Proc Zool Soc (July-Sept 2019) 72(3):263–272
https://doi.org/10.1007/s12595-018-0267-x

RESEARCH ARTICLE

Paradigm Shift in Fishing Technology of Chilika: The Largest Brackish Water Wetland of Asia

Saibala Parida[1] · Pranaya K. Parida[2] · Krupasindhu Bhatta[1] · Subodha K. Karna[2]

Received: 7 November 2017 / Revised: 26 March 2018 / Accepted: 18 June 2018 / Published online: 29 August 2018

Abstract Chilika is the largest brackish water wetland of Asia and well known for its fish and fisheries. Traditional fishing methods in Chilika were of specific characters and endemic in nature and quite different from the fishing practices found in other parts of the country. With change in time and advancement of technology, the materials being used have been changed though methods of fishing are almost similar. The traditional fishing methods were (1) Bahani (net fishing), (2) Jano fishing (enclosure fishery), (3) Dian fishery (peripheral fishery near Jano), (4) Uthapani fishery (catching of landward moving fishes during early monsoon) and Prawn khati (trap fishery). Modern fishing gears like Khanda (filament twine net box), Gill net, Drag net, Almi net (boat seine), Hooks and line, Cast net, Bag net and various traps are in operation in the lagoon, replacing the traditional fishing gear. Out of the new fishing gears few are detrimental to the fisheries of the Chilika. Suitable policy guidelines may be implemented for regulating the mesh size and the operational area for improving the fisheries resources of Chilika.

Keywords Fishing gears · Traditional fishing methods · Modern fishing methods · Fishing crafts · Chilika lagoon

✉ Pranaya K. Parida
pranayaparida@gmail.com

[1] Chilika Development Authority, C-11, BJB Nagar, Bhubaneswar, Odisha 751014, India

[2] ICAR - Central Inland Fisheries Research Institute, Barrackpore, Kolkata 700120, India

Introduction

Chilika lagoon is regarded as a Ramsar site of international importance because of its rich biodiversity and the largest brackish water tropical coastal lagoon located at east coast of India (Mohanty et al. 2007). Total length of Chilika is 64.3 km and maximum breadth is 18 km. The water spread area is 906 km^2 in summer and 1165 km^2 in monsoon. The total catchment area of the lagoon is 3560 km^2 (Ghosh and Pattanaik 2005). Ecologically, it has been divided into four sectors; southern, central, northern and outer channel. Basically the northern sector is fresh water dominated zone, central sector is a brackish water zone and southern sector is a higher saline area. The outer channel sector is marine in nature with high salinity but during monsoon, the sector turns into fresh due to discharge of flood water through this zone into the sea (World Bank 2005). Temperate and subtropical estuaries are widely recognized as productive areas which serve as habitat for many fish species (Boesch and Turner 1984). Chilika has a great seasonal fluctuation in salinity, turbidity, tidal effect of water current and other environmental factor, for this reason, the lake is having high diversity of flora and fauna. Fishing gears are fundamental part of the fishing process, without the fishing gears human being are very ineffective predators in the aquatic environments (Watson et al. 2006). Chilika lagoon is one of the major sources of capture fisheries of Odisha, supports nutritional and livelihood security to more than 0.2 million fisher folk living in and around the lagoon (Mohanty et al. 2009; CDA 2013). As one of the direct benefits of Chilika ecosystem, fisheries output shares more than 71% of its economic value. Chilika lagoon also supports the state economy to a large extent through fisheries, which is about 4.6 billion INR (CDA 2013). Fish production of the lagoon significantly

increased after opening of the new mouth on the east coast of the lagoon in September 2000 (Mohapatra et al. 2007; Mohanty et al. 2009; CDA 2013). But in recent years, the fisheries and biodiversity of the lagoon suffered the most, both due to natural and man induced perturbations. Many investigations has been done about the fish diversity (Jones and Sujansinghani 1954; Satpathy and Panda 2009; Mohapatra et al. 2007) and fish landing of Chilika (Bhatta and Panda 2008; Parida et al. 2013a, b). Although, some overviews of different gears operated in Chilika have been reported (Mohapatra 1955; Jhingran and Patnaik 1964; Roy and Banerjee 1980; Bhatta and Samant 1986; Remesan et al. 2011; Parida et al. 2013a), but a complete scenario of fishing crafts, gears and mode of operation throughout the lagoon is still scanty. Viewing of this gap, an effort has been made in the present study to explain the process of shifting of traditional fishing methods to the modern fishing gears in the lagoon.

