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Abbreviation - *Mar. Fish. Infor. Serv., T & E Ser.*

Cobia broodstock in cage

Hauling the shoreseine at Karwar

Heap of oilsardine landed at Arnala

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The Marine Fisheries Information Service : Technical and Extension Series envisages dissemination of information on marine fishery resources based on research results to the planners, industry and fish farmers, and transfer of technology from laboratory to field.

Successful seed production of cobia *Rachycentron canadum* and its prospects for farming in India

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Introduction

Availability of adequate quantity of high value marine finfish seed is the major prerequisite for initiation and expansion of finfish mariculture. Breeding and seed production of marine finfishes of high value have been expanding in recent years internationally. Large quantities of hatchery produced seeds meet the need for sea cage farming in many countries (Hong and Zhang, 2003). It is well understood that the first step towards seed production technology is the development of broodstock. Prior to 1980s, broodstock of finfishes were grown mainly in indoor concrete tanks. Since early 1980s, wild-caught broodstock have been raised either in outdoor earthen ponds or in sea cages. It has been proved that broodstock development in sea cages was highly effective in improving gonadal development for most finfish groups like groupers, pompano, red seabream, cobia, Japanese flounder and yellow croaker. The development of hatchery technology for commercial level seed production of marine finfishes is still in its infancy in India, except for the Asian seabass, *Lates calcarifer.* Hence, research and development need to be focused in evolving technologies for the seed production and farming of highly priced marine food fishes.

In recent years, seed production and farming of cobia (*Rachycentron canadum*) is rapidly gaining momentum in many Asian countries (Liao and Leano, 2007). Cobia is distributed worldwide in warm marine waters. They are found throughout the water column and are caught in both coastal and continental shelf waters, although they are typically considered to be an offshore species. Wild-caught cobia does not support a major commercial fishery and generally is considered as incidental catch. Sexual maturity is reported in males at 1-2 years and in females 2-3 years, with females growing larger and faster with maximum size upto 60 kg (Shaffer and Nakamura, 1989).

Fast growth rate, adaptability for captive breeding, low cost of production, good meat quality and high market demand especially for *sashimi* industry are some of the attributes that makes cobia an excellent species for aquaculture. Under culture conditions, cobia can reach 3-4 kg in body weight in one year and 8-10 kg in two years. The species has a protracted spawning season and it can spawn in captivity. The fecundity is very high. Aquaculture research on cobia was first reported in 1975 with the collection of wild caught cobia eggs off the coast of North Carolina. Larval development was described and after the termination of 131 day rearing trial, it was concluded that cobia has a good aquaculture potential because of its rapid growth and good flesh quality. Further research on cobia was conducted in the late 1980s and early 1990s in the USA and Taiwan Province of China. Research continued and by 1997 the technology to raise large quantities of cobia fry was developed and Taiwan Province of China was producing cobia juveniles for grow-out mostly in nearshore cage systems. Cobia production is also reported in the United States, Puerto Rico, Bahamas, Martinique, Belize, Brazil and Panama (Bennetti *et al.,* 2008). Envisaging the prospects of cobia farming in India, broodstock development was initiated at the Mandapam Regional Centre of the Central Marine Fisheries Research Institute in sea cages in 2008 and the first successful induced breeding and seed production was achieved during March - April 2010.

Cobia broodstock development - general aspects

The capacity to produce large, dependable quantity of quality seeds is the key for establishing reliable and sustainable cobia aquaculture. The major bottlenecks in the development of commercial aquaculture are the control of reproductive processes of fish in captivity and production of biosecure and quality-certified fry. Broodstock management usually includes collection, selection and domestication of brooders as well as control of maturation, spawning and egg collection. Wherever available, cobia broodstock can be procured from the wild during the spawning season, then transfer them to culture systems for rather short time, and either spontaneous natural spawning or hormone induced spawning can be obtained.

Cobia being a very active fish which grows to large size, broodstock development is mostly practised in sea cages in order to ensure good water exchange and healthy environment. Brood fishes can be stocked at a density of about 2 kg/m^3. Trash fishes (sardines, scads *etc.*) are fed once in a day at the rate of 5% of biomass or till satiation. The trash fish has to be supplemented with vitamins and HUFA (fish oil, squid liver oil). Broodstock nutrition is very important and there is positive correlation between HUFA in the broodstock diets and in the eggs and larvae.

Cobia attains maturity when the fish is about two years old. It has a protracted spawning season in the Indian seas. It spawns under captivity naturally as well as on inducement. It has high fecundity, ranging from 0.05 to 0.25 million eggs per kg. Bigger fishes of 10-15 kg weight having normal shape without any deformity and with healthy behaviour are selected as broodstock. The other important criteria for broodstock include bright colour and with anus easily recognisable. Broodstock nutrition plays a key role in the quality and viability of the larvae. Best temperature for maturation is around 27 ºC and the best salinity range is 30-34 ppt. Separation of males and females from the broodstock cage is required for conditioning the fish for breeding. It is required for controlling the breeding and planning the seed production. The best time for separation is one month before the breeding inducement. Conditioning the brooders ensures best maturation as well as egg and larval quality. Cannulation can be done to assess the maturity condition of the female. The maturation characteristics of female include egg with size above 0.7 mm, non-adhesive, white colour and round shape. In the case of mature males, by gently pressing the belly, the milt oozes out. Brooders are characterised by big belly, chasing behavior and red, swollen anus. The selected brooders can be brought from the cages and transferred to cement tanks. Usually two males and one female are introduced to the spawning tank. Natural spawnings also can be obtained if brooders are selected properly. Induction of spawning can be done by injecting LHRHa 20 µg kg^{-1} for females and 10 µg kg^{-1} for males. Spawning occurs within 12-24 h after the injection. Egg collection can be done manually from the tank by employing 500 µm net.

Optimisation of captive broodstock management protocols still remains a challenge to establish reliable bio-secure hatcheries with genetic diversity and consistent production of high quality eggs and larvae.

Broodstock development and captive breeding at Mandapam

The broodstock at Mandapam was developed in sea cages (Fig. 1 & 2) of 6 m diameter and 3.5 m depth (Gopakumar, 2008). The wild collected cobia brood fishes in the size ranging from 2-10 kg weight were stocked during December 2008 to February 2009. The fishes were stocked without separating sexes. All the fishes were collected from the hooks and line commercial catches. After transporting to hatchery, the fishes were treated with 100 ppm formalin for 2-5 min and conditioned for two to three days in 10 t FRP tanks before transferring to cages. These fishes were fed twice daily at 0900 and 1530 hrs with sardines (*Sardinella* sp.) and other fish species like *Pellona* and *Ilisha* and occasionally with squids and portunid crabs @5% of their body weight. Vitamin and mineral supplements were also given

Fig. 1. Broodstock cages for cobia at Mandapam

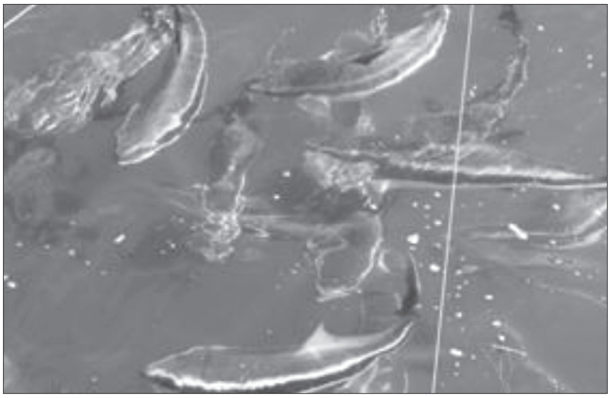

Fig. 2. Cobia broodstock in cage

Fig. 3. Cannulation of cobia to assess the maturity

twice a week along with the feed in order to complement any possible nutritional deficiencies in their diet. A total of 40 fishes were stocked in four cages. The length range and corresponding weight range of the brood fishes recorded during April 2009 ranged between 80 and 127 cm, and 4 and 20 kg respectively. The sexes were separated by cannulation using a flexible catheter (2 mm inner diameter) in June 2009 and stocked in separate cages. Thereafter, the females were cannulated (Fig. 3) every fortnight to assess the diameter of the intra-ovarian eggs.

