CMFRI Special Publication No : 114

ISSN : 0972-2351

# FISHERY MANAGEMENT PLAN FOR ASHTAMUDI LAKE CLAM RESOURCES

2013

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भाकृ अनुप
ICAR

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CMFRI Special Publication No. 114

Published by :
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ISSN : 0972-2351

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December 2013

Citation: Mohamed K.S., V. Venkatesan, V. Kripa, D. Prema, Mathew Joseph, P.S. Alloycious, Jenny Sharma, K.K. Valsala, K. K. Saji Kumar, N. Ragesh, John Bose and Anjana Mohan (2013). Fishery Management Plan for Ashtamudi Lake Clam Resources. CMFRI Special Publication No: 114 48p.

# Preface

Clams form a subsistence fishery throughout the Indian coastal regions, particularly along the southern states. The potential yield for clams and cockles in India is 113,189 tonnes as per the Government of India's recent (2011) estimates and current yield is around 80,000 tonnes (71% of the potential). Although, they do not form a high unit value resource, there are certain species such as the short-neck or the yellow-foot clam, *Paphia malabarica*, which is exported to niche markets such as Japan fetching high value. Almost 90% of this export is sourced from the Ashtamudi Lake, and in 2009, India exported 542 tonnes of clam meat in various forms valued at US$ 1.15 million (nearly Rs. 6 crores). This lake, which is the second largest brackish water lake system in Kerala, is a very important ecosystem in south Kerala and has been declared as a Ramsar site for the purpose of conservation of habitats.

The Central Marine Fisheries Research Institute (CMFRI) has been studying the exploitation and biology of the key clam resource in the Ashtamudi Lake ecosystem from the late nineteen seventies. As a result of such concerted studies, an intervention for the scientific management of the clam resources could be made in the nineteen eighties, and ever since then, a sustained fishery for the short-neck clam is being practiced by the fishers.

Realizing that the short-neck clam fisheries is one of the few scientifically managed fisheries in India, the World Wide Fund for Nature (WWF, India) initiated steps to get the fisheries certified or ecolabelled as per the criteria of the Marine Stewardship Council (MSC). This survey report and fisheries management plan is a direct result of the WWF's positive steps and the WWF has provided logistic support for the survey conducted by the CMFRI. We would like to place on record our sincere thanks to Mr. Vinod Malayilethu, Senior Coordinator, Marine Conservation Programme, WWF, India for all support and help. We are also thankful to the Director, CMFRI for facilities, constructive criticism and encouragement to bring out this work as a special publication of the institute.

View of Ashtamudi Lake; *Photo credit CMFRI*

# Contents

Clam fisher in Ashtamudi Lake; *Photo credit Mr. M. Vinod WWF*

# Background

Among the exploited bivalve resources of India, clams are undoubtedly the most widely distributed and abundant. The clams of the estuarine and backwater regions provide livelihood for the fishers who exploit them for their meat and shells. Clam meat is rich in protein and is also cheap when compared to other seafood. The clam shells are used for industrial purposes mainly as a raw material for lime shell industries. Among clams, the venerid clams are in demand and three genera namely *Marcia*, *Mertrix*, and *Paphia* are important. Of these, *Paphia malabarica* (Short neck or yellow foot clam) is widely distributed and continuously exploited clam along the southwest coast for local consumption as well as for export. Due to its high nutritive value and importance in the economy of coastal fishing villages coupled with the development of export market for frozen clam meat, targeted research on ecobiology of clams was initiated nearly three decades ago (Narasimham, 1991).

| | |
|---|---|
| Location | Kollam District, Kerala |
| Primary inflows | Kallada River |
| Catchment area | 1,700 km$^2$ (660 sq mi) |
| Surface area | 61.4 km$^2$ (23.7 sq mi) |
| Max. Depth | 6.4 m (21 ft) |
| Water volume | 76,000 Mm$^3$ |
| Surface elevation | 10 m (33 ft) |

Ashtamudi Lake (Lat. 8°45'-9°28'N and Long. 76°28'-77°17'E) is the second largest Lake estuary of Kerala. It lies 145 km south of Kochi and has an area of 61.4 km$^2$. It remains connected with the Arabian Sea throughout the year and the Kallada River which empties into the lake is the main source of fresh water. Clam fishery forms the livelihood of more than 500 families in and around the estuary. Clams are fished throughout the year except

Vigorous seiving of clam dredgenet ensure escape of young clams; Photo credit Mr. M. Vinod WWF

during unfavourable environmental conditions or during the ban periods. Initiation of frozen clam meat export, particularly short-neck clam, *P. malabarica* in 1981 led to increased fishing effort for clam exploitation, especially from the estuarine part of the lake (Appukuttan *et al*., 1985). The alarming increase in the exploitation of clams in the following years forced the local administration to impose a ban on the fishing activities during the clam breeding season and also place restriction on the mesh size of clam dredges based on the recommendations of the Central Marine Fisheries

Research Institute (CMFRI) in 1993. The CMFRI had conducted a survey on the resources abundance of clams in 1984, 1996 and assessed the total potential stock (Narashimham *et al*., 1997).

Considering the intense fishing pressure on the clam resources of Ashtamudi Lake, a rapid survey was conducted by CMFRI during May 2011 to assess:

- The ecological status of clam beds
- The present status of clam resources
- The existing bivalve resources and the potential for exploitation
- Develop plans for conservation and management of clam fishery

It is hoped that this report would provide the basic information essential for planning future development programmes on clams in the Ashtamudi Lake.

Clam fishery in progress in Ashtamudi Lake; *Photo credit CMFRI*

# Fishing Area

About 173 hectares (1.73 km$^2$) of area near the bar mouth surrounded by Neendakara and Dalavapuram villages in the north, Sakthikulangara village in the south, Chavara Thekkumbhagom in the east and Sakthikulangara Bar-mouth in the west is the clam fishing area. The water depth of the fishing area varied from 1-3m and the bottom was either muddy or a mixture of loose sand, gravel and broken shells. Zone I is located near the bar-mouth. The water spread area of this Zone is 15 ha with maximum depth of 3m. Zone II is located between Zone I and Zone III. The water spread area of this Zone is 60 ha with average depth of 1.5 m. Zone III is situated in adjacent to Zone II occupies an area of 50 ha with maximum depth of 2.5m. Zone IV is located in adjacent to Zone III and Zone V. The water spread area of this zone is 31.7 ha with maximum depth of 2.25m. Zone V is located adjacent to Zone IV. The water spread area of this zone is 16.6 ha with average depth of 1.25m.

