

## Juvenile abundance and post-larval incursion of mud crabs (*Scylla* spp.) in Chilika lagoon

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Study was carried out on the juvenile abundance and post-larval incursion of two species of *Scylla* into the lagoon for period of two years from August, 2005-July, 2007. Occurrence of juvenile, *S. serrata* were throughout the year, while in *S. tranquebarica*, juveniles were not encountered during December-February. December-May register higher median CPUE values with peak in March for *S. serrata*. In *S. tranquebarica*, the peak juvenile abundance period was restricted to June-September with peak in July. The CPUE values for juveniles indicted that the recruitment was intense for *S. serrata* during post-winter (January-April) and for *S. tranquebarica* during monsoon (June-September). The crab seeds were available throughout the year which gave a clear evidence for the year round recruitment with the peak during the months of November-March for *Scylla* species from the Bay of Bengal to the Chilika lagoon. During the study period, the megalopa and first crab instar recruitment per net-hour collection was significantly higher during spring tides than neap tide phase ( $p < 0.05$ ) and also higher incursion was observed in the night hours than day hours ( $p < 0.05$ ). Significantly higher night collections of mud crab juveniles (mixed population of both species) from net box traps (khandas) were obtained during new moon phases ( $t=3.88$ ;  $d.f.=11$ ;  $P < 0.01$ ).

**Keywords:** Chilika lagoon, *Scylla* spp., megalopa incursion, juvenile abundance

### Introduction

The mud crabs *Scylla* spp., represent a valuable component of small-scale coastal fisheries in many countries of tropical and sub-tropical Asia and African coast. Though the mud crabs are marine dwellers, they immigrate into brackish water system during their post-larval stages, grow fast, attain maturity and form a lucrative fishery in estuaries, backwaters and lagoons. With great demand for live export and increased price, the fishery and aquaculture of mud crabs have gained importance in India and abroad. Over last two decades, exploitation of mud crabs from the known natural habitats, particularly from the estuarine areas, has been

intensified in many South-East Asian countries after the starting of live mud crabs export in the early eighties. Chilika lagoon on the east coast of India is famous for its crab fisheries. The two mud crab species (*S. serrata* and *S. tranquebarica*) are coexisting in the lagoon<sup>1</sup>. The lagoon was in a degraded state during the last few decades tending towards a freshwater ecosystem due to the natural changes coupled with anthropogenic pressure. The fishery showed a major decline during the eco-degradation phase and the combined landing of both the species of mud crab declined to the all-time low of 3.0 t during 1994-95. The overall average salinity of the lagoon declined from 16.85 PSU in 1958-59<sup>2</sup> to 8.5 PSU in 1998-99<sup>3</sup>, which had grave implication for the biodiversity as well as fisheries of Chilika lagoon. In the process of eco-degradation, both environmental values and resources development opportunities were threatened by potential loss of marine influence and lagoon characteristics. However, the hydrological intervention by opening an artificial lagoon mouth at a strategic location and dredging of the inlet channel

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and connecting it to the river confluence was carried out by Chilika Development Authority (CDA), Bhubaneswar during September, 2000 to restore the lake. The opening of the new artificial mouth yielded encouraging results by way of not only rejuvenating the ecosystem of the lagoon but also spectacularly enhanced the fisheries resources, mainly due to effective recruitment of juveniles of fish, prawn and crabs. The average annual landings of mud crabs (combined population of the two species) from Chilika lagoon during the last decade (1990-91 to 1999-2000) before opening of the new artificial lagoon mouth was 12.9 t which spectacularly increased to 155.51 t (post-hydrological intervention period). Despite the successful recovery of fisheries resources after hydrological intervention in 2000, fisheries management problems are mounting due to increasing destructive fishing practices<sup>4</sup>. This calls for early conservation and management measures for mud crab fishery in Chilika lagoon, which requires knowledge on population recruitment pattern for further conservation. Therefore, the present study assumes greater significance under the changing ecological scenario of Chilika lagoon after the hydrological intervention for alternative livelihood practices for fisher folk of Chilika lagoon.

### Materials and Methods

For monitoring of juvenile abundance and post-larval incursion of mud crabs, sampling were carried out at 4 stations in tidal outer channel sector during August, 2005-July, 2007. Environmental variables

(turbidity and salinity) were also monitored at the sampling stations during sampling following the standard methods<sup>5</sup>.

