Fish Faunal Diversity of Chilika Lake, Odisha, India

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Abstract:
Chilika Lake, an assemblage of marine, brackish and freshwater ecosystems, on the east coast of India is a designated Ramsar site and a biodiversity hotspot. Intensive Fish Faunal inventories and biodiversity assessments were carried out and now documented 317 species belonging to 207 genera, in 88 families and 23 orders, including two endemic (Gobiidae) and one exotic cichlid species (*Oreochromis mossambicus*). This paper presents that the lake fishery is largely migratory species-dependent. An account of faunal characteristics for 129 commercially important species is provided. This also documents 48 threatened species and 103 species under different categories of conservation status.

Key words: Fishfauna, Chilika Lake, Biodiversity, Checklist, thereatened species, CDA.

INTRODUCTION:

Pisces are the major group of vertebrates which shows an enormous diversity in shape, size, biology and habitat (Bobdey, 014). Biodiversity is an important factor for the stability of an ecosystem (Shukla & Singh, 2013). India is one of the megadiversity countries in the world. There are 450 families of freshwater fishes globally, out of which 40 families are represented from India (Keshave et al., 2013)Pisces are the major group of vertebrates which shows an enormous diversity in shape, size, biology and habitat (Bobdey, 2014). Biodiversity is an important factor for the stability of an ecosystem (Shukla & Singh, 2013). India is one of the megadiversity countries in the world. There are 450 families of freshwater fishes globally, out of which 40 families are represented from India (Keshave et al., 2013)Pisces are the major group of vertebrates which shows an enormous diversity in shape, size, biology and habitat (Bobdey, 2014). Biodiversity is an important factor for the stability of an ecosystem (Shukla & Singh, 2013). India is one of the megadiversity countries in the world. There are 450 families of freshwater fishes globally, out of which 40 families are represented from India (Keshave et al., 2013)Pisces are the major group of vertebrates which shows an enormous diversity in shape, size, biology and habitat (Bobdey, 2014). Biodiversity is an important factor for the stability of an ecosystem (Shukla & Singh, 2013). India is one of the megadiversity countries in the world. There are 450 families of freshwater fishes globally, out of which 40 families are represented from India (Keshave et al., 2013)

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Conservation and sustainable management of Fish Faunal biodiversity in an aquatic ecosystem assume a greater importance in India as fishery resources have historically been, and continue to remain, a base for livelihood and access to high quality animal protein. Thus during the pre-restoration period (until 2000) a total of 233 species had been reported as present in the lake. As reported by Mohanty et al. (2007), during 2000–2003 (post-restoration phase) a total of 43 species were recorded for the first time, bringing the total to 276 species.

The present work provides an intensive inventory of the ichthyofauna of Chilika Lake. This will serve as a baseline of the Fish Faunal diversity of the lake and will facilitate future Fish Faunal surveys, monitoring and fish biodiversity studies (Figure 2).

Study Area:

The study area comprises the entire Chilika Lake, which is located along the east coast of India in the state of Odisha between latitudes 19°20′13.06″ N and 19°54′47.02″ N and longitudes 085°06′49.15″ E and 085°35′32.87″ E (Figure 1). The innundation area of the lake varies between 1,165 km^2 during monsoon to a minimum of 906 km2 during the dry summer season. The lake's length is 64.3 km and its mean width 20.1 km (Ghosh and Pattnaik 2005). The lake is separated (Figure 1.1) from the Bay of Bengal by a sandbar of 100–1,500 m width; an outer channel 32 km long connects the main lake with the Bay of Bengal.

(Figure 1: Location map of Chilika lake)

Figure 1.1 (Chilika lake of Odisha)

Materials and Methods:
The work done by following methods
Sampling and data analysis

Fish

samples were collected fort nightly during the study period with help of skilled fishermen by fishing craft and gears with mesh size 3/8 ".

Collected fish species were preserved in 10% formalin in laboratory. The fishes were identified by referring standard literature (Day, 1958; Jhingran, 1992; Jayram, 2010).

