An assessment of the impact of the Solar 1 Oil Spill on ichthyoplankton abundance, composition and distribution in Southern Guimaras, Central Philippines

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Abstract: The potential impact of the Solar 1 Oil Spill on the ichthyoplankton in southern Guimaras was investigated. Plankton samples were collected by means of 5 min surface horizontal tows using a 0.25 X 0.75m rectangular plankton net fitted with a bag of 300 mm mesh. At least 12 stations were sampled on each of 3 occasions corresponding to 2 weeks, 3 weeks and 7 weeks after the spill. The results covering this period showed that fish egg and larval densities were no different from densities observed in the reserve in 2000 and 2001. The relative age distribution of the larvae showed the absence of flexion to late stages 2 weeks after the spill, indicating high egg and early larval mortality during this period. The major larval species groups observed in this study were the same dominant groups observed in previous surveys, except for the absence of nemipterids up to at least 3 weeks after the spill. In previous surveys, nemipterids made up about 11% of all larvae. Their absence immediately after the spill may likely affect subsequent recruitment in the area.

Keywords:
Oil spill; ichthyoplankton; Central Philippines

Introduction

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 settling of deposits formed at the surface.

Not all possible effects, however, are visible to the naked eye, while others may emerge long after visible contamination has dissipated. Plankton consist of microscopic organisms 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, mollusks are planktonic. The eggs and larvae of most fish are likewise planktonic (Leis, 1991). 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 as well.

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

The investigation was limited to the marine reserve for two reasons: (1) the availability of baseline (pre-spill) data from surveys conducted in 1998 and from August 2000 to December 2001, and (2) covering a wider area would not allow completion of a time series of data within the three months allotted for the rapid assessment. Because processes in the plankton occur on such fine time scales, potential trends could be discernible by sampling the area repeatedly over several weeks.

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Ichthyoplankton were collected during the day from 12-13 stations within the reserve on 26 Aug, 03 Sep and 01 October. These dates are, respectively, two, three and seven weeks after the oil spill. A rectangular (0.25m X 0.75m) plankton net with a 2.25m long 300mm mesh bag attached to it was towed alongside the boat within the top 0.5m of the water for 5 minutes at each station. 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 using the keys of Leis and Carson-Ewart (2000), Okiyama (1988), Ozawa (1986) and Moser, *et. al* (1984). Larvae were considered "unidentified" if they were damaged, too young to identify, or were not described in literature. Larval developmental stages were determined using the criteria outlined in Table 1 below.

Estimates of egg and larval densities, together with taxonomic and relative age composition of the larval assemblage were compared with baseline (pre-spill) data collected from surveys conducted in 1998-99 (Campos and Delola, 1998) and 2000-01 (Campos et al., 2002). In the present plankton surveys, a total of 12-13 stations were sampled within the reserve. Of these, only five (5) were sampled in previous surveys. To assess the potential impact of the spill on overall egg and larval concentrations within the reserve, data from only those stations sampled in previous and current surveys (Fig. 1) were used to minimize additional spatial variability attributable to differences in station location.

Results & Discussion

Overall Trends

The seasonal trend in the abundance of fish eggs and larvae within the reserve is shown by data collected from all stations. Fish egg (no./m3) and larval (ind./100m3) densities for August, September and October 2006 are shown in Table 2. Egg concentrations increased from 4.4 per m3 two weeks after the spill (26 Aug) to over 20 per m3 the following week (03 Sep), then to 9.5 per m3 in 01 October. The increase in 03 September is also accompanied by high spatial variation (sd = 49; coeff. var. > 200%), which indicates high patchiness. Hence what might appear as an overall increase in egg density in September is likely an artifact of high concentrations observed in a single station (2). Excluding this sample, mean egg density in the rest of the stations for this month is about 8.4 per m3 (sd = 7.4).

Larval concentrations, on the other hand, showed a gradual decrease from 66.1/100m3 two weeks after the spill to 50.4/100m3 a week later, then to 43.7/100m3 after another four weeks. This trend is consistent with the overall decreasing trend in larval concentrations in the area during this time of the year, as shown by data from previous surveys (Fig. 2). This is likewise consistent with known spawning seasonality of fish in the country, with peaks in subsequent settlement (i.e., recruitment) during the transition months between monsoons. Hence, relatively high larval concentrations during the late southwest monsoon (Aug-Sep) generally show a decrease during the transition to the northeast monsoon (October-November), as post-larvae settle from the plankton.

