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## 960 SURVEY OF GREEN MUSSEL SEED RESOURCES OF KERALA AND KARNATAKA

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### Introduction

Farming of marine mussels is practiced extensively in the temperate and Southeast Asian countries. In India two species of mussels, *Perna viridis* and *Perna indica* commonly known as the green and brown mussels respectively have been reported. Of these, the green mussel has a wider distribution occurring along the east and west coasts of India, while brown mussel is restricted to southwest coast upto central Kerala. The annual production of mussels ranges between 6000 and 10,000 tonnes through fishery, production from commercial mussel farms being negligible. In the recent years farmed mussels also have contributed to the annual mussel production.

Since 1995, the Central Marine Fisheries Research Institute (CMFRI) has made fervent efforts to popularize mussel mariculture by setting up demonstration farms in estuaries and open sea systems with active participation of local fishers. Along with this, activities like short-term training courses at the village level, awareness programs to State Govt. and welfare officers and publicity through mass media during the harvests led to the development of mussel mariculture as a small scale, financially viable activity along the southwest coast of India. In addition to providing part time employment to unskilled fishers, mussel mariculture activities produced about 600 tonnes of mussel in 1999. This is a significant achievement for a nation, which did not have any commercial mussel farms till 1996.

With the commercialization of mussel

mariculture, the demand for seed especially in the states of Kerala and Karnataka has increased considerably. Though the hatchery techniques for mussel seed production has been developed majority of the mussel farmers depend on wild seed for farming. Requisite data on the seed settlement season, its spatial distribution and type of material to be used for collection is well documented for most of the temperate species. In India, information on mussel biology like growth pattern relative to shell and somatic parts and reproduction are available. Similarly, the techniques of mussel farming and the results of the programs implemented at different locations along the Indian coasts have been published by several researchers of CMFRI and National Institute of Oceanography (NIO). However, quantitative information on the seed resources and their spatial distribution is not available though mention has been made on the major seed settlement along Kerala and Goa coasts. With the upsurge of mussel mariculture data on seed availability has become essential for correct management of this industry so that farmers can plan and initiate their farming activities in advance. Besides, such data is essential to policy makers in deciding the number of farms and extent of mussel farming that can be practiced.

To find solutions for queries like 'when' 'where' and 'how much' seed can be collected, a rapid seed assessment survey was conducted along the Kerala and Karnataka states during 1999-2000. The significant observations made during this survey are presented in this paper.

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**Sampling procedure**

The survey was conducted during July to November 1999 and from November to April 2000 along Kerala and Karnataka coasts respectively. For estimating the biomass, the faunal settlement on the hard rocky / laterite substratum was completely scraped from a unit area of 25 x 25 cm marked by a quadrant (Fig.1). Two to three samples from each site (Fig.2) were collected from the upper and lower



Fig. 1 Sampling of intertidal mussel beds using a 25 x 25 cm quadrant.

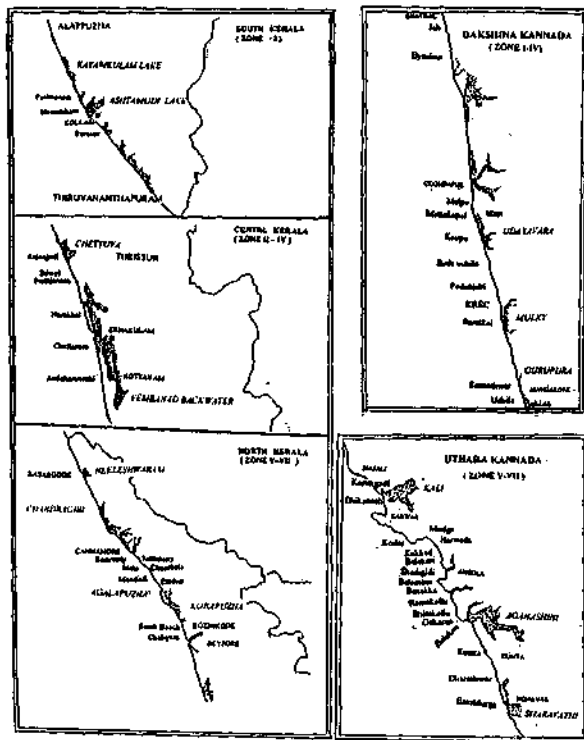


Fig. 2 Map showing the zone-wise seed sampling site used in the present rapid survey along Kerala and Karnataka coasts.