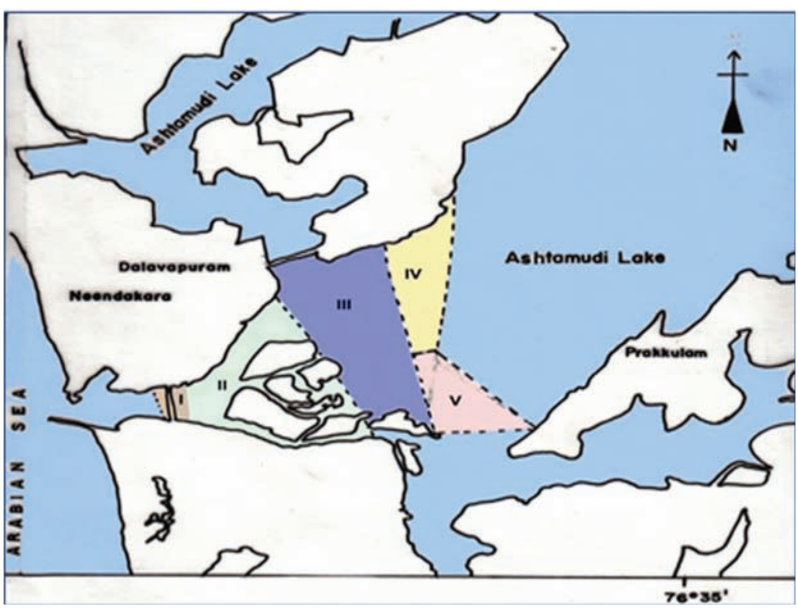



Fig.3 Map of Ashtamudi Lake showing five clam sampling zones

Clam dredge operation in Ashtamudi Lake; *Photo credit Mr. M. Vinod WWF*

# Fishing Methods

The clams are exploited by different methods which vary from the simple, traditional, hand picking to scooping and dredging. Fishermen of the surrounding villages are engaged in the fishing activity which is generally done at low tides. Fishermen pick out the buried clams after removing the sand with their feet or by a metal piece from waist deep water and collect them in net bags tied around their waist. A person collects approximately 40-50 kg of clams within 3 to 4 hours daily. Four types of fishing methods for clams are observed. They are: hand operated dredges from a dugout canoe, two divers collecting clams from a canoe, canoe with one diver and collection by hand picking from shallow water. The first method of collection is widely practiced in Ashtamudi, which gives the maximum yield (Appukuttan *et al.*, 1987). In deeper areas (2-3m), canoe with two persons can collect approximately 200-300 kg of clams per day. As the export demand for clam meat increased, local fishermen started operating hand dredges, which has reduced much of the physical effort and also increased the CPUE.

Yellow foot clam *Paphia malabarica* ; *Photo Credit CMFRI*

# History of clam fisheries in Ashtamudi Lake

*Paphia malabarica* is the dominant clam contributing to the fishery. Table 1 provides the taxonomic hierarchy of *P. malabarica*. The fishery for clam commences by February, every year. Till the middle of 1981, clams were collected from Ashtamudi backwaters mainly for local consumption. When the export market developed in1981, the fishery intensified during the period1982-1992, the catch rose to 6800 t with peak of 10,000 t in 1991. However, the catch declined to about 5000 t in 1993. This created concern among the fishermen and they demanded action against indiscriminate fishing in the estuary especially during spawning seasons. Spawning of clams commences by December and lasts till February. Young ones are abundant in the clam beds from January to March. The exporters collect the clam meat through local agents, who collect the live clams directly from the fishermen and do purification, boiling, meat extraction and grading prior to export ( Appukuttan *et al*., 1987).

In the early 1990s, the short-neck clam resource became depleted due to overexploitation caused by indiscriminate fishing practices. In response, an awareness program was arranged focusing on the deleterious effects of exploiting undersized clams. The program involved active participation by the Central Marine Fisheries Research Institute, the District Administration, and fishermen of the region. Based on the CMFRI's recommendations, the administration imposed ban on clam fishing every year from December to February, the peak spawning season of clams, regulations

| | |
|---|---|
| Kingdom | Animalia |
| Phylum | Mollusca |
| Class | Bivalvia |
| Order | Veneroida |
| Family | Veneridae |
| Genus | *Paphia* |
| Species | *malabarica* (Chenmitz) |

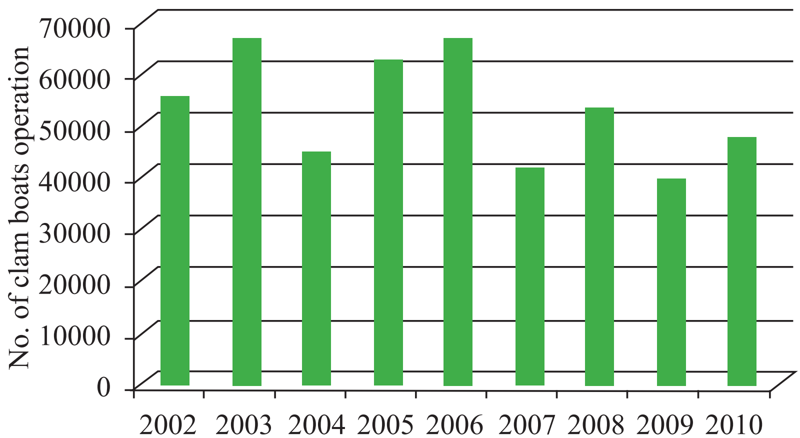



Fig. 1. Number of clam boats operated in Ashtamudi Lake during the period 2002-2010

requiring bag nets of hand dredge with a minimum mesh size of 30 mm, and a minimum export size of 1400 clams' meat/kg. These conservation measures have shown positive effects since 1994, when production began to increase considerably, allowing the fishers to sustainably exploit short-neck clams. Number of clam boat