Comparisons with Baselines

Comparisons with baseline data are presented in Fig. 3. Mean densities ranged from 5-6 per m3 for eggs, and 36-94 ind./100m3 for larvae during the period 26 Aug to 01 Oct 06. Egg densities in each of the 2006 surveys show little difference from baselines (Aug-Nov 00 and Sep-Dec 01), and are well within natural levels of variability (standard deviation bars) in the baseline data. Densities of fish larvae, however, show considerable deviations from baseline estimates, particularly during the first three (3) weeks after the spill (i.e., 25Aug06 & 03Sep06 data), with station densities ranging from 7 to 140 ind/100m3

Table 1. Description of developmental stages in fish larvae.

Stage	Description
Yolk Sac	Yolk sac (oil gobule in ventral body portion) present
Pre-flexion	Yolk sac completely resorbed; caudal notochord straight; initial development (thickening) of hypural region
Flexion a (early)	Caudal notochord flexed at angle < 45°; hypural fin rays visible
Flexion b (late)	Caudal notochord flexed at angle > 45 - 90°; caudal fin rays further developed
Post-flexion	Caudal fin rays extensively developed in both ventral & dorsal lobes
Juvenile	All vertical fin rays fully developed; individual appearance similar to adult

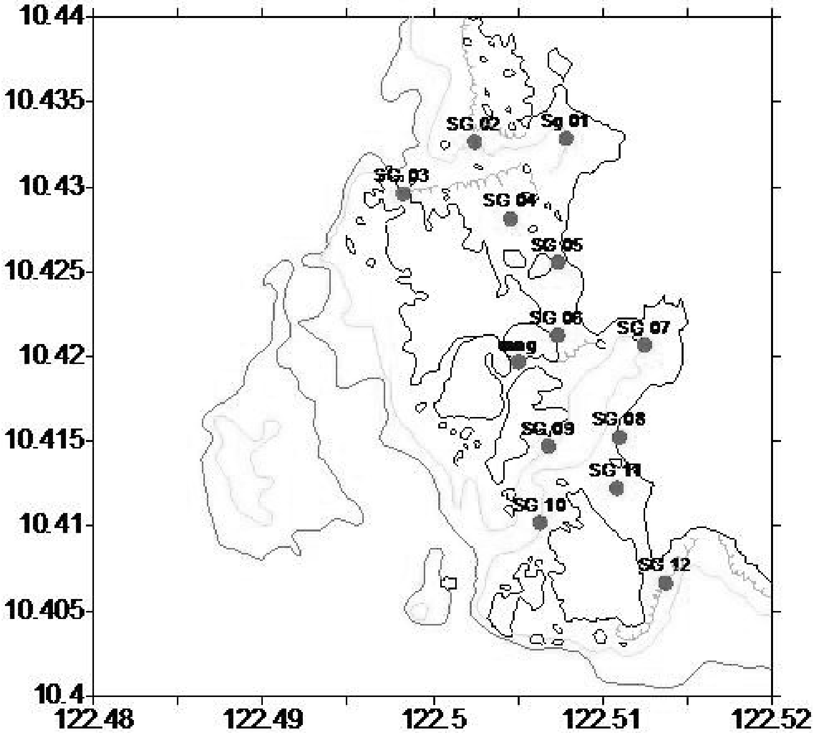

Figure 1. Location of stations surveyed during ichthyoplankton surveys conducted on 26 Aug, 03 Sep and 01 Oct 2006 in Southern Guimaras, Central Philippines. Blue circles indicate stations included in both previous and present surveys.

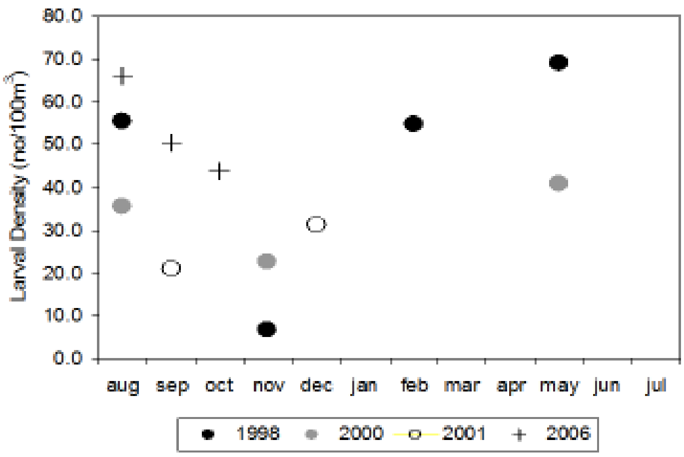

Figure 2. Seasonal trend in fish larval densities in Southern Guimaras based on data from surveys conducted in 1998-99 (Campos & Delola, 1998), 2000-01 (Campos, 2002). Density estimates for 2006 are indicated by "+" markers.

