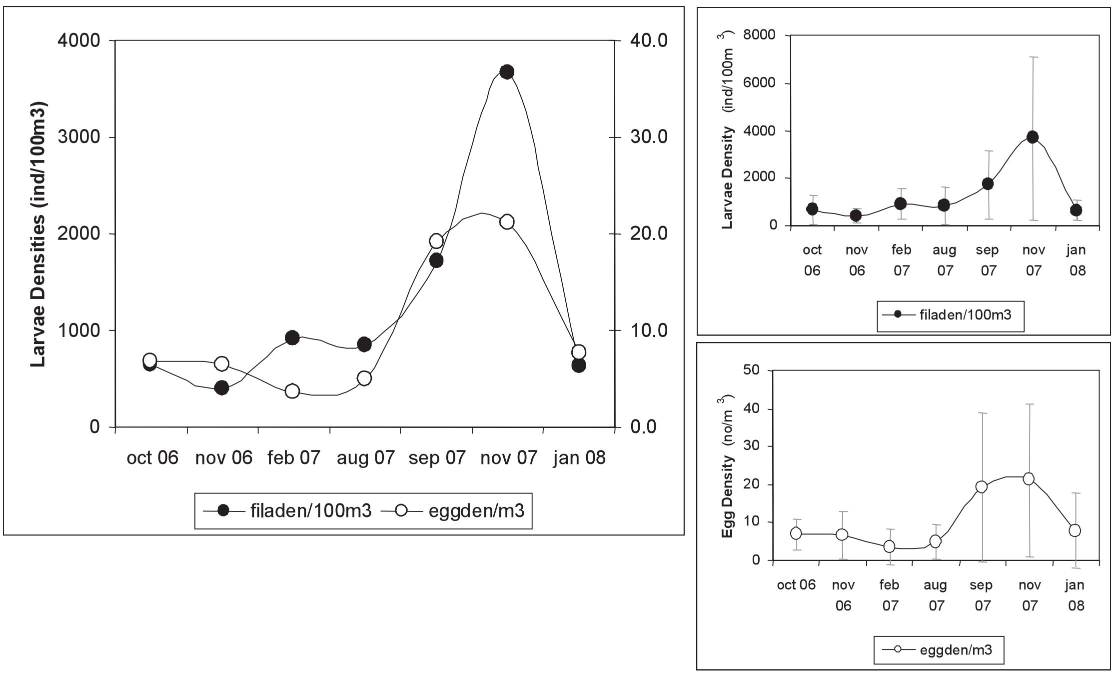

Fig. 3. Mean nighttime egg and larval densities recorded in the study area during each survey. The figures on the right show mean density +/- 1 sd (error bars).

and within survey variability was generally high when mean densities were also high. This is indicative of patchiness in larval densities within the study area.

Mean daytime egg densities ranged from 1.4 to 29.4 eggs/m^3, with an overall mean of 12.1 eggs/m^3 across the different surveys. Egg densities in both years were highest in September and generally lower during the NE monsoon months (Fig. 2). Similar to larval densities, spatial variability in egg densities was also highest in months with high densities. This is again indicative of patchiness within the study area.

Nighttime larval densities ranged from 401.4 to 3670.1 ind/100m^3 (Table 1) and were much higher than daytime densities. The highest mean night time density was recorded in November 2007 (Fig. 3), when highest within survey (= between station) variability was also highest. During this month, extraordinarily high larval densities were observed in the northern portion of the study area (stn 2 particularly; > 11,000 ind/100m^3) and within the mangrove channels of Tandog Is. (stn 13; > 8000 ind/100m^3). Excluding extreme values for this survey, the overall mean larval density at night would be 860.2 ind/100m^3, or roughly 20X more than the overall daytime mean density across the different surveys.

Egg densities during the night were comparable to daytime values, although spatial variability within any given survey was generally less during the night (Fig. 3). Within the year, egg densities showed a decrease towards the NE monsoon months, similar to the trend shown by daytime densities.

On the whole, a rough seasonal trend in egg densities can be recognized, which is consistent in 2006 and 2007 and from both day and night surveys. Egg densities were highest during the late SW monsoon season and decreased towards the NE monsoon. Aside from the Summer being another major spawning season for coastal fish, little else can be said about spatial and or temporal (between months) variability and distribution during these months. No surveys were conducted in the Summer of 2007 due to delays in the release of project funds. Surveys were conducted in March and May 2008 but the samples are still being processed. More surveys need to be conducted during the Summer to form a complete picture for spawning seasonality.

For larvae, high variability in both day and night samples masks any underlying seasonal pattern, if any. There is also a large and contrasting difference in the trends shown by day and night samples (Figs. 2 and 3). Clearly, relations with tidal, lunar and habitat conditions have to be examined more systematically to more meaningfully discuss the observed trends.

Aside from higher densities, larval assemblages were more diverse at night (Tables 2-6). The number of families observed in daytime surveys from October 2006 to September 2007 ranged from 11-19, while night surveys for the same period showed 27-45 families (Fig. 4). On average, the number of observed families at night was 2.4X the number observed during the day, with the largest diurnal differences shown by groups closely associated with the substrate (demersal and reef-associated groups) (Fig. 5). This has been documented in previous (pre-spill) investigations in the study area[3]. For the most part, the largest diurnal difference in assemblage composition was an increase in the proportion of gobies (family gobiidae) at night, with the appearance/disappearance of less abundant families at different times of the day (Tables 2-6). On the whole, gobies dominated both day and night surveys, with several less common families appearing only at night (Fig. 6). Of the more common groups, atherinids, carangids and clupeids appeared to be more abundant during the daytime, while apogonids were more abundant at night.

Spatial Distribution Patterns

Larval distribution patterns were similar in both day and night surveys, with areas of relatively high concentrations located in the northern portion of the study area (stn 2), within the channel between Tandog and Taklong Islands (stn 9) and in the channel within the mangroves of Tandog Is. (stn 13) (Figs. 7a-b). However, there seemed to be higher variability in the southern portion of the study area during the day than at night (Figs. 7c-d), particularly in the mangrove channel (stn 13), within Alman Bay (stn 7) and at the southern entrance to the reserve (stn 12). On the other hand, variability at night was highest at the northern entrance to the reserve (stn 2) and in the mangrove channel.