On 11.03.2010, one of the females with intra-ovarian eggs (Fig. 4) of around 0.7mm size was selected for induced breeding. The size of the female was 120 cm in total length and 23 kg in weight. Two males were also selected from the male cage. The sizes of the males were 100 cm and 103 cm in total length and weighed 11 kg and 13.5 kg, respectively. On the same day, the selected brooders were introduced in a 100 t roofed cement tank holding about 60 t of seawater. At around 1300 hours, the brooders were induced for spawning with HCG at doses of 500 IU per kg body weight for female and 250 IU per kg body weight for males (Fig. 5). Spawning (Fig. 6) was noticed at 0430 hours on 13.03.2010. The total eggs spawned were estimated as 2.1 million. About 90% fertilisation was recorded. Fertilised eggs (Fig. 7) amounted to 1.9 million. The eggs were collected by a 500 µm mesh and stocked in incubation tanks at varying densities.

The eggs were hatched after 22 h of incubation at a temperature range of 28-30 ºC (Fig. 8 & 9). The percentage of hatching was 80% and the total number of newly hatched larvae was estimated as 1.5 million. The newly hatched larvae measured 2.2-2.7 mm in total length. The mouth opening was formed on 16.03.2010 (on 3rd day post-hatch) at a length of around 200 µm.

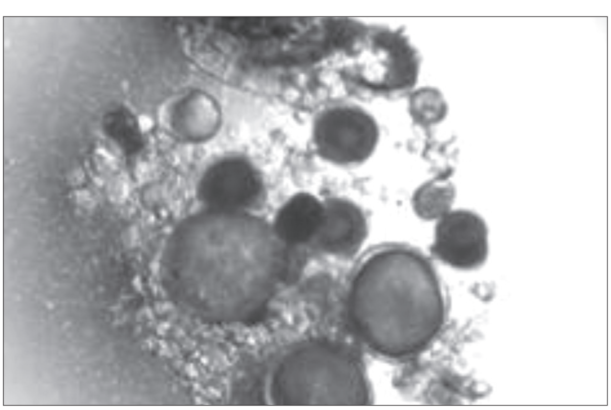

Fig. 4. Cannulated intra-ovarian eggs

Fig. 5. Administration of hormone for final oocyte maturation and spawning

Fig. 6. A view of the spawning behaviour of cobia inside the spawning tank

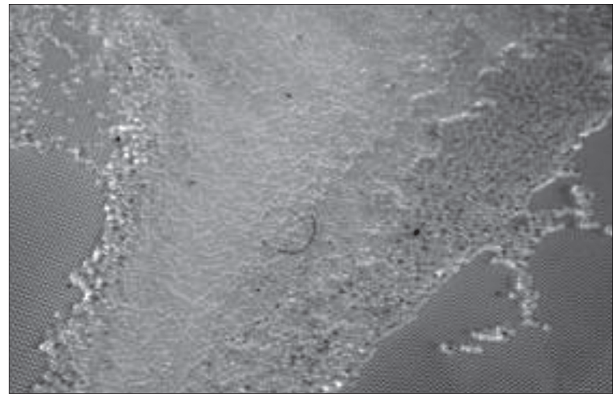

Fig. 7. Fertilized eggs collected on 500 μm mesh

Larviculture and seed production - general aspects

Cobia eggs are pelagic with single oil globule which is resorbed completely at 7 dph (day post-hatch). The egg diameter is 1.4 mm. Hatching occurs 26 h after spawning at 27 ºC. Newly hatched larvae measures 3.4 mm size (Holt *et al*., 2007). Though the larvae are vigorous, they are very sensitive to environmental conditions. However, they are more resistant to some stressors when compared to other tropical marine fish larvae (Liao *et al.,* 2004). Larval mouth opens at 2-3 dph (temperature dependent). Metamorphosis starts from 9-11 dph.

Newly hatched larvae (Fig. 10) generally start feeding at 3 dph and they can be fed with the enriched rotifer (*Brachionus rotundiformis*) @ 10-12 nos./ml, four times a day till 10 dph. From 8-10 dph, the larvae are fed with enriched *Artemia* nauplii @ 1-3 nos./ ml, 4-6 times per day. During the rotifer and *Artemia* feeding stage, green water technique is used in the larviculture system with the microalgae *Nanochloropsis oculata* at a cell density of $1x10^5$ cells/ml. Weaning to artificial larval diets is during 18 to 25 dph. While weaning, formulated feed has to be fed 30 min before feeding with live feeds. Continuous water exchange is required during weaning. Between 25-40 dph, the larvae are highly cannibalistic and hence size-grading is undertaken every four days to one week. During this stage the fry could be weaned totally to artificial diets. Larval rearing can be practised both intensively in tanks and extensively in ponds. The major factors affecting the growth and survival of larvae are nutrition, environmental conditions and handling procedures. Since there is high demand for essential fatty acids (EFAs), enrichment protocols are needed for live feeds. During the first 12 days of larviculture, water exchange has to be gradually increased from 10-100%. Surface skimmers are employed to remove oil particles from the water surface. After 18 dph, recirculation system is preferred. The environmental conditions required during the larviculture period are

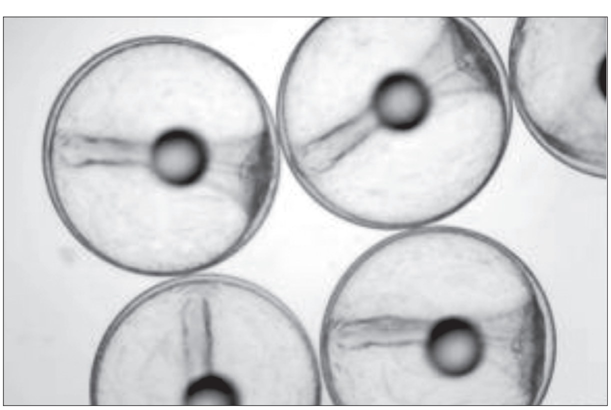

Fig. 8. Development of the embryo

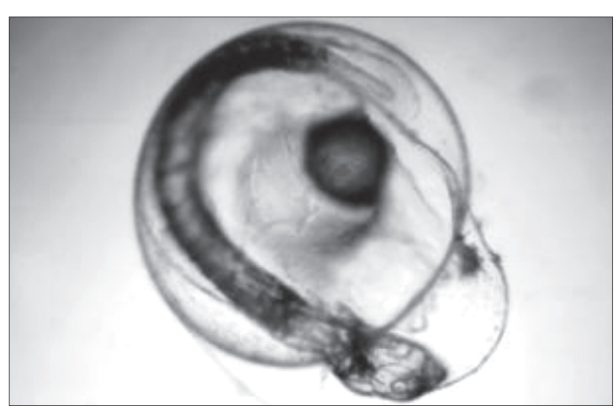

Fig. 9. Hatching of larva

Fig. 10. Newly hatched larvae

DO: >5 mg/l, NH_3: <0.1 mg/l, pH: 7.8–8.4, Salinity: 25-35 ppt, water temperature : 24-33 °C (Liao *et al.,* 2004).