(Table 3). These indicate that there is wide natural spatial variability (patchiness) in egg and larval densities within the reserve at any given time. Patchiness is brought about by the interplay of many factors, including spawning behavior (Thresher, 1984; Robertson, 1991), water circulation and habitat locations in the area. Thus, while there appears to be considerable differences between baseline larval densities and those observed immediately after the spill, these cannot be traced directly to the oil spill. To be attributable to the spill, such differences would need to be greater than the already high natural spatial variability. However, statistical tests comparing variances (Fmax-test) and means (t-test) of combined 2006 and baseline (2000 & 2001) data did not show any significant differences (Table 4).

Relative Age Structure

The developmental stages of larval fish serve as indicators of "relative age". Plots of relative age

Table 2. Density of fish eggs (no./m^3) and larvae (ind./$100m^3$) in Southern Guimaras in August, September and October 2006.

Table 3. Summary of fish egg and larval densities for those stations included in both baseline surveys (Aug/Nov 2000 & Sep/Dec 2001) and the present study.

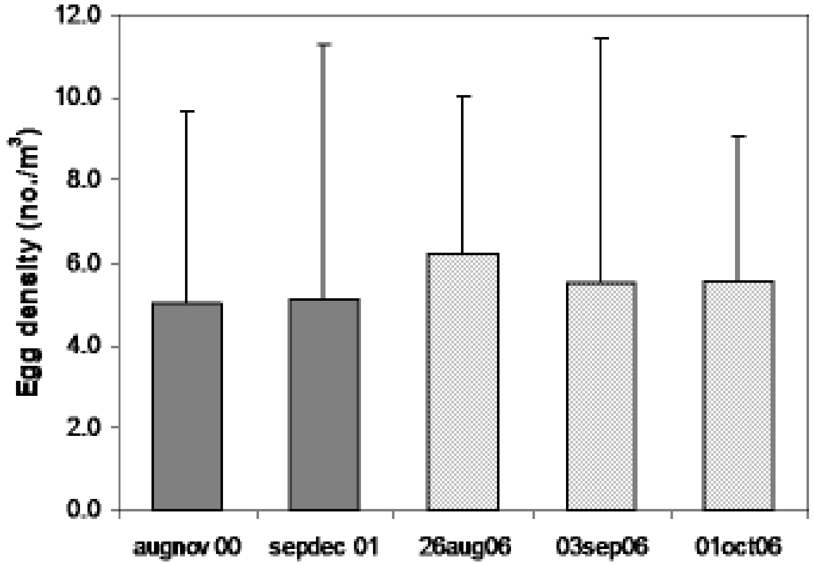

Figure 3. Egg (above) and larval (below) densities in previous and recent surveys in Southern Guimaras. Only the five (5) stations sampled in both sets of surveys are included in the comparisons. Error bars represent 1 standard deviation from the mean.

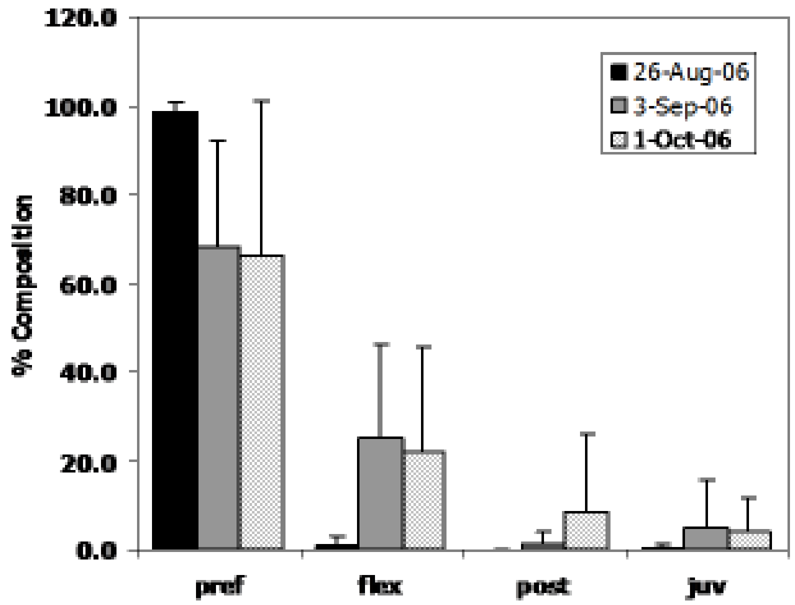

Figure 4. The % composition of developmental stages (relative ages) of fish larvae from samples collected in 26 Aug, 03 Sep and 01 Oct 2006 in Southern Guimaras.