Materials and Methods

The study was conducted in Chilika lagoon (19°28′–19°54′ North and 85°05′–85°38′ East) (Fig. 1) during June 2011–May 2012. Various information on fishing gears were collected from the field using participatory tools like key informant survey, group discussion and personal observation along with reviewing the earlier available literature. Photos, prototypes of different nets along with their mesh sizes, net material, net dimension, season of operation and variety of fishes caught in different nets were collected. Besides, the old fishermen were contacted during the festive period when they were available in the village for collection of information on traditional fishing methods. Generated data were analyzed using MS Excel 2007.

Results and Discussion

Fishery is one of the most important economic activities in Chilika. Fishermen of the lagoon use different types of gears depending upon their target species and size. In the present investigation it was observed that, there were 5 types of traditional fishing practices operated in different parts of the lagoon (Devasundaram 1952) viz. *Jano* fishing, *Dian* fishery, *Uthapani* fishery, *Bahani* and *Prawn khati*. Previously, these traps were used in large numbers and at present, hardly found in some corners of the lagoon on seasonal basis. However, the present fishing practices can be catagorized into 6 major groups like Barrier net

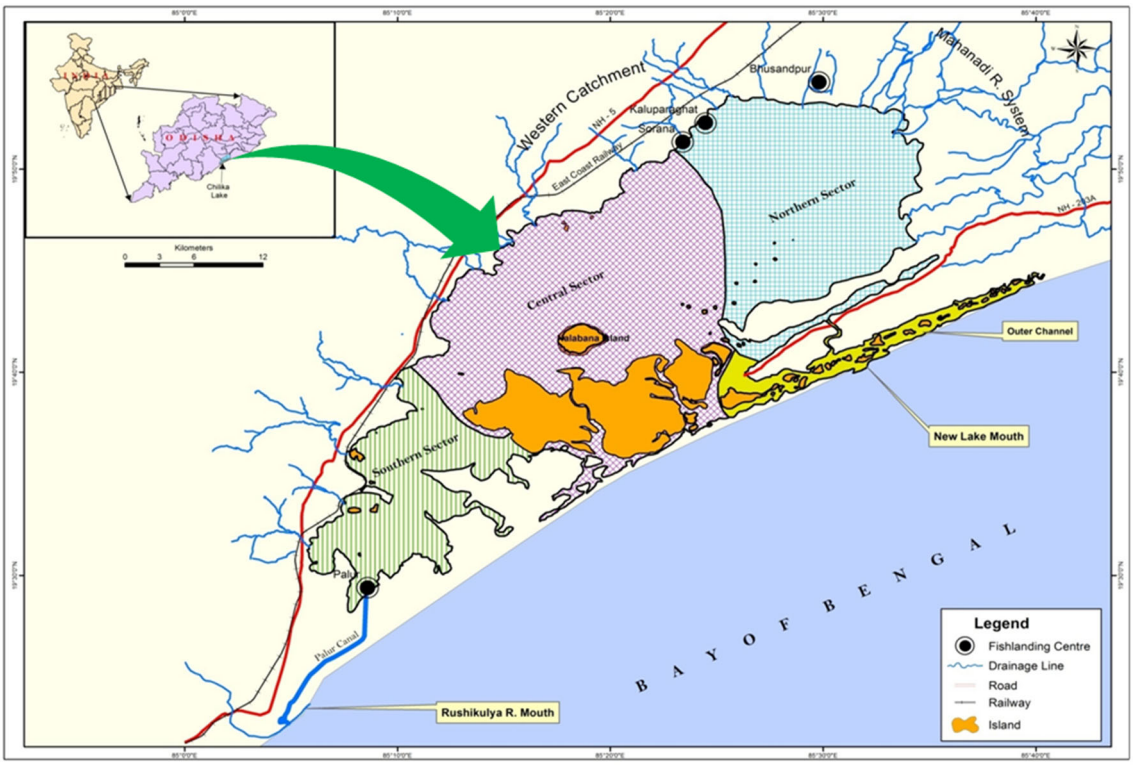

Fig. 1 Location map of Chilika showing ecological sectors

(Khanda), Gill net, Drag net, Hooks and line, Traps (crab trap, prawn trap, murrel trap) and miscellaneous gears like Cast net, Bag net, Scoop net etc. Fishing gears are broadly divided into 2 types: active and passive based on movement of the gear (Welcomme 1983). Both active and passive gears are in operation in Chilika lagoon, but majority of the gears are passive in nature. Therefore, brief details of individual (traditional and modern fishing) gears are presented herewith.