Larviculture protocols developed at Mandapam

Larviculture protocols were developed by appropriate management of live feeds in suitable quantities and also taking into consideration the nutritional requirements of the larvae. The larvae were stocked in FRP tanks of 5 t capacity for larviculture (Fig. 11). The intensive larviculture tanks were provided with green water at a density of about 1 x 10^5 cells/ml and rotifers enriched with DHA SELCO at a density of 6-8 nos./ml from 3 to 9 dph. The critical stage for the larvae was 5 to 7 dph when they entirely resorted to exogenous feeding from yolk sac feeding. During this period, large scale mortality (about 80%) was noted. Thereafter, the mortality rate was moderate. From 9 to 21 dph, the larvae were fed four times daily with enriched *Artemia* nauplii by maintaining a nauplii concentration of 2-3 nos./ml.

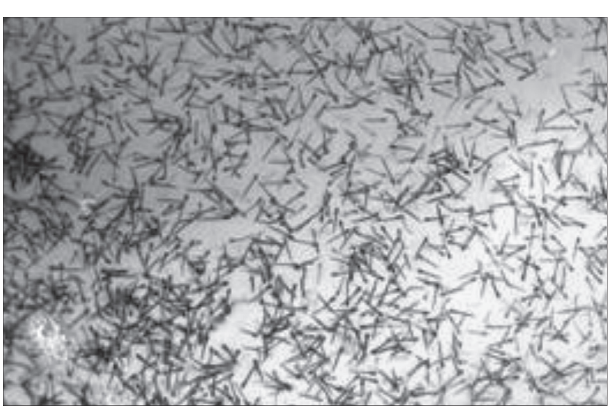

Fig. 11. Larvae in the rearing tank

During this period, co-feeding with rotifers was also continued due to the presence of different size groups of larvae. Green water was also maintained in appropriate densities in the larval tanks. From 18 dph onwards, the larvae were fed with newly hatched *Artemia* nauplii and weaning to larval inert feeds was also started as per details given below:

Stage of larvae (dph)	Size of larvae (cm)	Size of feed (µ)
18 - 19	2.3 - 2.6	100 - 200
20 - 23	2.5 - 3.5	300 - 500
23 - 30	3.5 - 8.0	500 - 800
31 onwards	> 4.0	800 - 1200

From 25 dph, grading of larvae was started. The shooters were fed exclusively with the artificial feed of size 500-800 µ and 800-1200 µ. On 30 dph, three size groups of juveniles were noted with mean sizes of 10 cm (10%), 6 cm (25%) and 4 cm (65%). The juveniles measuring 10 cm length were ready for stocking in hapas and the other two size groups would be ready for stocking in hapas after rearing for another two to three weeks. All the fingerlings (Fig. 12) of 10 cm length and above were stocked in hapas in the sea for nursery rearing for about a month before transferring them to the grow-out cages.

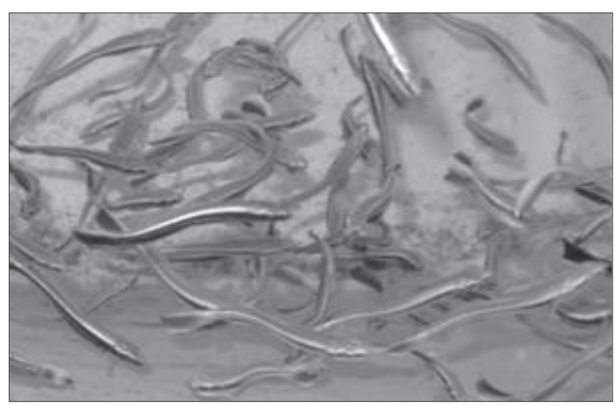

Fig. 12. Fingerlings of cobia

Cobia farming - general aspects

Nursery rearing

Nursery rearing of cobia generally comprises three phases. In first phase, 0.2 - 2g to 5g fry grow rapidly to fingerlings of 8-10 cm (20 to 45 dph). In the second nursery phase, cobia fingerlings are reared from 2 -5 to 30 g (45 to 75 dph) in large ponds with green water or in hapas in the sea. Artificial feed are provided manually to satiation, 5 to 6 times daily. The size of the pellet feeds is increased gradually as the fish grows. Even during this phase, grading should be undertaken. The third nursery phase is from 30 to 600 - 1000 g (75-150 dph to 180 dph). Nursery rearing is either in outdoor ponds or inshore cages. Grading is undertaken only once during this stage. It is not advisable to stock cobia juveniles smaller than 30 g size in offshore cages, because of their weak resistance to strong water currents and also due to the necessity of occasional grading to prevent cannibalism (Liao *et al.,* 2004).

Grow-out farming

Cobia is cultured in offshore grow-out cages until they reach marketable size. Culture period ranges between 6-8 months. Small scale family owned cage farms and commercial cage farms are employed for cobia grow-out farming. Usually most of the cage farms integrate nursery and grow-out culture in one area for convenient transfer of fish stock from nursery to grow-out cages. Sinking and floating pellet feeds are used in grow-out cages. Cobia juveniles are cultured in smaller cages for 4-5 months until they reach a size of about 800 g and then they are transferd to larger cages (Liao and Leano, 2007).

Nutritional aspects

Nutrition is paramount to production success and the design of specific diets for all stages including broodstock, larvae, juveniles and adults. Rotifers and *Artemia* enriched with *Isochrysis galbana* or with commercial products along with green water culture provided best survival for cobia larvae (Faulk and Holt, 2005). Survival of cobia larvae was improved by addition of *I. galbana* or *N. oculata* in rearing tanks. Growth and survival rate can be improved if *Artemia* feeding schedule is reduced, since cobia larvae could take larger food size by 14 dph. Recent work (Chou *et al.,* 2001) has reported optimum dietary protein and lipid levels in juvenile cobia as 45% and 5-15% dry weight respectively. However, there is limited information on amino acid and essential fatty acid requirements of cobia. There is no information available on vitamin or mineral requirements of cobia. At present, commercial cobia feeds are based on those for Asian seabass or grouper and achieve acceptable growth with feed conversion ratio ranging from 1.5-1.8 (Chou *et al*., 2004). In areas such as Taiwan, where cobia culture is popular, cobia are fed once a day at feeding rate of 0.5-0.7% body weight on a pellet diet consisting of 42-45% crude protein with 15-16% fish oil and achieve FCRs of around 1.5 during the grow-out stage (Liao *et al.,* 2004).

