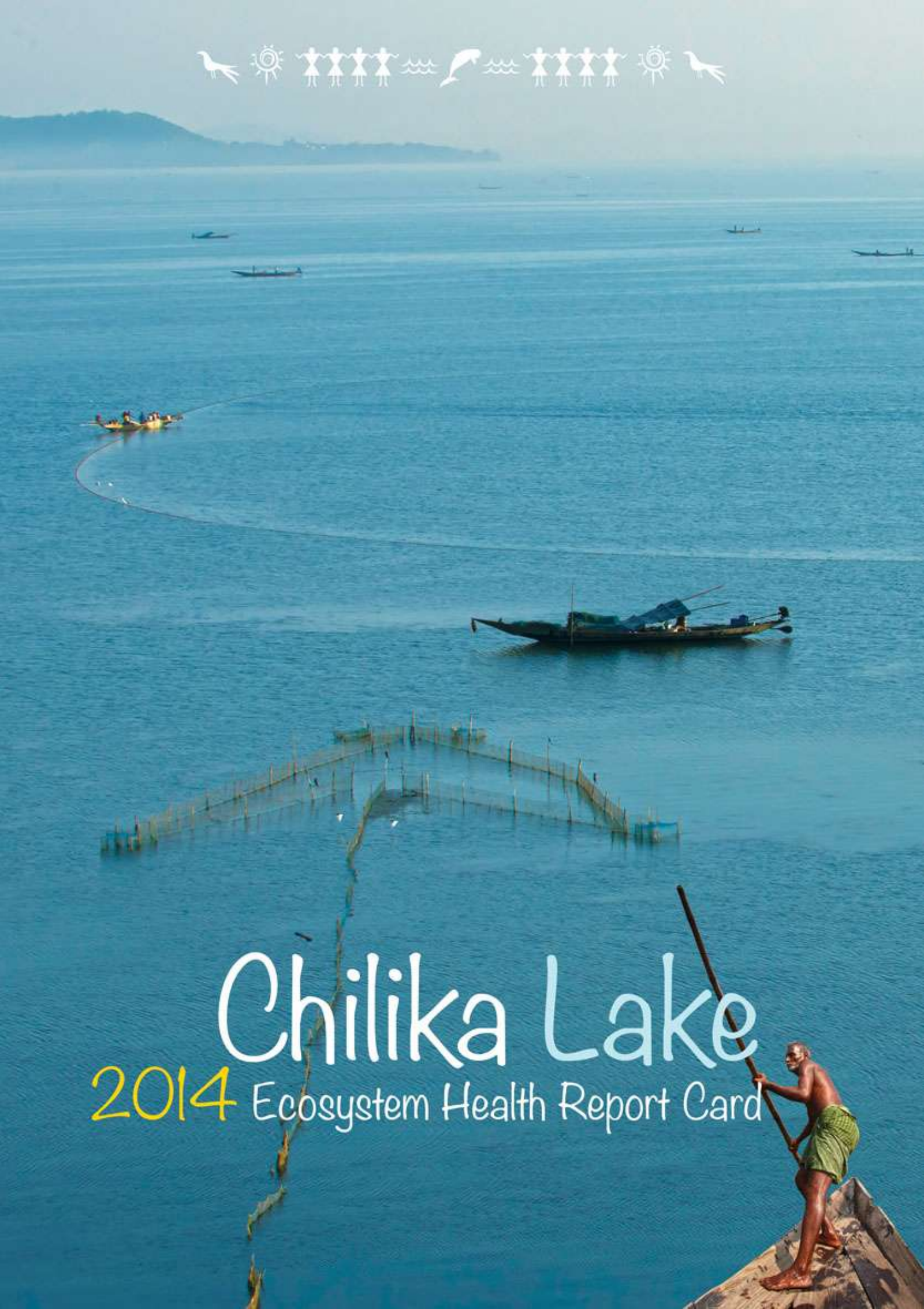


Chilika Lake

2014 Ecosystem Health Report Card

Introduction

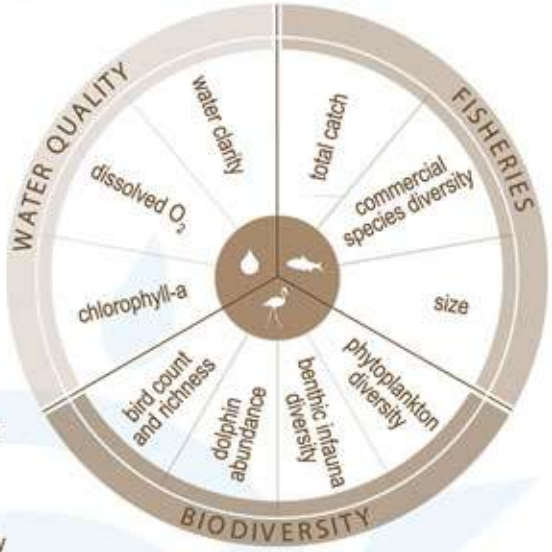
An ecosystem health report card emerged as an effective tool for tracking and reporting the ecological health of Chilika Lake. The report card has successfully communicated the complex volume of data and information gathered through the Lake monitoring program into a simple communicable format which was understandable and appreciated by a wide audience including local communities, policy makers, and the stakeholders.

The first in the series of Ecosystem Health Report Cards for Chilika Lake was developed in 2012, with an aim to enhance the understanding and management of the Lake. It was initiated through a collaborative project on "Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution, in support of Global Nutrient Cycle" with funding support from United Nations Environment Programme (UNEP/GEF)by Chilika Development Authority(CDA), National Centre for sustainable Costal Management (NCSCM) and in partnership with the Integration and Application Network from the University of Maryland Center for Environmental Science. The first "Chilika Ecosystem Health Report Card" was published bilingually (English and local language)based on wide multilevel consultation. The report card not only provided information about the status of the health of Chilika Lake, but also generated awareness about pressures which are affecting the ecological values and services of the Lake.

Chilika Lake maintains an unique salinity gradient due to monsoonal freshwater inflow and seawater exchange through the mouth, supporting an amazing biodiversity of life. The Lake is subjected to constant pressures from both natural processes and human activities. The major threats to the Lake's ecological integrity are over fishing, pollution, unregulated