A lifetime of mangrove research, management and advocacy

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Abstract

Apart from a decade of undergraduate teaching, my professional life has been directly or tangentially devoted to mangrove issues. Strife in my native Mindanao pushed my family and me to the peace and quiet of Panay Is. in central Philippines and to research on marine shrimp, the commercial superstars of the mangrove macrobenthos. My early focus was on broodstock development, larval rearing and pond grow-out of penaeids, mainly the mangrove-associated giant tiger prawn *Penaeus monodon* and the white shrimp *P. indicus*: Because brackishwater ponds are the dominant aquaculture system in the Philippines, species whose rearing requirements mimic the estuarine habitat, e.g., fluctuating salinity levels, have become the crops of choice. Published papers from this period include a classification of *P. monodon* egg quality types (Fig. 1: Primavera and Posadas 1981) which allows hatchery technicians to predict larval numbers and the corresponding tank water volume to prepare.

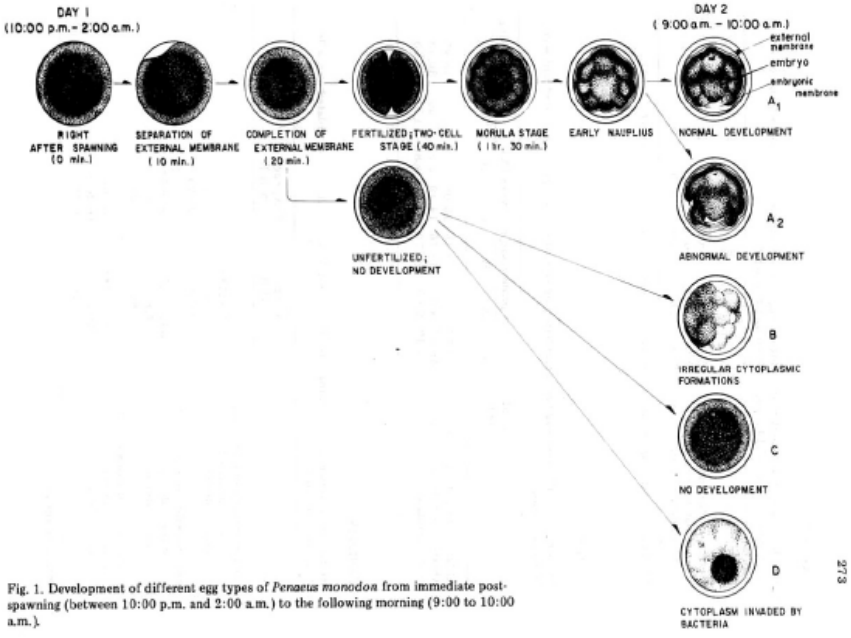


Fig. 1. Development of different egg types of *Penaeus monodon* from immediate post-spawning (between 10:00 p.m. and 2:00 a.m.) to the following morning (9:00 to 10:00 a.m.).

It was during visits to these coastal ponds that I first saw mangroves from an environmental perspective – as the former life of endless hectares of aquaculture ponds in the country (Primavera 1993, 1996, 2000a). With initially reported negative ecological and socio-economic impacts of unplanned aquaculture, including mangrove conversion to ponds (Primavera 1997b, 2006, spreading beyond Philippine shores, I joined international

colleagues in reporting these in *Science* (Naylor et al. 1998) and *Nature* (Naylor et al. 2000: Fig. 2).

