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Evaluation of lying-in hatchery concept as resource enhancement strategy for swimming crab

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Abstract
A lying-in hatchery set-up consisting of 50-liter plastic container with aeration for spawning-and-release trials was established in Tinambac, Camarines Sur to evaluate the performance of lying-in hatchery concept strategy as a resource enhancement strategy for swimming crabs. About 6,343,342 larvae were produced at salinity range of 30-32 ppt and temperature of 24-26°C. To determine the performance of "spawn and release" strategy, three concentric circles at 1km distance from the release point was established and larval sampling conducted. A decreasing larval density trend from the release point towards the outer circle was observed. Findings showed no direct evidence that measures the success of the lying-in project spill-over effect, suggesting further studies on traceability of the interventions with rigorous sampling procedures. Survey results showed positive support among fishers, traders and the community, which expressed willingness to provide berried crab, no buying of berried crab and cooperation from the community together with the LGU; hence, a change in their perspectives about resource management and conservation. In summary, the study demonstrated that it can be a practical and low cost strategy to stock enhancement given the support of stakeholders; therefore similar trials is recommended in other areas to further confirm its effectiveness and usefulness.

Key words: Lying-in, resource enhancement, spawn and release, swimming crab

INTRODUCTION

Fishing is also the largest extractive use of wildlife in the world with demand exceeding the supply. Unfortunately, the sad reality is that many of the known rich fishing ground (i.e. San Miguel Bay, Lagonoy Gulf, Ragay Gulf) are now experiencing varying degree of stock depletion and/ or overfishing. For instance, in San Miguel Bay, in terms of stock status, of the 17 species, 14 are exploited below the size at first sexual maturity, 11 species are exploited at sizes below 10 cm. Recent studies on swimming crabs (Nieves *et al*. 2013) showed that *P. pelagicus* and *C. feriatus are* overexploited (E > 0.50) species (Gulland 1971) with E optima from the Y'-PR (Yield-per-Recruit) indicating an exploitation rate of *C. feriatus* (35%) and *P. pelagicus* (10%) exceeded beyond the optimum exploitation ($E_{0.5}$), implying excess fishing effort and affirming an overfished fishery reported during in the Fishery Sector Program and San Miguel Bay-Resource and Ecological Assessment report. The LC_{50}, the population length at which 50% of the population is harvested (the other 50% remains): LC_{50} = 9.62 cm for *C. feriatus* and 10.53 cm for the *P. pelagicus*, is higher compared to the size at first maturity of 8. 3 cm and 10. 50 cm for *C. feriatus* and *P. pelagicus*, respectively. Gleaning from these findings, recruitment overfishing is a reality we cannot ignore. This means that the number and size of the adult population (spawning biomass) are heavily caught to the point that the reproductive capacity to replenish itself becomes limited.

In response to this, a series of stakeholder consultation was undertaken to identify doable management option that are fisher's-friendly and science-based. While there were several options identified, only a few was acceptable to fishers and LGU's. One of the acceptable options worth verifying is the use of lying-in container where egg-bearing swimming crabs will be held, monitored until spawning and the larvae returned into the fishing ground, or in marine protected areas (MPAs).

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While there is no scientific evidence yet known or reported, the practice of releasing larvae in fishing ground or in MPAs is seen as a sound resource conservation practice and therefore worth verifying. Thus, the present work is generally aimed at verifying the "lying-in hatchery concept" as an option for resource enhancement for swimming crabs. Specifically, (1) it evalautes the spawning success and hatching rate of swimming crabs in *lying-in* containers; (2) monitor selected water parameters affecting hatching success; and (3) determine the performance of lying-*in hatchery concept* as resource enhancement strategy for swimming crabs.

MATERIALS AND METHODS

A pilot lying-in set-up was established at the residence of Kgd. Vicente Abiog. The set-up consists of 50-liters capacity plastic containers (Fig. 1) filled with filtered seawater with salinity ranging from 30 to 35 ppt and temperature from 20 to 25°C. Aeration was also provided. Chlorination was done to eliminate any harmful materials detrimental to the survival of the larvae. This was accomplished by the application of 200 ppm chlorine, aerated and left to evaporate overnight and neutralized by sodium thiosulfate and EDTA.