Traditional Methods of Fishing

Jano Fishery (Enclosure Fishery)

Fishing practice, *Jano* was made by enclosing a large area with the help of split bamboo screens in shallow water zones of the lagoon during the month of October to February (Fig. 3a). Jano fishery was targeted to shoals of mullets during their recruitment into the lagoon, in the post flood situation. During this time, mullets migrate from sea to lagoon in large shoals for feeding and shelter purpose. During the migration of mullets, fishers enclose the large shoals in shallow areas for a period of 5–6 months to grow with natural feed available. After 5–6 months they were caught from Jano area to be sold in the market. There are three types of Janos operated in Chilika, one is circular in shape and other two are semicircular and U shaped connecting to the shoreline of the lagoon. During 1960s more than 112 numbers of Jano (134.76 km^2) were operated in Chilika (Jhingran and Natarajan 1969) which was reduced to 83 in 1993 (Mohanty et al. 2004). During the present study, it was observed that most of these Jano areas were converted into prawn gheries. The mullet catch was started declining after loss of Jano fishery grounds from 1995 onwards. Presently, Jano units are non-existent in Chilika due to expansion of prawn gharries (Mohanty et al. 2004). Jano fishing method was one of the eco-friendly fishing methods.

Dian Sources

This was a fishing practice operated in shallow water areas in the periphery of Jano grounds, and considered as a minor fishery. The fishes jump out or escaped from the split bamboo screen wall of Jano enclosures to shallow waters were caught by the fishermen. This fishing practice was known as Dian sources. Generally mullets and other small fishes were caught from Dian sources.

Uthapani Fisheries

This type of fishing was carried out in shallow areas adjacent to the shoreline and around islands during the first rains. Catfishes were contributed the major share of the Uthapani fishery. Uthapani contributes minor share to the annual fish landing of the lagoon. During first rain, the water from upland flows into the lagoon and at the same time catfishes like *Mystus* sp. and other fishes move landwards against water flow in large numbers. Those catfishes were caught by traps fixed in temporary small earthen check dams. Uthapani fishery was also reported as a fishing practice of Chilika by Jhingran and Natarajan (1969), which is no more in operation in the lagoon.

Bahani Fishery (Net Fishing)

Net fishing operations in Chilika lagoon are locally called *Bahani* (Fig. 3b), which were carried out in deeper waters of Chilika. Drag nets, gill nets of different mesh sizes were operated in Chilika lagoon with the help of plank-built flat bottom boats. Bahani fishing is operated throughout the year from the leased out fishery sources. Bahani fishery contributes around 50% to the annual fish landing. This method of fishing is still continuing in Chilika, however the average mesh size of the fishing gears has decreased with time.

Prawn Khati (Trap Fishing)

Traditional prawn khaties or prawn fisheries were operated in the leased out specified area for a particular period. Prawn fishing was carried out by split bamboo traps, set with a leader line of split bamboo screen having specified length. The bigger traps are known as *Dhaudi* and the smaller traps are *Baja*. Operation of prawn khati in Chilika was also reported by Mohapatra (1955). All penaeid prawns (*Penaeus monodon*, *Penaeus indicus*, *Metapenaeus monoceros*, *Metapenaeus dobsoni* and *Penaeus semisulcatus* etc.) are generally targeted in Dhaudi and smaller prawns (*Metapenaeus* sp. and fresh water prawns) in Baja. These traps operated during the month of March to August which contributes good amount of prawn catch to the annual fish landings. Now traditional prawn fisheries are either converted to prawn gheries or Khanda fishing, which are operated throughout the year and adversely affecting the migration and recruitment routes of most brackish water fishes.

Modern Fishing Methods

Of all modern gears, some are seasonal and some are used throughout the year. As water depth varies significantly among sectors, operation of fishing gears also varies sector to sector (Table 1). Among gears, screen barrier nets are used massively by the fishermen in the lake, accounted about 44% in number followed by 29% gill nets, 13% seine

nets, 9% traps, 2.2% hook and line and 1.9% sieve nets. Other fishing gears constituted 3% only (Fig. 2).