Egg density distributions were more similar and consistent between day and night surveys. High concentrations were observed at the northern entrance to the reserve and within the deep channel between Tandog and Taklong Is. (Figs. 8a-d). These areas also show the highest variability in egg densities and might be related to constrictions in the flow of water in the north, on the one hand, and a "funnel" effect in the deep channel in the central reserve area, resulting in an accumulation of eggs as water enters or leaves the reserve with the tides[4]. These are also the general vicinities where larval concentrations were high during the entire day. Interestingly, unlike larvae, egg densities were consistently low in the mangrove channel.

It is believed that the mangrove channel (stn 13) serves as a nursing area for larvae and that the dense mangrove stands and their high productivity bring about favorable food conditions for larvae that are transported into the reserve[4]. The relatively high larval densities observed in stn 13 during both day and night is consistent with this idea, although the accompanying high variability (Figs. 7b & d) indicates substantial seasonal (or month to month) variability, which point to considerable inconsistencies in larval abundances. A more systematic sampling regime considering the very shallow por-

Table 2. Taxonomic composition of fish larvae collected from all stations in day and night surveys conducted in the Marine Reserve in Sep/Oct 2006.

October 2006 DAY Taxon	Density	%	NIGHT Taxon	Density	%
Gobiidae	13.4	31.1	Gobiidae	414.7	62.1
Nemipteridae	7.4	17.2	Pomacentridae	63.6	9.5
Pomacentridae	3.5	8.1	Apogonidae	18.8	2.8
Atherinidae	2.8	6.4	Blenniidae	16.6	2.5
Apogonidae	1.4	3.3	Nemipteridae	12.3	1.8
Blenniidae	1.4	3.2	Engraulidae	11.9	1.8
Carangidae	0.9	2.2	Bregmacerotidae	3.7	0.5
Clupeidae	0.8	2.0	Congridae	2.8	0.4
Labridae	0.8	1.7	Atherinidae	2.8	0.4
Mullidae	0.7	1.6	Carangidae	1.7	0.2
Antennariidae	0.4	1.0	Ophichtidae	1.6	0.2
Microdesmidae	0.4	1.0	Mullidae	0.9	0.13
Triacanthidae	0.4	0.9	Gerreidae	0.8	0.12
Tripterygidae	0.2	0.6	Clupeidae	0.8	0.12
Mugilidae	0.2	0.5	Terapontidae	0.7	0.11
Hemiramphidae	0.2	0.5	Labridae	0.7	0.10
Scorpaenidae	0.2	0.4	Belonidae	0.6	0.09
Yolk Sac	4.5	10.5	Callionymidae	0.5	0.07
UNID	3.3	7.6	Trichiuridae	0.5	0.07
			Syngnathidae	0.5	0.07
Total	43.1	100	Fistuariidae	0.4	0.06
			Tripterygidae	0.4	0.06
			Scaridae	0.4	0.05
			Scorpaenidae	0.3	0.04
			Megalopidae	0.3	0.04
			Cirrhitidae	0.1	0.02
			Pinguipedidae	0.1	0.02
			Yolk Sac	80.8	12.10
			UNID	28.9	4.33
			Total	668.0	
	density	%		density	%
Demersal	24.2	68.6		447.8	80.2
Epipelagic	4.8	13.5		18.4	3.3
Mesopelagic	0	0.0		3.7	0.7
Reef-associated	6.3	17.9		88.4	15.8
no. families	17			27	
day only	5				
night only				15	

tions of the channel and the use of sampling techniques appropriate for use within the mangrove stand can provide more information that will allow verifying the importance of the mangrove stands of Tandog as "sinks" for early stage fish larvae.

Comparison with pre-spill years

Fish larval densities from August 2006 to January 2008 averaged 44.9 ind/100m^3. This is lower than the average densities observed from 1998-2001 (mean = 54.0) (Table 7), but well within the range of observed (natural) spatial variability within the study area (t-test; p = 0.2) in any given year (Fig.

Table 3. Taxonomic composition of fish larvae collected from all stations in day and night surveys conducted in the Marine Reserve in November 2006.

November 2006								
DAY			NIGHT					
Family	Den	%	Family	Den	%	Family	Den	%
Gobiidae	10.9	33.6	Gobiidae	201.2	49.84	Paralichthyidae	0.82	0.20
Atherinidae	4.4	13.7	Pomacentridae	55.11	13.65	Clupeidae	0.79	0.20
Carangidae	3.3	10.1	Engraulidae	41.71	10.33	Haemulidae	0.64	0.16
Pomacentridae	2.6	7.9	Leiognathidae	8.65	2.14	Synodontidae	0.61	0.15
Engraulidae	1.4	4.2	Carangidae	7.37	1.83	Gonostomatidae	0.52	0.13
Clupeidae	0.7	2.1	Apogonidae	5.48	1.36	Atherinidae	0.47	0.12
Monacanthidae	0.4	1.1	Myctophidae	5.22	1.29	Ammodytidae	0.33	0.08
Labridae	0.4	1.1	Sparidae	4.83	1.20	Cynoglossidae	0.33	0.08
Terapontidae	0.3	1.0	Bregmacerotidae	4.14	1.03	Meneidae	0.33	0.08
Fistulariidae	0.3	1.0	Nemipteridae	3.64	0.90	Hemiramphidae	0.32	0.08
Gonostomatidae	0.3	0.8	Terapontidae	3.40	0.84	Centriscidae	0.31	0.08
Callionymidae	0.19	0.6	Callionymidae	3.04	0.75	Drepaneidae	0.31	0.08
Myctophidae	0.19	0.6	Polynemidae	2.86	0.71	Trichonotidae	0.31	0.08
Bregmacerotidae	0.19	0.6	Mullidae	2.29	0.57	Blennidae	0.29	0.07
Ammodytidae	0.17	0.5	Tetraodontidae	1.99	0.49	Schindleriidae	0.29	0.07
Sphyraenidae	0.15	0.5	Penguipedidiae	1.80	0.45	Fistulariidae	0.26	0.06
Apogonidae	0.15	0.5	Monacanthidae	1.79	0.44	Lutjanidae	0.22	0.05
Blennidae	0.15	0.5	Gobiescocidae	1.31	0.32	Sphyraenidae	0.20	0.05
Tetraodontidae	0.15	0.5	Labridae	1.25	0.31	yolk sac	19.93	4.94
yolk sac	5.7	17.5	Solenostomatidae	1.07	0.26	UNID	16.32	4.04
UNID	0.6	1.8	Bothidae	1.06	0.26			
			Sillaginidae	1.00	0.25	Total	403.8	
Total	32.4	100.0						
no. families	19			40				
day only	0							
night only				21				
	Den	%		Den	%			
Demersal	23.17	88.6		359.2	97.7			
Epipelagic	1.9	7.1		4.85	1.3			
Mesopelagic	0.55	2.1		0.98	0.3			
Reef-associated	0.59	2.3		2.50	0.7			

9).

