CAGE CULTURE OF HILSA *(Tenualosa ilisha)* in Ukai Reservoir, Gujarat, India - A Novel Initiative

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Introduction

The Indian shad, *Tenualosa ilisha,* prevalently known as Hilsa is a tropical fish belonging to the family Clupeidae and is widely distributed in Asia between the Persian Gulf towards South China Sea. It occurs in the upper Bay of Bengal and is subsequently distributed in estuarine and freshwater stretches chiefly in riverine environments. Bangladesh waters record for 75% of the world's total Hilsa catch with 15% from Myanmar, 5% from India and 5% from Iran and Thailand (Whitehead, 1985; Coad *et al.,* 2003). Hilsa is considered as one of the most important commercial fishes of India. Externally, it looks silver, gold or purple with more than thirty scutes in the belly. Three species are available in Indian waters of which only *Tenualosa ilisha* forms a commercial fishery, whereas *Tenualosa toli* and *Hilsa kelee* are scarcely available in Indian waters. Fishery for hilsa is available in Indian riverine stretches including Ganga, Bhagirathi, Hooghly, Rupnarayan, Brahmaputra, Godavari, Narmada and Tapti.

Biology

Hilsa is a fast swimmer and also a highly migratory and anandromous fish that prefers to inhabit a part of its life in the sea, not far from the shallow coastal belt due to the presence of sub-surface oxygen, relatively low salinity, strong tidal action, high turbidity, heavy siltation and rich growth of plankton (Pillay and Rosa, 1963; Sahu *et al.,* 2016). Hilsa has a wide salinity tolerance and inhabits freshwater, estuarine and the coastal waters. Its population in Ganges and other large rivers is permanent. The upstream migration has been found to be associated with the state of sexual maturity as well as the volume of freshwater discharged from the river or estuary during monsoon (Bhaumik *et al.,* 2011). It is primarily a plankton feeder and has the habit of grubbing muddy bottoms. Fry (20-40mm) mainly feeds on diatoms, copepods, Daphnia and ostracods whereas the younger ones (up to 100mm) feed on smaller crustaceans, insects and polyzoa (Hora, 1940; De and Datta, 1990; Panhwar *et al.,* 2011). It is heterosexual where the females are distinguishable by their flat urinogenital opening and bulging abdomen whereas the males are recognised by a narrow genital opening with the prominent papillae. It has been reported that males of hilsa in the river Hooghly mature when they are 16-17cm in size and the females when they are 19-20cm in size (Pillay, 1957). Its favourable breeding season is during the monsoon months and there is a short breeding season between January and March.

Cage culture of *Tenualosa ilisha* is vital for Indian reservoirs

The vast availability of reservoir area coupled with very low production obtained from reservoirs, leaves sufficient scope for enhancing fish yields through capture based culture fisheries. With a decline in Hilsa production from capture during the last few decades', cage culture is being proposed as an opportunity to utilise existing reservoirs with enormous production potentials to enhance production. Cage culture of aquatic resources is an emerging technology for the culture of aquatic resources which are reared with higher stocking density from fry to fingerling and from fingerling to table sized fish in captivity that permits free exchange of water with the surrounding water body. The production of farmed aquatic organisms in caged enclosures is a relatively recent aquaculture innovation in the tropical Indian waters. Comprehensive cage farming of marine resources (seabass) was initiated for the first time in 2007 at Central Marine Fisheries Research Institute, Visakhapatnam, Andhra Pradesh. At present, many species of fin fishes and shellfishes are cultured in cages. With no available information on cage culture of hilsa from reservoir ecosystems, several cage culture trials were performed at Ukai reservoir in Gujarat, India.