tourism, and sedimentation. This has necessitated continuous monitoring of ecological health of Chilika Lake for sustainable management of biodiversity and ecosystem services. In order to report monitoring results, the report card based assessment has proved an effective tool for sustainable management of Chilika Lake. The current report card is the second in series and is useful for comparing the changes in Lake health over multiple years and progress towards Chilika Lake management goals.

Measures of ecosystem health

Ecosystem health of Chilika Lake was assessed, by taking into consideration 10 indicators organized into three broad indices: (i)Water quality (ii) Fisheries and (iii) Biodiversity. Together, these indicators represent the ecosystem features of Chilika Lake that are valued (e.g. fishing, tourism, and biodiversity) and the threats (over fishing, aquaculture, pollution, and sedimentation) to these values.



WATER QUALITY

Water clarity is a measure of light that penetrates through the water column. It plays an important role in determining the distribution and abundance of macrophytes, seagrasses, and phytoplankton. Dissolved oxygen is a very crucial parameter for the vitality of any aquatic life. The amount of dissolved oxygen needed for aquatic organisms varies from species to species. Chlorophyll-a, is a measure of phytoplankton (microalgae) biomass and is a good indicator of the health of an ecosystem (Smith et al., 1999). Elevated phytoplankton level can reduce water clarity and decomposing phytoplankton can reduce dissolved oxygen levels.

FISHERIES

Total catch of fish, prawns, and crabs was recorded monthly at 27 landing stations around the Lake. This monitoring allows Lake managers to monitor annual yield in comparison to a calculated theoretical maximum sustainable yield for the Chilika Lake (CIFRI-ICAR, 2005).