Barrier Net

Presently, Barrier net (*Khanda*) fishing is the most dominant fishing method among other methods operating in Chilika. Generally, *Khanda* (Fig. 3c) is made up of a long leader line with fish catching traps at fixed intervals. These screens or leader walls are made up of with High Density Polyethylene (HDP) nets. Different mesh size nets are used for preparation of leader line and traps (boxes), as per the species of targets. At present, about 5 types of *Khanda* are in operation in the in the lagoon, contributing major share to the commercial fishery of Chilika by catching all varieties and all sizes of fish and prawn. Juveniles of many fishes, prawns and crabs are also caught in *Khanda* since mesh size of net boxes are small and the trap is operated throughout the year. This fishing practice is adversely affecting the population of fish, prawn and crab along with the ecosystem of the lagoon. Mesh size of 'trap boxes' (locally called *puda*), length and spacing of leader lines and their concentration particularly along the recruitment routes i.e., along outer channel, Magarmukh, dredge channel and in Palur canal need to be regulated to attain sustainable fisheries in the lagoon.

Gill Net

Gill net is a major fishing gear, made up of nylon monofilament and operated in Chilika for catching targeted finfishes like mullets, seabass, polynemids, catfishes, clupeids and sciaenids. According to the targeted species and fishing grounds, various types of gill nets (species specific) are being operated. Commonly operated gill nets are *Disco jal* (Fig. 3d), *Saragara jal* (Fig. 3e), *Dubi jal, Sahala jal, Tar jal, Bhekti jal* (Fig. 3f), *Menji jal* etc. Gill nets contribute major share of commercial fish landing after Khanda. The 3-layred gill net (trammel net) with three different mesh sizes used in Chilika is known as "Dubi jal/ Super jal". This tramel net is operated from motorized boat by 4–5 fishermen to cast the net and one fisherman for operating the boat. In this method, a shoal of fish is encircled with the help of boat and the water is disturbed using bamboo poles to make the fish swim very fast and entangle themselves in the net. Encircling gill nets operated in the surface layers of the lagoon. After encircling a fish shoal, noise and other vibrations created by beating on the sides of boats or throwing pin stones into the water, driving the fish towards the net, by which fish will be either gilled or entangled. This type of fishing method was also explained by George in 1971.

Drag Net

Drag net (seine net) is an important active fishing gear operated in Chilika (Fig. 4a), which contributes a major share after Khanda and gill nets. The mesh size of different seine nets prevalent in the lagoon varies from 0 to 18 mm. Seine net is made up of nylon mono filaments with 500–900 m length and about 1.6 m depth, operated in central and periphery of southern sector of the lagoon, because of non availability of macrophytes. Small sized fishes like *Thryssa* sp., *Stolephorus* sp., *Nematalosa nasus* etc. are caught in huge quantity. One end of the net is fixed with boat while other end is tuned into semicircle by dragging the net towards boat with the help of 5–10 numbers of fishermen. But in this fishing gear, non-commercial fishes along with juveniles and fingerlings of many commercial fishes are caught, which is a matter of great concern for the ecosystem and their fisheries resource for proper management.

Patua Jal

This gear is having smaller mesh size of about 12–16 mm and used to catch *Stolephorus* sp.) (Figure 4b). However, the operation of small meshed patua jal is detrimental to the species like *Eleutheronema tetradactylum*, *Etroplus suratensis*, *Daysciaena albida*, *Nematalosa nasus* etc. as the juvenile of above species are caught in this net, before they contribute to the lagoon fishery. This gear is operated by 20–30 numbers of fishermen in the similar principles of drag net.

Alimi Jal

This giant size boat seine made up of mono filament twine having a length of about 500–900 m, operated near the mouth area along the outer channel to cover almost the entire width of the channel. Large shoals of immigrating fishes from sea to lagoon like *Tenualosa illisa*, *E. tetradactylum*, mullets etc. are caught by this net during breeding season (September–January). Operation of this huge net in the lagoon mouth area has become a serious threat to the rare Irrawady dolphins (*Orcaella brevirostris*) (Sutaria 2009) and fisheries of Chilika by catching the brood fishes.