### Juvenile recruitment pattern

The selective gear for catching juveniles (early juveniles and juveniles) is 'Khanda' (net box traps or 'Disco traps'). These 'Khandas' (Fig. 1) were generally set at the fishing ground near the sampling stations in the outer channel sector during night hours (1700-1900 hrs) and lifted in the next morning (0500-0600 hrs). Three numbers of 'Khandas' were set at each sampling stations; total number of 'Khandas' at 4 stations were 12 per month. Juvenile abundance was studied from the overnight catch/collection (12 hrs) of each 'Khanda'. Sampling by 'Khanda' was done once in a month (30 days interval). The juvenile recruitment pattern (seasonal variation) was studied from the catch per unit effort (CPUE) values (number of juvenile crabs  $\text{Khanda}^{-1} 12\text{h}^{-1}$ ) during night for 24 months during the sampling. With a view to study the recruitment pattern of both the mud crab species (*S. serrata* and *S. tranquebarica*), identifiable size (Juvenile crabs) of 30-70 mm CW for *S. serrata* and 40-80 mm CW for *S. tranquebarica* were considered for record.

The impact of lunar periodicity on the abundance of the juveniles (early juveniles and juveniles) of combined species of *S. serrata* and *S. tranquebarica* (15-80 mm CW) were studied from another set of 'Khanda' monitoring in the outer channel where the 'Khandas' were operated during night (1700-1900hrs)

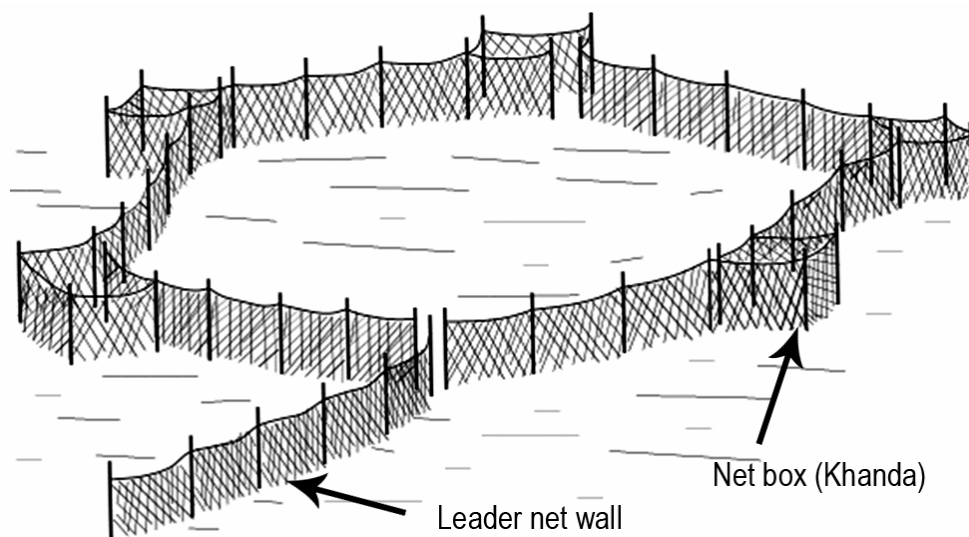


Fig. 1—Monofilament twine net box ('Khanda'/Disco trap) of Chilika lagoon.

in new moon and full moon phases. Three numbers of 'Khandas' at each sampling station were operated in each lunar phase (new and full moon) within 2-3 days before or after the new or full moon days, which are normally the high tide (spring tide) phases. In each month, 2 sets of observations covering 6 'Khanda' monitoring were performed for each sampling station in the outer channel. In total, 24 nos. of observations from 24 'Khandas' were recorded every month and a total of 576 observations (Khandas) were recorded during 24 months of sampling. The CPUE values from each Khanda observation recorded as;

$$\text{Mean CPUE} = \text{Nos. of juveniles Khanda}^{-1} 12 \text{ h}^{-1} \pm \text{S.E.}$$

Thus, 24 nos monthly mean CPUE values for new and full moon phases were worked out and the impact of lunar periodicity on juvenile recruitment was studied by performing t-test taking paired sampling CPUE data for new and full moon phases.