intertidal regions during low spring tides when the mussel beds were exposed. Samples from the subtidal beds were taken by engaging local divers. The approximate area of seed settlement was noted by observation and enquiry with mussel pickers. The samples were sieved through 5 mm mesh sieve and the mussel spat above 5 mm were collected and the total number and length of spat in unit area was noted. In case of dense settlement sub samples were taken and the length (mm) and weight (mg) of the mussels were taken. The biomass per m<sup>2</sup> was calculated based on shell-on weight of mussels inhabiting unit area. From this data, the biomass for each site and zone and the number of seed per kilogram were estimated.

**Mussel seed resources of Kerala**

Kerala has rich natural beds of green mussel from the intertidal zone upto 15 m depth along the coasts of Kollam, Alapuzha, Kochi, Kozhikode, Kannur and Kasargod. This State accounts for more than 95% of the national mussel production. For seed assessment, the coastal region from Paravoor in the south to Koduvally in the north was divided into seven zones. The resource potential of all the coastal districts except Trivandrum and Kasargod was estimated from the samples collected. About 7954 tonnes of seed mussel of average length 16 mm was distributed in 5,614,625 m<sup>2</sup> area during July to November 1999. The average mussel biomass per m<sup>2</sup> was 2915 g. Spat settlement was observed from July onwards. However, the coastal zone becomes congenial for spat collection only from September onwards. Details regarding extent of mussel bed, average biomass per sq. m, estimated biomass for the major sites and the average length of the seed collected during the sampling period are given in Table 1.

**South Kerala (Zone I) :** In the region between Paravoor and Parimanam the mussel biomass comprising both brown and green mussel was estimated as 24 tonnes spread over an area of 38,000 m<sup>2</sup>. At Paravoor, the southern most site, the majority of the beds observed were brown mussel beds. Settlement in the upper

TABLE 1 Mussel seed settlement along Kerala coast indicating major seed settlement sites IT - Intertidal; ST - Subtidal

Zone Location/ Area	Estimated extent of mussel bed in sq.m	Average mussel biomass per sq.m(g)	Estimated biomass in tonnes	Average size of mussel seed (mm)	Number of seed per kilogram	Nature of Bed	Date of sampling
<b>South Kerala</b>							
I Kollam district							
Paravoor	12000	7107	5.33	25.9	534	IT	05-Nov-99
Neendakara/Port Kollam	8000	3375	7.615	24.9	709	IT, ST	05-Nov-99
Cheriyazhikal/Parimannam	18000	9264	10.827	18.6	4190	IT	05-Aug-99
Total/Average	<b>38,000</b>	<b>6582</b>	<b>23.8</b>	<b>23.1</b>	<b>1811</b>		
<b>Central Kerala</b>							
II Alapuzha district							
Andakaranazhi	3000	184	0.587	6.8	16769	IT	17-Jul-99
III Ernakulam district							
Saudi/S.Chellanam	9750	184	0.587	6.8	16769	IT	17-Jul-99
Nayarambalam/Narakkal	3750	2348	7.807	12.6	2248	IT, ST	02-Aug-99
IV Thrissur district							
Perinjani/Azhikode	3000	156	0.277	6.9	10182	IT	25-Jul-99
Ethayal	1125	592	0.548	7.3	4767	IT	02-Sep-99
Anjangadi/Thottapu	6000	45	0.204	6.9	12077	IT, ST	25-Jul-99
Total/Average	<b>26,625</b>	<b>585</b>	<b>10.0</b>	<b>7.9</b>	<b>10469</b>		
<b>North Kerala</b>							
Malappuram district	(No significant resources)						
V Kozhikode district							
Chaliam/S.beach	800,000	1900	1520.0	18.8	400	ST	01-Oct-99
Elathur/Kollam	750,000	1700	1275.0	11.4	415	IT, ST	28-Aug-99
Moodadi/Thikkodi	2,400,000	1500	3600.0	13.2	350	IT, ST	22-Sep-99
Chombala	400,000	1500	600.0	19.5	350	IT, ST	22-Sep-99
VI Mahe	200,000	1000	200.0	20.1	350		28-Sep-99
VII Kannur district							
Thalassery/Thalal	500,000	2250	125.0	21.3	400	IT, ST	28-Sep-99
Koduvally	500,000	1200	600.0	20.5	400	IT, ST	28-Sep-99
Kasargod district	Not surveyed						
Total/Average	<b>5,550,000</b>	<b>1579</b>	<b>7920.0</b>	<b>17.8</b>	<b>361</b>		
<b>Grand Total/Average</b>	<b>5,614,625</b>	<b>2915</b>	<b>7953.8</b>	<b>16</b>	<b>4220</b>		