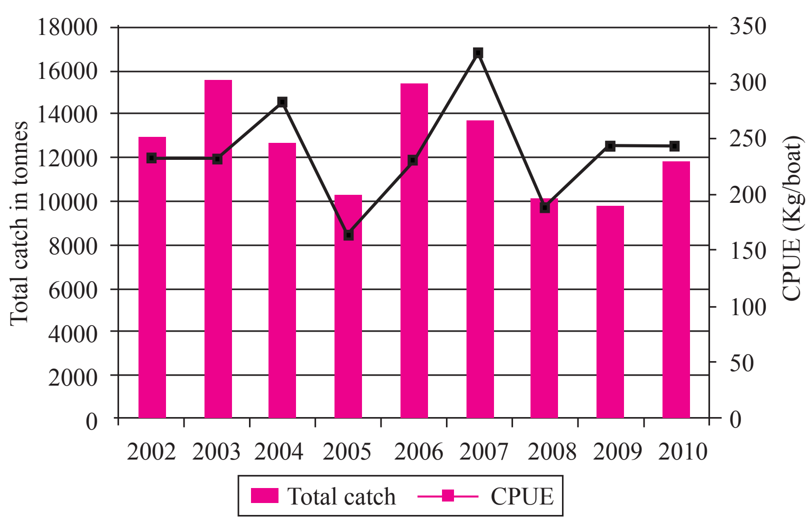



Fig. 2. Estimated manual landing (in tonnes) and CPUE of *P. malabarcia* at Ashtamudi Lake during 2002-2010

operations, average annual landings and CPUE of *P. malabarica* at Ashtamudi Lake during 2002-2010 is shown in Fig. 1 and 2.

The size of *P. malabarica* in the fishery ranged from 8-42mm. Fishing is carried out for about 9 months in a year. The total annual production of *P. malabarica* was 11698.2 t in 2010 with an average production of 974.9 t /month. The grades 300-900/kg always fetches the highest price (Rs 43/kg). A grade of more than 900/kg fetches less than Rs. 35.

Population characteristics of *Paphia malabarica* in Ashtamudi Lake (from Appukuttan *et al.*, 1996)

| | |
|---|---|
| Length infinity ($L\infty$) | 44.426 mm APM |
| Weight infinity ($W\infty$) | 19.2 g |
| Growth coefficient (K) | 0.839 |
| Age at zero length (t0) | 0.345 |
| Natural mortality (M) | 1.17 |
| Length at first year | 30 mm |
| Length at second year | 38 mm |
| Length at third year | 41 mm |
| Length at recruitment (Lr) | 22 mm |
| Length at first maturity (Lm) | 21 mm |
| Growth pattern | Isometric (b value 3.068) |

Heap of freshly caught *Paphia malabarica*; *Photo Credit MR. M. Vinod WWF*

# Survey Methods

The clam survey of the Ashtamudi was carried out during March 2011. Frequent visits were made prior to the survey to collect information on present location of clam beds, aspects of exploitation etc. The survey of the entire estuary could be carried out within twelve days. A fibreglass dinghy with an outboard motor was used. Sampling sites were fixed within five main zones of the estuary (Page.9.). Each zone was further sub divided into sub stations to facilitate adequate sampling. A quadrat square frame of 0.5 x 0.5 m size was used for sampling the clam bed. The bivalve distribution in a unit area was taken by demarking the area of clam bed. Observations on the area of the clam bed were recorded.

Hydrographic parameters like salinity, temperature, pH, dissolved oxygen and chlorophyll content were determined by "optical sensor method" using a multi parameter probe (YSI, V2 Data Sonde). Texture of the sediment was analysed for grain size and percentage of sand, silt and clay. International pipette method as given by Ganguly (1982) was followed for this. Organic carbon in the sediment was determined by 'Wet oxidation method' (Walky and Black method) as described by Jackson (1958).

The heavy metals such as mercury (Hg) content of sediment and tissue of the dominant clam *P. malabarica* was done using microwave (START D, Milestone, Italy) digestion followed by analysis using Atomic Absorption Spectroscopy (Perkin Elmer AA700, USA).

The data pertaining to all the subzones were pooled. From the pooled clam samples of *P. malabarica*, a random sub-sample of 100 numbers were taken for detailed biological studies. For estimating the species-wise standing stock for each bed, the number and weight of different species of clams were noted from each sample. Length (APM) was measured to the nearest 0.1 mm using vernier calipers

Fig. 3. The survey team at work in Zone II.


Under water video surveillance (ROV) to study the impact of clam fishing on benthic habbit; *Photo Credit CMFRI*

Canoe filled with Yellow Foot Clam; *Photo Credit CMFRI*

# Results

## Hydrology

while weights were observed to the nearest 0.1g using an electronic balance. Figure 3 shows the clam resource survey team at Ashtamudi Lake.

## Ecology of clam bed

The hydrographic parameters showed wide variations within the five zones. The data pertaining to salinity, dissolved oxygen, surface temperature, pH and chlorophyll of surface water are given in Table 2.

## Salinity

Salinity and substrate influences the distribution of clams in the Ashtamudi Lake. *Mertrix casta* prefers high salinities and sandy bottom. Zones I, II and V have high salinities ranging from 30.69 to 33.56 ppt due to its proximity to the sea while in Zone III and IV, the surface salinity ranged between 20.67 and 24.37 ppt indicating an estuarine zone. Although Zone III recorded salinity of 24.37 ppt, yet *M. casta* was not found in this zone.