#### Incurion of megalopas and first crab instars

Shooting net made of monofilament synthetic netting (3.0 meshes inch<sup>-1</sup>, 1 m diameter mouth ring, 1.9 m length and 12 cm dia at cod end) were operated near Satapada in the outer channel (Fig. 2) during day

and night time availing spring and neap tides on one hourly collection basis in each month for 24 months during the sampling period. 4 nos of shooting nets were operated in the outer channel (7 km up stream from the new artificial lagoon mouth), which is the only recruitment route connecting the sea and the main lagoon. Megalopa and the first crab instars were segregated from the total collections after every one-hour in four occasions (spring & neap tides, day & night) during each month. From the total net-hours and total collections of crab seeds (megalopa & first crab instars), the mean CPUE values were calculated for each occasion with S.E. The two final paired monthly CPUE values for 24 months were statistically analyzed through t-test to confirm whether the differences in the paired values were significant or not.

## Results and Discussion

#### Juvenile Abundance and Recruitment Pattern

Monthly variation in juvenile abundance (CPUE values ie. nos of juveniles Khanda<sup>-1</sup>12h<sup>-1</sup>) indicating recruitment pattern for *S. serrata* and *S. tranquebarica* in Chilika lagoon is furnished in

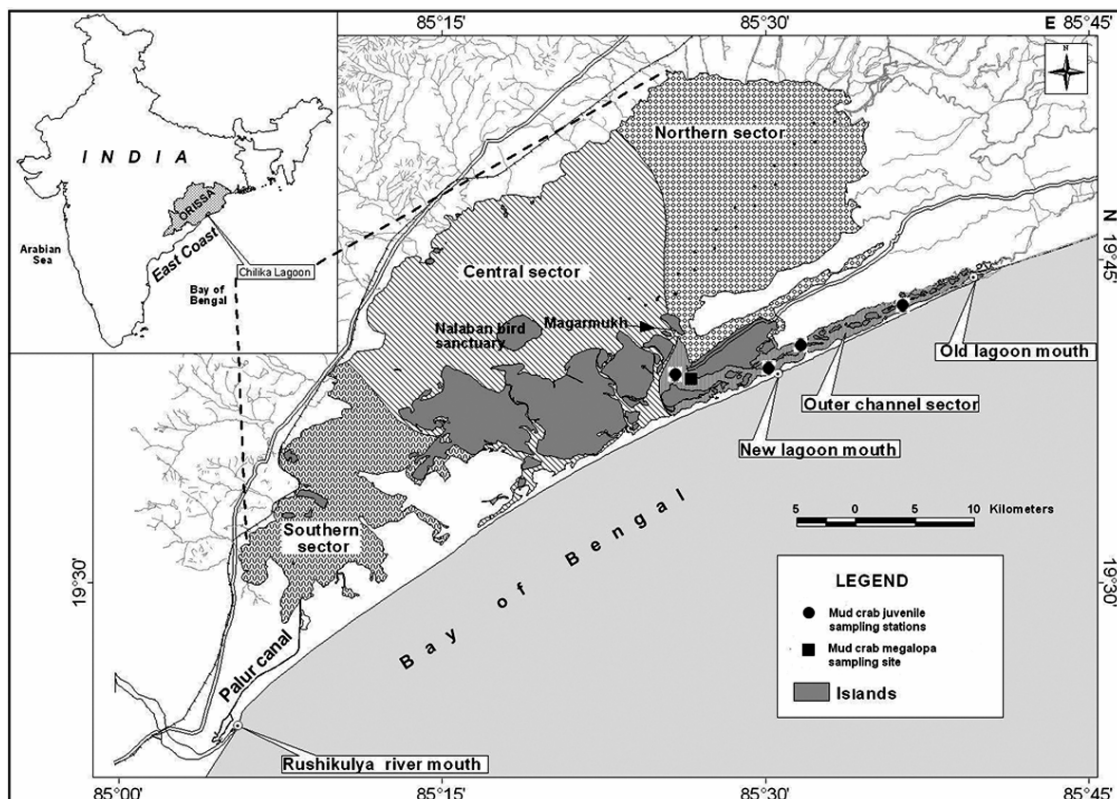


Fig. 2—Mud crab juvenile and post-larval sampling sites in Chilika Lagoon.