intertidal area was found to be destroyed due to desiccation during December-January. However, at Needakara (Port Kollam), the subtidal mussel beds harbouring both green and brown mussel showed good survival and growth throughout the year.

**Central Kerala (Zone II - IV) :** Moderate settlement of both species of mussel was observed in the coastal zone of Andakaranazhi to Chellanam (Zone II) where the biomass was estimated as 587 kg in about 3000 m<sup>2</sup>. Southern regions of Alapuzha district which are famous for mudbank formation during southwest monsoon were barren. Severe

destruction of seed mussel by desiccation and sand accumulation was observed during December-January. In Zone III covering the region on either sides of the Cochin barmouth about 8.4 tonnes of mussel seed of average length 15.7 mm was distributed in 13,500 m<sup>2</sup> during July-August. The settlement was mostly on the rocky sea walls bordering the coastal villages (Fig. 3 and 4) which were prone to sea erosion during the southwest monsoon. *P. viridis* dominated the mussel population. The mussel biomass was estimated as 1029 kg in 10,125 m<sup>2</sup> between Azhikode barmouth and Chavakkad (Zone IV). At Perinjani, the

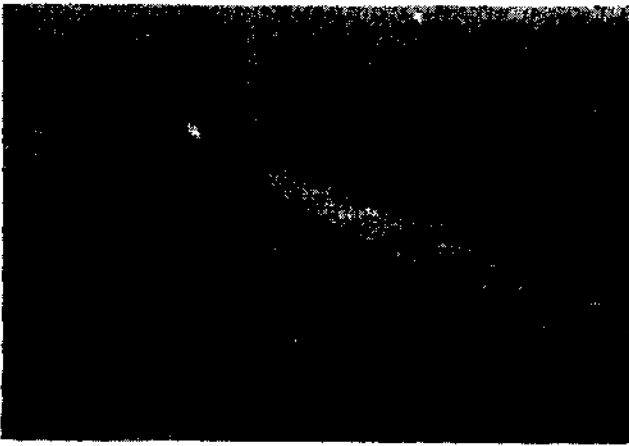


Fig. 3. Granite rocks (seawall) bordering the coasts of central Kerala for preventing sea erosion which have extensive mussel seed settlement