| Zone | Latitude | Longitude | Salinity | Temperature | pH | Dissolved oxygen | Chlorophyll |
|---|---|---|---|---|---|---|---|
| | Station positions | | ppt | °C | | ml/l | µg/l |
| I | 8° 56′ 162″ N | 76°32′ 661″ E | 33.6 | 30 | 7.9 | 4.6 | 4.9 |
| | 8° 56′ 577″ N | 76°32′ 661″ E | | | | | |
| II | 8° 56′ 519″ N | 76°32′ 661″ E | 30.7 | 29.9 | 8 | 4.7 | 2.8 |
| | 8° 56′ 219″ N | 76°32′ 661″ E | | | | | |
| | 8° 56′ 181″ N | 76°32′ 661″ E | | | | | |
| | 8° 56′ 862″ N | 76°32′ 661″ E | | | | | |
| III | 8° 56′ 779″ N | 76°32′ 661″ E | 24.4 | 29.3 | 8.2 | 6.2 | 6.1 |
| | 8° 56′ 671″ N | 76°32′ 661″ E | | | | | |
| IV | 8° 56′ 967″ N | 76°33′ 574″ E | 20.7 | 29 | 8.2 | 6.7 | 5.7 |
| V | 8° 56′ 287″ N | 76° 33′ 297″ E | 33.2 | 30.4 | 7.9 | 4.4 | 2.1 |
| | 8° 56′ 468″ N | 76° 33′ 353″ E | | | | | |

Table 2. Hydrological details (mean values) of the clam beds in Ashtamudi Lake

## Surface Temperature

Temperature affects almost every aspect of water quality. It affects the amount of dissolved oxygen, the rate of photosynthesis, the metabolic rates of the aquatic animals, and the aquatic organisms' sensitivity to known toxin in the water. Water temperature did not show much variation between the stations. The surface water temperature varied from 29 to 30.4 $^{o}$C.

## Dissolved Oxygen

Dissolved oxygen concentration is a measure of the amount of oxygen in a volume of water. Dissolve oxygen concentration of the surface water was maximum (6.7 ml/l) in Zone IV and minimum (4.4ml/l) in Zone V. In Zone I and II also the dissolved oxygen was comparatively low, 4.6 and 4.7 respectively. The surface dissolved oxygen in lake showed a gradual increase from 4.6 ml/l near the bar-mouth to 6.7 ml/l in the Zone IV. Zone V which was located in the upper most regions had low dissolved oxygen content. In Zone V, decomposition of organic loads which influxes from river run-off may be the reason for low dissolved oxygen.

## pH

pH is a measure of the acidity or alkalinity of water, expressed in terms of its activity of hydrogen ions. In the present study, pH of the surface water ranged between 7.9 to 8.22. No significant difference from normal was observed.

## Chlorophyll Concentration

Chlorophyll is the photosynthetic pigment that plants and algae use to convert sunlight into energy for growth. Its concentration, therefore, is commonly used as a measure of the density of the algal population of a lake. Measuring the levels of chlorophyll helps to determine the state of an organism and water quality. During the present survey, near-surface chlorophyll concentrations ranged from 2.05 µg/l in Zone V to 6.05µg/l in Zone III. The mean concentration between zones was 4.28 µg /l.

## Sediment texture

Data on soil texture of clam bed sediment indicated that the all Zones were coming under uniform textural class i.e. sandy. The mean percentage of clay, silt and sand content in sediments at different Zones are depicted in Figure 4 and Table 3.

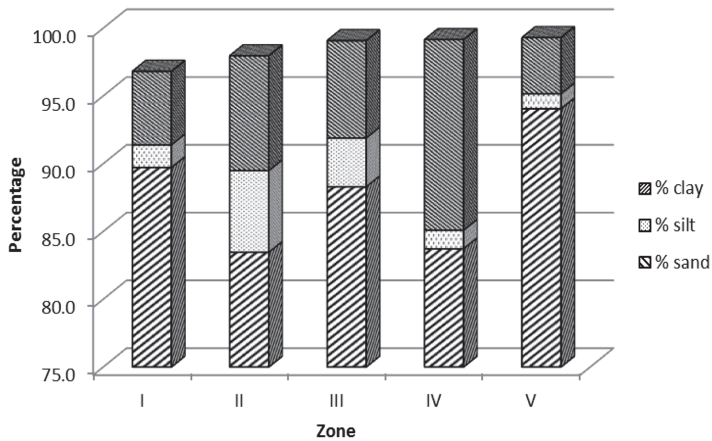



Fig.4 Zone-wise distribution of mean clay, silt and sand in sediment

| Zone | Wet pH | Soil salinity ppt | % Organic carbon | % Sand | % Silt | % Clay | Soil texture |
|---|---|---|---|---|---|---|---|
| I | 7.1 | 3.2 | 0.04 | 89.7 | 1.7 | 5.4 | Sandy |
| II | 6.8 | 12.9 | 0.08 | 83.5 | 6.0 | 8.5 | Sandy |
| III | 7.0 | 19.8 | 0.04 | 88.3 | 3.6 | 7.2 | Sandy |
| IV | 7.0 | 6.5 | 0.05 | 83.7 | 1.4 | 14.1 | Sandy |
| V | 7.0 | 4.2 | 0.03 | 94.1 | 1.1 | 4.1 | Sandy |
| Mean | 7.0 | 9.3 | 0.0 | 87.9 | 2.7 | 7.9 | |

Table 2. Hydrological details (mean values) of the clam beds in Ashtamudi Lake

Percentage of mean clay content in the bottom sediments of zones were found to vary between 4.1 at Zone V and 14.1 at Zone IV. Zones II, III and IV showed relatively higher content of clay while lower percentage of clay was observed in the Zone I and V. Percentage of silt in the bottom sediment was found to vary from 1.1 at Zone V to 6.0 at Zone II. Silt content in the bottom sediment at Zone II and III showed relatively higher percentage than the rest of the Zones. The mean percentage of sand in bottom sediment was found to vary between 83.5 at Zone II to 94.1 at Zone V.  Zones I, III, and V showed relatively higher percentage of sand content while lower percentage was recorded in the Zone II and IV. Overall, all zones were classified as sandy.

