Mud Crab Recruitment Literature Reviews - focusing on *Scylla serrata*

Prepared for the

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Prepared by
Chris Calogeras
C-AID Consultants
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1. Introduction

As part of the National Mud Crab Fishery Research Strategy Workshop (NMCFRSW) held in Darwin, Northern Territory (NT) on 20 June 2007, a literature review was undertaken to identify and provide a brief on previous research undertaken to capture and identify juvenile mud crabs, specifically *Scylla serrata*.

The literature review focused on variables that may influence recruitment such as identifying any spatial, temporal, physical and chemical parameters, along with potential catching methods that may provide information to assist in capturing juvenile mud crabs. The Department of Primary Industry, Fisheries and Mines (DPIFM) provided the literature for review.

Although very little sound and consistent information was available, it appears that juvenile mud crabs are most prevalent during the post wet period in the intertidal area in the vicinity of river mouths, shorelines rich in seagrass and algal communities, muddy substrates and/or in the vicinity of mangroves roots and other sheltered conditions. These findings were presented at the NMCRFRSW and are summarised in this review.

2. Scope

The project's scope was to review around 100 papers, journals and reports provided by the DPIFM. The major focus was on *S. serrata* as there appears to be significant life history variations between it and the other three *Scylla* species. Information was specifically sought which may be relevant to the development of a recruitment index based on finding, identifying and measuring juvenile *S. serrata*.

Although not strictly limited to, information was mainly sought that would allow easy field analysis to specifically identify *S. Serrata*. For the purpose of the review this was a size of at least 50 mm across the carapace (see Section 7).

Where possible, information of particular relevance to northern Australia was sought, as much of the work on *S. serrata* has been undertaken in more temperate regions such as South Africa and South East Queensland, and there appears to be significant variations in factors affecting recruitment based on latitude, species, climate and river flows.

It was also noted that in many instances species identification pre-1998 may not have accurately differentiated between the four species of *Scylla*, especially with respect to work that had been undertaken in Asia. Species identification was clarified by Keenan et al in 1998 and is now used as the standard.

The information in the literature is grouped by the author into categories so it could be used to catalogue the information obtained through the review. These categories are:

- Spatial – where juveniles are found or are more prevalent, and if there was any pronounced movement
- Temporal - time of the year when juveniles are found or more prevalent
- Sampling methods - identify what methods have been used and if they were successful
- Other – other possibly relevant information that didn't fit into the above categories.

3. SPATIAL

Of the literature reviewed, many made reference to where juvenile mud crabs, specifically *S. Serrata,* were found during sampling. Most identified that juveniles were evident in the intertidal zone ranging from mangrove communities to the seagrass and algal beds.

The majority of the literature referred to work by Heasman (1980) and Hill et al (1982) undertaken in south east Queensland in the early 1980's.

The findings from Hill et al (1982) demonstrated that there appeared to be size and spatial distribution of juvenile mud crabs (<100 mm), and;

- Over a two year period over 300 juvenile crabs in the size range 20 to 80 mm were collected under tiles placed in the intertidal zone with a large component found on large intertidal flats
- In warmer months over 900 crabs, mainly between 80 to 130 mm, were caught using nets with an average 19 crabs each set
- The majority of crabs caught in pots intertidally were sub adult.

Heasman (1980) found 20 - 80 mm juvenile mud crabs in reed beds associated with macrophytes. He suggested that juveniles seek sheltered conditions and are found in small creeks, under stones, in seagrass and around pneumatophores of mangroves.

Hyland et al's (1984) work on *S. serrata* and their movement, within and between different habitats, showed that when post larval *S. serrata* recruited to an area there was probably limited movement. Catch in an area is therefore not dependant on migration of adults, but on the number of juveniles that settle in an area.

Chandrasekaran and Natarajan's (1994) work in south east India on seasonal abundance and distribution of *S. serrata,* showed that the greatest catch of juvenile mud crabs was found in the post monsoon period, in muddy substrates in shallower water with areas of rich seagrass and algal community, more so than areas of mangrove roots.