In comparison, mean daytime egg density from 2006-08 (mean = 12.2 eggs/m^3) was twice the mean from earlier years (mean = 6.1 eggs/m^3) and in spite of high spatial variability within the study area (Fig. 10), this difference is large enough to be significant (t'-test for unequal variances; p = 0.055). Many factors can affect observed fish egg densities in either small or large scales. On the fine scale, time of day, tidal stage, habitat conditions, weather and spawning behavior are among the major factors, while climate, coastal topography, hydrography and year-to-year differences are responsible for large scale variability. In the study area, year-to-year differences can be recognized between densities recorded in 2006 (Aug – Nov, shortly after the oil spill), with lower values (mean = 8.4 eggs/m^3; sd = 7.03), and observed densities in 2007 (also Aug – Nov) (mean = 20.9; sd = 7.74) (Table 8; Fig. 10). While this difference is significant (t-test; p = 0.04), it may not necessarily be directly linked to the oil spill.

In our previous report, the very low relative abundance of late larval stages (postflexion and early juvenile) on 26 Aug 06 was attributed to high egg and also perhaps yolk sac larvae mortalities immediately following the oil spill incident two weeks before (i.e., 11 Aug 06). Had there been no such high mortality, eggs spawned around the time of the oil spill would

Table 4. Taxonomic composition of fish larvae collected from all stations in day and night surveys conducted in the Marine Reserve in February 2007.

February 2007								
DAY			NIGHT					
Family	Den	%	Family	Den	%	Family	Den	%
Atherinidae	15.1	35.6	Gobiidae	406.9	44.29	Plesiopidae	1.5	0.16
Gobiidae	12.3	29.1	Pomacentridae	169.5	18.45	Leiognathidae	1.5	0.16
Pomacentridae	1.6	3.8	Apogonidae	72.3	7.86	Gerreidae	1.3	0.15
Blenniidae	1.4	3.2	Clupeidae	24.6	2.67	Labridae	1.3	0.15
Monacanthidae	0.8	1.9	Blenniidae	21.9	2.39	Solenostomidae	1.2	0.13
Engraulidae	0.7	1.7	Myctophidae	20.1	2.18	Syngnathidae	1.1	0.12
Carangidae	0.6	1.5	Engraulidae	15.0	1.63	Trichonotidae	0.9	0.10
Myctophidae	0.6	1.5	Nemipteridae	12.2	1.32	Ephippidae	0.9	0.10
Bregmacerotidae	0.5	1.1	Microdesmidae	11.8	1.28	Monacanthidae	0.9	0.10
Lobotidae	0.3	0.6	Sparidae	11.7	1.27	Serranidae	0.7	0.07
Callionymidae	0.2	0.5	Bregmacerotidae	6.8	0.74	Bothidae	0.6	0.06
Clupeidae	0.2	0.5	Eleotrididae	6.4	0.69	Cynoglossidae	0.5	0.06
Gerreidae	0.2	0.5	Berycidae	4.7	0.52	Sillaginidae	0.5	0.06
Gobiesocidae	0.2	0.5	Terapontidae	4.5	0.50	Mugilidae	0.5	0.05
Microdesmidae	0.2	0.5	Scorpaenidae	4.2	0.45	Paralichthyidae	0.4	0.05
UNID	7.4	17.5	Callionymidae	3.7	0.40	Synodontidae	0.4	0.05
			Pinguipedidae	3.7	0.40	Serrivomeridae	0.4	0.04
Total	42.4	100	Tetraodontidae	3.5	0.38	Hemiramphidae	0.4	0.04
			Carangidae	2.5	0.27	Fistulariidae	0.3	0.04
			Atherinidae	2.4	0.27	Paralepididae	0.3	0.04
	day	night	Scombridae	2.2	0.24	Congridae	0.3	0.04
			Mullidae	1.8	0.19	UNID	87.2	9.49
			Ammodytidae	1.6	0.17			
			Balistidae	1.6	0.17	Total	918.7	100.0
no families	15			45				
day only	2							
night only				32				
	Den	%		Den	%			
Demersal	32.6	93.1		813.8	97.9			
Epipelagic	1.6	4.5		9.6	1.1			
Mesopelagic	0.4	1.2		2.7	0.3			
Reef-associated	0.4	1.2		5.5	0.7			

have grown and developed into late stage larvae at the time of the survey. Their absence two weeks after the spill has thus been inferred to result from high egg mortalities. While this scenario may make sense, a comparison with more recent data covering 2007 show that late larval stages were also rare in August 2007 (Fig.11). Late stage larvae start appearing in the samples in September in both years and are present until the following NE Monsoon, at least in late 2006 to early 2007. Whether this is consistent from year to year can be verified once samples for early 2008 have been completely processed.

On the other hand, it is not known if late stage larvae are truly rare during all the SW monsoon months. It is believed that most coastal fish in the tropics exhibit protracted spawning, with population peaks either in the Summer or the transition from SW to NE monsoon, or both. The presence of eggs and larvae year-round, though in varying concentrations, and more so the presence of shallow water fish groups year-round (Fig.12), are clear indications of year-round spawning in various fish groups. If this is so, seasonal differences in spawning frequency/intensity alone may not result in the rareness of late stage larvae in August.

A closer examination of conditions during specific surveys

Table 5. Taxonomic composition of fish larvae collected from all stations in day and night surveys conducted in the Marine Reserve in August 2007.