Diseases

Diseases caused by bacteria, viruses and parasites occur in all stages of culture of cobia. During larval stage, *Epistylis* and *Nitzchia* infestation is very common. During the nursery stage, a viral disease *viz*., *Lymphocystis* is common, but not fatal as long as good water and feed management are employed. *Amyloodinium ocellatum* also cause problem which can result in high mortality if left uncontrolled. *Trichodina* infestations are also common during the nursery stage. Mixosporidian infections are also reported among cobia nursery phases causing mass mortality (Chen *et al.,* 2001). In grow-out stage, the ectoparasite *Neobenedenia* sp. Is common which together with secondary bacterial infection causes blindness to cobia juvenilies. Pasteurellosis caused by *Photobacterium damsela* is one of the most common diseases during cobia juvenile phases which can cause mass mortality. Vibriosis affects fingerlings, juveniles and adults and the causative agent is *Vibrio anguillarum*. Another bacterial problem in sea cages is caused by *Vibrio alginolyticus* which result in hemorrhages and subsequent mass mortality.

Prospects

Cobia is recognised as a finfish with emerging global potential for mariculture. Following successful development of cobia culture in Taiwan, this activity expanded very fast in south-east Asia, the Americas and the Caribbean regions. Cobia has all the qualities required for a successful species for aquaculture. The global aquaculture production of cobia has been increasing from 2003 onwards and the major contributors are China and Taiwan. It has been noted that rapid growth rate and good flesh quality of cobia make it one of the best species for future expansion of production. Increasing the supplies from aquaculture combined with effective marketing can substantially enhance cobia production in the near future. The present success in the captive breeding and seed production in India can be considered as a milestone towards the development of lucrative cobia farming in the country. However, this is only a first step and standardisation of technologies for seed production and farming of cobia to suit our environmental conditions have to be further pursued on a priority basis so that India can also emerge as a contributor for cobia production in the near future.

Emergence of oilsardine fishery as an alternative resource for dolnetters at Arnala

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Arnala is one of the major dolnet landing centres in Thane District of Maharashtra. Dolnet is a gear exclusively used in Maharashtra and Gujarat. In Maharashtra, they are anchored to poles fixed to the sea bottom and are generally operated from August to May. At Arnala, approximately 375 dolnets are operated and the operation is generally confined to a depth range of 18-22 m.

Of the total fish catch, 60% is sun dried and the rest sold in fresh condition. The sun dried fish is sold through three outlets *viz*., petty merchants (70%), dry fish market (25%) and at retail market (5%). At Arnala in the year 2002, the most dominant fishery was of Bombayduck followed by *Coilia dussumieri*, non-penaeid prawns and *Acetes* spp. (Fig. 1).

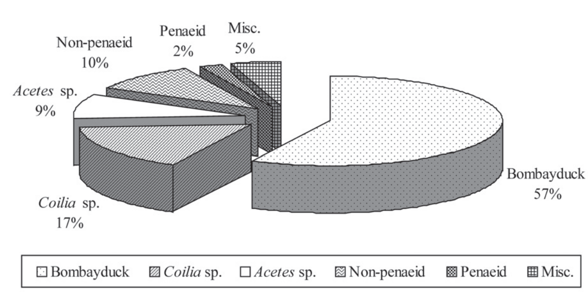

Fig. 1. Species composition of dolnet catch at Arnala in 2002

Of late, the Indian oilsardine, *Sardinella longiceps,* has started appearing in large quantities in the dolnet catches. The species composition during the year 2006 was more or less the same except for the increase in sardine percentage (Fig. 2). Unusual and unprecedented landings of oilsardine by dolnetters were observed at Arnala during January

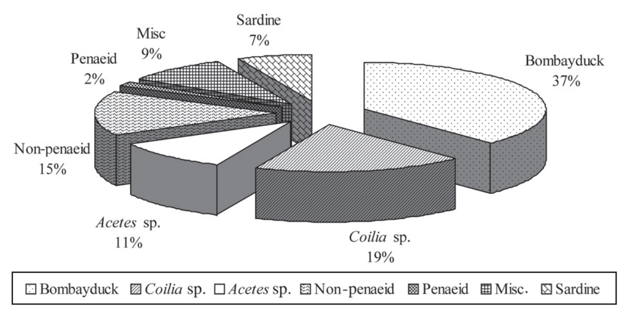

Fig. 2. Species composition of dolnet catch at Arnala in 2006

and February 2007. On 19-1-07, a total of 18,360 kg of sardines landed with a catch per unit effort of 270 kg boat^{-1} (Fig. 3). A total of 68 units were operated on that day. The dolnet was of 50 m length with a cod end mesh size of 25 mm. The boat was 14 m in length and were operated at 20 m depth towards the north-west direction. A total of 104 fishes were measured for length frequency. The length of sardines ranged between 77 and 178 mm with a mode at 160-169 mm (Fig. 4). Most of them were lean with the head comparatively

Fig. 3. Heap of oilsardine landed by dolnetters at Arnala

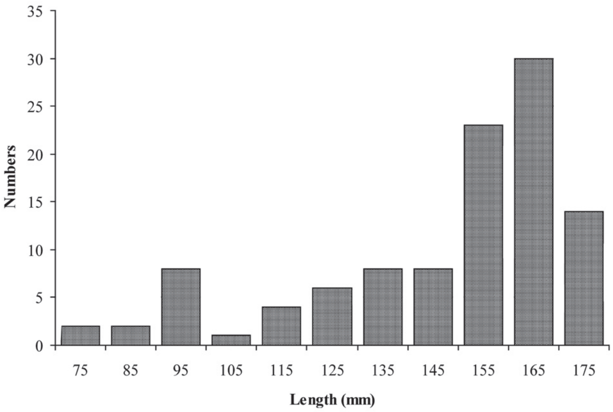

Fig. 4. Frequency distribution of *S. longiceps* landed at Arnala

looking larger than the body and showed a starved appearance (Fig. 5).

Fig. 5. Oilsardine *Sardinella longiceps* landed at Arnala

The catch of oilsardine by trawlers also increased substantially at all the major landing centres of Mumbai such as New Ferry Wharf and Sassoon Dock. However, for better comparison, dolnet catches were considered (Fig. 6). It was observed that the period of abundance was during September-December. The annual catch of sardines by dolnetters at New Ferry Wharf increased from 6,067 kg (2005) to 31, 972 kg (2006) and at Sassoon Dock from 35,446 kg (2005) to 69,799 kg (2006). A similar trend was observed in Arnala also but with a larger magnitude. The catch increased from 2,150 kg in 2005 to 1,33,180 kg in 2006.

Oilsardine forms 10-18% of total fish landings of India mainly caught along the south-west coast. Hence the role it plays in the economic life of the fishermen is significant. Except for Kerala and Karnataka, oilsardine fishery is not a major resource in other states. Due to the advent of synthetic fibres

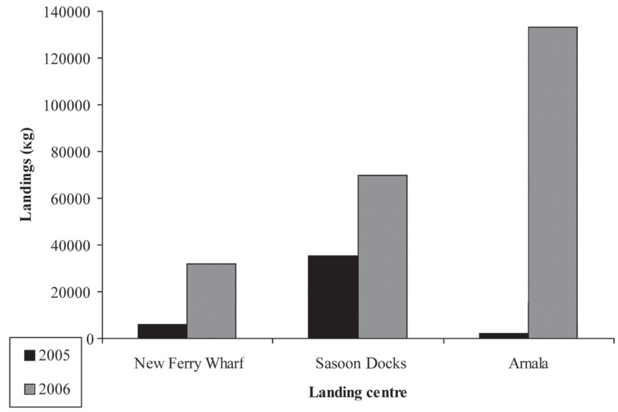

Fig. 6. Landings of *S. longiceps* by dolnets during 2005 and 2006

for net making and mechanisation of fishing crafts especially purseseines, the fishing strategy for the major pelagic fishes including oilsardine has changed. Oilsardine is known to occur in the Indian waters in large schools in the inshore waters.