Fig. 1. Fifty-liter plastic container set-up as spawning / holding area used in the project.

Gravid female swimming crabs (*Scylla serrata* and *Portunus pelagicus*) with exogenous brownish-black egg (Fig.2) purchased from local traders were used in the spawning trials. Prior to stocking, the breeders were disinfected with 150 ppm formaldehyde solution for 30 minutes.

Breeder's carapace length, width and weight were recorded prior to stocking for spawning and stocked at one breeder per container. After spawning, the breeders were removed, weighed and transferred to another container. Larval monitoring follows immediately after by taking a sample to determine the larval density, larvae condition, and hatching rate. After two days larval rearing, the stock was released in a designated area along the coast of Tinambac within San Miguel Bay (SMB) at coordinates 13°48'34.22"N Latitude and 123° 16' 50. 75" E Longitude. Water temperature and salinity was monitored before and after spawning.

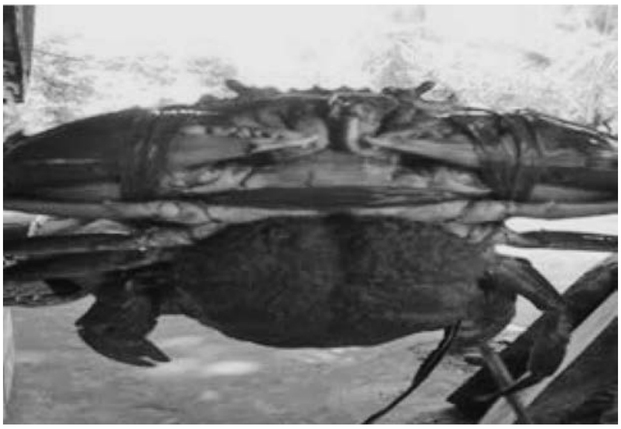

Fig. 2. Mud crab breeder (*Scylla serrata*) with exogenous brownish-black egg used in the study.

To generate information on the spill-over effect of "spawn and release" strategy, sampling stations in Tinambac to represent with the project and Mercedes to represent without the project was established as shown in Fig. 3. Three concentric zones within the release area with 1 km radius from each zone were designated as collection sites (Appendix A) for crab larval samples.

Sampling of crab larvae was carried out from August to September 2015, which coincides with the southwest and northeast monsoon seasons (Nieves *et al*. 2013). Samples were collected at night and near water surface to ensure more larvae will be caught (Tagatz 1968). Plankton net with a mesh size of 80*u*m and ring diameter of one meter was used. The gear was located approximately 2.5 meters away from the hull of the boat to minimize being disturbed by the vessel during the course of sampling.

Each towing takes about ten minutes at a speed of one to two knots. Necessary precaution was taken not to completely submerge the net during towing. The start and end of each tow was marked using a Global Positioning System (GPS) to determine the total distance covered.