As part of Knuckey's PhD thesis (1996) considerable effort was expended in the NT trying to catch juvenile mud crabs in areas extending from the intertidal area into the mangroves and creeks with little success. However in 1997, on completion of his thesis, large numbers of 10 to 20 mm crabs were found in the saltmarsh wetlands behind the mangroves during the wet season, when the entire area was inundated with freshwater from monsoonal rains.

Walton et al (2006) used a range of methods to identify settlement of *Scylla* sp. (mainly *S paramamosain*) and ascertain the significance of mangrove and mudflats as nursery grounds for mud crab. They found that instar 1 crabs settled at the mangrove fringe on the surface and were still living on the surface to a size of 15 mm. By the time they reach 45 mm they begin to dig into the mud, or live subtidally, migrating into the area with the tide. Post wet, juveniles were evident on the sediment surface and around roots, recruiting into the mangrove fringe at 60 mm. Subadults were most commonly indentified moving out of mangroves at the end of the dry.

Webley and Connolly's (2007) work on vertical movement of *S. serrata* megalopa, in response to light, showed that megalopa tended to adopt a benthic habit and may therefore not be found in surface waters. This has been supported, as although there have been extensive surveys undertaken, they have not generally been found within estuaries. This means they probably metamorphise into crabs along the coast with migration to estuarine habitats shortly after, possibly during flooding tides, when they may enter estuarine and coastal areas as early stage crabs. This has been disputed in some research, such as that undertaken by Hill (1974), based on plankton tows in South Africa. This work caught larvae along the shore line and in mouths of rivers, with some megalopa caught within estuaries, where they may metamorphosis and settle into the mangroves.

The literature showed little result for the extensive amount of work undertaken in trying to catch juvenile *S. serrata*. There also appears to be conflicting information which was most likely species, environmental and regionally driven. However, in most literature it was consistent that juveniles are expected to be most commonly found:

- Near the mouths of estuaries
- In near shore areas rich in seagrass, algal communities and macrophytes
- In muddy areas
- In areas that have pneumatophores or other forms of shelter.

4. Temporal

The literature was assessed with a view to determining whether there was a clear seasonal timing when juvenile crabs may be more abundant. Most authors based their work on the premise that juveniles would be more prevalent during the post wet period.

Hill et al (1982) undertook substantial early work on the distribution of juvenile and sub adult *S. serrata* on tidal flats on Queensland's south east coast in Australia. This work is often referred to in other literature but it gives no clear indication, from tiles or stake net trapping, of any seasonal influx of juvenile crabs.

Kathirvel and Srinivassagam (1992) identified area availability in India for juveniles. They found that *S. serrata* appear to be continual breeders with peak catches of juveniles prevalent in the backwaters during May to October, and in the mangroves during January to February.

Chandrasekaran and Natarajan's (1994) work on seasonal abundance and distribution of mud crabs in mangroves, in south east India, identified that the time of greatest catch of juvenile recruits was during the post monsoon period, with nil evident during the monsoon.

Knuckey (1996) in his work on *S serrata* population dynamics in the NT, undertook extensive year round sampling, but there were few juveniles caught, and no cycle identified.

Based on work undertaken on seasonal abundance, distribution and recruitment of mud crabs (*Scylla* sp) in the Philippines by Walton et al (2005), it was found that the spawning period becomes more pronounced with decreasing latitude. The majority of this work focuses on other *Scylla* species with little on *S. serrata*.

Zafar et al (2006) found that in Bangladesh recruitment for *S. serrata* was continuous for both sexes, but males peaked during May to August, and females had two peaks, with the largest in May (pre wet) and another in August to October (late to post wet). Interestingly this work showed an L_∞ of only 105 mm, which is significantly smaller than that identified in many other studies.

Although this review focussed on juvenile crabs it was noted that Sara et al (2006) undertook plankton sampling over a two year period to identify abundance and distribution patterns of *Scylla sp.* larvae in Indonesia. They found three peaks of zoeal abundance (beginning of dry, dry season and wet) although peaks were expected at periods of high nutrient and food potential associated with monsoon activity.