Commercial species diversity is the number of species landed each year that are commercially important for the livelihood of fishermen. The body length of landed Bagada or tiger prawns (***Penaeus monodon***), Khainga or mullet (***Mugil cephalus***) and Chilika Crabs (***Scylla serrata***) should be above (or between) a prescribed length to ensure sustainability of the species.

BIODIVERSITY

Bird count and richness: Count of the number of birds and bird species utilizing the Lake for feeding, resting, and breeding. Chilika Lake is the largest wintering ground for migratory waterfowl found anywhere on the Indian sub-continent. Bird are good indicator of the aquatic ecosystem.

Dolphin abundance: Count of the endangered Irrawaddy dolphins (top of the food chain of the Lake) surveyed annually in the Lake.

Macro-benthic faunal diversity: Simpson's Index of Diversity (D) is used to assess the condition of this community. Macro-benthic fauna are organisms living in or on the bottom areas (sub-stratum) of the Lake (e.g. gastropods, bivalves, polychaetes, isopods, amphipods etc.) and are a key food source for many species, particularly fishes.

Phytoplankton diversity (microalgae): Simpson's Index of Diversity (D) is used to assess the condition of microscopic algal community through analysis of the number of species present and the abundance of each species. Phytoplankton is an important component of the Lake's food web.

Indicator thresholds

Desired conditions were arrived at basing on available guidelines, current scientific knowledge, and historical data and trends, and taking into account the influence of a variable climate from year to year. The table below outlines the desired condition and threshold values developed or identified for each indicator.

Category	Indicator	Desired condition (Threshold)	Source of data to derive thresholds
Water quality	Water clarity	≤30 NTU	CPCB, New Delhi; The Environment (Protection) Rules, 1986
	Dissolved oxygen	≥ 5 mg/L or 60% sat.	CPCB, New Delhi; The Environment (Protection) Rules, 1986
	Chlorophyll-a	≤ 5 µg/L	25th percentile of Chl-a data: monthly data of June 2011 to Dec 2014 CDA
Fisheries	Total catch	%deviation above or below maximum sustainable yield (11,500t/yr)	CIFRI-ICAR, 2005
	Commercial species diversity	Ratio of species landed: desired(45 sp. desired)	CDA
	Size	Proportion of species landed above a sustainable size limit. M.cephalus:219-461mm;P.monodon: 116-197 mm; S.serrata:87mm	CDA
Biodiversity	Bird count and richness	Ratio to maximum bird count and diversity recorded since 2003	CDA
	Dolphin abundance	Ratio to maximum dolphin count recorded since 2001	CDA
	Macro-benthic faunal diversity	Simpson's Index of Diversity(1-D)	CDA
	Phytoplankton diversity	Simpson's Index of Diversity(1-D)	CDA

Calculating the ecosystem grade for Chilika Lake

Chilika Lake was divided into four sub-assessment zones, together creating a Lake-wide report card. The grades were calculated from the average of water quality, fisheries, and biodiversity indices, comprised of data collected between January to December 2014. DO and chlorophyll-a data was assessed from 30 and 13 monitoring stations, respectively, during the period. For turbidity, YSI databuoy data from each of the four zones was assessed over three seasons in 2014: May (summer), September (monsoon), and December (winter).Monthly fish landing data was considered for the indicator of fisheries. Bird count and richness, and dolphin abundance data from Chilika were collected during January and February 2014, respectively. For macro-benthic faunal diversity and phytoplankton diversity (Simpson's Index), monthly data were used (30 stations for benthic diversity and 13 stations for phytoplankton).

What does the grade imply?