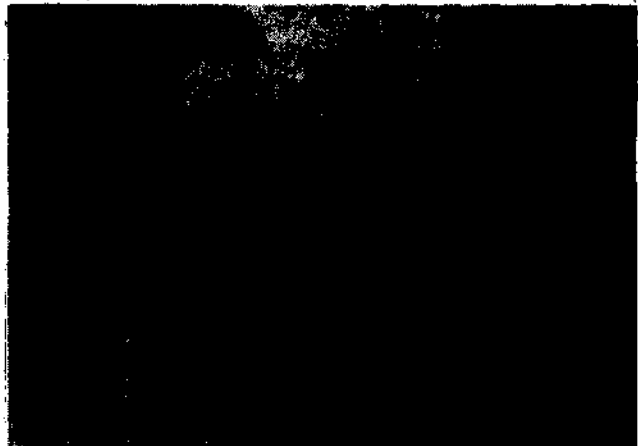


Fig. 5 Mussel seeds in sub-tidal beds in northern parts of central Kerala (Zone IV)

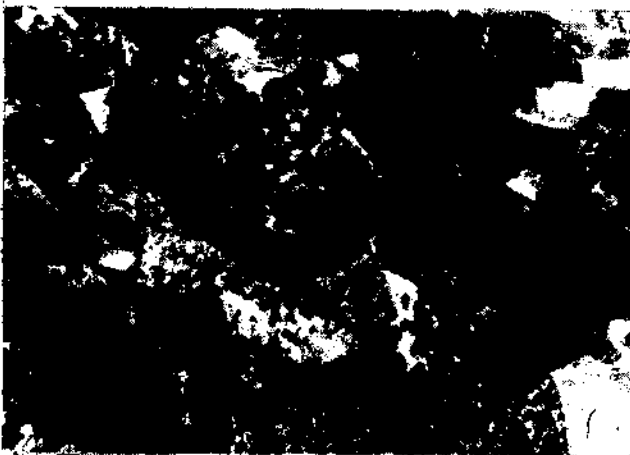


Fig. 4. A view of the mussel seed settlement on the sea wall along central Kerala coast.

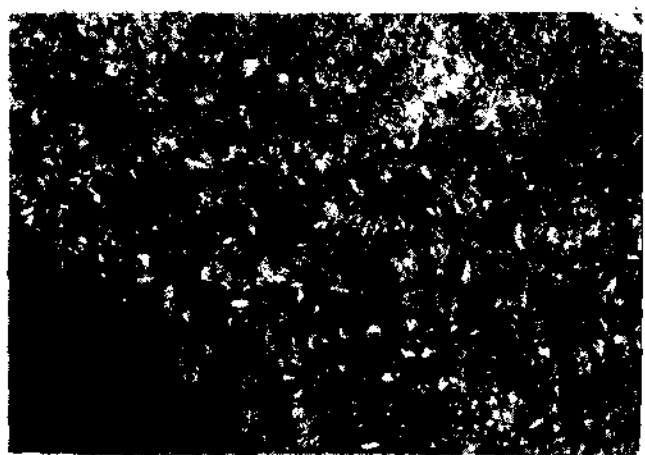


Fig. 6. Seed settlement on laterite rocks in north Kerala.

mussel spat perished due to desiccation by November. Brown mussel spat occurred only in stray numbers in all the samples collected. However, the subtidal seeds (Fig.5) settled in the northern part of this zone which is submerged even during postmonsoon survives and this supports a fishery.

**North Kerala (Zone V - VII) :** About 76% of the seed settlement area of the state is in Zone V extending between Chaliyam and Chombala in Kozhikode district which has extensive subtidal regions with laterite substratum suitable for attachment of mussel spat. The mussel beds located along coastal region of Thikkodi, Chaliyam, Elathur and Chombala was estimated as 43,50,000 m<sup>2</sup> with a biomass of 6995 tonnes. The natural crevices found in the laterite substratum (Fig.6) ensured

incomplete removal by mussel pickers. However destruction of seed mussels which were fished along with large mussels and mortality due to silting and desiccation was noted at Elathur and Kollam. Zone VI which covers the coastal area of Mahe had an estimated biomass of 200 tonnes in 2,00,000 m<sup>2</sup> area. Mussel spat settlement was observed on granite and laterite rocks. The intertidal and subtidal areas of Koduvally and Thalassery (Zone VII) in Kannur district had 725 tonnes of mussel spat of average length 23.1 mm in 10,00,000 m<sup>2</sup> contributing to 9.1 and 18.0% of the States mussel biomass and mussel bed area.