August 2007								
DAY			NIGHT					
Family	Den	%	Family	Den	%	Family	Den	%
Gobiidae	19.80	57.07	Gobiidae	615.5	74.50	Percophidae	0.4	0.05
Blenniidae	4.80	13.73	Pomacentridae	76.9	9.31	Ammodytidae	0.4	0.05
Pomacentridae	4.64	13.23	Blenniidae	26.0	3.14	Scombridae	0.4	0.04
Clupeidae	2.85	8.13	Apogonidae	23.6	2.86	Syngnathidae	0.4	0.04
Engraulidae	0.33	0.95	Terapontidae	3.2	0.39	Myctophidae	0.4	0.04
Sillaginidae	0.19	0.54	Mullidae	2.1	0.25	Sillaginidae	0.2	0.03
Microdesmidae	0.19	0.54	Engraulidae	2.1	0.25	Hemiramphidae	0.2	0.02
Mullidae	0.19	0.53	Clupeidae	1.7	0.20	Mugilidae	0.2	0.02
Serranidae/Anthiinae	0.19	0.53	Tetraodontidae	1.5	0.18	Ambassidae	0.2	0.02
Monacanthidae	0.18	0.51	Sparidae	1.4	0.17	Labridae	0.2	0.02
Atherinidae	0.14	0.39	Atherinidae	1.3	0.16	Microdesmidae	0.2	0.02
Yolk sac	0.00	0	Leiognathidae	1.2	0.14	Scorpaenidae	0.2	0.02
			Nemipteridae	0.9	0.11	Trichonotidae	0.2	0.02
UNID	1.35	3.84	Bregmacerotidae	0.9	0.11	Ophichthidae	0.2	0.02
Total	34.8		Gerreidae	0.7	0.09	Siganidae	0.2	0.02
			Callionymidae	0.6	0.07	Sphyraenidae	0.2	0.02
			Carangidae	0.4	0.05	UNID	61.9	7.49
			Pinguipedidae	0.4	0.05			
						Total	826.1	100.0
no families	11			34				
present day only	2							
present night only				29				
	Den	%		Den	%			
Demersal	32.43	96.8		759.5	99.4			
Epipelagic	0.57	1.7		2.6	0.3			
Mesopelagic	0	0.0		0.4	0.1			
Reef-associated	0.50	1.5		1.6	0.2			

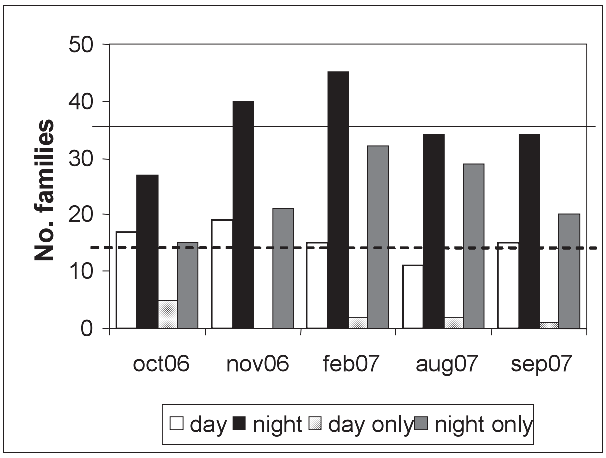

Fig. 4. Number of fish families recorded during day and night surveys in the study area from October 2006 to September 2007. The dashed line indicates the mean number of families recorded during all daytime surveys included in the analysis, while the solid line indicates the mean number of families recorded during night surveys.

conducted in August (with late stages rare) and September (with late stages present) of both years show different tidal stages (semi-diurnal flood on 26Aug08; diurnal ebb on 03Sep06) and tidal (spring vs neap) and lunar (new vs 1st Q) phases in 2006 (Fig. 13a). Conditions in 2007, however, were very similar, except for lunar phase (full on 28Aug07 vs new on 11Sep07) (Fig. 13b). The consistent difference in conditions in both years was lunar phase. This factor has to be treated systematically in designing future surveys. Unfortunately, ontogenetic staging was not performed on samples collected from 1998-2001, precluding any comparison with historical data. In the future, along with referencing with lunar phase, more frequent surveys have to be conducted during the SW monsoon months, or perhaps starting in the Summer, to examine seasonal spawning and recruitment in more detail.

Table 6. Taxonomic composition of fish larvae collected from all stations in day and night surveys conducted in the Marine Reserve in September 2007.

September 2007								
DAY			NIGHT					
Family	Den	%	Family	Den	%	Family	Den	%
Gobiidae	19.09	43.3	Gobiidae	774.7	42.1	Cynoglossidae	1.9	0.1
Pomacentridae	8.50	19.3	Pomacentridae	602.8	32.7	Tetraodontidae	1.7	0.1
Clupeidae	3.42	7.8	Engraulidae	80.2	4.4	Scaridae	1.4	0.1
Blenniidae	3.09	7.0	Blenniidae	59.1	3.2	Solenostomidae	1.4	0.1
Atherinidae	2.26	5.1	Apogonidae	57.2	3.1	Carangidae	1.4	0.1
Carangidae	1.10	2.5	Nemipteridae	26.5	1.4	Syngnathidae	1.3	0.1
Engraulidae	0.96	2.2	Sparidae	20.7	1.1	Microdesmidae	1.0	0.1
Pinguipedidae	0.51	1.1	Leiognathidae	11.7	0.6	Lutjanidae	0.9	0.1
Apogonidae	0.32	0.7	Pinguipedidae	7.5	0.4	Myctophidae	0.9	0.0
Monacanthidae	0.27	0.6	Clupeidae	6.0	0.3	Soleidae	0.6	0.0
Cynoglossidae	0.27	0.6	Terapontidae	4.0	0.2	Berycidae	0.6	0.0
Platycephalidae	0.26	0.6	Callionymidae	3.6	0.2	Paralichthyidae	0.5	0.0
Tetraodontidae	0.26	0.6	Bregmacerotidae	3.4	0.2	Mugilidae	0.4	0.0
Sparidae	0.25	0.6	Sillaginidae	3.3	0.2	Platycephalidae	0.4	0.0
Nemipteridae	0.23	0.5	Atherinidae	3.2	0.2	Ambassidae	0.4	0.0
			Hemiramphidae	2.4	0.1	Gobiesocidae	0.3	0.0
Total	44.11	100.0	Labridae	2.4	0.1	UNID	154.7	8.4
			Scorpaenidae	2.2	0.1			
						Total	1840.7	
no families	15			34				
day only	1							
night only				20				
	Den	%		Den	%			
Demersal	38.42	94.2		1670.8	99.1			
Epipelagic	1.36	3.3		7.8	0.5			
Mesopelagic	0	0.0		2.4	0.1			
Reef-associated	1.00	2.5		5.0	0.3			