Table 1—Catch per unit effort (CPUE) analysis for mud crab juveniles (30-70mm CW for *S. serrata* and 40-80 mm CW for *S. tranquebarica*) collected from net box trap (Khandas) in Chilika lagoon during sampling period. (N= number of Khandas units observed during each month. CPUE values are expressed as number of juveniles net box trap<sup>-1</sup> 12h<sup>-1</sup>)

Month and Year	N	<i>S. serrata</i>		<i>S. tranquebarica</i>	
		Mean CPUE ± S.E	Median	Mean CPUE ± S.E	Median
August, 2005	12	8.19±2.29	8.00	5.70±2.60	6.00
September, 2005	12	4.33±2.50	4.00	5.19±3.29	5.00
October, 2005	12	2.41±2.02	2.00	3.70±2.41	4.00
November, 2005	12	7.22±4.70	7.00	3.11±2.55	2.00
December, 2005	12	16.78±6.53	16.00	0.00±0.00	0.00
January, 2006	12	22.41±6.70	20.00	0.00±0.00	0.00
February, 2006	12	28.07±5.59	30.00	0.00±0.00	0.00
March, 2006	12	36.70±9.37	36.00	2.37±2.10	2.00
April, 2006	12	23.3 ±7.12	23.00	2.04±1.53	2.00
May, 2006	12	21.19±7.78	20.00	3.78±3.21	3.00
June, 2006	12	11.26±5.92	10.00	7.96±5.03	7.00
July, 2006	12	7.11±3.48	7.00	8.26±3.88	8.00
August, 2006	12	7.59±3.59	8.00	6.29±2.18	6.00
September, 2006	12	6.28±3.01	6.00	5.24±2.49	5.00
October, 2006	12	3.59±2.19	3.00	3.29±2.61	3.00
November, 2006	12	8.36±3.78	8.00	3.09±2.41	3.00
December, 2006	12	17.26±5.53	17.00	0.00±0.00	0.00
January, 2007	12	21.28±5.29	20.00	0.00±0.00	0.00
February, 2007	12	26.51±5.21	27.00	0.00±0.00	0.00
March, 2007	12	33.21±8.52	33.00	1.08±0.94	1.00
April, 2007	12	20.18 ±6.24	22.00	2.19±2.01	2.00
May, 2007	12	19.21±6.78	20.00	4.01±4.19	4.00
June, 2007	12	9.69±4.81	10.00	8.59±4.96	8.00
July, 2007	12	6.33±4.48	6.00	9.21±5.29	10.00

Table 1. Occurrence of juvenile *S. serrata* throughout the year was observed, while in *S. tranquebarica*, juveniles were not encountered during December-February. December-May register higher median CPUE values (16.0-36.0) with peak in March (36.0) for *S. serrata*. In *S. tranquebarica*, the peak juvenile abundance (recruitment) period was restricted to June-September when CPUE median values ranged from 5.0-10.0 with peak in July (10.0). The CPUE values for juveniles indicated that the recruitment was intense for *S. serrata* during post-winter (January-April) and for *S. tranquebarica* during monsoon (June- September). It was observed that the mud crab population in southern sector was still poor during the sampling.

Juvenile recruitment for *S. serrata* and *S. tranquebarica* were studied from catch per unit effort (CPUE) for night collection of net box traps (Khandas) in the outer channel sector (recruitment route for fish, prawn and mud crabs) as shown in Table 1. The abundance of *S. serrata* juveniles round the year in Chilika lagoon with the large seasonal variation in salinity (Fig. 3) is of similar resemblance with the observation made in India for *S. serrata* from Tuticorin coast<sup>6</sup> and other estuaries and brackishwater

habitats along east and west coast of India<sup>7-11</sup>. Similar observations were also made at Kenyan coast<sup>12</sup> for *S. serrata* and Mekong Delta, Vietnam<sup>13</sup> for *S. paramamosain*. Litulo<sup>14</sup> reported year round juvenile recruitment in fiddler crab (*Uca inversa*) population in south Mozambique.