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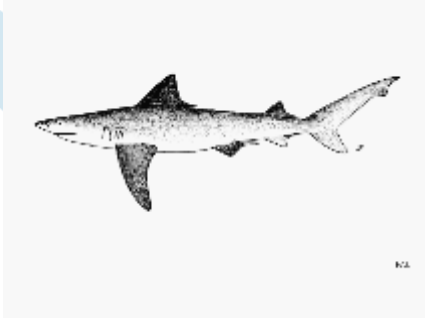
Result & Discussion:

Species diversity

An updated checklist of fishes reported from Chilika Lake during the last 84 years of pre-restoration (1916–2000) and14year sofpost-restoration(2000–2014) results in a total of 317 valid species (18 cartilaginous and 299 bony fishes) belonging to 207 genera, 88 families and 23 orders (Table 1 figure 3). These are inclusive of 77 new records made during the post-restoration period. Eschmeyer and Fong (2014) considered the family Mugilidae as Perciformes and placed this family between Cepolidae and Cichlidae. However, Nelson (2006) placed this family in Mugiliformes, as did Froese and Pauly (2014) and that classification is followed here. One sparid species, *Acanthopagrus latus*, earlier recorded from Chilika Lake was later considered as *Acanthopagrus longispinnis*. Similarly, the name of the Indian species, *Lutjanus russellii* (Lutjanidae) was reassigned as *Lutjanus indicus* (Allen et al. 2013). The Indian snapper *Lutjanus indicus* was invariably confused with its sibling species *L. russellii* (Allen et al. 2013). Species collected during surveys carried out during the post-restoration period are indicated with single asterisk (*) and new records collected during the same period are indicated with double asterisks (**); thus the checklist includes 178 earlier reported species and 77 new records (Mohapatra et al. 2007; Mohanty et al. 2007; Satpathy and Panda 2009; Mohapatra et al. 2013 and 2014) made during the post-restoration period totaling 255 collected out of 317 species known from the lake, accounting for a 80.44%

(Figure 2: Fish Species in Chilika Lake/Lagoon)

 *Trachinotus blochii* **Class:** Teleostei **Order:**Carangiformes **Family:** Carangidae	 *Trachinotus mookalee* **Class:** Teleostei **Order:**Carangiformes **Family:** Carangidae	 *Carcharhinus leucas* **Class:** Elasmobranchii **Order:**Carcharhiniformes **Family:** Carcharhinidae
 *Carcharhinus limbatus* **Class:** Elasmobranchii **Order:**Carcharhiniformes **Family:** Carcharhinidae	 *Carcharhinus melanopterus* **Class:** Elasmobranchii **Order:**Carcharhiniformes **Family:** Carcharhinidae	 *Glyphis gangeticus* **Class:** Elasmobranchii **Order:**Carcharhiniformes **Family:** Carcharhinidae
 *Scoliodon laticaudus* **Class:** Elasmobranchii **Order:**Carcharhiniformes **Family:** Carcharhinidae	 *Chanos chanos* **Class:** Teleostei **Order:**Gonorynchiformes **Family:** Chanidae	 *Channa gachua* **Class:** Teleostei **Order:**Anabantiformes **Family:** Channidae
 *Channa marulius* **Class:** Teleostei **Order:**Anabantiformes **Family:** Channidae	 *Channa punctata* **Class:** Teleostei **Order:**Anabantiformes **Family:** Channidae	 *Channa striata* **Class:** Teleostei **Order:**Anabantiformes **Family:** Channidae

Chirocentrus dorab

Class: Teleostei
Order: Clupeiformes
Family: Chirocentridae

Etroplus suratensis

Class: Teleostei
Order: Cichliformes
Family: Cichlidae

Oreochromis mossambicus

Class: Teleostei
Order: Cichliformes
Family: Cichlidae

Clarias batrachus

Class: Teleostei
Order: Siluriformes
Family: Clariidae

Lepidocephalichthys guntea

Class: Teleostei
Order: Cypriniformes
Family: Cobitidae

Cynoglossus lida

Class: Teleostei
Order: Pleuronectiformes
Family: Cynoglossidae

Cynoglossus lingua

Class: Teleostei
Order: Pleuronectiformes
Family: Cynoglossidae

Cynoglossus puncticeps

Class: Teleostei
Order: Pleuronectiformes
Family: Cynoglossidae

Cirrhinus cirrhosus

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Gymnostomus ariza

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Labeo boga

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Labeo calbasu

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Labeo catla

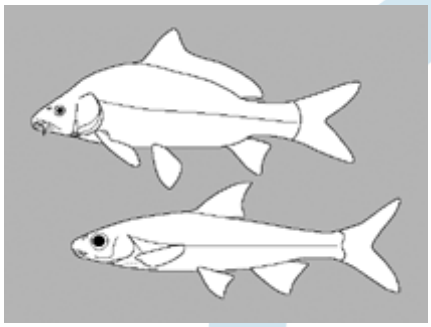
Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Labeo gonius