Conclusion

The overall results of the study do not show any conclusive link between observed egg and larval abundance, distribution and composition on one hand, and the potentially deleterious effects of the oil spill in August 2006. While some of the observed differences between data from post-spill and earlier surveys may be attributed to an expected impact from the oil spill (e.g., differences in observed densities and the (age) composition of larval assemblages), these cannot be separated from what appears to be natural levels of spatial and or temporal (tidal, diurnal, lunar, month-to-month, and or seasonal) variability. Hence, the focus of future monitoring efforts will shift towards determining an appropriate sampling scheme to systematically address the spatio-temporal and habitat factors having a major influence on ichthyoplankton abundance and distribution in coastal waters.

Acknowledgements

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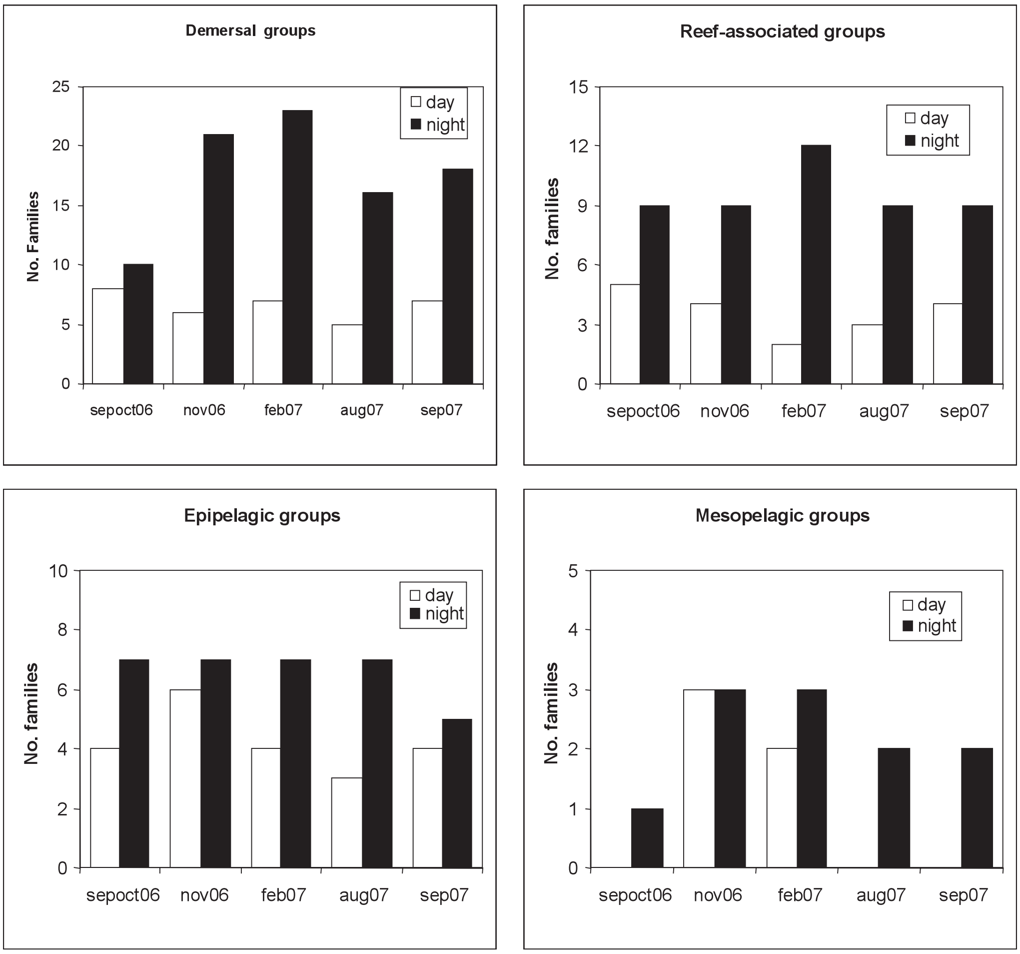

Fig. 5. Number of fish families by general habit (demersal, reef-associated, epipelagic or mesopleagic) observed in day and night surveys in the study area from October 2006 to September 2007.

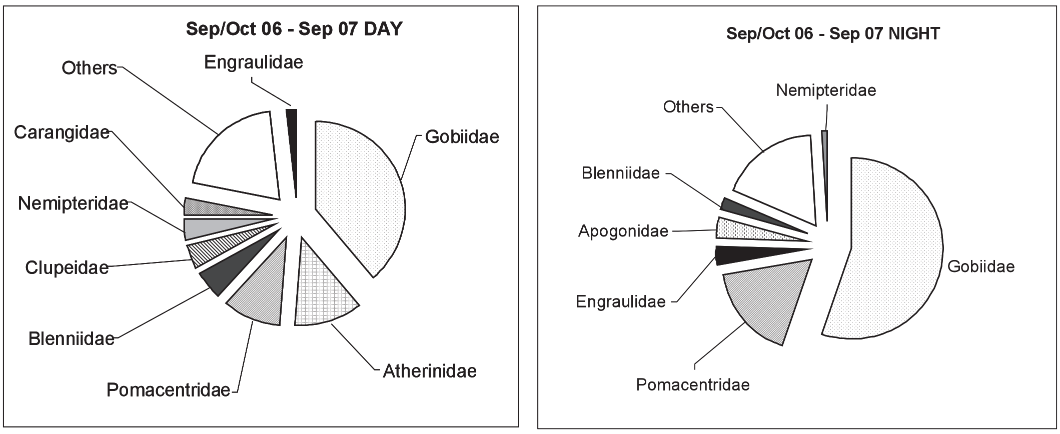

Fig. 6. Composition (%abundance) of larval assemblages for all daytime (upper) and nighttime (lower) surveys combined (Oct 06 to Sep 07).