It must be remembered that when discussing seasons in Asian countries the monsoon occurs during June to September, with little rain during November to February; the opposite of conditions in Australia.

Moser et al (2004) found that *S. serrata* had little capacity for horizontal movement so they most likely depended on favorable currents for successful recruitment into nursery areas. Sara et al (2006) also believed that selective tidal stream transport may be important for larval dispersion, megalopa settlement and consequently juvenile recruitment.

Although most authors believed the majority of juveniles would be prevalent during the post wet period, there were generally low numbers caught in all instances. A summary follows:

- There was no evidence of seasonal influx in *S serrata* (there may be a continuous recruitment to the fishery in other *Scylla* species).
- It is believed that spawning periods become more pronounced with decreasing latitude (this is possibly related to water quality and monsoonal influences).
- Few or no juveniles were caught during the monsoon
- The majority of juveniles would appear to be caught in the post wet
- Due to the low numbers caught, there is really no real clear cycle identified for *S. serrata.*

Henmi (1992) found in Japanese crab that there were widely varying times and numbers of recruits to the fishery, based on a range of variables. Similar variability may also take place with for *S. serrata*.

5. Catching methods

Extensive fieldwork has been undertaken to catch large numbers of juvenile mud crabs for research purposes. Although the previous categories have focused on *S. serrata* this section has cast the net wider, to identify methods used to catch any species of mud crab as well, as some other similar species. A summary of the methods follows.

<u>Nets</u>

A range of nets, including cast, drag, stake, fyke, scoop and seine have been used to capture juvenile mud crabs. Information on each of the net types follows.

Cast nets with a 5 mm mesh were successfully used in the Philippines in the intertidal area, especially in seagrass, to catch *Scylla* sp, mainly *S. olivacea* (Walton et al 2005) and also in India by Prasad and Neelakantan (1988).

Walton et al 2005 used a 2 mm drag net in the Philippines and a similar drag net method was used in Bangladesh during spring tide lows (Enamul et al 2005). A 4 mm net was also used in the Philippines (www.inco-cams.seafdec.org.ph).

Chandrasekaran and Natarajan (1994), using a combination of cast and drag nets, had catch rates of 7 per 50 m^2 sampled (234 juveniles), ranging in size from 8 to 60 mm with 20 to 30 mm the most common.

Stake nets of 30 mm mesh, as used by Hill et al (1982), caught 900 juvenile mud crabs, ranging in size from 80 to 130 mm.

A 500 m fyke net with 15 mm mesh was used at night along the mangrove edge to capture juveniles of 40 to 50 mm at ebb tide (Walton et al 2006).

Seine nets used below the mangrove line in the intertidal zone in Madagascar caught juvenile crabs between 60 to 110 mm carapace, whereas those caught in the mangroves and subtidal areas were adults (Hill et al 1982).

Scoop nets have been used at the mangrove fringe at night, with a torch, to catch juveniles of 10 to 20 mm (Walton et al 2006).

Traps and pots

Traps and pots have been used extensively, often utilising various mesh sizes as a selectivity tool.

Traps with 30 mm mesh caught juvenile *S. olivacea* and *S*. *paramamosain* of 100 to 200 g in Thailand during spring tides (Tongdee 2001). In Sri Lanka 30 to 40 mm mesh dilly pots caught immature crabs ranging from 45 to 115 mm, with an average of 85 mm (Jayamanne 1992).

In Queensland, Gould et al (2001), using commercially made 'Manyana' pots inside creeks, caught mainly juveniles' between 100 to 130 mm carapace width in the post wet period.

Habitat

The use of artificial shelters such as tiles, rocks and habitat traps (Heasman 1980, Hill et al 1982, Knuckey 1996) has shown that juvenile crabs can be caught using this method set in a range of habitats (from mud flats to the mangroves), but catches were not large with Hill only catching 300 over a two year period.

Knuckey (1996) noted that after his fieldwork had completed in the NT, juvenile mud crabs (10 to 20 mm) were caught in habitat traps consisting of hoop nets, with large tufts of frayed rope in the middle acting as a shelter. These were set in the saltmarsh wetlands behind the mangroves during the wet season when the entire area was inundated by the monsoon rains.

