An assessment of the Short-neck clam biomass in Ashtamudi Lake

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Ashtamudi Lake (Lat. 8°45' - 9°28' N and Long. 76°28' - 77°17') supports more than 500 families who depend on the clam resources available here for their livelihood. Among clams, the Short neck clam (*Paphia malabarica)* is widely distributed and continuously exploited for local consumption as well as for export. The alarming increase in the exploitation of *P. malabarica* immediately after the initiation of frozen clam meat export during 1981, forced the local administration to impose a ban on clam fishing during the breeding season (December to February) and also place restriction on the mesh size of clam dredges in 1993, based on the recommendation of the Central Marine Fisheries Research Institute (CMFRI). The CMFRI has conducted Resource Abundance Surveys of clams in 1984, 1996, 2012, 2014 and 2015 and assessed the total stock. After the creation of the Fishery Management Plan (FMP) for the Ashtamudi Lake Clam Fisheries Governance Council (ACFGC) during 2013, the fishery became the first Marine Stewardship Council (MSC) certified fishery in the country in November 2014, indicating that the fishery is managed as per globally accepted standards.

Considering the fishing pressure on the clam resources of Ashtamudi Lake, two surveys were undertaken in the five clam fishing zones (Fig.1) during 2015 in February (Survey #1) and May (Survey #2) to assess the status of existing clam resources and potential for exploitation. The results of the two surveys are shown in the Tables 1a and 1b.

The study revealed that the estimated fishable biomass in both surveys of 2015 were considerably lower than the 10,438 tonnes (t) estimated in 2014. The Survey #1, was carried out during 9th to 11th February, 2015 i.e., before the fishery opened on March 1st 2015. Clams were present in all the five zones, but poor in Zones III, IV and V. Biomass was estimated as 5283 t which was 49% less than last

Fig. 1. Map of Ashtamudi Lake showing the five clam fishing zones (I-V) and the new clam bed

Table 1a. Zone-wise assessment of *P. malabarica* in February 2015

Zone and Area (in ha)	*P. malabarica* Spat: Mean density (million numbers/ zone)	Spat: Mean biomass (tonnes/ zone)	Juvenile: Mean density (million numbers/ zone)	Juvenile: Mean biomass (tonnes/ zone)	Large size-Adult: Mean density (million numbers/ zone)	Large size-Adult: Mean biomass (tonnes/ zone)	*M. casta*: Mean density (million numbers/ zone)	*M. casta*: Mean biomass (tonnes/ zone)
I (15)	9.36 (62)	0.84 (5.62)	16.08 (107)	28.46 (189.7)	68.64 (458)	5.38 (2461.9)	-	-
II (60)	286.08 (477)	37.19 (61.9)	22.08 (37)	13.25 (22.1)	146.88 (245)	1645.06 (2741.8)	-	-
III (50)	36 (72)	21.6 (43.2)	-	-	34.18 (68)	393.77 (787.5)	20.36 (41)	148.86 (297.7)
IV (31.7)	3.04 (10)	0.30 (0.96)	-	-	3.04 (10)	38.04 (120)	-	-
V (16.6)	23.15 (139)	5.55 (33.5)	-	-	28.84 (174)	203.29 (1224.7)	-	-
Total	357.63	65.48	38.16	41.71	281.58	2285.55	20.36	148.85

a) Total estimated number of *P. malabarica* (zone I-V) = 677.37 million
b) Total estimated actual biomass of *P. malabarica* (zone I-V) = 2392.75 t
c) Total estimated number of *M. casta* (zone I-V) = 20.36 million
d) Total estimated actual biomass of *M. casta* (zone I-V) = 148.9 t
e) Estimated mean harvestable size = 7.8 g
f) Estimated fishable biomass (shell-on weight) of *P. malabarica**= 5283.49 t

year. The presence of very small spat indicated that spawning had occurred late. Unlike previous years the clam beds in Zone III (main production zone) were much depleted. In the Survey #2, biomass survey was carried out during the fishing season and clams were observed in Zone I and II. Zone III was totally devoid of clams as 40% of the zone had become a sand bar exposed to air at most tides. The presence of small spat (< 10mm size) indicated further late spawning.

Clam Density

In survey #1,density of clams was highest (758 numbers/m^2) in zone II. A slightly lower density of 627 numbers/m^2 was observed in zone I. *P. malabarica* was the single species contributing to high density in all the zones. Density was as low as 19, 140 and 313 numbers/m^2 in Zone IV, III and V respectively. Spat and large clams were present in all the zones (I-V) while juvenile clams were present in Zone I and II. *M. casta* was present only in Zone III (41 numbers/ m^2). Total estimated densities in all zones were 561.7 million. In Survey # 2, low densities of 752 and 782 numbers/m^2 were observed in Zones I and II respectively, while in Zones III-V, clams were completely absent. Total estimated densities in the Zones I and II together formed 561.7 million.