#### **Mussel seed resource of Karnataka**

Mussels, locally known as *Ajir / Pachila* are

fished by coastal fishers and marketed locally and in neighbouring states like Kerala and Goa. The coastal region of Karnataka was divided into seven zones with four in Dakshina Kannada district and rest in Uttara Kannada district. The total mussel biomass was estimated as 178 tonnes spread over an area of 50,675 m<sup>2</sup>. About 73% of the mussel beds were in Uttara Kannada district with 23% of the total mussel biomass. The average biomass was estimated as 5149 g per m<sup>2</sup> comprising of seeds of length 26 mm. The mussel beds in Dakshina Kannada are mostly subtidal in nature, while in Uttara Kannada it is intertidal as well as subtidal. Uttara Kannada has more extensive natural rocky shores (Fig.7 and 8) than Kerala. Details regarding extent of mussel bed, average biomass per m<sup>2</sup>, estimated biomass for the major sites and the average length of the seed collected during the sampling period are given in Table 2.

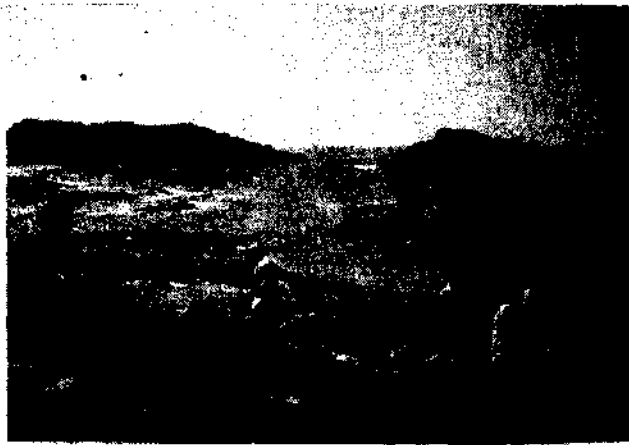


Fig. 7 The natural rocky shore of Karnataka that supports extensive mussel spat settlement.

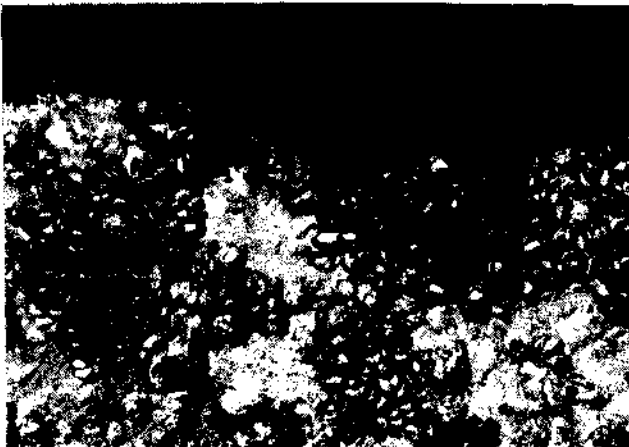


Fig. 8. A view of a mussel bed in Malpe Islands along Karnataka coast.

**Dakshina Kannada (Zone I-IV) :** The coastal area between Someshwara and Uchila (Zone I) harboured about 8 tonnes of mussel seed in 1063 m<sup>2</sup> with more than 99% of the bed of this zone located at Someshwara. At this site the average mussel biomass was 7718 g per m<sup>2</sup>. In the second zone extending from Suratkal to Padubidri about 22 tonnes of mussel seed was found to occur in an area of 1915 m<sup>2</sup>. Though the extent of mussel bed area was only 3.7% of the States' total mussel bed, it harboured nearly 12% of the total biomass. The average biomass was as high as 15,264 g per m<sup>2</sup>. The coastal area between Bada Uchila and Malpe (Zone III) had 59 tonnes of mussel seed in 6292 m<sup>2</sup> area. This zone had the maximum biomass and area suitable for spat settlement in Dakshina Kannada. Malpe, Kaupu and Bada Uchila were the main sites suitable for spat collection. The coastal region between Malpe and Coondapur did not have any mussel resource. From Gangolly to Bhatkal lies the extensive Trasi-Byndoor beds where mussel settlement was noted in 4280 m<sup>2</sup> area. The mussel seed biomass was estimated at 42 tonnes contributing to 24% of the State's mussel seed biomass.