Hook and Line

Hook and line fishing is operated by resettled Bengali fishermen (refugees from Bangaladesh) (Fig. 4c). In this method, fishing is carried out in small wooden country boat and the gear made up of nylon monofilament twine with (0.8–2.0 mm) diameter having a length of 50–200 m is

Table 1 Details of fishing gears operated in different areas of the Chilika lagoon

Fishing gears	Local name	Mesh size/dimension	Active/passive gear	Area of operation in lagoon	No of fishermen involved	Operational month
Barrier net	Fish khanda	38	Passive gear	Whole lagoon	3–4	Throughout the year
	Fish khanda	24	Passive gear	Whole lagoon	3–4	Throughout the year
	Khanda	20	Passive gear	Whole lagoon	3–5	Throughout the year
	Prawn khanda	16	Passive gear	Central and northern sector	3–6	Jan–July
	Panu khanda	8	Passive gear	Central and northern sector	3–6	Feb–June
Gill net	Dubi jal (Trammel net)	60	Passive gear	Whole lagoon	5–6	Throughout the year
	Disco jal	54	Passive gear	Whole lagoon	6–7	Throughout the year
	Sahal jal	58	Passive gear	Whole lagoon	5–6	April–Sept
	Tar jal	70	Passive gear	Whole lagoon	5–6	Throughout the year
	Bhekti jal	65	Passive gear	Whole lagoon (except outer channel sector)	5–6	Aug–Dec
	Saragara jal	20	Passive gear	Whole lagoon (except outer channel sector)	4–5	Throughout the year
	Menji jal	35	Passive gear	Whole lagoon (except outer channel sector)	5–6	Throughout the year
Seine net (Drag net)	Almi jal	18	Active gear	Outer channel sector	5–6	Throughout the year
	Boby jal	15	Active gear	Whole lagoon (except outer channel sector)	5–6	Throughout the year
	Patua jal	12	Active gear	Whole lagoon (except outer channel sector)	25–30	Throughout the year
	Masari jal	0	Active gear	Whole lagoon (except outer channel sector)	4–5	Throughout the year
Hook and line	Kanta size (hook size)	12	Passive gear	Whole lagoon (except northern sector)	2	Throughout the year
	Kanta size (hook size)	10	Passive gear	Whole lagoon (except northern sector)	2	Throughout the year
	Kanta size (hook size)	5	Passive gear	Whole lagoon (except northern sector)	2	Throughout the year
	Kanta size (hook size)	4	Passive gear	Whole lagoon (except northern sector)	2	Throughout the year
	Kanta size (hook size)	3	Passive gear	Whole lagoon (except northern sector)	2	Throughout the year
	Kanta size (hook size)	1	Passive gear	Whole lagoon (except northern sector)	2	Throughout the year
Trap	Kankada Khadia (Crab trap)	50 cm × 20 cm × 50 cm	Passive gear	Central and outer channel sector	2	Except summer season
	Murrel trap	45 cm × 45 cm × 45 cm	Passive gear	Northern sector	2–3	November–June
	Prawn trap	85 cm × 25 cm × 85 cm	Passive gear	Northern sector	2–3	November–June
Others	Bag net	25–40 mm and cod end 10–15 mm	Passive gear	Outer channel sector	4–5	November–June
	Cast net	10–25 mm	Active gear	Outer channel sector	1	Throughout the year
	Scoop net	5–10 mm	Active gear	Central and outer channel sector	1	Throughout the year

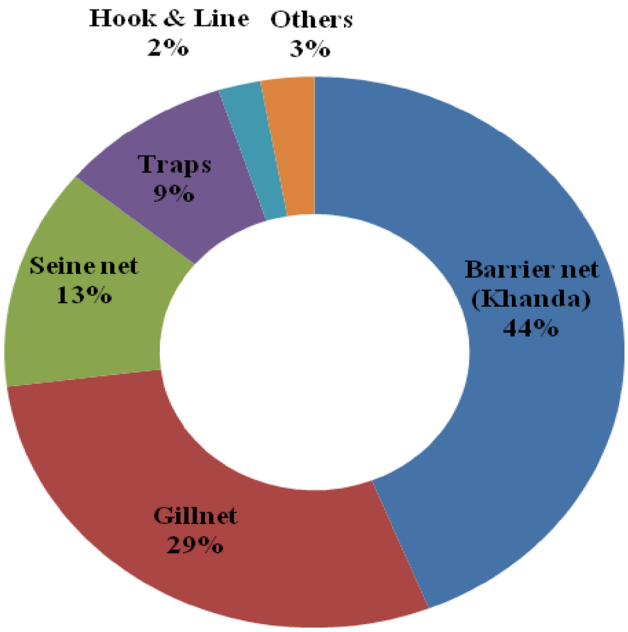

Fig. 2 Percentage contributions of fish catch by different fishing gears in Chilika lagoon