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Labeo rohita

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae



Osteobrama peninsularis

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Osteobrama vigorsii

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Pethia ticto

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Puntius chola

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Puntius sophore

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Puntius vittatus

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Systomus sarana

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Tariqilabeo latius

Class: Teleostei
Order: Cypriniformes
Family: Cyprinidae

Amblypharyngodon mola

Class: Teleostei
Order: Cypriniformes
Family: Danionidae

Chela cachius

Class: Teleostei
Order: Cypriniformes
Family: Danionidae

Danio rerio

Class: Teleostei
Order: Cypriniformes
Family: Danionidae

Esomus danrica

Class: Teleostei
Order: Cypriniformes
Family: Danionidae

Laubuka laubuca

Class: Teleostei
Order: Cypriniformes
Family: Danionidae

Rasbora daniconius

Class: Teleostei
Order: Cypriniformes
Family: Danionidae

Rasbora rasbora

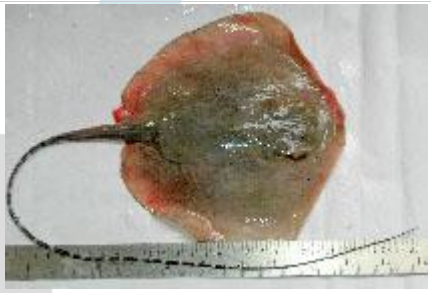
Class: Teleostei
Order: Cypriniformes
Family: Danionidae

Salmostoma bacaila

Class: Teleostei
Order: Cypriniformes
Family: Danionidae

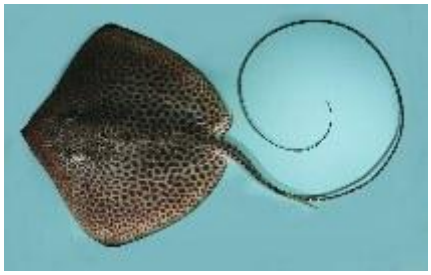
Brevitrygon imbricata

Class: Elasmobranchii
Order: Myliobatiformes
Family: Dasyatidae



Himantura marginata

Class: Elasmobranchii
Order: Myliobatiformes
Family: Dasyatidae



Himantura uarnak

Class: Elasmobranchii
Order: Myliobatiformes
Family: Dasyatidae

Pastinachus sephen

Class: Elasmobranchii
Order: Myliobatiformes
Family: Dasyatidae

Diodon hystrix

Class: Teleostei
Order: Tetraodontiformes
Family: Diodontidae

 *Amblygaster leiogaster* **Class:** Teleostei **Order:**Clupeiformes **Family:** Dorosomatidae	 *Amblygaster sirm* **Class:** Teleostei **Order:**Clupeiformes **Family:** Dorosomatidae	

The higher Fish Faunal inventory made during the post-restoration period may be attributed to a number of interventions, including the opening of a new artificial lake mouth nearer to the main water body of the lake (11 km from Magarmukh), desiltation of 14 km long Palur canal restoring the connectivity with the sea through the mouth of Rusikulya River, dredging of a 27 km long new channel connecting Magarmukh and the river confluence point in the northern sector, and desiltation of the lead channel between Magarmukh and the lake mouth. The hydrological intervention in 2000 increased the tidal flux by 44% and salinity level in the lake by 35% as compared to the pre-restoration period. Because salinity dynamics are the main driving force enhancing fisheries in general and fish diversity in particular, the enhancement of Fish Faunal diversity recorded during post-restoration period was likely mainly attributable to it. In general, opening of the new lake mouth in the year 2000 showed positive impact on the lake fisheries due to improvement in overall water quality (Mohanty et al. 2009). Recruitment success, effective seaward migration of catadromous fishes and restoration of degraded habitats being facilitated by hydrological intervention also likely helped enhance Fish Faunal diversity. The entire scenario changed during the eco-restoration period with positive effects. The freshwater fish fauna of the Mahanadi River system was reflected in the freshwater fish fauna of Chilika Lake as the tributaries of Mahanadi River drain into it.