Self recruiting population of Hilsa available in Ukai Reservoir

The hilsa has a smooth passage from the Arabian Sea up to the Ukai reservoir through the Tapti estuary, though the migratory pathway is threatened to be obstructed by the proposed Navagam dam across the Tapti. Moreover, fry and fingerlings of hilsa were released periodically by the Central Inland Fisheries Research Institute, Barrackpore and the Gujarat State Fisheries Department during the seventies and eighties which eventually got acclimatised and became established as a natural stock in the reservoir (Panicker, 1954; Malhotra *et al.,* 1973). Bhaumik (2015) reported that annual production of adult hilsa constituted 2-3% of the total reservoir fish yield. According to them, the contribution of juveniles was however, much higher. They calculated that across all size groups, 6-7% of the reservoir yield comes from hilsa alone.

Cage site in Ukai reservoir

Ukai, also known as Vallabhsagar, is the largest reservoir in Gujarat situated on the river Tapti at 21° 15'N and 73°35'E. This multi-purpose reservoir has a catchment area of 62,255sq km and water spread area of 52,000 ha with a mean depth of 11.8m. Ukai witnesses climatic extremes with the air temperature going above 45°C during summer and a minimum of 6.0°C during the winter months. The water is rich in micro and macro nutrients and dissolved salts, both from the autochthonous and allochthonous sources and mainly due to the flooded fertile soil. The cages were installed at Latitude: 21°20'39"N and Longitude: 73°49'13"E.

Cage fabrication

Cage is an aquaculture production system made of a floating frame, net materials and mooring system similar to a round or square shape floating net pen to hold fishes which could be installed in reservoir, river, lake or sea ecosystems. The fabricated cages for rearing Hilsa at Ukai reservoir were made up of High Density Polyethylene (HDPE) and were circular in shape. Observations on the swimming behaviour of fishes suggest that circular shape is better in terms of space utilisation. HDPE cage frame with a 6m inner diameter and 8m outer diameter was setup with provisions for connecting HDPE outer predator, net with the inner grow out and bird nets. The outer and inner frames were made up of 140mm HDPE pipes (PE 100 PN 10). A cat-walk and hand rail made of 90mm HDPE pipe (PE 100 PN 10) was provided for the safety of the workers and for routine cage management. The bottom HDPE ballast was filled with weight for keeping the nets in entire shape and volume. The collars *viz.,* horizontal, diagonal and vertical base brackets were made up of HDPE. The cage used two floatation pipes filled with expanded polystyrene as a precaution in case of damage and avoiding loss of floatation force. The ballast pipe was with holes for the free flow of the water and for increasing the weight.

Tying the net

The outer net has a mesh size of 25mm and the inner net varies between a mesh size of 8mm for nursery rearing and a 12mm for grow-out. The outer net (predator net) was suspended from the outer floating collar and kept in tension by the ballast suspended from it to prevent the predators from entering from outside and the inner net (fish net) was supported by the inner floating collar and kept

under tension by the inner ballast for holding and culturing of the stocked fish. As the Indian shad or hilsa swims very fast, to avoid it's hitting and rubbing in the inner net, another inner knotless fish net was provided with smooth surface webbing for safety and survival of the stocked fish. Nets were replaced every two months because of excessive algal fouling and molluscan attachment. A bird net of 35 mm mesh was tied on the top of the cage to prevent birds from entering into the cage.

Fig 1: Tying the net

Mooring clamp and mooring chain

The mooring clamp made of galvanized iron was of 6mm thickness and 110mm diameter. Clamps were coated with zinc chromate and edges were grinded to avoid sharp corners. The mooring chain, 50m long was of 14mm long linked alloy steel material. It was supported with a 5T capacity revolving shackle for the cage to move around in tune with the wind and wave action. Three floats were attached to the chain for effective floatation.