## Sediment organic carbon

Organic carbon is the most important factor determining the fertility status of soil. The distribution of organic carbon content at different zones is depicted in Figure 5. The range of organic carbon in sediment varied from 0.03 to 0.08%. Highest mean value was recorded in Zone II followed by 0.05 % Zone IV. Zone I and III had the similar mean values. Lowest mean value (0.03%) was observed

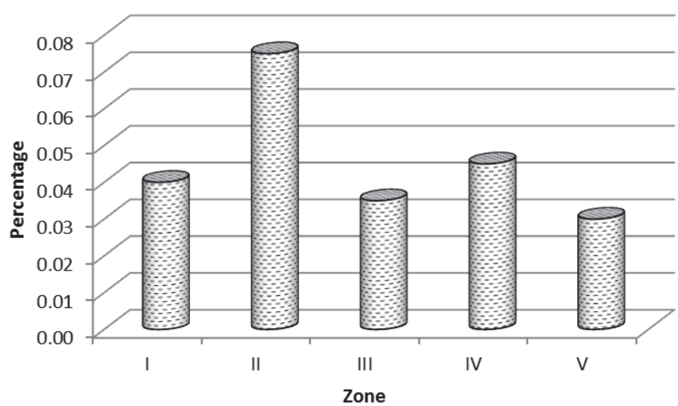



Fig. 5 Percentage of mean organic carbon content in sediments at different zones

in Zone V. Mean values indicated that Zone II was more fertile than the rest of the zones.

## Pollutants

## Heavy metals in sediment

The Hg content in sediment was extracted using microwave digestion followed by analysis using Atomic Absorption Spectroscopy. Mercury content in sediment of Ashtamudi Lake at all the zones was found to be below detectable level (BDL).

## Heavy metals in clam tissue

The mean concentration of mercury (Hg) in dried tissue of *Paphia malabarica* at different zones of Ashtamudi Lake is depicted in Fig. 6. The mean mercury content in the tissues of clam was found

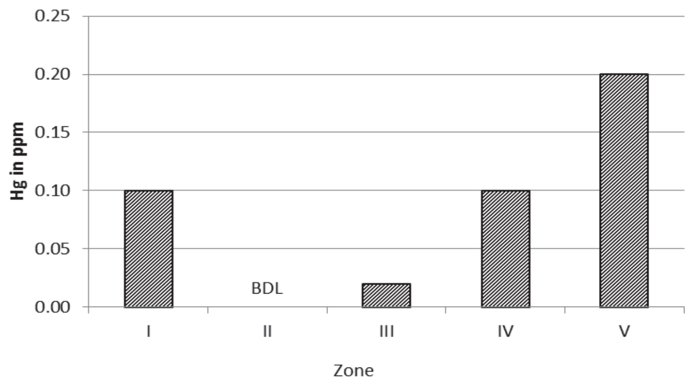



Fig.6 Mean mercury content in the tissue of *Paphia malabarica* at different Zones

to vary from BDL at Zone II to 0.2 ppm at Zone V. Mean value in clam tissues showed an increasing trend from Zone III to Zone V, However, all values were below the permissible limits (2.2 $\mu g.g^{-1}$ on dry weight basis) as per WHO guidelines.

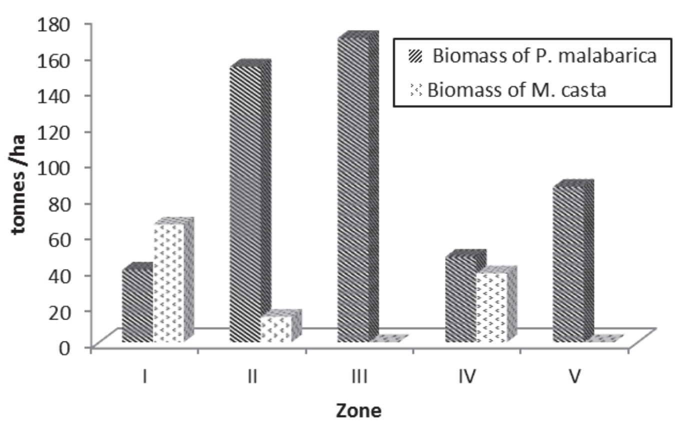



Fig.7 Mean biomass of clams in different zones of Ashtamudi Lake

## Clam Biomass

*Meretrix casta* and *P. malabarica* were found to be the prominent clams contributing to the clam population biomass. *P. malabarica* was the dominant clam, forming about 87.4 % of the total population. *M. casta* was the next in abundance. Biomass of clam species in tonnes /ha in different zones of Ashtamudi Lake is shown in Fig. 7. Clams were observed from Zone I to Zone V with an estimated area of 173.3 ha. Zones II, III and IV were rich in *P. malabarica*; Zones I and V also had a moderately rich population of *P. malabarica. M. casta* was distributed in Zone I and IV and it was moderately rich in Zone II. *P. malabarica* was present in all zones whereas *M. casta* was absent in Zone III and V.

## Density and Biomass in clam beds

Average density, average biomass, estimated density and biomass with respect to the area of clam beds are summarized in Tables 4 - 6.

*P. malabarica* were found in very high densities in the zones II, III, and V (5376, 3136, and 1120/$m^2$) whereas in Zone I and V it was in moderate densities (800 and 640/$m^2$). *M. casta* were found in zone I and IV in moderate densities (688 and 416/$m^2$). The mean density of *M. casta* in Zone II was 96 numbers/$m^2$.

The biomass was highest in Zone II at 10022.4 tonnes, *P. malabarica* contributed 91.6 % and *M. casta* 8.4 % to the total biomass

| Zone | *P. malabarica* | | *M. casta* | | Total |
|---|---|---|---|---|---|
| | density (No/m²) | biomass (g/m²) | density (No/m²) | biomass (g/m²) | biomass (g/m²) |
| I | 800 | 4016 | 688 | 6528 | 10544 |
| II | 5376 | 15296 | 96 | 1408 | 16704 |
| III | 3136 | 16880 | 0 | 0 | 16880 |
| IV | 640 | 4744 | 416 | 3824 | 8568 |
| V | 1120 | 8624 | 0 | 0 | 8624 |