Sporadic instances of heavy landings of sardine was recorded earlier along both east and west coasts such as Pondicherry, Chennai, Cuddalore, Pazhapan, Rameswaram, Pamban, Srikakulum, Tuticorin, Uchila and Ullal including Saurashtra. The fishery season for the oilsardine is generally during June-December, when about 90% of the annual catch is obtained, though it occurs throughout the year. Even though the period of spawning extends from May to November, its peak is from June to August. Oilsardines have a very high fecundity ranging from 37,000 to 80,000 with the egg diameter ranging between 1.20 and 1.23 mm. Distribution of oilsardine is restricted to certain localities having rich production of phytoplankton which forms the main food of this species.

In the past several decades, the oilsardine fishery has shown fluctuations spatially, seasonally and annually. Out of the many reasons for fluctuations, one of the reasons might be changes in diatom production. An increase in the strength of the monsoon over its critical limit would be favourable for an increase in the catch and below the critical value the catches were found to decline. In general, the south-west monsoon and the resultant biological, oceanographic and meteorological conditions seem to be responsible for the catch fluctuations to a large extent. Resource potential of oilsardine of the west coast is high despite its inherent fluctuations.

Oilsardine never formed a sizeable fishery along the Maharashtra coast earlier and the present report deals with the emerging fishery along this coast. Due to lack of demand for fresh fish, the bulk of the catch was sun dried on the beach and later sold to agents who supplied the same to some companies for the manufacture of poultry feed or as manure.

The shoals of oilsardine can either be migrating from south-west coast of India or from the off shore. The wind driven surface currents of the west coast, seawater temperature and salinity appear to influence the oilsardine migration. Conservation of the resource and proper management of the fishery need attention in view of its wide fluctuations coupled with increasing intensity in fishing effort.

Unusual heavy landings of the catfish *Arius dussumieri* in Rajapara Bay of Gujarat coast

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Rajapara is one of the most important dolnet fishing centres in Saurashtra region and the landing centre is a small semicircular bay without any major concrete berthing facilities (Fig. 1). Though, a well constructed jetty is not present in this centre, fishing boats of 10 -14 m size operate and small canoes are used to unload the catch. About 240 dolnet units are under operation, of which 120 are four netters, 90 are three netters and the rest are two netters. Duration of each operation lasts for 4 to 5 h. Depth range of fishing ground is 24 to 40 m and it takes 4-5 h to reach the fishing area.

Fig. 1. Semicircular bay type landing centre at Rajapara

There was heavy landing of around 28 t of the catfish *Arius dussumieri*, in 11 dolnet units with an average of 2,545 kg per dolnet at Rajapara landing centre on 23-3-2009 (Fig. 2). Weight of each fish varied between 3.6 and 5.2 kg with an average weight of 4.65 kg (Fig. 3). Length frequency analysis showed a single dominant size group with the mode at 70-74 cm and the range between 56-92 cm.

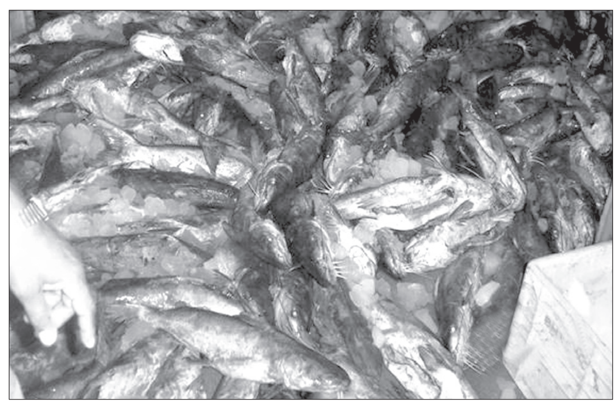

Fig. 2. Heavy landing of catfish at Rajpara landing centre on 23-3-2009

Fig. 3. Weighing of *Arius dussumieri* in temporary sheds at the landing centre

Females were found to be dominant in the population. The gonadal studies indicated that 42% of the females were in the advanced ripe condition, 17% were mature and 8% were in the maturing stage (Fig. 4).

Fig. 4. Mature gonads of female *A. dussumieri*

Observations made in the nearby landing centre of Nawabunder by Fishery Resources and Assessment Division of CMFRI had also reflected the same trend. Totally 108 dolnet units were deployed and the total catfish catch was estimated as 74.9 t. The trawlnets operated in Veraval, Mangrol, Porbunder and Okha have also shown a similar trend during the previous two months. Based on local enquiry, it was found that comparatively higher catch was observed during this year than the previous years.

The gut content analysis showed that majority of the fishes fed on *Acetes* which was predominant in the guts of all fishes observed. Second important food item was *Coilia dussumieri* which was found in 50% of the fishes. The other important food items were *Chirocentrus dorab*, seerfish, carangids, ribbonfish, non-penaeid prawns and other unidentifiable digested matter (Fig. 5).

Fish unloaded by small canoes at Rajpara Landing Centre were carried in vehicles or as head load by fisherwomen to the nearest fish processing sheds for further processing. After weighing, the fishes were cut open to remove the airbladders and the gonads. The ovary and airbladder were kept separately in different tubs. The egg mass of each fish was sold in the local market at the rate of Rs. 40/-. The airbladders were kept in plastic tubs and chemical was added to remove the blood stain

Fig. 5. Major food items encountered in the gut of *A. dussumieri*

and other impurities (Fig. 6). The airbladder thus cleaned was sold to the middlemen from Nawabunder. Further processing was carried out at Nawabunder and it was exported to China for making isinglass.

Fig. 6. Chemically treated airbladders of *A. dussumieri*

Soon after removing the gut, the fish were arranged in plastic tubs with ice and was sold to the buyers from Nawabunder at the rate of Rs. 25-30/- per kg. It was further processed in Nawabunder fish curing yards. The catfishes were beheaded and cut longitudinally into two halves and then washed thoroughly in brine solution. The fishes were arranged in layers one above the other, with salt in between them to a height of 1 to 1.5 m (Fig. 7) and were allowed to remain for 4 days. On the fifth day, they were removed, brushed to remove the excess salt if any and soaked again in brine solution. The fishes were then sun dried for a period of 3 days in multi-tier system of wooden platforms specially made

Fig. 7. Salt curing of catfishes

Fig. 8. Multi-tier system of wooden platforms specially made for sun drying of catfishes

for this purpose (Fig. 8). After proper drying, the fishes were removed and kept in a separate shed where they were packed and sent for export mainly to Sri Lanka (Fig. 9).

Fig. 9. Dried catfishes ready for export

Spawning migrations of *Arius thalassinus* and *Arius tenuispinis* towards shallow waters of less than 10 m depth have been reported during the south-west monsoon from the west coast. Considering the fact that majority of the female specimens analysed were in the advanced stage of gonadal maturity, it appears that *A. dussumieri* also would have migrated towards shallow waters of the Gujarat coast during February-March.