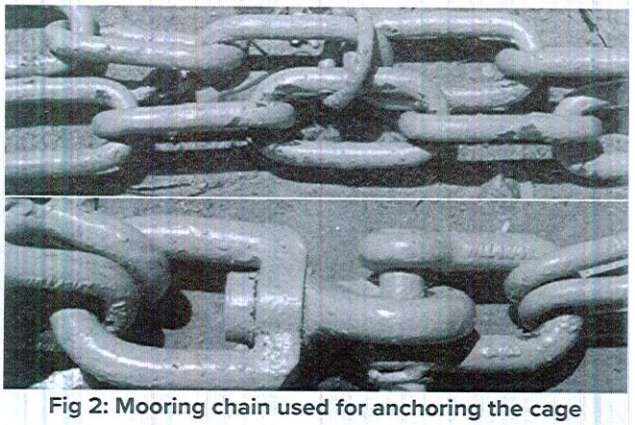


Fig 2: Mooring chain used for anchoring the cage

Fig 3: Hilsa cage farm at Ukai reservoir, Tokorva, Songarh, Gujarat

Anchor

The cages were moored with 15 concrete blocks (2x2x2 ft) made of inner iron mesh and an upper hook of 16mm rod. The mooring chain was fixed to the anchor with "D" shackles. The cages were fabricated on the land close to the cage site for easy launching, after which, the cages were attached to the mooring chain and nets were tied before stocking hilsa.

Hilsa stocking and feeding

Hilsa juveniles were collected from the nearby cage site with *mahajaal* (drag net) during the early hours and evening hours of the day. The collected fishes were segregated out in the water and the healthy hilsa juveniles were transported immediately to the cage site. These juveniles were exposed to prophylactic treatment of iodophore for avoiding handling stress and infection prior to stocking in the cage. Plankton filtered from the reservoir with 160µ mesh plankton collector was fed to the juveniles during morning and afternoon hours. Fishes were fed daily with ABIS shrimp feed once in the morning hours at 10% of biomass initially which was gradually reduced to 5%. Feed was soaked and made into dough and applied inside 0.6m rectangular plastic trays suspended from the top in the middle of the cage. Proximate composition of the feed was protein 38%, fat 6%, fibre 2% and moisture 12%.

Biological parameters of harvested hilsa from cages

Average sex ratio (male : female) of harvested fish was 1:0.96. Average gonadosomatic index (GSI) was 2.30 (1.49-4.17). On an average, 35% of the females

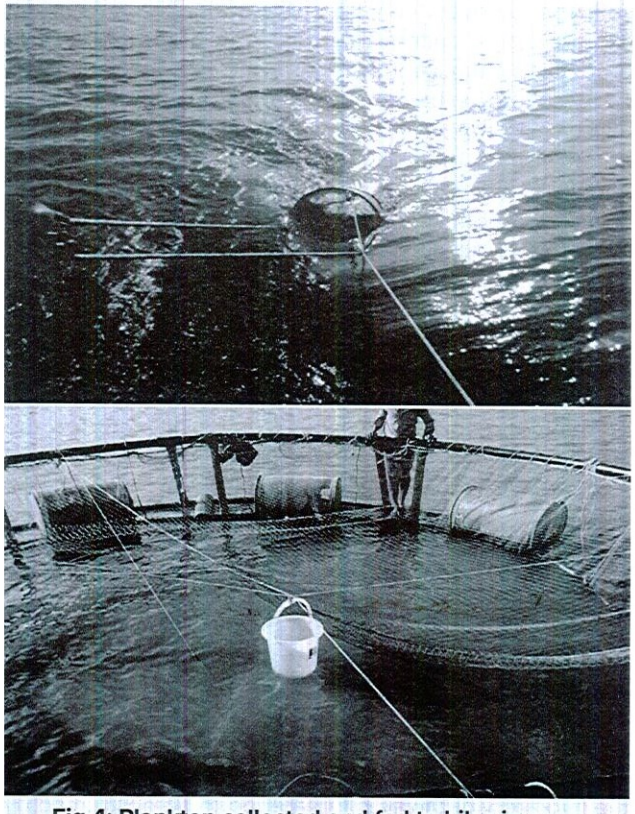
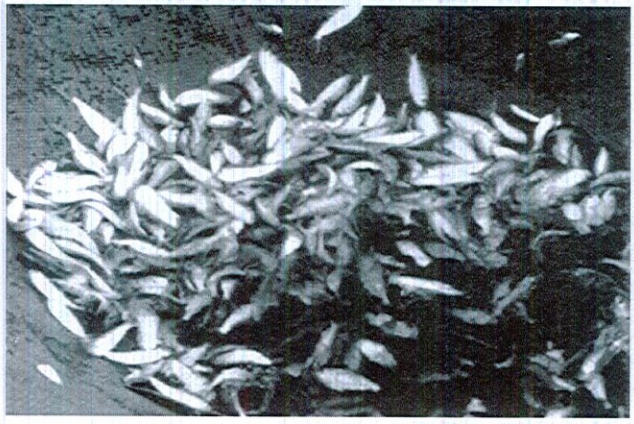