Others

The use of trawls in intertidal zones in Madagascar (Hill et al 1982) had some success in collecting juvenile mud crabs. In the USA, Baeta et al (2005) used a 2 m beam trawl, with a tickler chain and 5 mm mesh size in the cod end, to capture juvenile green crabs (*Carcinus maenas*).

Digging and sieving an area has been used in Japan on *Macrophthalmus japonicas* (Henmi 1992). Anecdotal advice from the NT indicates that such a practice may also work on *S. serrata*. However Hill et al (1982) noted that as juvenile *S. serrata* dig in the mud and hide in mangrove roots, they may prove difficult to find using this method.

In Thailand it appeared that female *S. olivacea* were less easily trapped than males (Moser et al 2004) but this has not been identified as a problem for other mud crab species.

What is abundantly clear from the literature is the collection of juvenile *S. serrata* has not proven particularly successful in obtaining large numbers of animals.

6. Physical and chemical variables

In many instances researchers believed that a range of chemical or physical cues may stimulate recruitment. By identifying these variables, the timing of recruitment to the fishery could possibly be determined.

S. serrata are considered to be less tolerable of freshwater than other *Scylla* sp. (Walton et al 2005, Moser et al 2004) with some juveniles of other species able to tolerate salinities as low as 2 ppt, but generally preferring around 34 ppt (Le Vay 2001). Based on work undertaken in South Africa (Hill 1974) growth was faster at salinities of 20 to 22%.

Freshwater run may be an important cue to allow juveniles to identify and locate estuary systems (Robertson 1996). Chandrasekaran and Natarajan (1994) found that after the monsoon juveniles moved into areas as salinity increased and re-established populations. This is relevant for northern rivers influenced by the monsoon, but as Webley and Connolly (2007) noted, for much of the recruitment season in temperate Australia, estuary mouths have similar salinities to offshore waters. Therefore they believed that salinity was not the key stimulus for settlement, but that it may be other stimuli such as water depth, tidal pressure or chemical cues.

Hill (1974) showed that larvae could not tolerate water temperatures above 25^{o}C in South Africa, but in northern Australia, the water temperatures often exceed that.

The abundance of mangroves present was considered to be important as an area of recruitment, but Robertson (1996) found that in South Africa recruitment is patchy and not dependant on mangroves being present, but some suitable substrate is required.

From the references it was unclear what physical or chemical cues may drive recruitment and settlement of juvenile crabs, but the following were considered as possibilities;

- increasing salinities
- freshwater run
- depth or pressure
- chemicals (sediment traces, mangroves etc)
- temperature.

7. Other factors

Preferred feed for juveniles

By investigating the type of feed preferred by juvenile mud crabs it may be possible to identify areas and timing of settlement.

Work undertaken by Prasad and Neelakantan (1988) in India showed that detritus was the major component (over 50%) of food in the gut of juvenile crabs (< 70 mm) whilst sub-adult (80 to 100 mm) and adult (> 110 mm) crabs had larger amounts of fish and crustacean remains. Kathirvel and Srinivassagam (1992) and Jayamanne (1992) supported the findings that crustaceans were a preferred diet of mud crabs.

Size at which juvenile mud crabs can be recognised in the field

Based on Australian studies of S. *serrata*, maturity occurs between 90 and 110 mm and all crabs are mature at 120 mm (Heasman 1980; Knuckey 1996). Although smaller sizes at maturity have been noted in the literature there may be problems with species identification, as prior to Keenan et al (1998), there was some misreporting of species.

Based on aquaculture work it appears that at 50 mm it is relatively simple to discriminate juvenile *S. serrata* from other crab species, and by 80 mm to sex individuals (personal comment – Darwin Aquaculture Centre).

Work done on other *Scylla* species (*S. paramamosain*) has shown that males and females may recruit to the fishery at different sizes and there is massive variability in the time it takes them to reach maturity (Moser et al 2004) and the size at maturity (Walton et al 2006).

Webley and Connolly (2007) believe that as juveniles grow very quickly in the estuarine system and this may limit the opportunity to sample.

8. References

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