Emergence of shore fish traps 'pattivalai' - their design and economics of operation along Mandapam coast

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Shore fish traps, locally known as "pattivalai" are being operated along the Palk Bay and the Gulf of Mannar coast from Thangachimadam to Pudumadam for a stretch of 35 km. In 1990, there were only a few numbers, which has since increased to more than 30 at present (Fig. 1). This new fishing operation was introduced by Srilankan refugees staying in Mandapam camp. Mostly, this permanent or semi-permanent structure is placed in the near shore waters depending on the weather conditions and in some areas during a particular season. During rough weather condition (April - September) in Gulf of Mannar, this structure

Fig. 1. Pattivalai distributed along Mandapam coast

is fixed in the Palk Bay and *vice versa* in the Gulf of Mannar during October to March when the Palk Bay is rough.

Fishermen, mostly Sri Lankan refugees themselves build fish traps which may yield on an average 100 to 300 rupees per day per trap. This depends on the location and periodicity of use. A fisherman has to invest around Rs 28,245 - 30,500/- initially and spent about Rs. 500/- as maintenance cost per month in order to operate a single pattivalai successfully.

The shore fish trap is comprised of mainly four parts: heart-I or 'patti' with a single or double entrance, heart-II or 'pudukuda' with a single or double entrance, two entrance funnels or 'highesh' and long tail or 'vaal' running perpendicular to shoreline (Fig. 2a, b).

Fig. 2a. Shore fish trap or pattivalai fixed along Mandapam coast

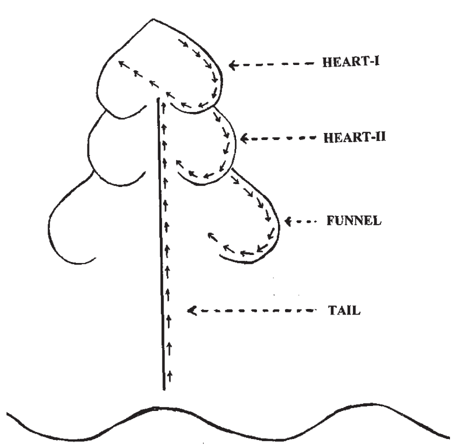

Fig. 2b. Different parts of shore trap. Arrow indicates movement of fish into the trap

Pattivalai design and construction

At first, fishermen get ready all their required materials for the erection of pattivalai as given in Table 1. They select suitable locations for their trap based on tidal amplitude, wind direction, bottom substratum, depth (3-6 cm) *etc*. Then they mark the area where the trap is to be erected. Damaged or discarded net (mesh size: 3 cm) available in local shops are purchased for making the mesh wall of pattivalai whose width/height will vary according to the depth. The height of mesh wall and pole should be from bottom to 50-100 cm above the maximum sea level. The damaged portions of waste net are mended by synthetic twine. The upper edge of the wall with head rope is stitched by hand. Similarly the bottom end of the wall with the foot rope having loops of equal intervals (100-200 cm between two loops) is stitched. The diameter of loop is generally little smaller than the pole (dia: 6 cm) for fixing the pointed pole with loop / foot rope of mesh wall under the soil. Poles are stuck into the ground along with loops in the marked area and then the mesh wall is rolled out against the poles. Another set of poles are stuck alongside the inner poles and the head rope is fastened with pole. The entire structure is erected as shown in Fig. 2a and b.

Pattivalai operation

Shoals of finfish/cephalopods/crustaceans moving along the coastal waters will meet with the tail of the trap. They swim along the tail and enter the heart-shaped part or body of the trap. The heart shape is very important according to the fishermen. Fish will swim along the mesh wall and pass through the mouth or entrance and get trapped. Harvesting is carried out by fishermen or divers working from a catamaran (2 persons/raft) or tyre-tube having bag like structure at centre (Fig. 3) with face mask, flippers and specially designed dragnet. Each fisherman checks his trap everyday at 0500 hrs. A specially designed dragnet with small sized mesh (1.5 cm) having height equal to the mesh wall of heart with floats at the head rope and sinkers at the foot rope is used (Fig. 4). Indigenously designed flippers are made of round aluminium plate (dia: 27 cm and 2 mm thickness) and broad strip of tube (2 mm) (Fig. 3). Messenger rope is fitted at bottom of the dragnet through which bottom portion is closed. When they (usually: 2 persons/raft/trap)

Table 1. Details of cost involved in fabrication and operation of pattivalai along the Mandapam coast

Components/portions of shore trap and labour charge	Building materials and others	Cost (Rs.)/kg/ pole/float// piece	Total materials required for trap (cm / no. / kg)	Total cost (Rs.)
Heart-I, Heart-II and two entrance funnel	Waste netting	285	14 kg	3990
	Nylon rope (3 mm)	240	3.5 kg	840
	Poles (180-450 cm)	60 - 90 (75)	35 nos.	2625
Tail	Waste netting	285	15 kg	4275
	Nylon rope (3 mm)	240	6.5	1560
	Poles	60 - 90 (75)	65 nos.	4875
Catamaran/Lorry tyre tube	Catamaram (2x1 m)	2000 - 3000 (2500)	1 no.	2500
	Tyre tube	250	1 no.	250*
Flippers	Round aluminium plate (dia: 27 cm)	75	1 pair	150
Face mask	–	75	1 no.	75
Plastic can (50 l)				70
Labour charges				2000
Drag net	Floats	2.0	10	20
	Sinker	90	1.5 kg	135
	Knitting (Mesh :1.5 mm)	300	22 kg	6600
	Pole	75	2 nos.	150
	Labour charge			700
Total cost				30,565

Note: * = the cost of tyre tube is not included in the total

Fig. 3. Lorry tyre tube with flippers used by pattivalai fishermen

Fig. 4. Drag net designed for harvest of fish from pattivalai

reach heart-II portion of trap, the catamaran is moored. Two divers get down with face mask and flippers and then lower the drag net. Each diver swims and carries each pole of dragnet and drags it along the periphery of heart-II in such a way that fish will not escape through the entrance. Fishes are thus forced to move into the heart-I portion of trap. Once again the drag net is dragged along the periphery and two opposite side pole is brought together slowly. The messenger rope is pulled so that the bottom end can be closed. Entire drag net with trapped fishes is rolled like a mat. Entire rolled structure of net is brought to shore for collecting trapped fishes. The fishes are collected into plastic can. Unwanted fishes are released back into the sea.

Economics of operation

Fishermen have to spend Rs. 2000/- for preparation and erection of mesh wall of trap and Rs 7600/- for drag net. Cleaning of mesh wall of trap against the fouling organisms is done once in a month by washing the net with bleaching powder at shore. Re-erection of entire structure is being carried out for Rs. 500/-. Sometimes incidental expenses may occur due to the damage caused by trawler movement in the region.

This method of fishing results in fish staying alive until the time they are brought to local market. Traps have historically proven to be effective but are non-selective *i.e.*, traps capture a high percentage of non-target species. In fact, fish trapping has already been banned in several areas of the world because of its detrimental effect on coral reef communities.