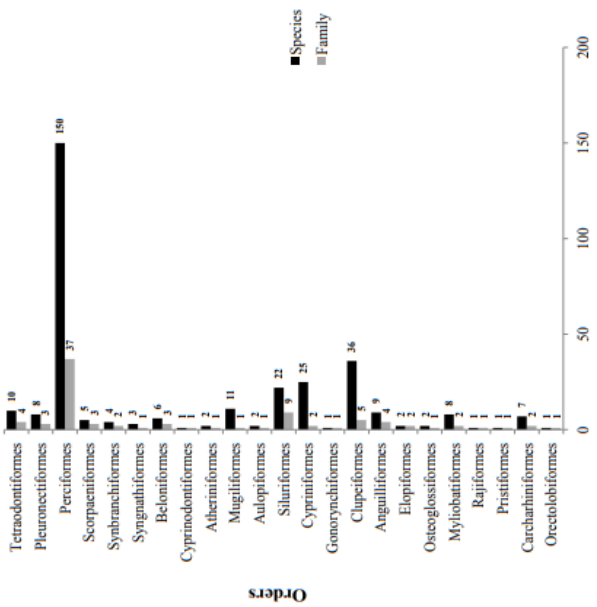
The families and species numbers in each order is depicted in (Figure 4), indicating that Perciformes is numerically the largest with 150 (47.32%) species followed by Clupeiformes with 36 (11.36%) species, Cypriniformes with 25 (7.89%) species and Siluriformes with 23 (7.25%) species. Pristiformes, Rajiformes, Gonorynchiformes, Orectolobiformes, and Cyprinodontiformes were repre-sented by single species only (Figure 4).

In total, 15 families (Balistidae, Diodontidae, Acan-thuridae, Ephippidae, Mullidae, Nemipteridae, Lac-tariidae, Tetrarogidae, Synbranchidae, Atherinidae,

Table 1. Number of families, genera and species, and total for each taxonomic category.

Order	Family	Genus	Species
Orectolobiformes	1	1	1
Carcharhiniformes	2	5	7
Pristiformes	1	1	1
Rajiformes	1	1	1
Myliobatiformes	2	4	8
Osteoglossiformes	1	2	2
Elopiformes	2	2	2
Anguilliformes	4	6	9
Clupeiformes	5	18	36
Gonorynchiformes	1	1	1
Cypriniformes	2	17	25
Siluriformes	9	16	22
Aulopiformes	1	2	2
Mugiliformes	1	5	11
Atheriniformes	1	1	2
Cyprinodontiformes	1	1	1
Beloniformes	3	5	6
Syngnathiformes	1	3	3
Synbranchiformes	2	3	4
Scorpaeniformes	3	5	5
Perciformes	37	95	150
Pleuronectiformes	3	4	8
Tetraodontiformes	4	9	10
23	**88**	**207**	**317**

(Figure 3: Orders, families and species numbers for ichthyofaunal components of Chilika Lake)



Dussumieridae, Synodontidae, Hemiscylliidae, Sphyrn-idae and Rhinobatidae)- and five orders (Tetradonti-formes, Atheriniformes, Aulopiformes, Orectolobiformes and Rajiformes) were documented for the first time in Chilika Lake during the post-restoration survey. No rep-resentatives of two families, namely Chirocentridae and Cobitidae, were found during the survey after open-ing of the new mouth. Sixty-five species of fish, most-ly Gobiidae, were not re-collected during the post-res-toration period. Two elasmobranchs (*Glyphis gangeticus* and *Pristis pectinata*) have never been recollected since they were first reported.