structure by sampling date show the presence of only early (yolk sac & pre-flexion) stage larvae in 26 Aug, with later developmental stages appearing only after another week (starting 03 Sep) (Fig. 4). Since larval assemblages are generally comprised of many different species (from at least 15-25 families from 26Aug – 01Oct 2006), it is unlikely that all of them were spawned at the same time. Hence, early and late stage larvae (from different species) would likely be present all year round although their relative contributions may differ seasonally. The relative absence of "older" stages in late August suggests that there was high larval, and/or perhaps even egg, mortality immediately following the spill, with increasing survival a week or so later. Such a scenario would be consistent with the presence of only early stage larvae up to 2

Table 4. Results of statistical tests comparing larval density estimates from recent surveys with baseline estimates in 2000 (AugNov00) and 2001 (SepDec01). Only data from the five (5) stations common to all surveys were used in the analyses.

	Comparison of Variances			Comparison of means		
	df	F_{max}	prob	df	t	prob
AugNov00	9					
vs Aug06	3	1.079	0.533	12	1.294	0.110
vs Sep06	3	6.845	0.070	12	0.843	0.208
vs Oct06	4	0.93	0.423	13	0.183	0.858
SepDec01	9					
vs Aug06	3	0.825	0.360	12	1.682	0.059
vs Sep06	3	5.234	0.100	12	0.667	0.259
vs Oct06	4	0.711	0.307	13	0.463	0.325

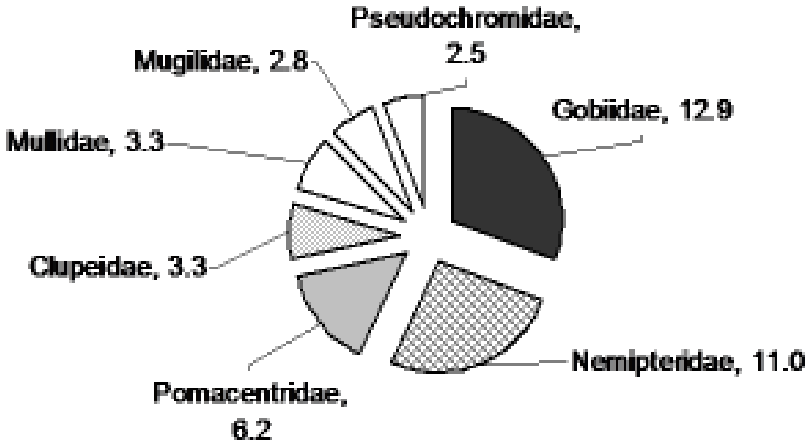

Figure 5 (a). The major larval groups in Southern Guimaras based on surveys conducted from August 2000 to May 2001 (from Campos et al., 2002).

weeks after the spill with a tendency towards "normalization" of relative age structure thereafter.

Spawning of fish stocks in the Philippines is driven by the monsoons, with peak recruitment generally during the inter-monsoon months (Pauly and Navaluna, 1983). The effect of a possible mass mortality of eggs and or early stage larvae over a 2-3 week period may not necessarily reduce overall recruitment in local stocks, because larval mortality rates in fish are (naturally) typically high (Houde, 1987) and spawning (in tropical fish) generally takes place over periods of a few months within seasons (Murphy, 1982). However, impairment or aberrations in adults resulting from possible latent effects of oil on early stages may have serious consequences on recruitment.

Larval Assemblage Composition

The composition of larval assemblages within the reserve from Aug-Oct 2006 (Figs. 5b-d) is similar to the composition shown in previous surveys (Fig. 5a). The major taxa present from August to October (Gobiidae & Pomacentridae) are also the dominant groups observed in the surveys from August 2000 to May 2001. The absence of nemipterid larvae up to 13 September 2006 and their appearance in high