Table 4. Zone-wise average density (No/$m^2$) and average biomass (g/$m^2$) of the dominant clams in Ashtamudi Lake

| Zone | Area of clam bed (ha) | *P. malabarica* | | *M. casta* | | Total biomass (t) |
|---|---|---|---|---|---|---|
| | | Estimated biomass (million / zone) | Estimated biomass (t/zone) | Average biomass (million / zone) | Estimated biomass (t/zone) | |
| I | 15.0 | 120 | 602.4 | 103.0 | 979.2 | 1581.6 |
| II | 60.0 | 3226.0 | 9177.6 | 58.0 | 844.8 | 10022.4 |
| III | 50.0 | 1568.0 | 8440.0 | 0.0 | 0.0 | 8440.0 |
| IV | 31.7 | 203 | 1503.8 | 132.0 | 1212.2 | 2716.1 |
| V | 16.6 | 186.0 | 1431.6 | 0.0 | 0.0 | 1431.6 |
| Total | 173.3 | 5302.00 | 21155.4 | 293 | 3036.2 | 24191.6 |

Table 5. Estimated biomass (in weight and numbers) of clams in Ashtamudi Lake.

| Zone | Area of clam bed (ha) | *P. malabarica* | | *M. casta* | | Total density (t/ha) |
|---|---|---|---|---|---|---|
| | | Average density (million/ha) | Average density (t/ha) | Average density (million/ha) | Average density (t/ha) | |
| I | 15.00 | 8.0 | 40.2 | 6.90 | 65.3 | 14.9 |
| II | 60.00 | 53.8 | 153.0 | 1.00 | 14.1 | 54.8 |
| III | 50.00 | 31.4 | 168.8 | 0.00 | 0.0 | 31.4 |
| IV | 31.66 | 6.4 | 47.4 | 4.20 | 38.2 | 10.6 |
| V | 16.63 | 11.2 | 86.2 | 0.0 | 0.0 | 11.2 |
| Total | 173.29 | 110.7 | 495.6 | 12.0 | 117.6 | 122.9 |

Table 6. Estimated density (in number and weight) of clams in Ashtamudi Lake.

in Zone II. The total biomass of Zone I was 1581.6 t and comprised 38.1 % of *P. malabarica* and 61.9 % *M.casta*. The total biomass of Zone III was 8440 tonnes, wholly contributed by *P. malabarica*. In Zone IV, the total biomass was 2716.1 tonnes comprising 55.37 % of *P. malabarica* and 44.63 % *M. casta*. The total biomass of Zone V was 1431.6 tonnes wholly comprised of *P. malabarica*.

The total clam biomass in the Ashtamudi Lake was 24191.6 tonnes in an estimated bed area of 173.3 ha. The estimated biomass of *Paphia malabarica* is 21155.4 tonnes contributing 87.4 % to the total biomass and *M. casta* 3036.2 t forming 12.6 % of the total biomass.

## Length composition of clams

Length composition of *P. malabarica* in the five zones is given in Table 7. The distribution of the clam was not uniform and it differed between the zones. In zones I, II and III both larger and smaller

| Mid Length(mm) | Zone I | Zone II | Zone III | Zone IV | Zone V |
|---|---|---|---|---|---|
| 9 | 18 | 36 | 0 | 0 | 0 |
| 11 | 11 | 33 | 0 | 0 | 0 |
| 13 | 65 | 0 | 0 | 0 | 0 |
| 15 | 45 | 45 | 15 | 0 | 0 |
| 17 | 119 | 34 | 17 | 0 | 0 |
| 19 | 38 | 19 | 0 | 0 | 0 |
| 21 | 63 | 63 | 0 | 0 | 0 |
| 23 | 23 | 46 | 46 | 69 | 0 |
| 25 | 75 | 100 | 100 | 100 | 100 |
| 27 | 297 | 0 | 162 | 189 | 54 |
| 29 | 609 | 58 | 29 | 145 | 29 |
| 31 | 248 | 0 | 62 | 279 | 62 |
| 33 | 198 | 33 | 132 | 363 | 66 |
| 35 | 140 | 210 | 35 | 280 | 140 |
| 37 | 111 | 37 | 370 | 74 | 37 |
| 39 | 0 | 0 | 78 | 78 | 39 |
| 41 | 0 | 0 | 41 | 41 | 41 |
| Total | 2060 | 714 | 1087 | 1618 | 568 |
| Mean size | 25.75 | 22.31 | 31.06 | 31.12 | 31.56 |
| Sample No. | 80 | 32 | 35 | 52 | 18 |
| Sample wt (g) | 397 | 105 | 345 | 391 | 238 |

Table 7. Length composition of *Paphia malabarica* in different zones in Ashtamudi Lake

individuals of *P. malabarica* were present while only larger ones were present in zones IV and V. *Paphia malabarica* of 9 to 41 mm mid-length were observed in the clam population. Zone IV and Zone V had higher mean size ranging from 31.12 to 31.56.

Estimated mean size of the clam in lake showed a gradual increase from Zone I (25.75 mm) to Zone V except in Zone II where it was minimum (22.31mm).

Seed clams (below 15 mm) formed 9.7% and 3. 35 % of the population in Zone I and III respectively, while in Zone II their contribution was as high as 32.26%. In zones IV and V, seed clams were completely absent.

Clam fisherman setting out for fishing ; *Photo Credit CMFRI*

Unloading the clam catch; *Photo credit Mr. M. Vinod WWF*

# Maximum Sustainable Yield (MSY)& Reference Points for Management

Based on the survey and the total clam biomass estimates, a basic estimate of the MSY for clams was made as per Gulland's (1971) formula.

MSY = 0.5 x M x Bv

Where, M is the natural mortality coefficient and Bv is the biomass of the unexploited (virgin) stock. Here, M was taken as 1.0, as a conservative estimate instead of 1.17 which is the actual estimate. Accordingly, the BMSY for clams in Ashtamudi Lake was estimated as 12,096 tonnes. Currently, the fishery is being exploited at 96.7% of the MSY level. Therefore, there is no scope for further increase in effort and production, and it is advisable that the current levels of effort and production be maintained.

MSY estimate for clams in Ashtamudi Lake is 12,096 tonnes

The concept of reference points in fisheries management was introduced at United Nations Conference on Environment and Development (UNCED) in 1992. Since then, it has been adopted and developed by the UN Fish Stocks Agreement, the FAO Code of Conduct for Responsible Fisheries, and the FAO Guidelines on the Precautionary Approach. In the guidelines included in the UN Fish Stocks Agreement two categories of reference points were defined: target reference points (TRPs) corresponding to situations considered as desirable and to be achieved on average; and limit reference points (LRPs) indicating situations that are undesirable and to be avoided at all costs.