used as the main line. The branch line is of 1 m length and 0.6 mm diameter to which barbed hooks of size (numbers) ranging from 1 to 15 are attached. Most of the fishermen use two hooks of smaller sizes on the main line. A lead piece or an iron ring weighing 20–30 g is attached at one end of the main line to keep the hook closer to the bottom. One or two fisherman carried out fishing operations during early morning at a depth of 1.0–3.0 m in the lagoon. Each group of fisherman operates 6–7 numbers of main lines with different hook size. The hook and line fishing locally known as "Suti-kanta" is used in Chilika targeting at *Plotossus cannius, Lates calcarifer,* Croakers, Murrels, Perches etc.

Cast Net

Cast net, (locally called *Finga jal*) is another traditional fishing gear used in small scale particularly in outer channel area of the Chilika (Fig. 4d). Nylon mono and multi filaments are used for fabrication of the net. At present, readymade webbings available are used for fabrication by shaping and joining the different pieces of nets. Main webbing is folded inwards and fixed to the body of the net at regular intervals to form pockets. These peripheral pockets along the footrope are used for collecting fishes. The net used in Chilika are having 5–20 mm mesh size attached to a metal ring and the lower end of the gear has 10–40 meshes attach to hauling lines. Small lead sinkers of aggregate weight 2.0–3.0 kg are attached to the lower end of the net. Cast nets are used for catching small fishes, prawns, and are operated in both day and night time.

Bag Net

Bag net is a conical shape passive gear, made up of nylon twine ranging from 1.5 to 2.0 mm diameter with mesh 100 mm in the mouth region reducing to 20 mm at the cod end (Fig. 4e). The mouth of the net always fixed against the flow of the current using 20–24 mm HDPE ropes, which is opened with the help of bamboo poles fixed at both ends of the wing and near the bottom region of the net. Fishes are collected at the cod end as the water current drive the fish inside the net. These nets are generally used only when there is sufficient flow of water current. These nets are set at night and hauled at early morning. The contribution of bagnet to the total fish landing of Chilika is very minimal.

Crab Traps

Crab traps are locally called "*Kankada khadia*" made up of split bamboo, having a dimension of 50 cm × 20 cm × 50 cm (length × breadth × height) (Fig. 4f). The crabs enter into the trap through non returnable entrance, which is made up of 14 sticks of 20 cm each. At four corners, stones are attached as sinkers, weighing about 400 g each. Trash fish is kept inside the trap as bait to attract mud crabs. Fishermen used about 15–20 traps at a time for a period of 10–12 h. Another type of crab trap locally called as "*bonda*" is also used in the lagoon. It is made up of nylon net attached to a rectangular bamboo frame of dimension 60 cm × 60 cm. The bamboo frame is hanged with four piece of nylon twine attached to a single float. Four sinkers are attached at the four corner of the bamboo frame. Trash fishes are kept inside the nylon net as bait to magnetize the crab to be trapped in the net attached to rectangular bamboo frame. The crab entangled in the nylon webbing can't escape from the net. After setting the traps, they were periodically checked and collect live crab from the trap without breaking their legs for good price in the export market. Crab traps are operated frequently in outer channel sector of the lagoon.

Murrel Trap

Murrel trap mostly used in northern sector of Chilika, especially in the weed infested areas (Fig. 5a). These are square shaped boxes made up of spilt bamboo. The dimensions of these traps are about 45 × 45 × 45 cm. The non returnable mouth is also made up of bamboo strips having 18 cm long. These traps are set during evening for about 10–12 h. Live fishes collected from these traps are kept in aluminum boxes and pots containing water; meant

Fig. 3 **a** Traditional *Jano*, **b** Bahani, **c** Khanda, **d** Gill net—Disco jal, **e** Gill net—Saragara jal, **f** Gill net—Bhekti jal

for live fish transportation to West Bengal (mainly to Howrah fish market) for fetching high market price.

Prawn Traps

There were two types of prawn traps operated in Chilika. Bigger one is known as *Dhaudi* (Fig. 5b) operated in deeper zone having water depth 1.0–1.5 m while, smaller one's are known as *Baja* (Fig. 5c) operated in shallow areas (water depth 0.5–6.0 m). Dhaudi (85 × 25 × 85 cm), having two non returnable entrances and are made up of spilt bamboo. A sub merged ladder line of about 20 m long made up of HDPE netting is fixed in shallow region across the channel (in traditional fishing ladder line of split bamboo mat was used). Around 10–15 traps are arranged together facing the entrance funnel of the traps towards the shore. The ladder line forces the prawns to be guided automatically to the enclosures and gradually the prawn falls in to the trap. Baja (prawn trap) is the smaller dimension of prawn traps used to capture smaller sized prawns (*Metapenaeus* sp.) and other small fishes. Both these traps are used massively in the shore-lines of northern sector only.