Pristis pectinata, once a wide-ly distributed sawfish, has been eliminated from large areas of its former range, and therefore its absence from Chilika Lake indicates its likely elimination from the lake ecosystem. (Mohanty et al.2015).However, the sawfish recorded as *Pristis pectinata* from Chilika Lake may be refered as *Pristis cla-vata* as observed by Faria et al. (2013). The Ganges Shark (*Glyphis gangeticus*) was once recorded from Chilika Lake (Chaudhuri 1916b) but the species has never been sighted or reported thereafter. Most literature records and specimens identified as this species are actually Bull Sharks *Carcharhinus leucas* or other carcharhinids. How-ever, after an extensive search over 10 years, a few spec-imens of this species were sighted in 1996 in the lower reaches of the Ganges River in West Bengal, India (Com-pagno 2002, 2007). There is no verified marine record of the *G. gangeticus* to date. Therefore the only report from Chilika was perhaps due to misidentification and con-fusion with *C. leucas*, which definitely occur in the lake.

Migratory and resident species

Out of the total 317 species, 271 (85.49%) and 46 (14.51%) were categorized as migratory and resident species respectively. Therefore the lake fishery is strongly migratory species-dependent. The migratory species are either seasonal migrants or incidental visi-tors to the lake from both the sea and inflowing rivers. The higher number of migratory species is perhaps due to ecorestoration measures implemented after 2000, particularly the opening of the new lake mouth and resultant improvement in water quality . Because migratory species form the major component of the lake fishery, sustainability of ecorestoration measures, particularly the optimal functioning of the lake mouth and Palur canal to enhance recruitment and breeding migrations assume greater significance. Migra-tory species included 14 catadromous species (*Anguilla bengalensis, Anguilla bicolor bicolor, Chanos chanos, Liza macrolepis, Liza melinopterus, Liza parsia, Liza planiceps, Liza subviridis, Ellochelon vaigiensis, Lates calcarifer, Mool-garda cunnesius, Moolgarda seheli, Moolgarda speigleri* and *Mugil cephalus*) and 13 anadromous species (*Ano-dontostoma chacunda, Brachirus orientalis, Hilsa kelee, Ilisha megaloptera, Pastinachus sephen, Pisodonophis boro,Pisodonophis cancrivorus, Rhinomugil corsula, Stolephorus commersonnii, Tenualosa ilisha and Tenualosa toli*).

Categorization of marine, estuarine/brackish and freshwater species

Chilika Lake being an assemblage of marine, brack-ish and freshwater ecosystems, harbors fish species belonging to these three regimes thereby enhancing Fish Faunal diversity and contributing to the com-mercial landings. A modified form of the widely accepted categorization by Elliot et al. (2007) is adapted here to categorize the fishes of Chilika Lake into marine, brackish and freshwater species. All marine species are considered as marine migrants and many of the freshwater species are riverine migrants. Our study of Fish Faunal diversity in Chilika Lake indicates that marine, brackish and freshwater species constitute 35.65%, 43.85% and 20.50% respectively (Figure 4).

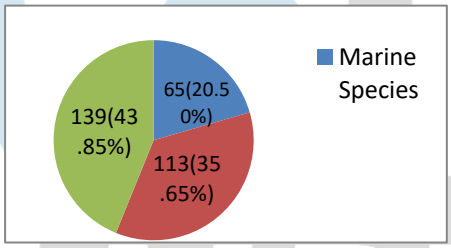


Figure 4. Fish Faunal composition of marine, brackish and freshwater species of Chilika Lake.

Faunal characteristics

The fish fauna of Chilika Lake includes two endemic gobiid species (*Acentrogobius griseus* and *Bathygobius ostreicola*) and one exotic cichlid species (*Oreochromis mossambicus*), which entered the lake during 1998 from aquaculture units on island villages. In total, there are 13 high value target species (*Mystus gulio, Strongylura strongylura, Channa striata, Etroplus suratensis, Tenu-alosa ilisha, Hyporhamphus limbatus, Lates calcarifer, Liza macrolepis, Moolgarda cunnesius, Mugil cephalus, Eleu-theronema tetradactylum, Daysciaena albida* and *Sillago sihama*) out of a total of 129 commercially important species, these are in large demand in the market and command higher unit prices. The current ichthyofau-nal analysis further documented for the first time 114 species belonging to 48 families with ornamental value for home and public aquarium use, a resource with con-siderable economic potential. Documentation of native ornamental fish germplasm resources from Chilika Lake calls for conservation and wise use that could poten-tially augment livelihoods of local communities through small-scale ornamental fish trade and captive breeding practices. Further research is warranted to develop tech-nologies for artificial propagation (captive breeding) and rearing of important native ornamental fishes from Chilika Lake. The faunal characteristics also indicated that 56 species are breeding in the lake and five species (*Daysciaena albida, Eleutheronema tetradactylum, Gerres setifer, Leiognathus equulus and Nematalosa nasus*) have two populations, one in the lake and the other in coastal waters. Similarly *Rhinomugil corsula*, the only freshwater mullet in the region, also has two populations one in the lake and the other in the rivers. Out of 317 fish species known so far from Chilika Lake, 278 are known to be food fishes (129 are commercially important – the oth-ers are eaten but neither commercially harvested nor have consumers demand).