**Uttara Kannada (Zone V-VII) :** In the region between Basaldurga and Kumta (Zone V) mussel settlement was observed in 2280 m<sup>2</sup> area with 2.1 tonnes of mussel. The adjacent zone (Zone VI) had extensive areas, 21,526 m<sup>2</sup> with mussel seed settlement. About 26 tonnes of mussel seed spread along 7 sites was present in this region. The major mussel bed extending to 8000 m<sup>2</sup> was located along the coast of Belekeri that is characterised by extensive rocky coves and submerged rock formation had 10 tonnes of mussels. In Zone VII the extent of mussel bed was 13,319 m<sup>2</sup> contributing to 26.5% of the States' mussel bed. The mussel biomass was estimated as 19 tonnes in the region between Harwada and Kumta.

#### Settlement pattern and spawning period

An analysis of the spatfall and spat length data shows that there is a clear settlement pattern with a trend from south to north.

TABLE 2 Mussel seed settlement along Karnataka coast indicating major seed settlement sites IT - Intertidal; ST - Subtidal

Zone Location/ Area	Estimated extent of mussel bed in sq.m	Average mussel biomass per sq.m(g)	Estimated biomass in tonnes	Average size of mussel seed (mm)	Number of seed per kilogram	Nature of Bed	Date of sampling
<b>Dakshina Kannada</b>							
I Uchila	43	6453	0.277	19.6	842	IT, ST	27-Oct-99
Someshwara Temple	1020	7718	7.872	18.5	1951	IT, ST	25-Oct-99
II Surathal Beach	630	8384	5.282	20.2	1473	IT, ST	15-Nov-99
KREC beach	475	8672	4.119	16.8	2548	IT, ST	15-Nov-99
Padubidri	810	15264	12.359	21.1	1110	IT, ST	03-Jan-00
III Bada Uchila	1500	12544	18.814	20.4	911	IT, ST	05-Jan-00
Kaupu	2005	12840	25.744	16.8	1810	IT, ST	03-Jan-00
Mattukopal	250	5643	1.411	14.7	877	IT, ST	05-Jan-00
Malpe Islands	2537	5130	13.013	12.5	2573	IT, ST	14-Dec-99
IV Byndoor to Gangolly	4080	9760	39.821	20.5	855	ST	12-Jan-00
Bhatkal (Jall)	200	8784	1.757	19.1	770	ST	12-Jan-00
Total/Average	<b>13550</b>	<b>9199</b>	<b>130.469</b>	<b>18.2</b>	<b>1429</b>		
<b>Uttara Kannada</b>							
V Basaldurga	1280	900	1.152	35.4	402	IT, ST	04-Feb-00
Dhareshwar	620	940	0.582	35.0	405	IT, ST	27-Mar-00
Kumta (Light house)	380	590	0.365	37.0	320	IT, ST	27-Mar-00
VI Tadri (Belekan)	1850	850	1.527	37.0	325	IT, ST	27-Mar-00
Gokarn	1400	675	0.945	35.0	368	IT, ST	27-Mar-00
Bhimkallu	2420	920	2.226	36.5	355	IT, ST	26-Feb-00
Ramakallu	120	875	0.105	36.5	350	IT, ST	26-Feb-00
Banakkal	2760	1490	4.112	30.3	622	IT, ST	05-Feb-00
Belambar	4326	1530	6.618	30.2	610	IT, ST	05-Feb-00
Shedigidi (Ankola)	650	650	0.422	26.8	706	IT, ST	06-Jan-00
Belekeri	8000	1255	10.040	25.5	730	IT, ST	06-Jan-00
VII Harwada	1500	1470	2.205	38.4	326	IT, ST	14-Apr-00
Kukkad (Bharekallu)	5415	1520	8.230	38.5	320	IT, ST	14-Apr-00
Mudga Amddall	2600	1410	3.666	38.6	318	IT, ST	13-Apr-00
Kodar, Ambekodar, Alebete	2400	1480	3.312	37.3	320	IT, ST	24-Mar-00
Light house (Bhikanashi)	264	980	0.259	35.0	360	IT, ST	05-Feb-00
Kurumgad	1140	1160	1.322	35.0	370	IT, ST	26-Feb-00
Total/Average	<b>37125</b>	<b>1100</b>	<b>47.088</b>	<b>34.6</b>	<b>424</b>		
<b>Grand Total/Average</b>	<b>50675</b>	<b>5149</b>	<b>177.557</b>	<b>26</b>	<b>927</b>		