Scoop Net

Scoop net is a small hand net (Fig. 5d) operated by a single person. This net is having a handle to which a small bag made up of netting material is attached. Scoop net is generally used to catch small fish from surface waters. The contribution of scoop net is negligible to the total fish landing of Chilika.

Fishing Crafts of Chilika

The commonly used fishing craft in Chilika is wooden plank-built canoes, known as *Danga* or *Naha*. The fishing crafts (*Danga*) are categorized as motorized boat (canoes with 6.0–9.0 HP engines), medium size boat and small boats (locally called *refugee boat*). The dimension of

Fig. 4 **a** Drag net, **b** Drag net—Patua net, **c** Hook and line, **d** Cast net, **e** Bag net, **f** Crab trap

motorized *Danga*, has a length ranged from 12 to 15 m, width 1.8 to 2.1 m with a depth of 0.45 to 0.6 m. Motorized boats are used for transportation of fishes and other domestic materials inside the lagoon. Medium size boats, having a dimension of 8–12 m length, width 1.3–1.5 m, used mostly for fishing purposes. Refugee boats are small canoes with dimension of 7.5 m × 1.0 m × 0.45 m and are operated manually for hook and line fishing.

Sector Wise Variation in Operation of Gear

Traps dominant in the Northen sector of the lagoon as it is shallow in nature. The central sector, where mean water depth is below 2 m, the fishermen use wider nets along with hooks and lines (Suti-kanta). Southern sector is having higher water depth (1.5–3 m), it forces fishermen to fish mostly in the periphery. However, some fishermen used to fish in the higher water depths area with medium to large meshed gill nets having width 1.5–2 m. The outer channel prevails with high current, so fishermen use different types of nets with heavy anchors attached to them to withstand the force of the water current.

Conclusion

Most of the traditional fishing methods like Jano fishing (enclosure fishery), Dian fishery (peripheral fishery near Jano), Uthapani fishery (catching of landward moving fishes during early monsoon) and Prawn khati (trap fishery) are gradually decreasing in operation which found hardly in some patches of the lagoon. However, these traditional fishing practices were eco-friendly in nature without having any negative impact on the fishery resources of Chilika. At present, these traditional gears are replaced by new fishing methods. Among the new fishing methods, Khanda, Almi net and Patua jal (smaller mesh size dragnet) are detrimental for the environment as they are catching the

Fig. 5 **a** Murrel trap, **b** Prawn trap—Dhaudi, **c** Prawn trap—Baja, **d** Scoop net

juveniles along with the target fish and prawn species. The present fishing practice is also blocking the migration route of many commercial migratory species. As Chilika fishery is well-known for the migratory brackish water fishes, policies should be made to regulate the mesh size of the nets used for preventing the catch of juveniles and declaring the migratory route as non fishing zones to improve the fishery resources in the lagoon.

Acknowledgements The authors are thankful to the fishermen of Chilika lagoon: Kalia Behera (Kalupadaghat), Rama Chandra Behera (Chandraput), Kalia Behera (Gajpatinagar), Bidesi Behera (Alupatna) for sharing their valuable fishing knowledge. Thanks are also due to Manas Maharana, Padma Charan Pradhan, Sadananda Sahu and Bhikari Jena, fish landing surveyor for their support during this study. The authors also thankful to Ministry of Forest and Environment, Govt. of India, New Delhi for financial support for the current study.

References

Bhatta, K.S. and S. Panda. 2008. Post hydrological changes in landings of Fishery resources in Chilika lagoon. In *Proceeding of Taal 2007: The 12th World Lake conference,* 1894–1902.

Bhatta, K.S. and N.C.S. Samant. 1986. Crafts and Gears of Chilika. In *National Conference on Natural Heritage Conservation, Berhampur, Orissa*, 18.

Boesch, D.F., and R.E. Turner. 1984. Dependence of fishery species on salt marshes: The role of food and refuge. *Estuaries* 7: 460–468.

CDA. 2013. Annual report of Chilika Development Authority, Bhubaneswar, 1–53.