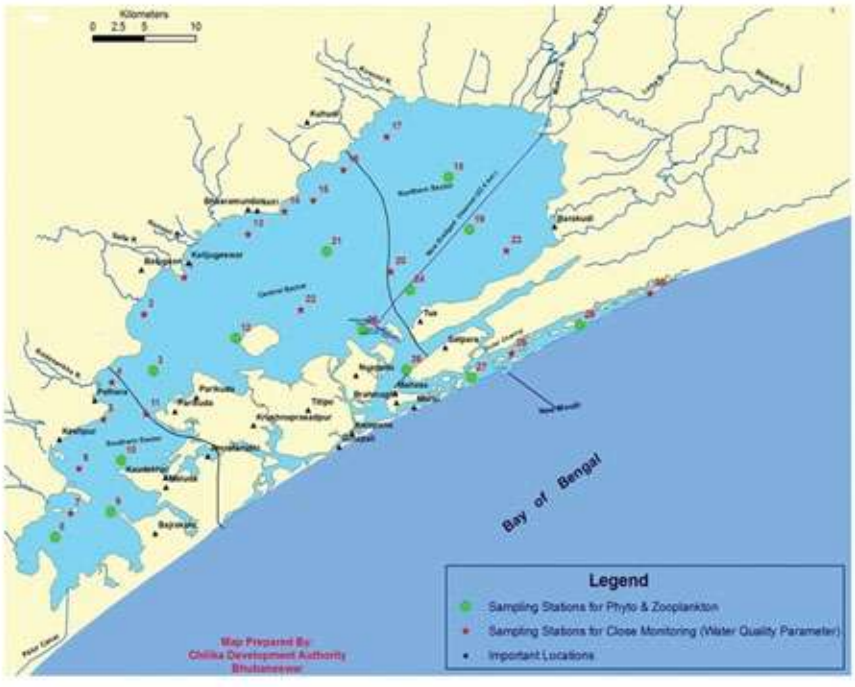
A 80–100%. All water quality and biological health indicators meet desired levels. Quality of water in these locations tends to be very good, most often leading to very good habitat conditions for fish and shellfish.

B 60–80%. Most water quality and biological health indicators meet desired levels. Quality of water in these locations tends to be good, often leading to good habitat conditions for fish and shellfish.

C 40–60%. There is a mix of good and poor levels of water quality and biological health indicators. Quality of water in these locations tends to be fair, leading to fair habitat conditions for fish and shellfish.

D 20–40%. Some or few water quality and biological health indicators meet desired levels. Quality of water in these locations tends to be poor, often leading to poor habitat conditions for fish and shellfish.

F 0–20%. Very few or no water quality and biological health indicators meet desired levels. Quality of water in these locations tends to be very poor, most often leading to very poor habitat conditions for fish and shellfish.



Sampling stations for water quality, phytoplankton, and benthos sample collection in Chilika Lake

Chilika Lake 2014 Report Card

Overall, Chilika Lake scored a **B** for ecosystem health based on performance of water quality, fisheries, and biodiversity indices. The Lake as a whole displayed excellent (**A**) for dissolved oxygen concentrations, total fishery catch, and size. However, for chlorophyll-a concentrations,the Lake received a **D** score when compared to the desired conditions. Scores of the ten indicators that were assessed for water quality, fisheries, and biodiversity in each of the zones were:77% (**B+**) in the Southern zone, followed by 74 % (**B**) in the Central zone, 71% (**B**) in the Outer Channel zone and 63% (**B-**) in the Northern zone. A breakdown of these indicators by zone is provided below.

Grades

- A 100-80%
- B 80-60%
- C 60-40%
- D 40-20%
- F 20-0%

Northern Zone B-

The Northern zone displayed excellent results for fisheries, mix of good and poor level of water quality and biodiversity.

Central Zone B

The Central zone displayed excellent results for fisheries, mix of good and poor level of water quality and good biodiversity highlighted by dolphin abundance and bird count richness.

Southern Zone B+

The Southern zone displayed excellent results for fisheries, good water quality (with the exception of chlorophyll-a) and good biodiversity highlighted by dolphin abundance, macro-benthic faunal diversity and phytoplankton diversity.

Outer Channel Zone B

The Outer channel zone displayed good results for fisheries, good water quality (with the exception of chlorophyll-a) and good biodiversity highlighted by excellent dolphin abundance, benthos and phytoplankton diversity.