Clam Biomass

In Survey#1, higher biomass of clams were observed in Zone I (2.7 kg/m^2) and II (2.8 kg/m^2). Very low biomasses were recorded in Zone V (1.3 kg/m^2), III (0.831 kg/m^2) and IV (0.121 kg/m^2). *P. malabarica* was present in all Zones contributing to biomass while *M. casta* was observed only in Zone III (0.298 kg/m^2) (Fig.2).

In Survey #2, higher biomass of *P. malabarica* were observed in Zone I (3.4kg/m^2) and Zone II (3.6 kg/ m^2) while in the rest of the zones, clams were completely absent (Fig. 2). Total estimated fishable biomass from all zones together was 4381 tonnes (Table 1b).

Ecology of clam bed

The water quality parameters recorded at each clam fishing zone in Ashtamudi Lake during February and May 2015 are given in Table 2a and 2b respectively.The surface salinity of Ashtamudi Lake showed a gradual reduction from Zone I to Zone IV

Table 1b. Zone-wise assessment of *P. malabarica* in May 2015.

Zone and Area (in ha)	*P. malabarica*						*M. casta*	
	Spat		Juvenile		Large size-Adult			
	Mean density (million numbers/ zone)	Mean biomass (tonnes/ zone)	Mean density (million numbers/ zone)	Mean biomass (tonnes/ zone)	Mean density (million numbers/ zone)	Mean biomass (tonnes/ zone)	Mean density (million numbers/ zone)	Mean biomass (tonnes/ zone)
I (15)	3.40 (23)	0.58 (3.9)	22.60 (151)	27.79 (185.3)	86.8 (579)	482.93 (3219.5)	-	-
II (60)	1.53 (41)	0.61 (16.3)	193.92 (323)	252.09 (420.2)	253.44 (422)	1899.65 (3166.1)	-	-
III (50)	-	-	-	-	-	-	-	-
IV (31.7)	-	-	-	-	-	-	-	-
V (16.6)	-	-	-	-	-	-	-	-
Total	4.93	1.19	216.52	279.88	340.24	2382.58	-	-

a) Total estimated number of *P. malabarica* (zone I-V) = 561.69 million

b) Total estimated actual biomass of *P. malabarica* (zone I-V) = 2663.65 t

c) Estimated mean harvestable size = 7.8 g

d) Estimated total fishable-size biomass (shell-on weight) = 4381.18 t

**Fishable-size biomass is estimated by prospectively calculating of spat growth and mortality; Density and biomass values in parenthesis are in number/m^2 and gram/m^2 respectively; Areas of clam bed zones are given in parenthesis under each zone.*

during both the surveys which was influenced by its proximity to the sea. During Survey #1, surface salinity in zones I-III (28.5ppt to 31.4ppt) were relatively higher than during Survey #2 (12.6 ppt to 17.9 ppt). Surface and bottom salinity exhibited relatively wider variations in zones III-V compared to I and II. Temperature showed normal variations in all zones with minima ranging from 27.9°C to 31.3°C during Survey #1 and maxima ranging from 30.3°C to 31.8°C during the Survey #2. Surface and bottom temperatures and pH also did not show much variations in all the zones during both the surveys. Dissolved oxygen (DO) (6.7-7.0 ml/L) never reached a limiting concentration in any of the zones in both the surveys. Nitrogen components such as Ammonia (NH_3), Nitrite (NO_2), and Nitrate (NO_3) are important water quality parameters that impacts health and well-being of clam and must be within threshold levels in an aquatic system. NH_3 excreted by clam and other aquatic animals or released from uneaten food is