Low and intense recruitment of *S. serrata* juveniles during low salinity period (August-December) and high salinity period (January-May) in Chilika was a common observation as reported from different locations in India<sup>10,15</sup> and Thailand<sup>16</sup>, Vietnam<sup>13</sup> for *S. paramamosain*, South African coast<sup>17-18</sup> although the climate-dependant and geographical location-based low and high salinity period differ. The abundance of juveniles of *S. tranquebarica* in Chilika during low salinity and high turbidity period (June-September) lends support to the remarks of regarding salinity tolerances of different *Scylla* species either at larval or post-settlement stages<sup>19</sup>. Despite of large seasonal salinity variation, the CPUE data (Table 1) indicates stable populations and continuous recruitment of juveniles through periods of extreme low salinity and high turbidity in Chilika lagoon. Predominance of males in juvenile population up to 70 mm CW in *S. serrata* agrees with the observations

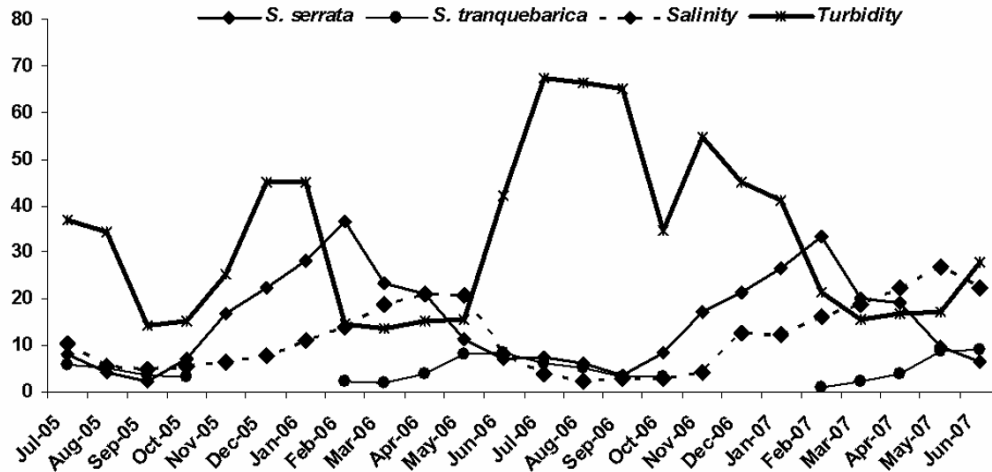


Fig. 3—Median values of CPUE for *S. serrata* and *S. tranquebarica* and seasonal variations in salinity and turbidity during sampling period.

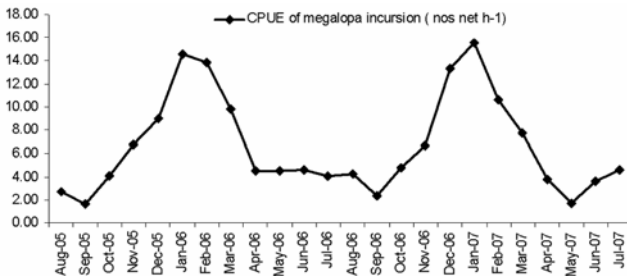


Fig. 4—Polled Average CPUE values of megalopa incursion.

made in the Phangnana Bay, Thailand<sup>16</sup> and in Khulana Sunderbans of Bangladesh<sup>20</sup>. Male dominance in juvenile population of *S. tranquebarica* up to 100 mm CW in Chilika is beyond the scope of comparison as the population studies separately for this species are hitherto unreported.

Monitoring of juvenile movement into the southern sector indicated poor abundance due to blockages in water channels by illegal pen culture of prawn (ghery) and close barricades of small meshed nets in the entire length of Palur canal preventing the movement of crab juveniles. The early juveniles of *S. serrata* in large number were also observed in push net collections near Satpada and Magarmukh in the outer channel during November-December which supported the peak spawning season during August-November.