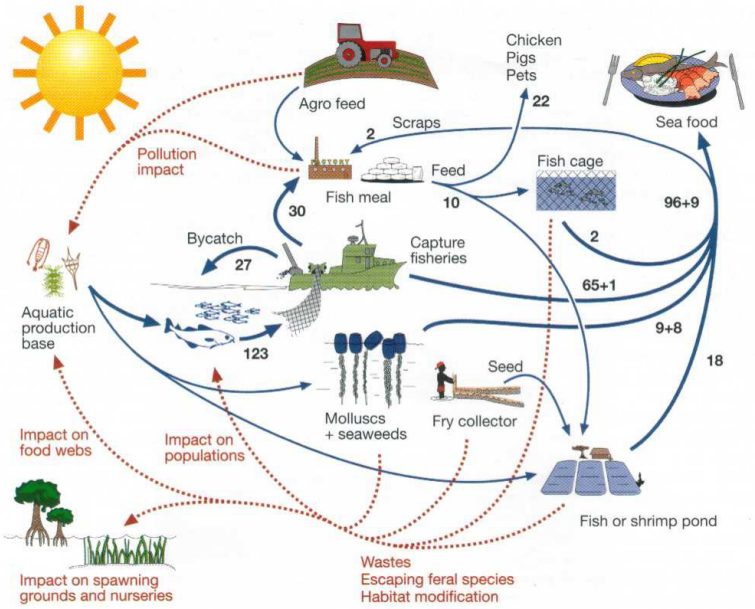
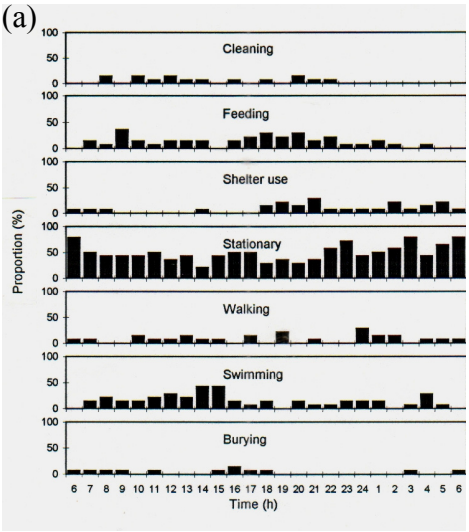


Fig. 2

My studies then shifted from applied (prawn culture) to basic research (prawn biology), such as the use of mangrove structures by juvenile shrimp for shelter as reflected in diel activity patterns (Figs. 3a, b show the original graph in Primavera and Lebata (2000) and its cartoonized form, respectively) for a doctoral thesis on the Role of Mangroves as Prawn Nurseries at the University of the Philippines (Primavera 1996, 1997a, 1998; Primavera and Lebata 1995). These pieces of information have contributed to a poster on the Life Cycle of *Penaeus monodon* (Fig. 4).

(a)



(b)

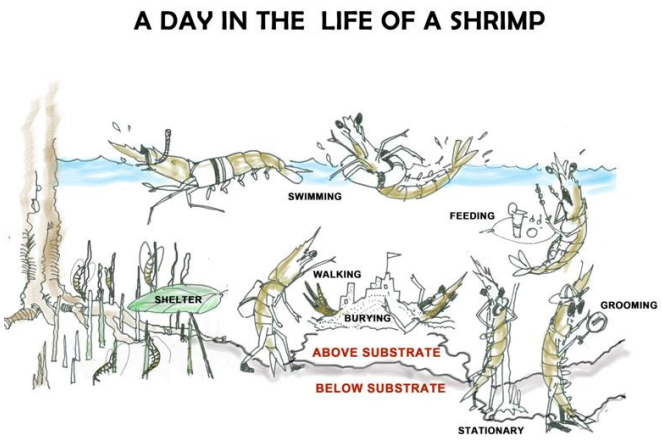


Fig. 3

Before retirement from active research, I looked at the possibility of integrating mangroves and aquaculture (Primavera 2000b) as an alternative to the pro-aquaculture policy of the Philippine government that led to massive clearcutting of mangroves in the 1950s-1970s. Sustainable aquaculture requires 4 hectares of mangroves for every hectare of pond (Saenger

et al. 1983). Yet only ~256,000 ha (Long and Giri 2011) of Philippine mangroves remain while culture ponds have increased to ~232,000 ha, giving a little over a 1: 1 mangrove-pond ratio. However, integrating ponds and mangroves is easier said than done. Mangrove-friendly aquaculture, also called Aquasilviculture, combines cultured crops with mangrove trees either in the same stand, or in separate ponds. Whereas mangroves need the regular ebb and flooding of sea water, aquatic species like shrimp and fish require a permanent water column, therefore their requirements are incompatible. Only the mud crab *Scylla*, a member of the macrobenthos which can withstand low tide exposure, can be farmed alongside mangroves in netpen enclosures – provided the trees are fully grown, as crabs like to consume the tender leaves of young plants (Primavera et al. 2009).