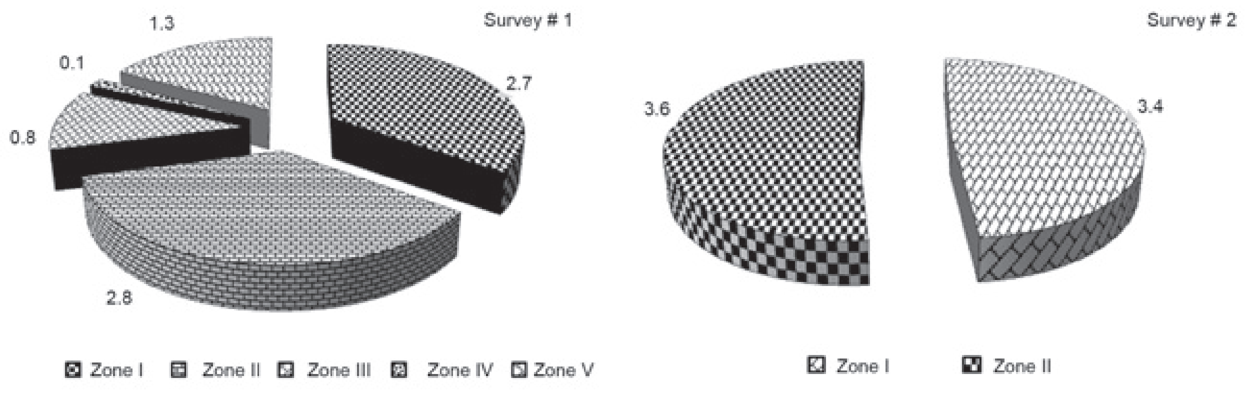

Fig. 2. Zone wise clam biomass (kg/m^2) during Survey #1 and Survey #2

Table 2a. Mean values of water parameters in each clam-bed zones during February 2015 (Survey# 1)

Zone	Salinity (ppt)		Temperature (°C)		DO (ml/L)	pH		Chl a (mg/m^3)	TSS (mg/L)	PIM (mg/L)	POM (mg/L)	NH_3 (ppm)	NO_2 (ppm)	NO_3 (ppm)	PO_4 (ppm)
	Surface	Bottom	Surface	Bottom	Surface	Surface	Bottom								
I	31.4 ± 1.85	ne	28.6 ± 0.26	ne	4.9 ± 0.3	6.7 ± 0.00	ne	0.036	95	ne	ne	0.002	0.004	0.003	0.016
II	31.3 ± 2.23	ne	27.9 ± 0.33	ne	5.2 ± 0.9	6.9 ± 0.3	ne	0.202	68	ne	ne	0.001	0.003	0.002	0.003
III	28.5 ± 1.32	ne	29.3 ± 0.63	ne	5.1 ± 0.1	7 ± 1.00	ne	0.116	71	ne	ne	0.006	0.002	0.005	0.006
IV	9.8 ± 2.63	ne	30.3 ± 0.28	ne	5.2 ± 0.9	6.7 ± 0.00	ne	0.261	75	ne	ne	0.004	0.001	0.002	0.004
V	17.2 ± 4.48	ne	31.3 ± 0.41	ne	4.9 ± 0.3	6.7 ± 0.00	ne	0.053	69	ne	ne	0.002	0.003	0.003	0.005

ne = not estimated

Table 2b. Mean values of water parameters in each clam-bed zone during May 2015 (Survey# 2)

Zone	Salinity (ppt)		Temperature (°C)		DO (ml/L)	pH		Chl a (mg/m^3)	TSS (mg/L)	PIM (mg/L)	POM (mg/L)	NH_3 (ppm)	NO_2 (ppm)	NO_3 (ppm)	PO_4 (ppm)
	Surface	Bottom	Surface	Bottom	Surface	Surface	Bottom								
I	14.3 ± 1.17	14.9 ± 1.09	31.6 ± 0.26	31.1 ± 0.27	4.9 ± 0.3	6.7 ± 0.00	6.7 ± 0.04	8.22	140	55	85	0.103	0.002	0.012	0.006
II	17.9 ± 2.53	18.9 ± 3.96	30.9 ± 0.37	30.8 ± 6.56	5.5 ± 0.9	6.6 ± 0.10	6.6 ± 0.09	3.05	92	57	35.3	0.028	0.001	0.007	0.003
III	12.6 ± 0.47	20.8 ± 0.53	31.8 ± 0.21	31.2 ± 0.33	5.0 ± 0.1	6.7 ± 0.00	6.6 ± 0.00	4.57	90	23	66.7	0.139	0.002	0.046	0.003
IV	9.8 ± 2.63	21.7 ± 7.26	30.3 ± 0.28	29.9 ± 0.77	5.2 ± 0.9	6.7 ± 0.00	6.6 ± 0.00	4.49	78	58	19.8	0.057	0.001	0.011	0.006
V	17.2 ± 4.48	29.8 ± 2.84	31.3 ± 0.41	31.0 ± 0.28	4.9 ± 0.3	6.7 ± 0.00	7.3 ± 0.64	2.51	68	41	26.8	1.028	0.025	0.098	0.013