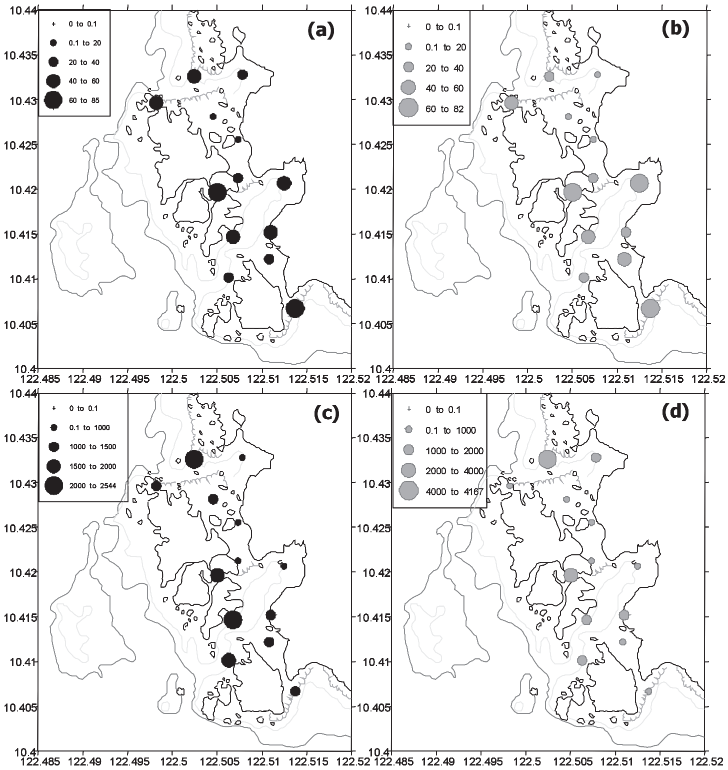

Fig. 7. Distribution of mean (a) and standard deviation (b) of larval densities during the daytime; distribution of mean (c) and standard deviation (d) of larval densities during the night. Values are based of data from combined surveys during the period Oct 2006 to Jan 2008. Note: density units are in ind./100m^3.

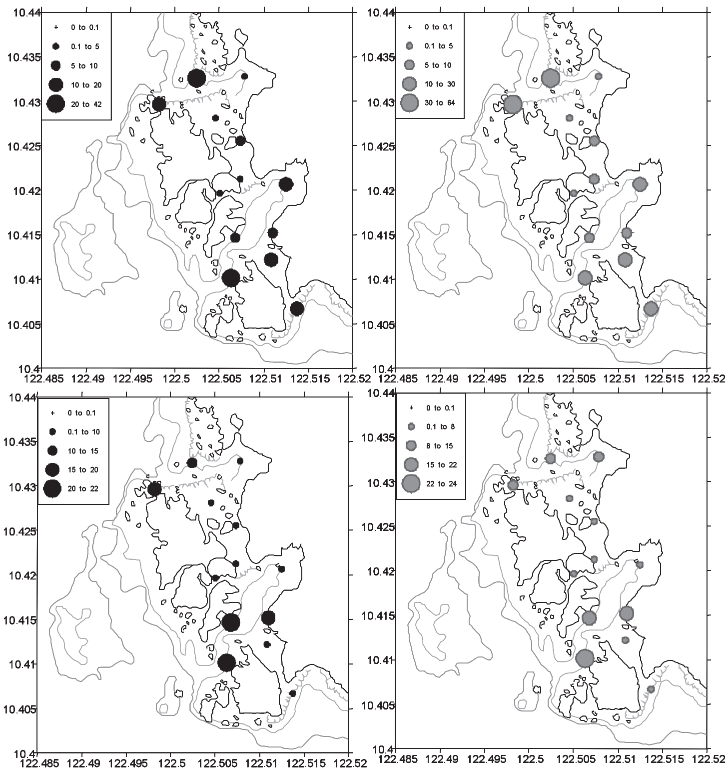

Fig. 8. Distribution of mean (a) and standard deviation (b) of fish egg densities during the daytime; distribution of mean (c) and standard deviation (d) of fish egg densities during the night. Values are based of data from combined surveys during the period Oct 2006 to Jan 2008. Note: density units are in eggs/m^3.

Table 7. Summary of egg (no./m^3) and larval (ind./100m^3) densities from previous (1998-2001) and post-spill (2006-08) ichthyoplankton surveys done in the Marine Reserve.

	1998-2001		2006-08	
	larvae	eggs	larvae	eggs
n	9	7	9	9
mean	54.0	6.1	44.9	12.2
sd	27.6	4.3	14.4	8.9

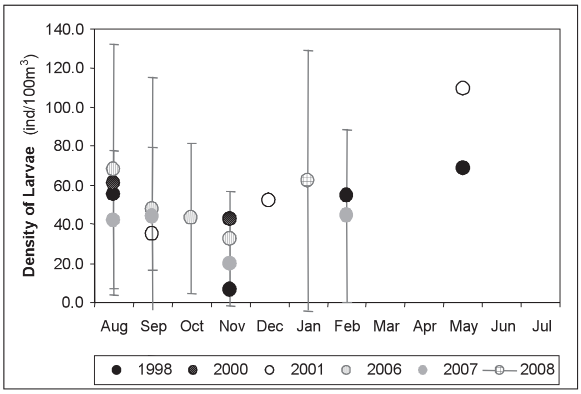

Fig. 9. Comparison of daytime larval density estimates from previous surveys[1,2] with estimates from the more recent (post-spill; 2006-08) surveys conducted in the vicinity of the Taklong Island National Marine Reserve. The same net and sampling procedure was employed in all surveys. Note: vertical error bars indicate +/- 1 sd from the mean.