Fig 4: Plankton collected and fed to hilsa in cage

Fig 5: Hilsa juveniles collected for stocking in the cages

Table 1. Evaluation of growth performance of stocked fish

Type of culture	Period of culture	Stocking no./m3	Stocking mean size (mm)	Harvesting mean size (mm)	Rate of survival
Nursery rearing	Feb'15 to July'15	5.3	63	116	23.5
Nursery rearing	Oct'15 to Jan'16	10.4	28	68	2.9
Nursery rearing	Sept'16 to Jan'17	4.0	27	107	28.0
Grow-out culture	Feb'15 to July'15	1.7	142	205	18.4
Grow-out culture	Oct'15 to Dec'15	0.65	167	184	30.1
Grow-out culture	Jan'16 to July'16	2.0	127	191	31.0



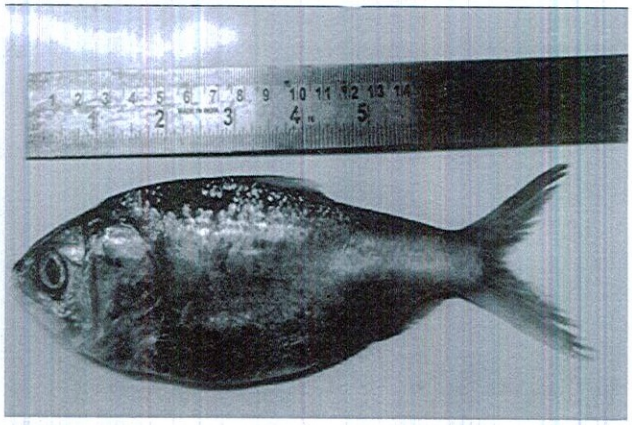


Fig 6: Harvested hilsa from cages

were immature and 61% were maturing, whereas 4% were mature with ova diameter varying from 300 - 360 µm. Copepods (60%) were the dominant food items encountered in the gut of cage cultured fishes, followed by Pediastrum (20%), Biddulphia (5%), Microcystis (4%), Thalassiothrix (3%), Daphnia (2%) and Coscinodiscus (1%).

Length-weight relation was worked out separately for males, females and also for the pooled population which are as follows:

Pooled: logW = -1.6 + 2.61logL

Male: logW = -1.72 + 2.70logL

Female: logW = -1.5 + 2.53logL

Feeding intensity was studied. Stomach state was assessed based on the distension and the degree of fullness and were classified as empty, trace, ¼ full, ½ full, ¾ full, full and gorged. For the ease of presentation of results and for resolving ambiguities over closely related stomach states, the states were merged as empty - trace, ¼ full - ½ full and ¾ full - gorged. Fishes with empty to trace amount of food in stomach represented 42.6%, with ¼ full to ½ full amount of food represented 31.9% and with ¾ full to gorged amount of food represented 25.5%.

The water quality parameters were monitored every fortnight from the vicinity of the cage. The mean values are presented in Table 2.