Settlement starts in July in southern parts of Kerala while along northern parts of the same State settlement commences only by August - September. In Karnataka, the settlement is much later starting only by Sep-Oct. From the size of spat at the time of observation and assuming a growth rate of 0.3 to 0.33 mm per day and a larval metamorphic period of 20 days, the spawning period of green mussel in these two States was inferred (Fig. 9). Though southwest monsoon commences by June in both the States, the intensity of rainfall increases from south to north.

Spawning of mussels starts by June - July in southern and central Kerala, while in N. Kerala spawning is only by July / August. Along Karnataka, the natural environment becomes

conducive for spawning from August in the South, while for the same species the spawning period is from middle of September to November in N. Karnataka. This spawning sequence of green mussel from the southern tip of Kerala to Uttara Kannada is reflected on the seed settlement pattern.

Generally bivalve spawning is triggered by a sudden change in water temperature. It is presumed that the decrease in the intensity of rainfall, which will result in increase in water temperature, sets in earlier along southern and central Kerala than in north Kerala and Karnataka. This could explain the progression of settlement from south to north. However, more detailed analysis of hydrographic parameters

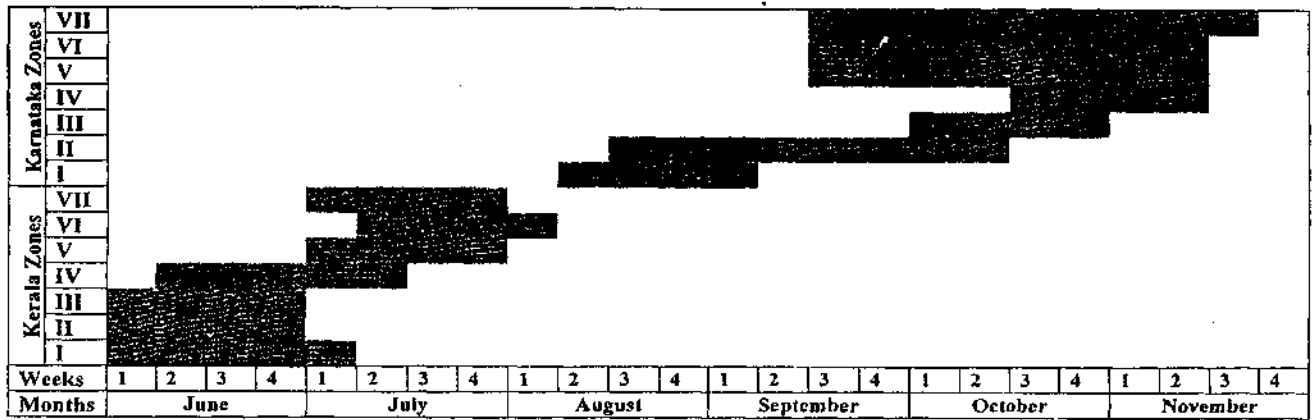


Fig. 9. State-wise and zone-wise green mussel spawning periods (commencement) inferred from collected spatfall data\*

\* assuming an initial growth rate of 0.3 - 0.33 mm/day and larval metamorphic duration of 20 days.

especially water temperature and number of bright days in a month are necessary before making final conclusions.