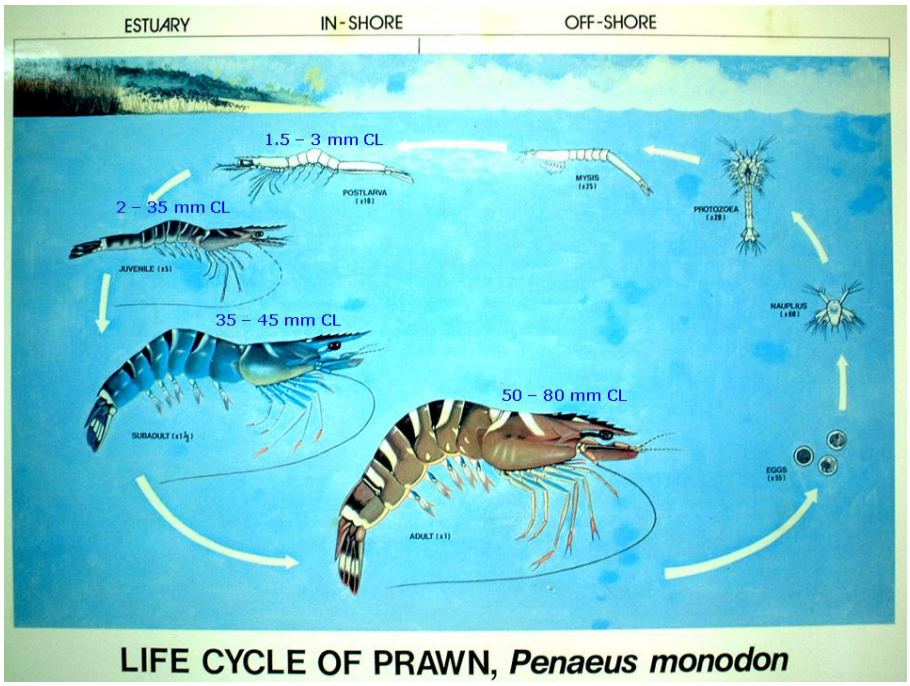


Fig. 4

Mangrove: Shrimp/Fish Pond Ratios (Primavera, 2007)

Mangrove: Pond Ratio	Function	References
8.9:1 7.8:1	N filter: intensive shrimp culture P filter: intensive shrimp culture	Boonsong & Eiumnoh, 1995
7.2:1 21.7:1	N filter: intensive shrimp culture P filter: intensive shrimp culture	Robertson & Phillips, 1995
2.4:1 2.8:1	N filter: semi-intensive shrimp culture P filter: semi-intensive shrimp culture	Robertson & Phillips, 1995
6.4:1	N filter: semi-intensive shrimp culture	Kautsky et al., 1997
5.4-8.2:1	N filter: intensive shrimp culture	Primavera et al., 2007
1.8-2.7:1	N filter: semi-intensive shrimp culture	Primavera et al., 2007
4:1	**Ecosystem health**	**Saenger et al., 1983**
7.4:1	Philippines: 450,000 ha mangroves **(1920)** 60,998 ha ponds **(1940)**	Primavera, 2000
0.5-1:1	Philippines: 120,000-247,360 ha mang. + **(1994)** 232,000 ha ponds	Primavera, 2000; NAMRIA, 2003

The other Aquasilviculture model features mangroves as biofilters for adjacent but separate intensive shrimp/fish ponds, requiring 2-8 hectares and up to 20 hectares, respectively, of mangroves to process the nitrogen and phosphorus effluents produced by one hectare of pond (Primavera et al. 2007). These ratios are even higher than the 4:1 ratio earlier recommended for aquaculture sustainability and environmental health (Table 1).

My mangrove advocacy started in the 1990s, but a complete crossover from research to the environmental NGO community came only after 2000. This was made possible by generous grants from a Pew Fellowship in Marine Conservation (2004) and the Zoological Society of London for the Community-based Mangrove Rehabilitation Project or ZSL-CMRP (2009). In support of mangrove conservation through formal education and local governance, the Pew grant produced instructional mangrove modules for the primary and secondary school levels, and constructed three footwalks in collaboration with local governments in Panay Is. Taking off from the Pew gains, the CMRP expanded coverage to seven towns and shifted focus from local officials to local communities as *de facto* managers of mangroves. The CMRP aimed to increase coastal protection and improve livelihoods through rehabilitation of mangrove greenbelts, reversion of abandoned fish/shrimp ponds, and protection of remaining forest stands. Over four years, it has organized the rearing of 43,400 seedlings of a dozen mangrove species in community nurseries, planted 90,500 mangrove seedlings/saplings in seafront sites and abandoned ponds; facilitated the establishment of two mangrove ecoparks (managed by fisherfolk cooperatives); and produced various information-education-communication materials, e.g., tidal calendars, mangrove manuals, planting guides, leaflets on mangrove laws, videos (Fig. 5: Primavera 2009a, b).

These various rehabilitation, conservation and other mangrove initiatives have been science-based, with adjustments made in consideration of socio-economic realities. For example, natural regeneration is the ecologically correct way to restore abandoned ponds to mangroves, but it takes all of 15-20 years, a luxury of time the Philippines can scarcely afford. Adding to the urgency of environmental rehabilitation is Climate Change that will increase the frequency and severity of the country's yearly quota of 20 typhoons and accelerate sea level rise in many parts of the archipelago.