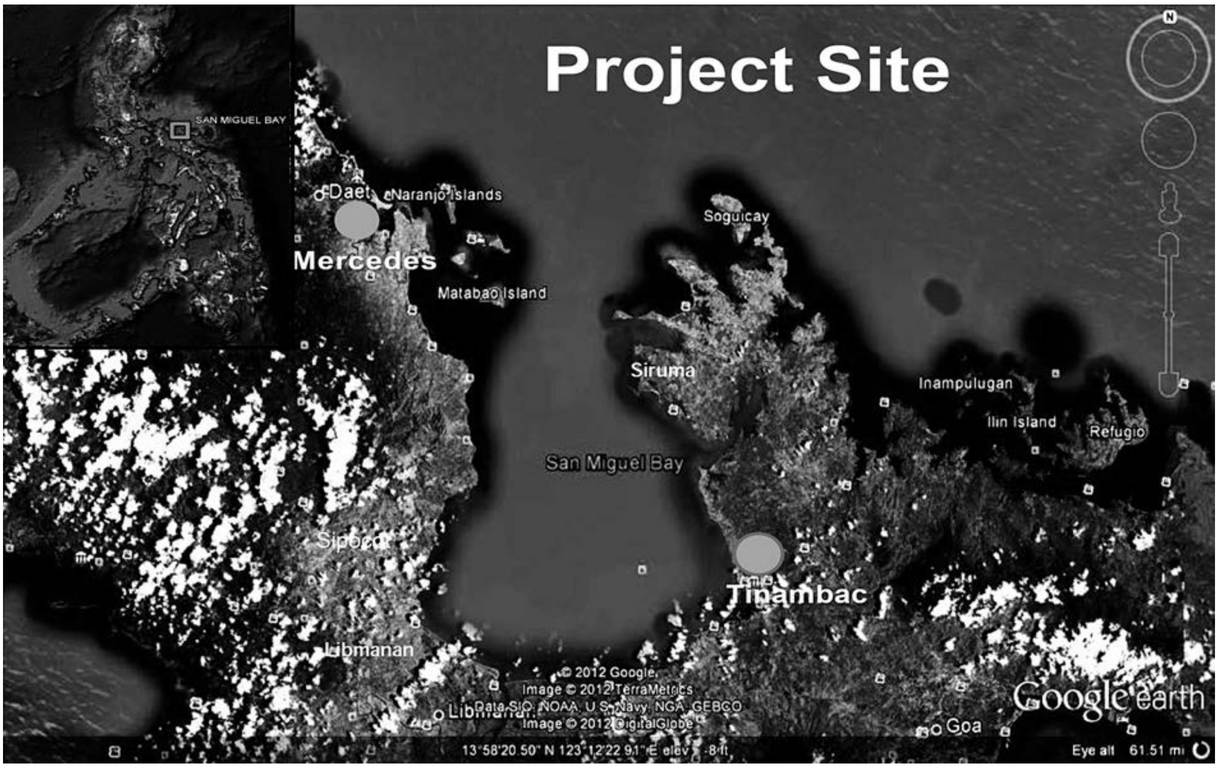

Fig. 3. Project site where spawn and release monitoring was carried out.

RESULTS

A total of 6,343,342 crab larvae were produced from 22 breeders with mean hatching rate of 31.5% using the 50-liters plastic container and released in SMB (Appendix B). The number produced is quite very low compared to the fecundity of swimming crabs.

Although, the set-up obtained very low survival, it is more practical and low cost compared to the BFAR-PNAP design (Fig. 4) using hard plastic box measuring 40'x 20'with six (6) 12' x 9' sub-boxes used as holding area ("lying-in"). The spent crab can still be returned to fishers or traders at no cost to LGU or BFAR.

The salinity and temperature are two of the most important environmental factors affecting the hatching rate and time of eggs (Aktas *et al*. 2004). Hamasaki, 1996 and Heasman and Filder (1983) reported that temperature is known to affect the rate of egg development, larval survival rate and development in many brachyurans (Zeng and Li 1992). Arshad *et al*. (2006) also reported that temperatures significantly affect the incubation period and hatching rate of egg. The best hatching rate of eggs *for P. pelagicus* were obtained at temperature in the range 28-32°C (Arshad *et al*. 2006). In the present study, spawning and hatching was noted two to three days after stocking females with brownish-black eggs at salinity of 30 ppt and temperature of 28°C.

Fig. 4. BFAR - PNAP hard plastic container box design (right) for lying-in set-up.

To generate scientific information on the performance of the intervention, larval sampling in the designated concentric zones within the release area was undertaken. Findings showed that the spillover effect of the lying-in hatchery showed different pattern from one kilometer to three kilometers concentric circle. However, it does not show direct evidence that measures the success of lying-in in terms of spill-over effect.