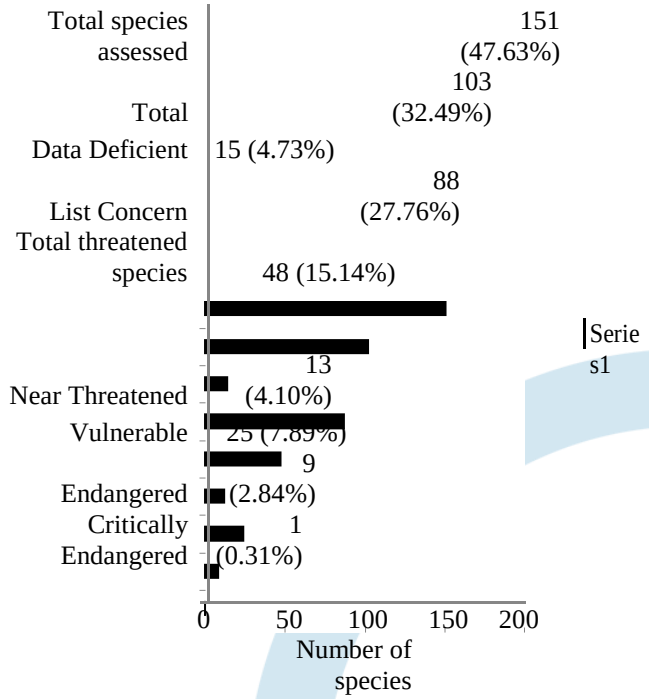


Figure 5. Number of species assessed for different categories of biodiver-sity status.

Biodiversity status and threatened species

An assessment of biodiversity status for the listed species and assessment of threatened fishes from the total of 317 fish species known from the lake was attempted for the first time in the present study. Review of literature on the biodiversity status of fishes and threatened fishes of India based on IUCN criteria (Ponniah 1993; Molur and Walker 1998; Menon 2004; Barman et al. 2007; Lakra et al. 2010; IUCN 2014; Froese and Pauly 2015) documented a total list of 151 species from Chilika Lake which were assessed for biodiversity status. In total, 35 species in 25 families were recorded as threatened and categorized under Critically Endangered (CR), Endangered (EN), Vulnerable (VU) (Table 2; Figure 5). Further, 13 more species in eight families are categorized as Near Threatened (NT) that need conservation measures unless they may slip to threatened category very soon. Only 88 species (27.76%) were assessed as List Concern (LC), whereas 15 species (4.73%) were categorized as Data Deficient (DD). Most importantly, 166 species (52.36%) of fishes of Chilika Lake were Not Evaluated (NE) for their conservation status. In other words, status of 52.36% of fishes is unknown, and need to be evaluated at least at the national level.

The most of the common threats to the biodiversity of fishes of India stems from various anthropogenic and natural stressors (Das et al. 2004; Kurup and Radhakrish-nan 2006; Rout et al. 2007), as has been observed for fishes in Chilika Lake. There, the most relevant threats were degradation of aquatic environment, siltation and encroachment of spawning grounds in the lake by *Ghery* operation, other destructive fishing practices, unabated expansion of illegal large pen culture units (*Gheries*),

Table 2. Assessment of biodiversity status of Chilika fishes (Categorization of threatened and non-threatened species with conservation status).