**Remarks**

The rapid survey for assessment of mussel seed settlement in the two southern states shows considerable spatial and temporal variation. Mussel spat settles in the intertidal and subtidal region on three different substrata viz. natural rocky shore, laterite rocks and on granite rocks placed as seawalls bordering the shore line prone to sea erosion during monsoon season. It was observed that the seed on the first two substrates survive and grow to fishable size. However, those settling on the sea walls perish due to desiccation and sand deposition. Each year, considerable quantity of good natural spat is lost along the central Kerala coast. If this resource is used for farming, the seed which otherwise would have perished can be allowed to grow into a commercial seafood product.

Along Kerala coast, though the seed starts settling by July and the coastal area becomes suitable for collection and farming only from September. Thus the ideal period for spat collection along Kerala and Karnataka coasts are Aug-Jan and Oct-Jan respectively (Table 3). A good percentage of the settled seeds perish due to unfavourable environmental conditions and the rest survives to support the fishery. Assuming that at least 65% of the available biomass can be used for farming, there is potential for seeding 51,70,000 and 1,16,000 numbers of mussel ropes of one-meter length in Kerala and Karnataka respectively. Comparatively, the seed resource is higher along



Fig. 10. A mussel farmer collecting seed from natural beds for mussel farming.

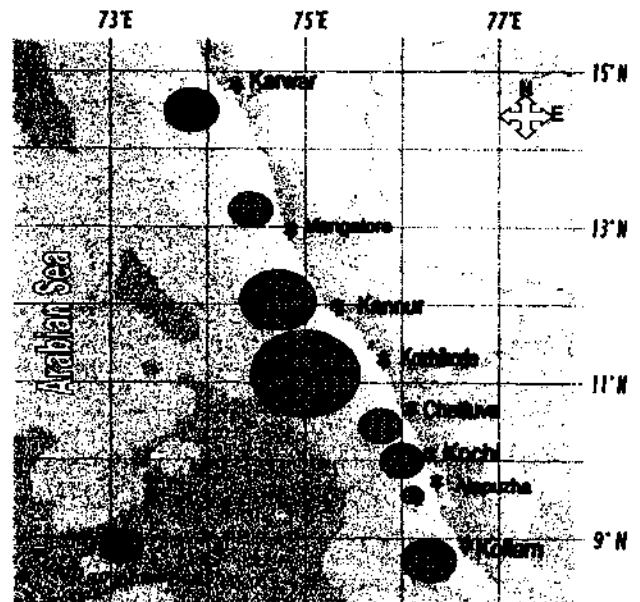


Fig. 11. Map of coastal Kerala and Karnataka showing extent of mussel beds



TABLE 3 Statewise estimated mussel seed resources, period of occurrence and potential seedable ropes

State	Estimated extent of mussel bed in sq.m	Estimated biomass in tonnes	Period of occurrence of 15-25 mm seed	Estimated potential of 1 metre mussel ropes which can be seeded
Karnataka	50,675	178	Oct-Jan	115,700
Kerala	5,614,625	7954	Aug-Jan	5,170,100
<b>Total</b>	<b>5,665,300</b>	<b>8,132</b>		<b>5,285,800</b>

north Kerala coast. Already, coastal fishers utilize part of this resource every year for mussel farming (Fig.10). The extent and areas of mussel biomass (in decreasing order) based on the survey can be given as North Kerala, Uttara

Kannada, Dakshina Kannada, Central and South Kerala (Fig.11). However, year to year variations in biomass can occur with growth and mortality. This information can be utilised by prospective farmers to plan their farming activities.