Statistical analysis showed no significant differences on abundance ($P > 0.05$). Circle 1, 2 and 3 have values 0.45, 2.76 and 5.91 crab larvae /100m^3, respectively. It should be noted that the location of the sampling area where female crabs usually breed and spawn (Ong 1964, Hill 1974, Robertson and Kruger 1994 as cited by Quinitio *et al*. 2001) have direct influence on the larval density.

DISCUSSION

The study demonstrated that crab larvae can be produced using the 50-liter plastic lying-in containers despite the very low hatching rate compared to the fecundity of swimming crabs (1,513,660 to 6,357,133/females with CW from 8.3 cm to 15 cm.), but the effort is of paramount importance to stock enhancement as it may lead to a change in the perspectives of fishers about swimming crab resource conservation. The practice may not be so popular now but it may turn into a habit or an acquired behavioral pattern among fishers which will make managing the resource easier or voluntary.

The poor hatching rate (31. 5%) was attributed to the mortalities encountered during the entire duration of the trials. Handling stress, changes in temperature, salinity and power failure were the causes identified. Handling stress occurred from collection to market. It should be noted that the breeders were procured from local crab traders; hence, handling stress may directly or indirectly affect spawning, egg hatchability and larval survival. Under stress condition, they become weak, settle at the bottom and hardly able to move and feed resulting to mortalities. Unsynchronized hatching also occurs due to stress during transport. The unforeseen power failure likewise contributed to 100% mortality.

Although, the set-up obtained very low survival, it appears to be more practical and low cost (P300.00/container) compared to the BFAR-PNAP design (Figure 4) using hard plastic box measuring 40'x 20'with six 12' x 9' sub-boxes used as holding area ("lying-in"). First, the 50-l plastic container can be easily installed in one's backyard as long given an access to seawater and electricity. Second, using the set-up for "spawn-and-release" strategy, stock enhancement at the community level can be facilitated and therefore may positively contribute to stock improvement at a relatively low cost. The spent crab can still be returned to fishers or traders at no cost to LGU or BFAR.

While the initial success showed some prospects, further studies is needed for more conclusive results. According to Dumanski *et al*. (1998), the concept of sustainability as opportunity emphasizes that choices for future production systems are not compromised by decisions made today. It is also worth noting that when fishers actually observed the release of larvae, they soon realize the value of the conservation efforts to resource sustainability. Given this change in perspectives among fishers, traders and the community from extract all to conserve some for the future, stock enhancement and sustainability can be achieved. This will likewise help the Department of Agriculture-Bureau of Fisheries and Aquatic Resources (DA-BFAR) Philippine Blue Swimming Crab Management Plan.

Salinity and temperature are two of the most important environmental factors affecting the hatching rate (Aktas *et al*. 2004). Hamasaki (1996) and Heasman and Filder (1983) reported that temperature is known to affect the rate of egg development, larval survival rate and development in many brachyurans (Zeng and Li 1992). On the other hand, Arshad *et al*., 2006, reported that temperatures significantly affect the incubation period and hatching rate of egg. The best hatching rate of eggs *for P. pelagicus* was obtained at temperature ranging 28-32°C (Arshad *et al*. 2006). In the present study, spawning and subsequent hatching was noted two to three days after stocking females with brownish-black eggs at salinity of 30 ppt and temperature of 28° C. Similar observation was noted by Mhd Ikhwanuddin *et al*. (2010), which showed greatest spawning success at salinities 30-35 ppt hatching within 2-3 days.

To generate scientific information on the performance of the intervention as a resource enhancement strategy, larval sampling in the designated concentric zone within the release area was undertaken. Finding reveals that the spillover effect of the lying-in hatchery concept showed different pattern from one kilometer to three kilometers concentric circle. However, it does not show direct evidence that measures the success of lying-in in terms of spill-over effect.

Statistical analysis showed no significant differences on abundance ($P > 0.05$). Circle 1, 2 and 3 have values 0.45, 2.76 and 5.91 crab larvae /100m^3, respectively. It should be noted that the location of the sampling area where female crabs usually breed and spawn (Ong 1964, Hill 1974, Robertson and Kruger 1994 as cited by Quinitio *et al*. 2001) have direct influence on the larval density.