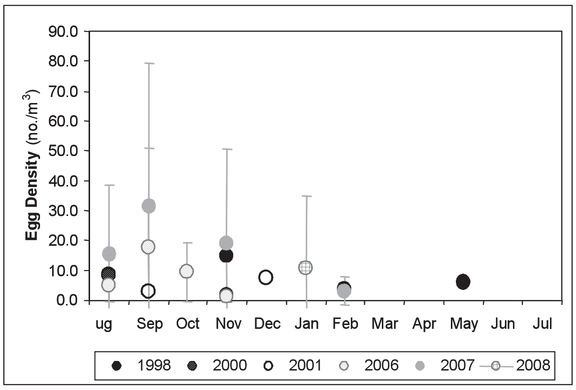

Fig. 10. Comparison of daytime egg density estimates from previous surveys[1,2] with estimates from the more recent (post-spill; 2006-08) surveys conducted in the vicinity of the Taklong Island National Marine Reserve. The same net and sampling procedure was employed in all surveys. Note: vertical error bars indicate +/- 1 sd from the mean.

Table 8. Summary of egg (no./m^3) and larval (ind./100m^3) densities in post-spill surveys done in the Marine Reserve in 2006 and 2007.

	2006		2007	
	Larvae	Eggs	Larvae	Eggs
n	4	4	3	3
mean	47.90	8.40	35.33	20.88
sd	15.00	7.03	13.56	7.74

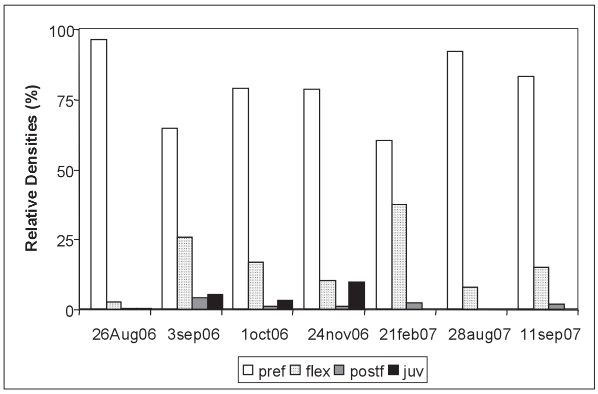

Fig. 11. Relative abundance of the different ontogenetic stages of fish larvae collected during daytime surveys in the Marine Reserve from Aug 2006 to Sep 2007. Note: pref = pre-flexion; flex = flexion; postf = post-flexion; juv = juvenile

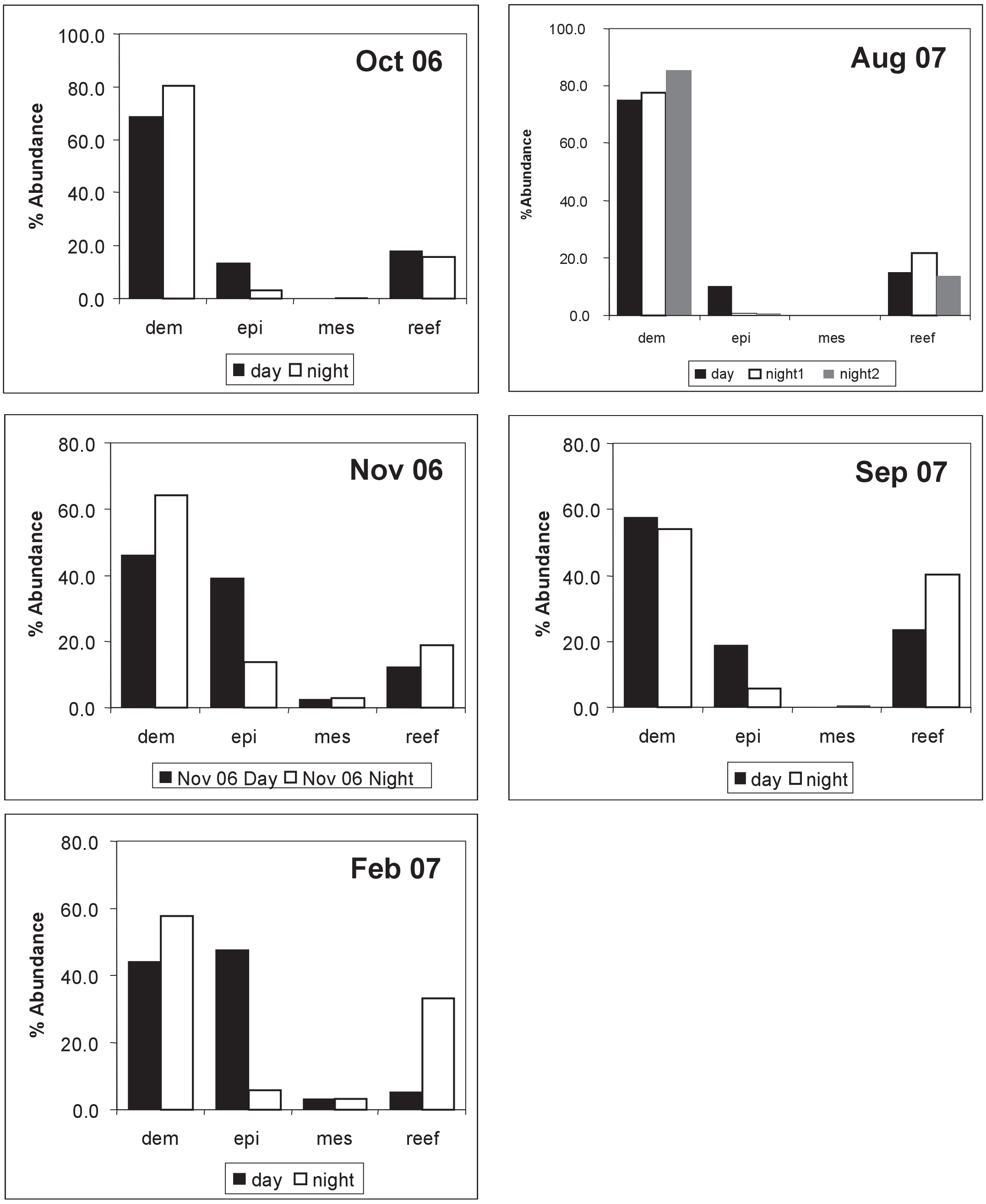

Fig. 12. Relative abundance of demersal (dem), epipelagic (epi), mesopelagic (mes) and reef associated (reef) larval families in day and night samples collected from the Reserve from Oct 2006 to Sep 2007.