On the basis of the current biomass estimate and $B_{MSY}$ estimate for clams, the following TRP and LRP are recommended.

| Reference Point | Decision Logic | Estimated Value |
|---|---|---|
| Target (TRP) – $B_{targ}$ | $B_{targ} = B_{MSY}$ (± 20%) | 12,000 tonnes |
| Limit (LRP) – $B_{lim}$ | $B_{lim} = 0.5B_{MSY}$ | 6000 tonnes |

If the stock biomass falls below Blim, then target fishing must cease for a period sufficient to rebuild the stock. The catch trend with respect to TRP (± 20%) and LRP is shown in Fig. 9.

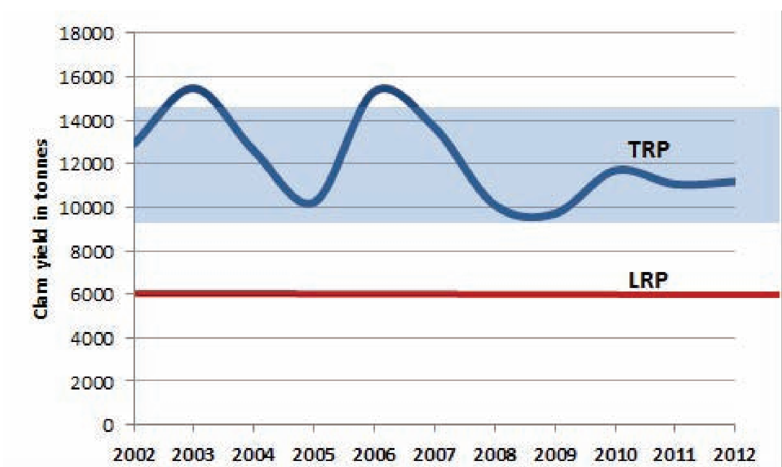



Fig. 9 Catch trend of clams in Ashtamudi Lake with respect to TRP and LRP

Clam catch from hand dredge; *Photo credit Mr. M. Vinod WWF*

Processed clam meat loading on to trucks in Ashtamudi Lake;
*Photo credit Mr. M. Vinod WWF*

# Clam Fishery Management Plan

Based on the survey and analyses the following recommendations are made for managing the clam resources of the Ashtamudi Lake ecosystem.

- Part of Zone I, under and west of the Neendakara Bridge should be declared as a no-take zone for clams all through the year. This will function as a protective zone where in regenerations of stocks will take place continuously and this will also help re-populate clams in other zones. This zone can function as a CLAM SANCTUARY. The provision of Declared Fisheries Zone

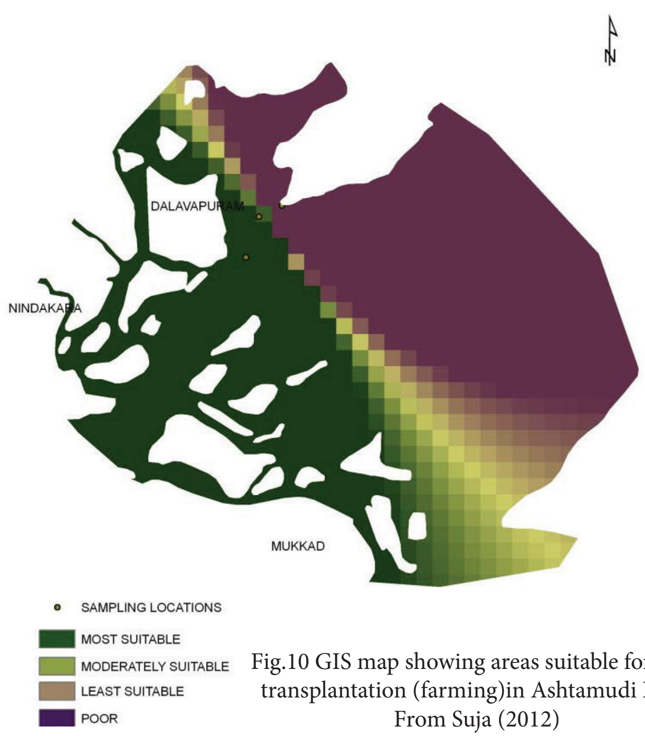
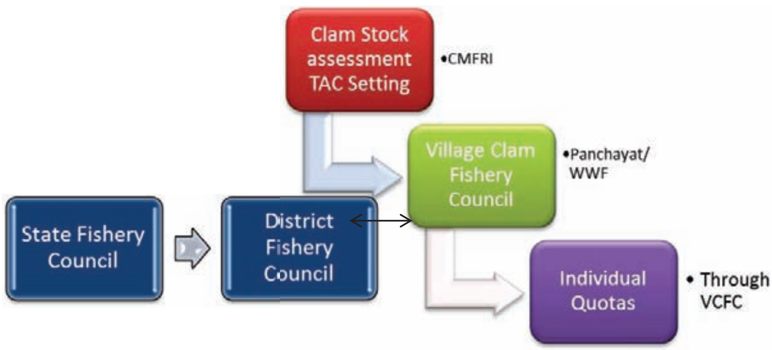



Fig.10 GIS map showing areas suitable for clam transplantation (farming)in Ashtamudi Lake. From Suja (2012)

(DFZ) of the Kerala Inland Fisheries Act may be invoked for this purpose by the State.