#### Post-larval incursion

The post-larval abundance (median CPUE value) of crab seeds in post larval or first crab instar stages at Satpada site (outer channel sector) is presented in Fig. 4 and Table-2. The crab seeds were available throughout the year which had given a clear evidence

for the year round recruitment with the peak during the months of November-March for *Scylla* species from the Bay of Bengal to the Chilika lagoon. Similar observations on year round recruitment of *Scylla* species were also observed from the Andaman Sea by Koolkalya et al.<sup>21</sup>. In Chilika lagoon the CPUE values increased from September to reach peak in January-February and then declined. Thus, the incursion depicts a single oscillation pattern. Forbes and Hay<sup>18</sup> observed year round *S. serrata* megalopa incursion in plankton collections in Natal (South Africa). Moser et al.<sup>22</sup> also observed year round recruitment of *S. olivacea* from Ranong Mangrove ecosystem.

During the study period, the megalopa and first crab instar recruitment per net-hour collection was significantly higher during spring tides than neap tide phase ( $p < 0.05$ ) and also higher incursion was observed in the night hours than day hours ( $p < 0.05$ ) which are presented in Table 2. The species identification was not possible at the megalopa and first instar stages. There might be the megalopa of other species like *Portunus pelagicus* and *P. sanguinolentus* besides the post larvae of *Scylla* species during the period of study. Since the population of other portunid crabs like *P. pelagicus* and *P. sanguinolentus* in Chilika lagoon are negligible, the collected megalopa and first instars were taken as belonging to mud crabs (*Scylla* spp.).

In order to collect *P. monodon* seeds (PLs) for aquaculture in Chilika area, huge quantity of these crab seeds are being destroyed by the fishers as by-catch. This huge by-catch loss causes colossal loss to the natural crustacean seed resources in Chilika lagoon. In other words such huge by-catch loss has

Table 2—Incursion (CPUE) megalopa and first crab instars during spring and neap tide phases and during day and night in the Chilika lagoon at Satapada (outer channel sector).

Months	Day	Night	Spring tide	Neap tide	Average
Aug-05	1.08±0.79	4.25±2.77	3.25±1.29	2.08±1.38	2.67±1.33
Sep-05	1.00±0.95	2.17±2.04	2.17±1.40	1.00±0.85	1.58±1.13
Oct-05	3.08±2.57	5.08±2.50	4.75±1.91	3.42±1.44	4.08±1.68
Nov-05	4.17±2.21	9.33±6.11	8.00±3.67	5.50±2.20	6.75±2.93
Dec-05	6.33±2.93	11.75±9.44	10.08±3.23	8.00±2.30	9.04±2.76
Jan-06	12.58±10.87	16.67±4.96	16.50±3.68	12.75±4.07	14.63±3.88
Feb-06	11.67±10.76	16.08±7.17	14.92±4.10	12.83±3.35	13.88±3.73
Mar-06	6.17±5.02	13.50±3.23	10.67±3.85	9.00±2.63	9.83±3.24
Apr-06	3.92±2.11	5.08±2.54	5.17±1.64	3.83±1.75	4.50±1.70
May-06	4.25±3.02	4.67±2.232	4.92±1.83	4.00±2.17	4.46±2.00
Jun-06	3.08±1.38	6.08±2.07	5.00±2.49	4.17±1.27	4.58±1.88
Jul-06	2.17±1.70	5.92±3.15	4.17±0.94	3.92±1.56	4.04±1.25
Aug-06	3.83±2.82	4.58±2.11	4.83±1.75	3.58±1.38	4.21±1.56
Sep-06	1.17±0.98	5.33±1.19	2.58±2.15	2.17±1.85	2.38±2.00
Oct-06	4.17±1.75	5.33±1.83	5.25±1.71	4.25±1.96	4.75±1.84
Nov-06	5.58±3.03	7.67±3.42	7.33±3.14	5.92±2.19	6.63±2.67
Dec-06	10.50±3.63	16.17±4.43	15.08±5.79	11.58±3.90	13.33±4.84
Jan-07	14.75±2.53	16.42±5.30	16.50±5.04	14.67±3.47	15.58±4.25
Feb-07	6.67±2.39	14.58±3.00	12.00±3.95	9.25±3.05	10.63±3.50
Mar-07	5.17±2.48	10.33±3.37	8.25±4.00	7.25±2.45	7.75±3.23
Apr-07	2.33±1.78	5.25±1.66	4.00±1.71	3.58±2.39	3.79±2.05
May-07	1.17±0.67	2.25±1.36	2.00±2.00	1.42±1.16	1.71±1.58
Jun-07	2.25±1.96	4.92±1.51	4.25±1.71	2.92±1.00	3.58±1.35
Jul-07	3.92±2.11	5.33±2.50	4.83±1.95	4.42±1.16	4.63±1.56