Devasundaram, M.P. 1952. Fishing methods for Chilika mullets. *Indian Farming* 12 (1–2): 22–25.

George, V.C. 1971. *An account of the inland fishing gears and methods in India.* Special Bulletin No 1, CIFT Kochin.

Ghosh, A.K. and A.K. Pattanaik. 2005. Chilika Lagoon: Experience and lessons learned brief. In *UNEP International Waters Learning Exchange and Resourse Network*. http://iwlearn.net/iw-projects/1665/experience-notes-and-lessons-learned/chilika/lagoon 115–132.

Jhingran, V.G., and A.V. Natarajan. 1969. A study of the fisheries and fish populations of the Chilika Lake during the period 1957–65. *Journal of the Inland Fisheries Society of India* 1: 49–126.

Jhingran, V.G., and S. Patnaik. 1964. On some interesting methods of fishing *Sparus* sp. 'Khuranti' in the Chilika lake. *Journal of Bombay Natural History Society* 61 (3): 701–703.

Jones, S., and K.H. Sujansinghani. 1954. Fish and fisheries of the Chilika Lake with statistics of fish catches for the years 1948–1950. *Indian Journal of Fisheries* 1 (1&2): 256–344.

Mohanty, R.K., A. Mohapatra, and S.K. Mohanty. 2009. Assessment of the impact of a new artificial lake mouth on the hydrology and fisheries of the Chilika Lake, India. *Lakes, Reservoir: Research and Management* 14: 231–245.

Mohanty, S.K., K.S. Bhatta, S. Mishra, A. Mohapatra, and A.K. Pattanaik. 2004. Fisheries enhancement after hydrological intervention in Chilika and strategies for responsible management. In *National seminar on responsible fisheries and aquaculture,* 67.

Mohanty, S.K., K.S. Bhatta, R.K. Mohanty, S. Mishra, A. Mohapatra, and A.K. Pattanaik. 2007. Eco-restoration impact on fishery biodiversity and population structure in Chilika Lake. In *Lakes and coastal wetlands*, ed. P.K. Mohanty, 24–44. Dordrecht: Springer.

Mohapatra, A., R.K. Mohanty, S.K. Mohanty, K.S. Bhatta, and N.R. Das. 2007. Fisheries enhancement and biodiversity assessment

of fish, prawn and mud crab in Chilika lagoon through hydrological intervention. *Wetland, Ecology and Management* 15: 229–251.

Mohapatra, P. 1955. The Thatta khanda—A screen trap of the Chilika Lake. *Journal of Bombay Natural History Society* 53 (2): 277–279.

Parida, S., S.K. Karna, K.S. Bhatta, and B.C. Guru. 2013a. Distribution of fishing gears in India's largest brackish water lagoon, India. *Bulletin of Environment, Pharmacology and Life Sciences* 2 (7): 62–67.

Parida, S., D. Mohapatra, and K.S. Bhatta. 2013b. Recent trends in fisheries of Chilika lagoon: A Ramsar site at East coast of India. *Fishing Chimes* 32 (10): 72–75.

Remesan, M.P., P. Pravin, B.K. Pradhan, and B. Meenakumari. 2011. *Fishing methods of Chilika lagoon*, 1–24. Kochi: CIFT Information Series, CIFT Cochin.

Roy, B., and B.K. Banerjee. 1980. *Fishing methods of Chilika Lake*, 1–7. West Bengal: Summer Institute on Brackishwater Capture and Culture fisheries, CIFRI Barrckpore.

Satpathy, D., and S. Panda. 2009. *Fish atlas of Chilika*, 1–74. Bhubaneswar: Chilika Development Authority.

Sutaria, N.D. 2009. Species conservation in a complex socioecological systems, Irrawaddy dolphins, *Orcaella brevirostris* in Chilika lagoon, India. Ph.D. Thesis, James Cook University, Australia. 1–217.

Watson, R., C. Revenga, and Y. Kura. 2006. Fishing gear associated with global marine catches: Database development. *Fisheries Research* 79: 97–102.

Welcomme, R.L. 1983. *River basins*. FAO Fisheries Technical Paper 202, 1–60.

World Bank. 2005. Scenario assessment of provision of environmental flows to Lake Chilika from Naraj Barrage, Orissa, India. Reports from the Environmental flows window of the bank Netherlands Water partnership programme (World Bank) to the Government of Orissa, India, 1–40.