	Conservation status (Number of species by family)								
Family	**CR**	**EN**	**VU**	**NT**	**Total threat-ened species**	**LC**	**DD**	**Total**	**Total species assessed**
Acanthuridae (surgeon fishes)						2		2	2
Adrianichthydae (rice fish)						1		1	1
Ambassidae (perchlets, glass fishes)						4		4	4
Anabantidae (climbing perches)							2	2	2
Anguillidae (freshwater eels)				2	2				2
Aplocheilidae (asian revulines)						1		1	1
Ariidae (sea catfish)						1		1	1
Bagridae (bagrid catfishes)			1		1	3		3	4

Belonidae (needle fishes)						1		1	1
Carangidae (jacks, trevallies, pompanos, scads)						1		1	1
Carcharhinidae (requiem sharks)	1			4	5				5
Channidae (snakeheads, murrels)						4		4	4
Cichlidae (cichlids)				1	1	1		1	2
Clariidae (air-breathing catfish)		1			1				1
Clupeidae (herrings, allies)			2		2	4		4	6
Cobitidae (loaches)						1		1	1
Cyprinidae (carps, minnows)			3		3	20	1	21	24
Dasyatidae (stingrays)			1	1	2		3	3	5
Datnioididae (freshwater triple tails)						1		1	1
Eleotridae (gudgeons)						3		3	3
Elopidae (tenpounders)						1		1	1
Engraulidae (anchovies)						2	1	3	3
Gerreidae (silver biddies)						2		2	2
Gobiidae (gobies)						6	3	9	9
Haemulidae (grunts, rubberlips)			1		1	1		1	2
Hemiramphidae (halfbeaks)						1		1	1
Hemiscyllidae (bamboo sharks)				1	1				1
Heteropneustidae (airsac catfish)			1		1				1
Latidae (lates perches/asian seabass)			1		1				1
Leiognathidae (pony fishes, silverbellies)						3		3	3
Mastacembelidae (spiny eels)						3		3	3
Megalopidae (tarpons)							1	1	1
Mugilidae (mullets)			1		1	4	1	5	6
Muraenesocidae (pike congers)			2		2				2
Myliobatidae (eaglerays)		1	1		2				2
Nandidae (leaf fishes)						1		1	1
Notopteridae (featherbacks)		1			1	1		1	2
Ophichthidae (snake eels)						2		2	2
Osphronemidae (gouramies)						2		2	2
Pangasiidae (shark catfish)			1		1				1
Platycephalidae (flatheads)							1	1	1
Polynemidae (threadfin fishes)			1		1				1
Pristidae (saw fish)		1			1				1
Pristigasteridae (pellonas)		1			1				1
Rhinobatidae (guitar fishes)			1		1				1
Scatophagidae (scats)						1		1	1
Schilbeidae (schilbid catfishes)		1	2		3				3
Sciaenidae (croakers)			2		2	1		1	3
Scombridae (mackerels, seerfishes, tunas, albacores)						2	1	3	3
Serranidae (groupers, rock-cods)			1	2	3		1	1	4
Siganidae (spinsfoots, rabbitfishes)						1		1	1
Siluridae (eurasian catfishes)		1	1	1	3				3
Sisoridae (sisorid catfish)		1	1		2				2
Sphyrnidae (hammerheaded shark)		1		1	2				2
Synbranchidae (swamp eels)						1		1	1
Syngnathidae (pipe fishes, sea horses)			1		1	1		1	2
Terapontidae (terapon perches)						2		2	2
Tetraodontidae (puffers)						1		1	1
Tetrarogidae (waspfishes)						1		1	1
Total	**1**	**9**	**25**	**13**	**48**	**88**	**15**	**103**	**151**
% to the total assessment of species	**0.66**	**5.96**	**16.56**	**8.61**	**23.18**	**58.28**	**9.93**	**76.82**	**100.00**

CR-Critically Endangered; EN- Endangered; VU-Vulnerable; NT-Near Threatened; LC-List Concern; DD-Data Deficient

drastic decline in salinity dynamics, and siltation at the river mouth and Magarmukh (the gateway between the inlet channel and the lake proper). Mohanty et al. (2007) reported that six economic species (*Tenualosa ilisha, Rhinomugil corsula, Acanthopagrus berda, Chanos chanos, Megalops cyprinoides and Elops machnata*) almost disappeared from commercial landings during the eco-degradation phase but gradually reappeared during the ecorestoration phase.

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