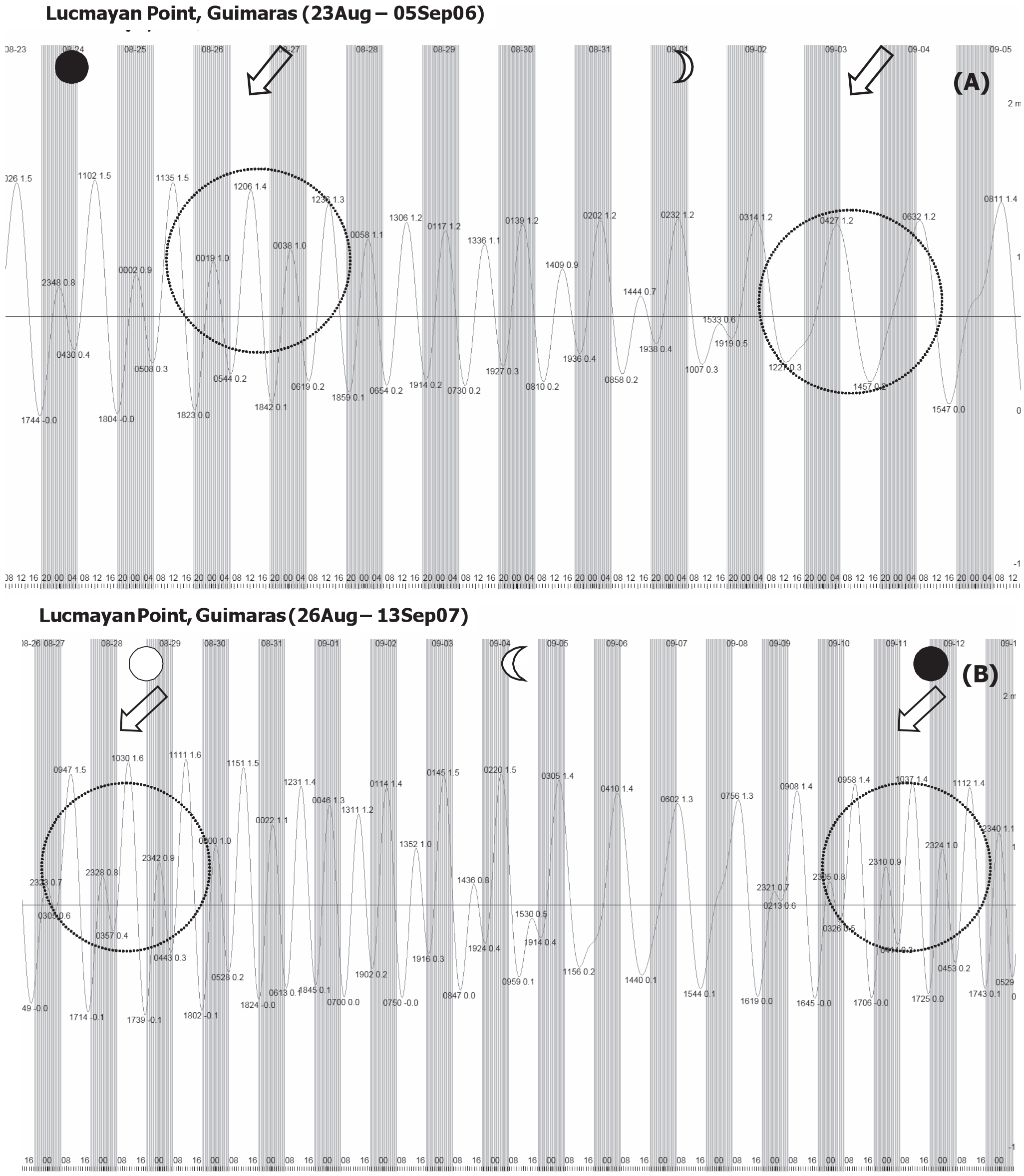

Fig. 13. Tidal and lunar phases during surveys conducted on (a) 26 Aug and 03 Sep 2006 (upper), and (b) 28 Aug and 11 Sep 2007 (lower). Note: Predicted tides are based on calculations for Lucmayan Point, Guimaras using the software WXTide32 (Hopper, 2003).

References

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

2) Campos, W.L., P.M. Alino, V.V. Hilomen, R. Samson, N. Lasola, and C. Villanoy (2004). Enhancing sustainable fisheries through improved marine fishery reserves (MFRs): Summary of results, in "Proceedings of the 3rd and 4th National Workshops on the Formulation of the Philippine Marine Sanctuary Strategy (PhilMarSaSt)" (ed. by Arceo, H.O., W.L. Campos, F. Fuentes, and P.M. Alino). University of the Philippines – Marine Science Institute, Diliman, Quezon City, pp. 103-112.

3) Campos, W.L. and A.S. Santillan (2005). Diel patterns in abundance, distribution and composition of ichthyoplankton in shallow reef areas in Southern Guimaras, Central Philippines. *Coastal Marine Science,* **30**(1):373-378.

4) Santillan, A.S., W.L. Campos, N.P. Evano, and P.D. Beldia II (2003). Fish Larval Flux in Taklong Island National Marine Reserve, Guimaras, Central Philippines. Paper presented at the 7th National Symposium on Marine Science, Cagayan de Oro, Misamis Oriental, October 2003.

5) Campos, W.L, (2003). Measuring larval spillover from a reserve: Taklong Island, Philippines. *MPA News,* **4**(9):3.

6) Kendall, A.W., E.H. Ahlstrom, and H.G. Moser (1984). Early life history stages of fishes and their characters, in "Ontogeny and sytematics of fishes" (ed. by Moser, H.G., W.J. Richards, D.M. Cohen, M.P. Fahay, A.W. Kendall, and S.L. Richardson). American Society of Ichthyologists and Herpetologists Special Publication 1, pp. 11-22.

7) Pauly, D. and N.A. Navaluna (1983). Monsoon-induced seasonality in the recruitment of Philippine fishes, in "Proceedings of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources" (ed. by G.D. Sharp and J. Csirke). San Jose, Costa Rica, 18-29 April 1983. *FAO Fish. Rep.,* **291**(3): 823-833.