$t = 2.16; d.f. = 23; p < 0.05$  (Night collection)       $t = 2.73; d.f. = 23; p < 0.05$  (Spring tide collection)

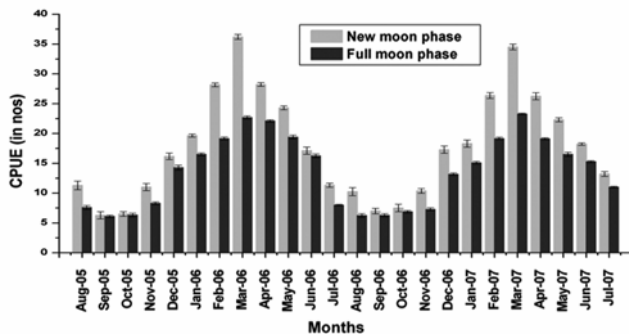


Fig. 5—Catch per unit effort (CPUE) analysis for mud crab juveniles (Predominantly *S. serrata*) in the outer channel sector (tidal zone) of the Chilika lagoon during New moon and Full moon phases of lunar periodicity. The CPUE values are expressed as number of juveniles  $\text{Khandas}^{-1} 12\text{h}^{-1}$ .

serious impact on the biodiversity of the lagoon. Also some of the juvenile groups caught by chance by the fishers operating khandas are killed unnecessarily without releasing them in the lagoon water.

#### Impact of lunar periodicity

The impact of lunar periodicity on the auto-recruitment of mud crab juveniles (Fig. 5) were studied by performing t-test for mean CPUE values of juvenile catches from 'Khandas' in tidal zone of outer

channel sector. Catch during new moon phase was significantly higher ( $t = 3.88, d.f. = 11; P < 0.01$ ). It was observed that the mud crab population in southern sector was still poor. Impact of lunar periodicity on the juvenile recruitment in Chilika lagoon was studied through CPUE analysis (Fig. 5). Such impact on the post-larval abundance of penaeid prawns along Orissa (India) coast<sup>23</sup> and on trap fishery of penaeid prawns in Chilika lagoon<sup>24</sup> was studied earlier. In the present study, significantly higher night collections of mud crab juveniles (mixed population of both species) from net box traps (khandas) were obtained during new moon phases ( $t = 3.88; d.f. = 11; P < 0.01$ ), discarding the null hypothesis that there is no difference in mud crab juvenile collections in 'khandas' during newmoon and fullmoon phases or there is no impact of lunar periodicity on the recruitment of mud crab juveniles.