Fig. 5

Another challenge is restoring the present 1:1 mangrove-pond ratio to 4:1, for ecosystem health and aquaculture sustainability. Past mangrove rehabilitation programs focused on open access, noncontroversial but biophysically suboptimal seafront sites which yield low survival (Primavera 2005). Rather than such problematic seafronts, the best bet to increase mangrove area is by reverting tens of thousands of hectares of abandoned ponds (Primavera and Esteban 2008). Though a socio-political minefield due to tenurial issues, these ponds are the ecologically correct sites for rehabilitation as they were former mangrove forests (Fig. 6) -- planting by ecology, not by convenience.

Other examples of science-based protocols are paradigm shifts from established practices in seafront planting – site selection during neap tide (rather than spring tide), planting in a seaward direction from the beach (rather than landward from the lower intertidal margin), installation of protective barriers, and harvesting excess wildings for nursery rearing.

Much of the knowledge to inform and guide mangrove management (including the contentious debate on aquaculture vs mangrove conservation) is already available, mainly in scientific journals, conference proceedings, and gray literature, but inaccessible to decision-makers and the general public. My career has been devoted to the packaging and dissemination of such information through the products of my Pew and ZSL grants, as well as invited lectures and seminar-workshops for coastal communities, civil society organizations, local government officials, scientific and academic groups, and other stakeholders.

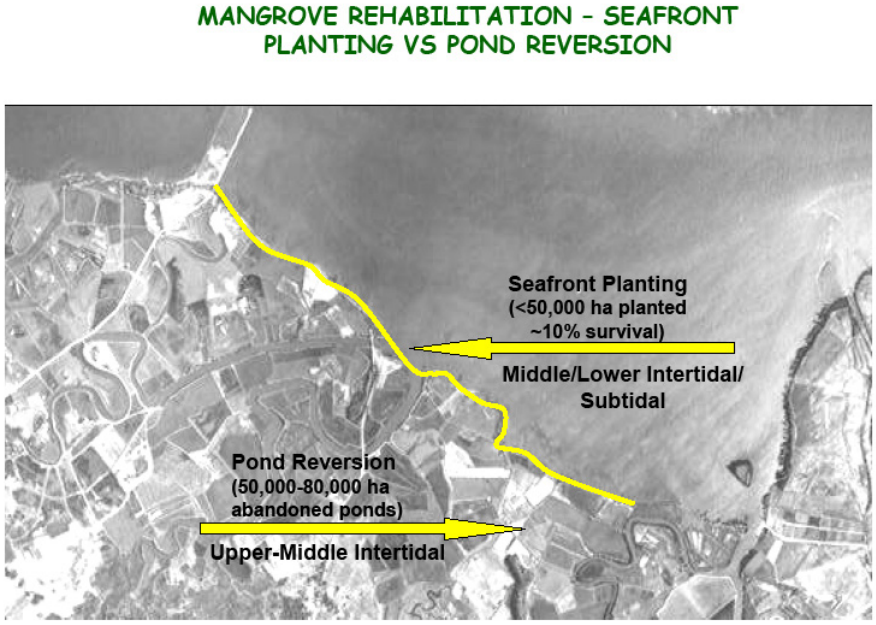


Fig. 6

Nevertheless, a great deal remains to be studied and the following MMM3 presentations are relevant to mangrove rehabilitation and conservation efforts:

i. Mangrove restoration/recovery/regeneration by Nehru and Balasubramanian (2012), Mohamed et al. (2012), Balaji (2012), Dahdouh-Guebas et al. (2012a), Reis-Neto et al. (2012), and Sakaya and Khalid (2012)
ii. Mangrove plantations by Wilson et al. (2012), Alcaria and Bagalihog (2012), Asaeda et al. (2012), Dahdouh-Guebas et al. (2012b), and Gevaña et al. (2012)
iii. Biophysical factors and seedling survival by Abu Hena et al. (2012), Balke et al. (2012), M'rabu et al. (2012a, b), and Ravikamar (2012)

iv. Socio-economics including ecotourism and MPAs by Kathiresan et al. (2012), Mwakha et al. (2012), Rajendran and Kathiresan (2012), Siddique (2012), and Thakur and Yeragi (2012).

Keywords
mangrove macrobenthos, aquasilviculture, community-based mangrove rehabilitation, NGO, sustainable management

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