Impact of *Phailin* on Chilika Lake Health

The 2014 Chilika Lake Report Card provides a different perspective of Lake health compared to the 2012 report card, as this follows an extreme climatic event i.e. the severe tropical cyclonic storm, *Phailin*, which struck the eastern Indian States of Odisha and Andhra Pradesh on October 12, 2013. *Phailin* with the damaging winds of more than 220 km/h, and storm surges of up to 3.5 m and torrential down pours. The landfall was at Gopalpur, which is radially just 20kms south of the Chilika Lake. Although, cyclonic events appear to be transient, they can cause a dramatic change in the ecological functioning of Lake ecosystems.

Immediately after *Phailin*, a survey on the biodiversity and water quality of Chilika Lake was conducted to capture the devastating impact of *Phailin* on the Lake. It was observed that precipitation due to *Phailin* significantly altered the salinity gradient of the Lake from estuarine to completely freshwater. However, after passage of the cyclone, seawater intrusion resumed, and an estuarine gradient resumed within a few months. Immediately, after the cyclonic event, there was a sharp decrease in the overall abundance of macro fauna, indicating that the severe cyclonic event had a cascading effect on sedimentary macro-benthic fauna. However, it was equally interesting to document that there was a sharp increase in macro faunal species diversity in the Lake after the cyclone. *Phailin* also had a drastic negative effect on the diversity, distribution, and productivity of macrophytes in Lake. Noticeably among these, there was significant damage to seagrass meadows and reduction in their habitats. It took almost a year for the seagrasses to overcome the damage due to Phailin.

Fishery resources of the Lake, which support the livelihood of more than 0.2 million fishermen, were also severely impacted by *Phailin*. It was estimated that around 8,198 boats and 31,058 fishing nets were damaged due to the cyclone and subsequent floods, thus causing heavy loss to the fishing community. Fish species composition and catch contribution showed increases in freshwater species and decreases in abundance of marine species. Exotic fish species such as *Ctenopharyngodon idella*(Chinese grass carp), *Oreochromis mosambicus*(Tilapia), and *Clarias gariepinus*(African catfish) increased in catch, which was a serious concern and required constant monitoring. However it was recorded that these exotic species did not survive for long following the return of the estuarine salinity regime.

Cyclone *Phailin* also had a severe effect on the bird population and substantially reduced their population size, diversity, and congregation areas. As the water level is a major determinant factor for the occurrence of water birds, the high water level caused the belated arrival and shifting of birds to other alternative suitable sites. The depletion of the *Potamogeton pectinatus* bed from the deep water zones of the Central zone due to strong wind generated waves and up-welling during the cyclone caused disappearance of the migratory ducks from such sites. Even though the effects of the cyclone on birds at Chilika Lake do not appear to be severe, it would make the documentation of the following migratory season interesting as to whether the Lake had resumed to normal regime not only in terms of water level and quality, but also with regard to biodiversity making a conducive environment for birds.

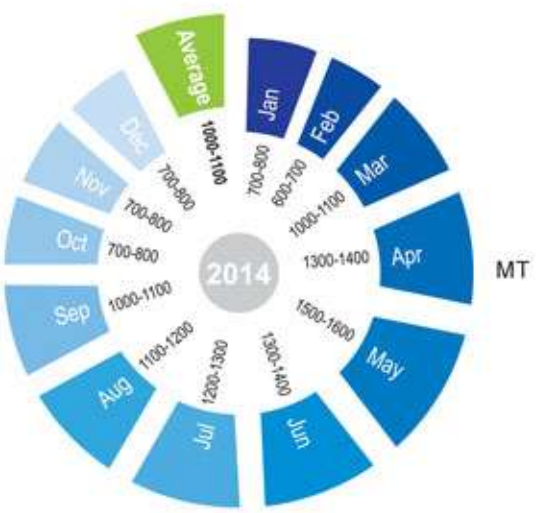
Over the last two years, systemic monthly monitoring of benthic faunal diversity indicated Chilika Lake is generally in good shape. Study of benthic macro fauna provided interesting insights of the resilient nature of Chilika Lake. The Lake was able to recover the diversity and abundance of macro fauna within few months after the cyclone Phailin. These findings demonstrates the highly resilient nature of benthic communities and Chilika Lake as a whole. In Chilika Lake, it has also been observed that certain key benthic species could be effectively used as "indicator species" for long-term monitoring and management of Chilika Lake.