Incidentally, Mercedes is known to be a spawning ground; hence, the pattern of larval density. Recruitment of crab larvae was also believed influenced by water circulation pattern controlled by prevailing wind (Villanoy *et al*. 1994). Villanoy *et al*. (1994) further reported that the residual circulations in SMB consist of a counterclockwise gyre south of 14° N during the northeast monsoon (NE); hence, larval transport from Tinambac may be dispersed towards Siruma and Mercedes area. While for the easterly and southerly wind force, the flow pattern from Tinambac is reversed with a clockwise gyre predominantly larval flow westward to Calabanga, Cabusao and near the mouth of the bay, thus, the variation in the larval distribution pattern.

Considering the social dimension aspect, the perception and support of fishers, traders, and the community relative to lying-in hatchery concept as a resource enhancement strategy, showed that majority (60%) are positive that the abundance of crabs can still be revived. More than half (52.24%) of the respondents believed that lying-in project can help enhance swimming crab population. As such, they are willing to help crab resource enhancement by providing berried crab for the project. No buying of berried crab is also considered as it directly affects their livelihood while the community assured their cooperation for the project. It is also interesting to note that the concern LGU is very supportive to the cause of resource enhancement, protection and management of municipal waters under their jurisdiction per R.A.7160 and R.A. 8550.

CONCLUSIONS AND RECOMMENDATIONS

Despite the higher mortalities or very low survival noted during the entire "spawning-and-release" trial due various factors such as temperature fluctuation and power failure, a total of 6,343,342 crab larvae were produced and released in SMB using a 50-liter spawning container filled with filtered seawater with aeration. From these results, the "spawn-and-release" strategy of the lying-in hatchery concept can be considered as a practical way of of stock enhancement for several reasons; (1) the set-up is simple and easy, (2) the method is more practical, (3) it produces results, (4) inexpensive since the breeder can still be returned to the owner without cost, and (5) supportive to the cause of the Philippine Blue Swimming Crab Management Plan.

Spill-over effect generated from larval sampling reveals that the intervention showed an increasing pattern from one kilometer to three kilometers concentric circle with no significant differences on its abundance ($P > 0.05$). However, no direct evidence measuring the success of the lying-in project in terms of spill-over effect. Result also showed that higher crab larvae were collected during the SW than NE monsoon which could be attributed to the current pattern in SMB during specific monsoon including the rainy season that affects light penetration for phytoplankton growth, thus resulting to less food available for crab larvae. This finding suggests further comprehensive scientific studies on traceability interventions for spawn and release strategy with rigorous sampling procedures.

More importantly, the study also demonstrates the changes in the perspectives of fishers about resource enhancement or conservation. The practice may turn into a habit or an acquired behavioral pattern among fishers, making managing resource easier and almost voluntary. This is evidenced by the support, fishers, traders, the community including the LGUs which responded positively about their willingness to support the lying-in hatchery project by providing berried crab for the project and no buying of berried crab while the community assured their cooperation for the project. On this basis, it is recommended that similar trials using the same set-up be established, replicated and evaluated to further confirm its effectiveness and usefulness.

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APPENDIX A

Coordinates of the sampling station established in Tinambac, C.S., and Mercedes, C.N.