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## References

- 1 Mohanty S K, Mohapatra A, Mohanty R K, Bhatta K S & Pattanaik A K, Occurrence and biological outlines of two species in the genus *Scylla* (De Haan) in Chilika lagoon, India. *Indian J. Fish.* 53(2006) 191-202.
- 2 Banarjee A C & Roychoudhury N C, Observation on some physico-chemical features of the Chilika lake. *Indian J. Fish.* 13 (1966) 395-429.
- 3 Bhatta K S, *Report on Chilika environmental monitoring*, Chilika Development Authority, (2001) 102p.
- 4 Mohapatra A, Mohanty R K, Mohanty S K, Bhatta K S & Das N R, Fisheries enhancement and biodiversity assessment of fish prawn and mud crab in Chilika lagoon through hydrological intervention. *Wetlands Ecol. Manage.* 15(2007) 229-252.
- 5 APHA, *Standard methods for examination of water and wastewater*, American Public Health Association, New York. 1998
- 6 Jameson J D, Murugan A & Natrajan P, Studies on the distribution pattern and morphometry of *Scylla serrata* (Forsk.) along Tuticorin coast. *Sea-food Export J.* 14 (1982) 17-20.
- 7 Pillai N K & Nair N B, Observations on the breeding biology of some crabs from the southwest coast of India. *J. Mar. Biol. Ass. India* 15(1973) 765-770.
- 8 Joel D R, Sanjeeva Raj P J, The breeding of three edible portunid crabs of Pulicat lake. In: *Progress in invertebrate reproduction and aquaculture*, T. Subramaniam and Sudha Vardharajan (ed), Indian Soc. Inver. Reproduction, Madras, (1982), pp135-140.
- 9 Lalithadevi S, Fishery and biology of crabs of Kakinada region. *Ind. J. Fish.* 32(1985) 18-32.
- 10 Kathirvel M, Srinivasagam S, Resource and exploitation of mud crab *Scylla serrata* (Forsk.) from India. In Angell, C. A. (ed.), Report of the Seminar on Mud Crab Culture and Trade. Bay of Bengal Programme, Madras 1992, BOBP/REP/51, pp.85-94.
- 11 Kathirvel M, Pandian K S, Balasubramanian C P, *Mud crab culture in India*. CIBA, Chennai, Tamil Nadu, India. *Bull. No.* 17 (2004) 1-60.
- 12 Onyango S D, The breeding cycle of *Scylla serrata* (Forsk., 1755) at Ramisi River estuary, Kenya, *Wetlands Ecol Manage* 10 (2002) 257-263.
- 13 Le Vay L L, Ut V N & Jones D A, Seasonal abundance and recruitment in an estuarine population of mud crabs, *Scylla paramamosain*, in Mekong Delta, Vietnam. *Hydrobiol.* 449 (2001) 231-240.
- 14 Litulo C, Population structure and reproductive biology of the fiddler crab *Uca inversa* (Hoffman, 1874) (Brachyura: Ocypodidae), *Acta Oecol.* 27 (2005) 135-141.
- 15 Chandrasekaran V S & Natrajan R, Seasonal abundance and distribution of seeds of mud crab *Scylla serrata* in Pichabaram mangrove, Southeast India. *J. Aquacul. Tropics* 9 (1994) 343-350.
- 16 Poovachiranon S, Biological studies of the mud crab *Scylla serrata* (Forsk.) of the mangrove ecosystem in the Andaman Sea. In Angell, C. A. (ed.), Report of the Seminar on Mud Crab Culture and Trade. Bay of Bengal Programme, Madras (1992), BOBP/REP/51, pp. 49-59.
- 17 Robertson W D, Biology of mangrove crab *Scylla serrata*. South African Association of Marine Biology Research, Poster No. 8. Oceanographic Res. Institute., Durban, S. Africa (1987)
- 18 Forbes A T & Hay D G, Effects of a major cyclone on abundance and larval recruitment of portunid crab *Scylla serrata* (Forsk.) in the St. Lucia Estuary, Natal, South Africa. *S. African J. Mar. Sc.* 7 (1988) 219-225.
- 19 Keenan C P, Davie P J F & Mann D, A revision of the genus *Scylla* de Haan, 1833 (Crustacea: Decapoda: Brachyura: Portunidae), *Raffles Bull. Zool.* 46 (1998) 217-245.
- 20 Ali M Y, Kamal D, Hossain S M M, Azam M A, Sabbir W, Murshida A, Ahmed A & Azam K, Biological studies of the Mud Crab, *Scylla serrata* (Forsk.) of the Sunderbans Mangrove Ecosystem in Khulna Region of Bangladesh, *Pakistan J Biol. Sciences* 7(2004) 1981-1987.
- 21 Koolkalya S, Thapanand T, Tunkijjanjujij S, Havanont V & Jutagate T, Aspect of spawning biology and migration of the mud crab *Scylla olivacea* in Andaman Sea, Thailand, *Fisheries Manage. Ecol.* 13 (2006) 391-397.
- 22 Moser S, Macintosh D, Laoprasert S & Tongdee N, Population ecology of the mud crab *Scylla olivacea*: A study in the Ranong mangrove ecosystem, Thailand, with emphasis on juvenile recruitment mortality, *Fisheries Res.* 71 (2001) 27-41.
- 23 Mohanty R K & Patnaik P N, Relative abundance and resource characteristics of Penaeid prawn seed in Orissa coast, *Indian J. Fish.* 49(2002) 67-72.
- 24 Jhingran V G & Natarajan A V, Study of the fishery and fish populations of the Chilika lake during the period 1957-65, *J Inland Fish. Soc. Ind.* 1 (1969) 47-126.