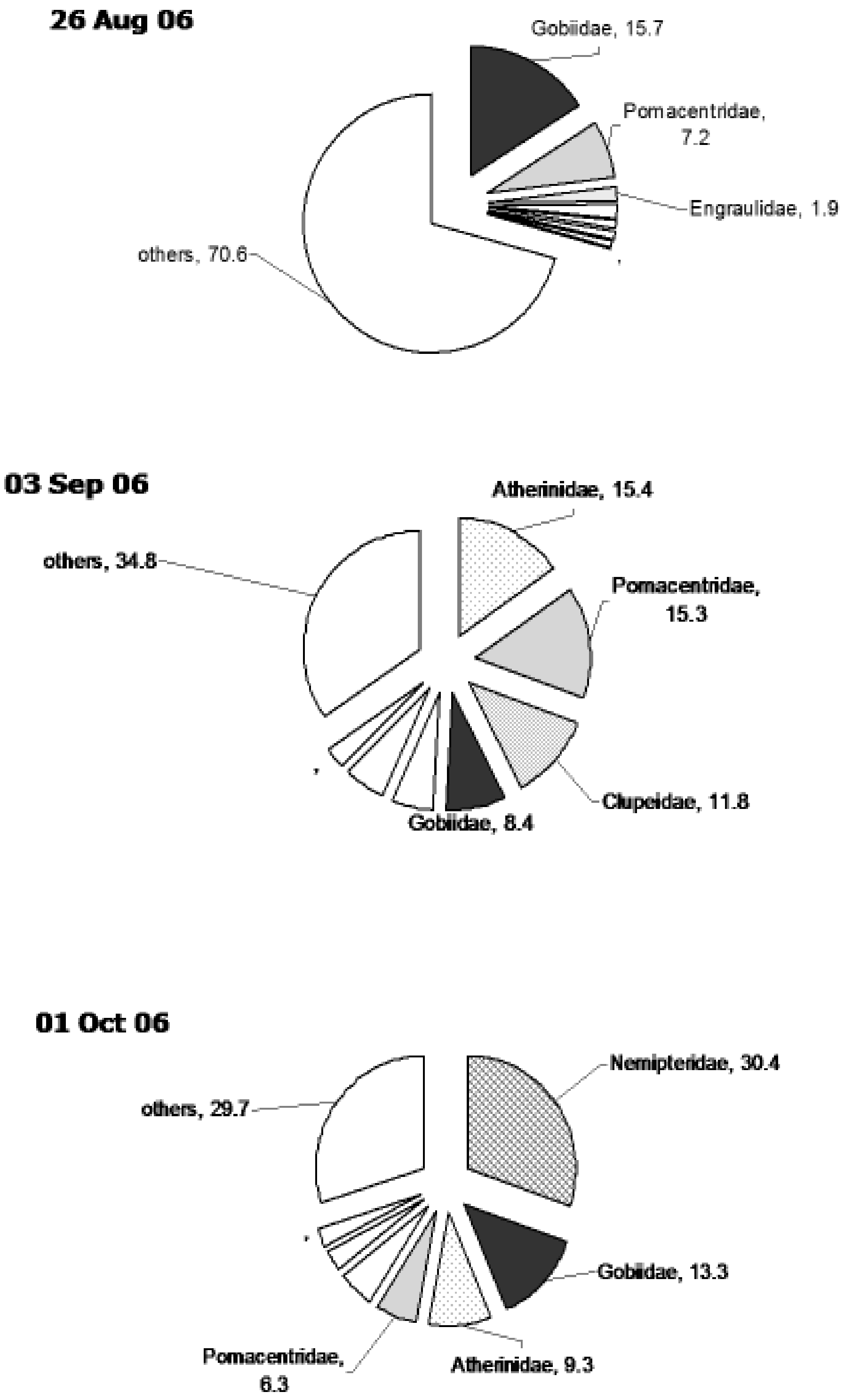

Figure 5. The major groups of fish larvae in Southern Guimaras from samples collected in (b) 26 Aug; (c) 03 Sep; and (d) 01 Oct 2006.

abundances (30.4%) in early October is noteworthy. In 2000-01, nemipterids comprised, on average, about 11.0% of all larvae recorded (Fig. 5a). Because they are typically among the dominant larval groups in the reserve and are typically present year-round, their absence up to at least three (3) weeks after the spill suggests that they may be especially vulnerable to oil. There are no studies on this subject in the literature. Possible sensitivity of nemipterid larvae to oil may have repercussions on capture fisheries in the area, because nemipterids comprise over 17% of fishery landings in Southern Guimaras (Campos, 2002). While losses in the larvae will be reflected in the abundance of subsequent juvenile stages, the impact on subsequent recruitment is not known.

Conclusion

Examining a combination of trends in larval abundance, age structure and assemblage composition provides more meaningful insights than data from any single set of characters. While there is a potential for latent effects and longer term consequences on local fish stocks, data from the first seven (7) post-spill weeks show that characteristics of the larval fish assemblage three (3) weeks after the spill are no longer different from those of assemblages in previous (uncontaminated) years. Whether this is a sign of recovery or just part of natural within-season variability is not certain. To determine when conditions will truly return to pre-spill levels, there needs to be monitoring at different time scales (e.g., diurnal, lunar/tidal) at regular intervals, since this is the only way we can verify when observed differences are well within previously observed spatial and seasonal patterns in variability.

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