Record of the rare serranid fish Boulenger's anthias *Sacura boulengeri* (Heemstra, 1973) from Mumbai waters

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The family Serranidae comprising of 62 genera with 449 species is divided into three subfamilies namely, Anthiinae, Epinephelinae (tribes Epinephelini, Niphonini, Liopropomatini, Diploprioni, Grammistini) and Serraninae. Among the genera, *Epinephelus* has the largest number of species and are the most commercially important. The Anthiinae, comprising fairy basslets and sea goldies, though relatively smaller and very colourful, do not make good aquarium candidates as they are exclusively planktivorus. The boulenger's anthias *Sacura boulengeri*, a very rare anthias, was previously known only from six specimens, five collected from Muscat (Gulf of Oman) in 1963 and one from Sindh (Pakistan) in 2004. The lectotype and paralectotypes of *S. boulengeri* are preserved at the British Museum of Natural History (No.1889.4.15.15 and 1889. 4.15.15). Between the period 2005-2006, *S. boulengeri* was reported from several landings in India, namely, Mumbai, Mangalore and Neendakara (Kerala). The specimens collected in Mumbai were landed at Sassoon Docks in the post-monsoon season on a single occasion (Fig. 1). On enquiry it was learnt that they had been caught from the mangrove area near Mahul by gillnet. All seven specimens observed were males as identified by their characteristic bright colouration of golden, mauve and lavender. As the specimens were freshly collected, their characteristic colouration was clearly noticeable. The body of this fish is ovate, laterally compressed, with a lunate caudal fin. The third spine of the dorsal fin is very prolonged as are also the 3rd and the 4th dorsal soft rays. Two specimens were collected and brought to the laboratory for morphometric and meristic analysis. Comparative morphometrics of *S. boulengeri* from various localities are given in Table 1.

Fig. 1. Male *Sacura boulengeri* (Heemstra, 1975) collected from landings at Sassoon Dock, Mumbai

The records from India can be considered a range extension of the species. The fact that it has not been recorded earlier may possibly be because of the comparative rarity of the species itself.

Table1. Comparetive morphometrics of *S. boulengeri* collected from various localities

Parameter	Location				
	Muscat (1979)	Sindh (2004)	Mangalore (2006)	Mumbai 1 (2005)	Mumbai 2 (2005)
Nos. examined	03	01	01	01	01
Sex	Male	Male	Male	Male	Male
Greatest body depth (% SL)	41- 43	41.7	41.8	41.9	42
Head length (% SL)	42- 43	39.2	44.0	35	37
Pectoral fin length (% SL)	29-32	29.2	29.2	33	32
Pelvic fin length (% SL)	25-29	28.3	29.2	24.1	23.7
Caudal peduncle length (% SL)	20-22	20.8	20.3	15.9	14.7
Caudal peduncle depth (% SL)	12 - 14	12.5	12.3	13.1	11.4
First dorsal spine length (% SL)	6.4-7.3	5.8	6	6.1	6.5
Second dorsal spine length (% SL)	9.7-11	7.5	9.9	8.9	9.2
Third dorsal spine length (% SL)	52-66	55	50.8	53	54.6
Fourth dorsal spine length (% SL)	13-15	14.2	13.6	13.2	14.6
Third dorsal soft ray length (% SL)	50-52	47.5	52.5	49.1	49.2
Anal fin length (% SL)	33-36	32.5	31.8	30.5	26.1
First anal spine length (% SL)	7.6-8	7.5	7.3	7.4	7.6
Second anal spine length (% SL)	14-17	15	14.6	14.1	14.4
Second anal soft ray length (% SL)	26-29	25	27.8	24.3	27.1
Pelvic fin length (% SL)	15-18	15	15.2	15.7	17.2
Snout length (% HL)	20-21	21.3	20.4	20.3	20.9
Orbit length (% HL)	26-28	27.7	27.6	22.3	24.2
Inter-orbital width (% HL)	20-22	23.4	22	22	23.3
Post-orbital distance (%HL)	53-56	53.5	57.2	63.1	63.3
Upper jaw length (% HL)	43-44	42.6	42.3	45.3	41
Maxilla depth (% HL)	14-16	17.3	16.3	16.9	17.1
Gill rakers (Upper)	14-16	N.S.*	12	12	12
Gill rakers (Lower)	30-33	N.S.*	27	27	27
Dorsal fin X, 14	X, 14	X, 14	X, 14	X, 14	X, 14
Anal fin	III, 7	III, 7	III, 7	III, 7	III, 7

Shoreseine (Yendi) operations during the monsoons at Karwar, Uttar Kannada District of Karnataka

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After the introduction of trawlers in the 1970s and purseseiners in 1980s, the rampan shoreseine, which was a gear of primary importance along the Uttar Kannada coast, was phased out or replaced and has gradually disappeared. Legislation was promulgated on fishing by mechanised boats in coastal areas in the interest of traditional fishers who fish within 10 m depth. However, the fishing practices of mechanised boats precluded larger quantities and sizes of commercially important species from reaching the nearshore areas where shoreseines are operated, resulting in landings of only small sized finfish and shellfish by shoreseines. Thus in due course of time, the labour intensive rampan fishery turned non-remunerative. Conversely, the yendi shoreseine, which was earlier used to harvest the catch impounded by the rampani net, has survived, though diminished in importance. The main reason for the continued existence of this fishery is that it targets areas and populations of fin- and shellfish not exploited by the trawler and purseseine fishery and caters to the local fresh and dry fish market.

Also, unlike the earlier rampan fishery, which exclusively targeted mackerel and sardine fishery during the October-March period, the yendi is now operated year round. In addition, the Government of Karnataka imposes a regular ban on mechanised fishery for boats powered with engines above 10 HP as a resource conservation effort. The ban normally extends over 47 days from 15th June to 31st July each year, covering monsoon months. During this period the local population depend mainly on shoreseines. The present study is an analysis of this fishery during the monsoon of 2008 at Karwar.

The yendi shoreseine operations were regularly monitored during the monsoon months (July and August) at Aligadda, the main landing centre for non-mechanised boats in Karwar. Data on species composition, catch, number of hauls and other details relevant to this fishery were collected.

Mesh size varies from 4 mm in the middle of the net, 6 mm in the lower middle and 8 mm at the ends of the net. The end portions of the net consist of nylon netting of no. 2 gauge, whereas the middle pieces are made of no. 3 gauge nylon netting (Fig. 1). The height of the net in the middle is approximately 25-26 feet and decreases to 13 ft height at both ends. The length of the net varies from 400 to 1000 m. The shoreseines weigh between 200 and 300 kg.

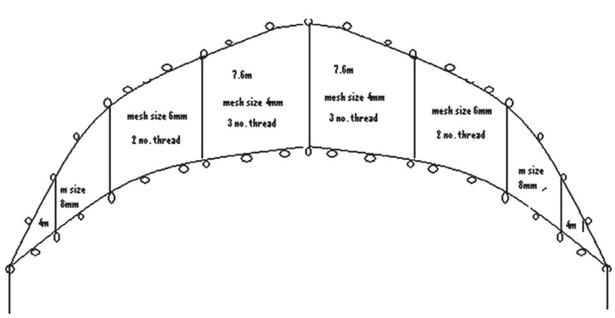

Fig. 1. Pictorial depiction of a conventional yendi shoreseine

The gear is operated at depths from 0 to 6 m. Operations take place normally from 0600 to 0830 hours. Operations are also launched during other daylight hours if shoals of fin- or shellfish are noticed. The shoreseine is operated by loading the net on to a small dhoni boat (8.5-10.7 m AOL), which then sails in a semicircular fashion, paying out the net, to a point at approximately 350-400 m from the starting point. This process is completed in 15-20 minutes. The net is hauled immediately after the dhoni reaches the end point. The hauling process is completed in 1½ to 2 h (Fig. 2).