Tinambac, Camarines Sur: With Lying-in				Mercedes, Camarines Norte: Without Lying-in			
Center Point Coordinates:13° 48'34.22"N Lat. / 123°16'50.75"E Long				Center Point Coordinates: 14° 2'3.84"N Lat. / 123°4'6.07"E Long			
Dist. of concentric circle from Center	Station	Coordinates		Dist. of concentric circle from Center	Station	Coordinates	
		Latitude	Longitude			Latitude	Longitude
1	1	13° 48' 54. 61" N	123°16'24.85" E	1	1	14°2'35.90" N	123°4'5.21" E
	2	13° 48' 14. 27" N	123°16'22.93" E		2	14°1'36.32" N	123°3'47.91" E
	3	13° 48' 26. 83" N	123°17'23.58" E		3	14°1'40.63" N	123°4'29.44" E
2	1	13° 48' 38. 67" N	123°15'44.36" E	2	1	14°2'0.02" N	123°2'58.08" E
	2	13° 49' 25. 69" N	123°17'31.84" E		2	14°2'43.25" N	123°4'59.22" E
	3	13° 47' 44. 55" N	123°17'34.42" E		3	14°1'27.53" N	123°5'21.11" E
3	1	13° 50' 10. 34" N	123°16'33.42" E	3	1	14°3'9.74" N	123°2'52.92" E
	2	13° 47' 27. 45" N	123°15'38.09" E		2	14°2'0.88" N	123°5'45.98" E
	3	13° 47' 52. 96" N	123°18'21.31" E		3	14°0'31.86" N	123°4'41.22" E

APPENDIX B

Results of spawning trials covering April to December 2015

Species ID	Mo.	No.	CW (cm)	CL (cm)	Wt. (g)	HR (%)	Total Count
Portunus pelagicus	Apr.	1	170.0	75.0	240	15.0	60,000
		2	147.0	68.0	160	42.0	110,000
Scylla serrata	May	1	17.0	12.0	700	43.2	2,592.00
Portunus pelagicus	June	1	10.9	4.6	100	43.2	66,000
		2	9.6	4.2	100	43.0	62,000
Portunus pelagicus	July	1	10.9	5.2	85	16.0	76,000
		2	9.0	6.1	96	16.0	76,500
		3	10.0	6.4	90	16.0	70,000
		4	8.6	5.0	85	16.0	74,250
		5	9.4	5.1	90	16.3	83,500
		6	10.1	6.0	100	15.0	63,500
		7	10.0	7.1	100	16.5	85,000
		8	8.0	5.5	80	15.0	70,000
		9	9.4	6.0	97	42.1	124,000
		10	8.8	5.4	90	13.0	49,000
Portunus pelagicus	Nov	1	4.5	11.5	110	75.0	1,335,000
		2	5.0	11.5	98		
		3	5.0	12.5	95	90.0	1,350,000
		4	4.0	11.0	100		
		5	4.3	11.5	85	80.0	1,260,000
		6	4.6	10.0	95	79.6	1,326,000
		7	4.5	10.5	98		
Total		22	480.6	300.1	2894	692.9	6,343,342
Mean			21.85	13.64	131.55	31.5	2,727

APPENDIX C

Estimated cost of materials for the set-up

1. BUTC lying-in hatchery set-up cost estimate.

No.	Unit	Item description	Qty.	Unit cost	Total cost
1	units	Storage box 50 liters capacity	5	300	1,500.00
2	units	Basin 40 liters capacity	5	200	1,000.00
3	units	Basin orocan 150 liters capacity	2	800	1,600.00
4	units	Rectangular plastic strainer	10	50	500.00
5	units	Dipper heavy duty	5	50	250.00
6	pcs	Air stone round # 2	15	20	300.00
7	roll	Air hose 3mm dia.	1	500	500.00
8	pc	Clip for air hose	5	30	150.00
9	ream	Fry bag	1	500	500.00
10	units	Two way portable aerator	2	500	1,000.00
11	unit	Medical oxygen tank 300 psi	1	4,000	4,000.00
		Total Expenses			11,300.00

2. BFAR (Samar) lying-in hatchery set-up cost estimate.

No.	Unit	Item description	Qty.	Unit cost	Total cost
1	roll	Polyethylene rope size #9	3	500	1,500.00
2	roll	Polyethylene rope size #12	2	700	1,400.00
3	roll	Polyethylene rope size #24	1	4,000.00	4,000.00
4	kg	Monoline Nylon 160lbs 200mm	5	500	2,500.00
5	pc	Bamboo full length	50	200	10,000.00
6	pc	Float (225 L capacity plastic drum)	12	650	7,800.00
7	bail	Polyethylene net #14	1	9,500.00	9,500.00
		Total Expenses			36,700.00