- Seed clams can be transplanted and cultured in shallow areas having similar water and sediment conditions of the clam beds. The suitable areas for such transplant culture are indicated in the report of Suja (2012) and an example GIS map is shown below (Fig. 10). The optimum stocking densities are also indicated in this report.
- Seed clams below 20 mm APM should not be allowed to be harvested, and if harvested, they should be relayed. This size may be declared as the Minimum Legal Size (MLS) for harvest by the DOF.
- As a long-term conservation measure, hatcheries have to be developed within the next 10 years for breeding the clams and spats can be relayed in suitable locations (indicated above) in Ashtamudi Lake.
- Transplantation of clams from one estuary to another must not be permitted as the ecological effects cannot be easily judged beforehand. No species introductions should be permitted in Ashtamudi Lake without a comprehensive study by a research institute and permission of the SFD.
- A system of licensing of clam fishers in the Lake and registration of boats and gears used for clam fishing should be urgently carried out by the SFD.
- No mechanical devices should be permitted for the harvest of clams in the Lake.
- The CMFRI should conduct clam biomass surveys in Jan-February every year, and come out with estimates of fishable stock in the ensuing season. The CMFRI should provide sufficient information to generate a Total Allowable Catch (TAC) which can be later converted to individual quotas for fishers on an annual basis.
- For effective management of the clam resources of the Ashtamudi Lake, a stakeholder council or Village Clam Fishery Council (VCFC) should be formed by the administration. This council

should have representation from panchayat, Department of Fisheries, CMFRI, NGO's working in the area and clam societies. They should meet once in a quarter. The Council should have powers to debate and formulate rules as necessary for effective management of the clam fisheries.




- Following the participatory mode 3-tier fishery management system, the VCFC should report to the District Fishery Council (DFC) and ultimately to the State Fishery Council (SFC). The modalities of such a management regime should be enunciated by the DOF.
- The southern and northeastern parts of the Ashtamudi Lake are currently devoid of clam populations. It was not so many years ago. This has happened due to deterioration in water quality in these regions through increased urbanization and unregulated waste dumping. This part of the Ashtamudi Lake needs special focus to improve the habitat quality for ecological sustainability of the Lake.
- Zones I to V as demarked in the map may be declared as Clam Management Area (CMA) of Ashtamudi Lake by the DOF for the purpose of framing necessary rules and regulations to govern the clam fisheries by the VCFC.
- Depuration of clams for hygienic consumption may be encouraged. This could be done by the fishers or processors or agents. A scientific depuration and meat shucking process has been developed by CMFRI and this maybe initially financially supported by the DOF as a scheme.

Clam heat shucking process; *Photo credit CMFRI*

# Summary & Conclusions

1. Ashtamudi Lake contributes approximately 90% of the overall clam meat export trade in India, providing livelihoods for at least 3,000 local people. The landed value of the clams is Rs. 6.3 crores (Rs. 63.13 million or US$ 1.15 million).

2. Water characteristics such as salinity, temperature, pH, dissolved oxygen and chlorophyll observed in the present study were in normal range for survival and growth of clams. The present level of chlorophyll (2.05 - 6.05 µg/l) was acceptable for survival and growth of clam.

3. Based on chlorophyll level, Trophic State Index for Ashtamudi Lake falls under mesotrophy *i.e.* a moderately productive lake (Pirnie, 2005). This mesotrophic productive state is good for growth and survival of clams.

4. Grain size analysis revealed that the texture of clam bed sediments at different zones was predominantly sandy. Compared to the clam survey conducted in1996 at Ashtamudi Lake, soil texture of the all the zones has changed. During 1996, soil texture in the sediment at different zones was found to vary from sandy-clay to clay.

5. Organic carbon values in sediment samples at different zones ranged from 0.03 to 0.08 %. The range of organic carbon content possibly indicates low bottom fertility. However, Zone II at Ashtamudi Lake was found relatively more fertile than the rest of zones in organic carbon content. Highest biomass observed at present study at the Zone II can be related to the higher organic content.

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6. Mercury (Hg) in sediment at different zones were found to be in the normal range. As per NOAA guidelines for sediment quality, the Probable Effect Level (PEL) for Hg is 0.7 ppm. Mercury in the sediments at different zones was found below detectable level (BDL).

7. Mean mercury content in the tissue of *Paphia malabarica* at different zones was found to vary from BDL to 0.2 ppm. As per WHO guidelines, permissible concentration of Hg in dried tissue is 2.2 ppm. Accordingly all tissue samples analysed were below permissible concentration in the case of Hg.

8. High densities and biomass in Zone II and III can be related to the texture of the soil and the higher organic carbon content. Sand content in Zones II and III were found comparatively less than the rest of the Zones whereas silt content was relatively more in Zone II and III.

9. The results of the present study indicate that mean size of *P. malabarica* within 31.1 - 31.6 mm was dominant in most of the zones. Appukuttan *et al.* (2002) reported that the exploitation of this size group is maximum in the Ashtamudi Lake. Since there is a market preference for large-sized clams, the exploitation is more on this size group. *P. malabarica*, which inhabits relatively deeper parts of the estuary, is always in better demand and has better price than any other clam.

10. The average price for 900 clams /kg of *P. malabarica* during the period of study was Rs. 43. This species forms about 87.4 % of the clam resources of Ashtamudi Lake.

11. The estimated standing stock biomass of bivalves in the Ashtamudi Lake during March, 2011 was 24191.6 tonnes in an estimated bed area of 173.29 ha. Compared to the clam survey in 1996 in the same estuary, there is a marginal decline in the estimated standing stock biomass (0.5%) of bivalve resource in the Ashtamudi estuary.

12. The estimated standing stock of *P. malabarica* in the present study is found to have decreased by 6.7% (by 1516.4 tonnes) whereas *M. casta* is found to have increased by 46% (by 1398.1

tonnes). Currently, the estimated catch per year is 11698.2 t which accounts for 48.4 % of the present estimated standing stock and therefore the stock appears to be in a healthy state.

13. An increase in exploitation from the present level is not recommended and maintaining the catches at 12,000 tonnes/year, which is the MSY level, is recommended. There are signs of exploitation of seed clams especially in first three zones, which in the long run could be detrimental to the fishery.

14. Pollution, overfishing and exploitation of undersized clams and reclamation of rich clam beds can cause detrimental effect on the clam resources of the Ashtamudi Lake.

15. Based on the findings of this study a Fishery Management Plan (FMP) is proposed for sustainable exploitation of clams from Ashtamudi Lake.



Steam shucked clam meat in clam processing unit at Pavumba, Ashtamudi Lake; *Photo credit CMFRI*

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