Fig. 2. Hauling the shoreseine

The frequency of operation of this gear is dependant on the availability of the target species, penaeid shrimps and manpower. Around 36-40 fishers are required to complete one operation during the monsoon. The nets and boats are owned by individuals and fishers are employed for operations as labourers. Revenue generated by the sale of landings is shared between the net owner and the fishers with 30% going to the owner and 70% being distributed equally among the fishers, inclusive of the dhoni boatman. Initial investment required at present is Rs. 40,000/- for a new dhoni boat and Rs.1.5 lakhs for a net. The major remuneration from yendi operations during the monsoons comes from the sale of penaeid shrimp caught. Depending on the quantity and size of shrimps caught, remunerations per haul fetches Rs.3,000-15,000/-. In hauls where shrimps are absent, remuneration per haul fall to Rs. 2,000 - 2,500/-.

In Karwar area, there are 16 nets operated in Aligadda, 22 in Kajubagh area and 15 in Kodibagh area. Of these only 1-3 nets are used per beach on a day in Aligadda area and upto 5-6 nets per day in Kajubagh area, owing to the presence of a longer stretch of beach.

The fishery during the period July-August 2008 was constituted mainly by the burrowing goby *Trypuachen vagina* (Fig. 3), forming 62.5% with a CPUE of 190 kg, followed by the tail eyed goby *Parachaeturichthys polynema* (Fig. 4) forming 12% with a CPUE of 36.2 kg, shrimps (10.81%) with a

CPUE of 32.7 kg, *Ambassis* sp. (7.74%) with a CPUE 23.43 kg, portunid crabs (4.48%) with a CPUE of 13.5 kg and other fishes (Table 1). *T. vagina* commonly called “loote” formed the dominant species in the landings, with the proportions of the catch increasing in August. Size range varied from 95-200 mm TL. The catch, having no market locally, was sold to agents from Goa who transported it in boxes with ice. The tail eyed goby *P. polynema* (Fig. 4), commonly called “mannuli”, formed the next major constituent of the fishery. Its catch declined during August. Size range recorded was from 84 to 104 mm TL. Sciaenids landed are mainly constituted by *Johnius belangeri* and *J. carutta*. Six species of leiognathids were landed, namely *Leiognathus bindus*, *L. blochii, L. brevirostris*, *L. splendens, Secutor insidator* and *S. ruconis*. Of these *L. blochii* and *S. ruconis* were dominant. *Pisodonophis cancrivorous* was the main eel species landed. *Thryssa malabaricus, T. setirostris* and *T. vittirostris* were the major engraulids landed. The major penaeid shrimps landed were *Penaeus merguiensis* and *Fenneropenaeus indicus.* Portunid crabs landed were *Portunus sanguinolentus and P. pelagicus.*

Juveniles of *Scomberomorus commerson, Leiognathus* spp., *Alectis ciliaris, A. indicus, Gnathonodon speciosus, Trachynotus blochii, Lutjanus russelli, L. johni* and *Sardinella* spp. were regularly observed during the fishery.

The catch is sorted and washed at the landing centre itself and sold in auction by the fisher ladies. During the monsoon season dealers from Goa frequent this landing centre for purchases. *T. vagina*

Table 1. Species composition of yendi shoreseine landings (kg) during the monsoon months

Species	July	August	Total	CPUE	%
Trypauchen vagina	14529	37688	52217	189.19	62.53
Parachaeturichthys polynema	7363	2638	10001	36.24	11.98
Ambassis sp.	6019	448	6467	23.43	7.74
Lactarius lactarius	124	243	367	1.33	0.44
Penaeid shrimps	2077	6953	9030	32.72	10.81
Portunid crabs	1917	1826	3743	13.56	4.48
Platycephalus crocodilus	134		134	0.49	0.16
Eels	388	37	425	1.54	0.51
Scomberomorus commerson (juvenile)	93		93	0.34	0.11
Lagocephalus inermis	326		326	1.18	0.39
Johnius spp.	93		93	0.34	0.11
Cynoglossus macrostomus	109		109	0.39	0.13
Solea elongata		75	75	0.27	0.09
Leiognathus spp.		53	53	0.19	0.06
Thryssa spp.		252	252	0.91	0.3
Miscellaneous	62	62	124	0.45	0.15
Total	33234	50275	83509	302.57	100
No. of boat trips	155	121	276	1	

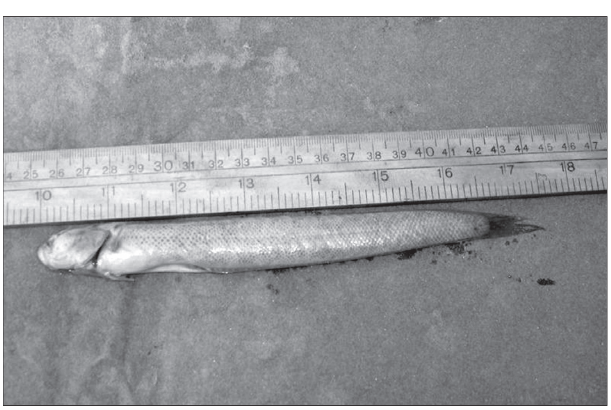

Fig. 3. *Trypauchen vagina*

Fig. 4. *Parachaeturichthys polynema*

fetches a price of Rs.6-8/kg. When there is demand from the dealers, *P. polynema* is sold for Rs. 3/kg. Otherwise the catch is discarded on the beach itself.

The annually recurring increased occurrence of *T. vagina* and *P. polynema* in the yendi shoreseine fishery is purely a monsoon phenomenon and is absent during other seasons of the year. As these fishes are poor swimmers and most of the catch is comprised of adults, it is possible that they are ordinarily denizens of the Kali river mouth, which is 2 km north of the current fishing ground, and that they get transported to the nearshore areas by local currents during the monsoons. A southerly drift of currents along the North Kanara coast has been mentioned by earlier workers (Noble, 1968). Dominant commercial species such as *Sardinella longiceps* and *Rastrelliger kanagurta* fail to make any significant contribution to the shoreseine monsoon fishery unlike in other months. Their absence is probably due to the lowering of surface salinity (6-15.5 ppt) in nearshore areas due to heavy river discharge during the monsoon, these species being highly susceptible to definite changes in hydrological conditions. The smooth blassop *Lagocephalus inermis*, which causes loss to shoreseine fishers by damaging the gear is also absent during this period.

The yendi shoreseine fishery provides income to traditional fishers during the monsoon months and also fresh fish to local communities. Being a comparatively non-destructive gear and the mainstay of livelihood during the lean period, this fishery should be encouraged with better marketing facilities and value addition of catch.

A large ray *Mobula diabolus* landed at Ponnani, Kerala

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On 23rd June 2009, a large ray *Mobula diabolus* was landed at Ponnani. The gear used was driftnet which was operated at 34 m depth. The weight of the ray was approximately 900 kg.

The measurement details are given below:

Fin to fin length	:	492 cm
Cephalic horn length	:	59 cm
Gap between cephalic horns	:	60 cm
Length (from head to caudal base)	:	221 cm
Length of tail	:	54 cm
Body width	:	188 cm

Fig. 1. *Mobula diabolus* landed at Ponnani