ne = not estimated

converted to NO_3 via NO_2 through nitrification. High concentration of total ammonia concentration especially un-ionized form is toxic to aquatic life. Mean total NH_3 concentrations in all Zones were observed in normal range except zone V (1.028) in Survey #2. High NH_3 production in zone V might be due to increase in the amount of organic material undergoing decomposition. The NH_3 content in all the zones during Survey #2 (0.028 ppm to 1.028 ppm) was comparatively higher than Survey #1(0.001 ppm to 0.006 ppm). NO_2 is an intermediate product during nitrification process. The NO_2 content (0.001- 0.004 ppm) in the present study was found within the normal range in all zones during both the surveys except Zone V (0.025 ppm) in Survey #2. NO_3 is a nitrogen by-product of nitrifying bacteria in a substrate consuming nitrite. NO_3 is far less toxic than NO_2 and and NH_3. The NO_3 content (0.002 - 0.098 ppm) in all the zones was found to be in optimal range during both the surveys.

Phosphate is an important nutrient for primary production in aquatic ecosystems, and it is available in relatively small amount in most unpolluted waterbodies. If sufficient NO_3 is available, elevated concentrations of phosphates will lead to algal blooms. Phosphate content (0.003 - 0.016 ppm) in both the surveys were in the normal range in all the zones. Total suspended solids (TSS) during both the surveys ranged between 71 to 140 mg/L with maximum concentration at Zone I in Survey #2. High concentration of TSS can lower water quality by absorbing light, thereby increasing the temperatures and decreasing oxygen retention capacity of water. TSS values in all zones (68 to 140 mg/ L) were within the acceptable limits during the both surveys.

Chlorophyll a (Chl a) is essential for photosynthesis and used as an indicator of phytoplankton abundance. Chl a content in Survey #2 (2.51 - 8.22 mg/m^3) was found to be more than Survey #1(0.036 - 0.261mg/m^3) with highest concentrations in Zone I during May. NO_3 is used for phytoplankton production. High Chl a content during Survey #2 might be due to terrestrial input of NO_3 mainly as land run off due to rainfall, resulting in lowered salinity. Higher content of NH_3 during survey #2 may have added NO_3 in the system through nitrification.

Length composition of clams

P. malabarica of 4.25 to 42.4 mm length were observed in the population. During Survey #1, the estimated total density of seed clams (<10 mm) in all zones together formed 40.9 % of total population while the rest was formed by juvenile (7.75%) and large-size clams (51.37%). Highest density of seed clams was observed in Zone II (25.66%) while the lowest was in zone IV (0.54%). Density of juvenile and harvestable size clams was found more in Zone I (30.39%) while the lowest was observed in Zone IV (0.54%).

In Survey #2, clams were present only in Zones I and II. Density of seed clams in all the zones together formed 4.16 % while the rest was formed by juveniles (30.8%) and adult clams (65.04%). Highest numbers of seed clams (2.66%) and adult clams including juveniles (48.41%) were observed in Zone II.

Conclusions

A lot of physical changes have taken place in the clam beds during the past year. The major clam fishing (Zone III) is now totally devoid of clams, and about 40% of this bed is always exposed to air. The fishing is mainly taking place in Zone 1 (under and west of Neendakara Bridge) which has been marked as a Clam Sanctuary and No-Fishing Zone as per CMFRI's Clam FMP. Fishing on the mother stock is detrimental to future harvests. Zones IV and V that were earlier poor in clams are even now devoid of clams because of excessive silt occurring in the clam bed.

A new part of Zone II (Mukkam, Aravana Kadavu) shows new clam settlement and fishery which has not formed part of our surveys. Part-time fishing to the tune of 15 canoes per day has been reported from this area. Although we are as yet unable to pinpoint the reasons for the decline in clam population, we believe that the water flow has been severely affected by the temporary bunds created under Dalawapuram Bridge during its construction. Another factor may be the changes in the monsoon pattern during 2014 and 2015.

Considering the results of the above study, the following is recommended to improve the standing stock of clams in Ashtamudi Lake.

a) Remove the temporary mud bunds created under the Dalawapuram Bridge ensuring tidal water flow between north and south regions of the Lake. This can also restore the most productive Zone III in the long run.

b) Strictly implement the no-take Sanctuary Zone in Zone I as per in CMFRI's clam FMP, through inspections and enforcements.

c) Strictly enforce the Minimum Legal Size (MLS) for clams as prescribed by the Government of Kerala notification G.O.(P) No. 40/15/F&PD dated 24th July 2015.

d) Encourage all concerned to preserve the ecological integrity and character of the Ashtamudi Lake ecosystem by proactively ensuring that encroachments and bunds are not allowed and no garbage or wastes are discarded into the lake.