Qualitative analysis of plankton at regular intervals

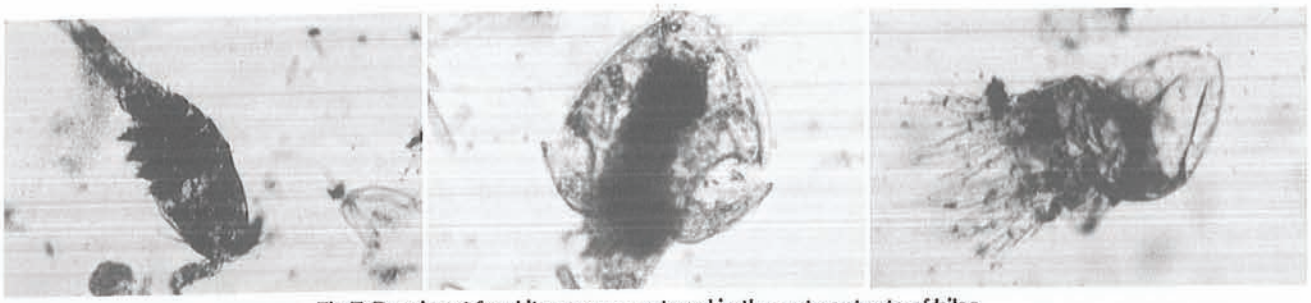


Fig 7: Dominant food items encountered in the gut contents of hilsa

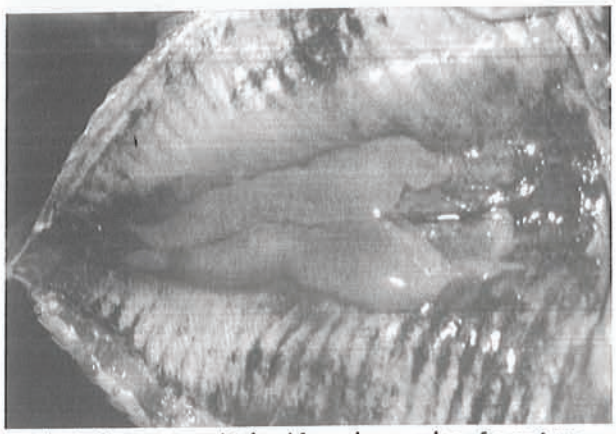


Fig 8: Mature ova obtained from ripe ovaries of a mature female hilsa

Table 2. Water quality parameters of the cage site at Tokorva, Hoodighat, Ukai, Gujarat

Sl. No.	Parameters	Value
1	Water temperature (°C)	23.4
2	Depth (meter)	14.5
3	Flow (meter/sec)	0.01
4	pH	8.4
5	Total dissolved solids (ppm)	78
6	Sp. conductivity (µS/cm)	327
7	Dissolved oxygen (ppm)	8.2
8	Turbidity (ppm)	23
9	Total Alkalinity (ppm)	120
10	Free carbon dioxide (ppm)	Nil
11	Total Hardness (ppm)	110
12	Total chloride (ppm)	35.64
13	Salinity (ppt)	0
14	Silicate (ppm)	24.30
15	Phosphate – P (ppm)	0.032
16	Nitrate – N (ppm)	0.025
17	Plankton density (No./l)	462

revealed an abundance of Microcystis, followed by Spirulina, Nostoc, Navicula, Pandorina, Nitzschia and Cyclops.

Conclusion

The present status of hilsa fishery in most river systems and coastal waters is collapsing and stocks are depleting at an alarming pace because of indiscriminate capture of brooders and juveniles. The present study is the first of its kind, wherein a fast swimming migratory fish was cultured and grown in captivity in reservoir. It is the need of the hour to focus on awareness programmes for encouraging fisher folk to take up cage farming of hilsa. The cage farming operations would be much more economical and profitable when done on a large scale using locally available materials and labour. Ukai reservoir with seeds of hilsa possesses tremendous potential for cage farming.

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