How does the Chilika Lake Health compare with 2012 report card ?

During 2012, the overall score was 'B' which is the same as reported here for 2014. Individual indicators also showed similar grades except chlorophyll-a which was used for the first time in this report card, instead of total chlorophyll in 2012 (the former is a better indicator of ecosystem health). The Northern zone obtained the score 'B-' which was also 'B' in 2012. This zone displayed excellent results for fisheries, mix of good and poor level of water quality and good biodiversity (with the exception of dolphin sightings) during the year 2014. Southern zone which was 'B' during 2012, scored 'B+' during 2014 due to excellent results for fisheries, good water quality (with the exception of chlorophyll) and good biodiversity highlighted by phyto, benthos and dolphin abundance. The central and outer channel zone obtained the same score as during 2012.

Lake Health & Fisheries

During 2014, the report card assessment year; the total annual fish landing (fish, prawn & crab) from Chilika Lake was estimated at 12173 MT valued at the highest ever 1724.91 million INR. The annual fish catch during the year was 7.06% less as compared to the annual catch in the previous year (2013). The average *per-capita* income of active fishers was registered at 49,679 INR. The overall salinity dynamics of the *Phailin* –impacted Lake seems to have impacted the fish catch with reduction in annual catch. The commercial catch during 2014 registered increased composition of freshwater species since the freshwater fishes from the nearby pond aquaculture units and rivers entered into the Lake due to high flush flood during *Phailin*.



Way Forward

During preparation of the 2012 health report card, it was identified that a few parameters such aschlorophyll-a (instead of total chlorophyll), total nitrogen, total phosphorous could be better indicators of ecological health. In addition to these, it is also considered that river inputs of total organic carbon, organic nitrogen and organic phosphorous need to be included as ecological indicators of Lake health. Following the release of first health report card (2012), more intensive studies were taken in thematic areas to bridge the knowledge gaps to further expand the scope of ecological indicators which could be useful in evaluating the ecological health of Chilika Lake. As a first step in this endeavor,chlorophyll-a has been assessed in this report card. As the challenge for arriving at the appropriate threshold values for the remainder of the parameters is enormous, the ideal way forward is to sustain continuous monitoring of the Lake to attain baseline information that can be used to develop threshold values specific to this tropical Lake in the future.Extensive monitoring and validation of the benthic 'indicator species' in Chilika Lake to test their effectiveness for identifying changes (natural or anthropogenic) would be required for the effective management of Chilika Lake.

About WRTC

Wetland Research and Training Centre (WRTC) was established in the year 2002 by CDA. The centre was recently expanded and upgraded with the support received from World Bank under the Integrated Coastal Zone Management Project component of Odisha. The centre being in close proximity to the Chilika Lake offers unique opportunity to perform in-situ research in the field of molecular biotechnology, microbiology, marine biology, biogeochemistry, hydrological modeling and GIS and remote sensing and advanced oceanography. This centre has turned as a vital hub of wetland research activity as it hosts excellent platform for inter-disciplinary research. The sustained research and monitoring programmes run at WRTC by CDA through the research personnel brings in wealth of data which has been analyzed for generating Health Report Card. Currently following studies are underway at WRTC focusing on the Chilika Lake

- Spatio-temporal distribution of sensitive trace metal in sediment and their geochemical fractions.
- Estimation of budget of nutrient and their biogeochemical cycle.
- Assessment of petroleum hydrocarbon (PHC)
- Spatiotemporal investigation of phytoplankton communities through a combination of traditional microscopic and modern molecular tools.
- Molecular ecological analysis of bacterial and phytoplankton communities
- Biology and stock status of commercially important fishes.
- Spatiotemporal distribution of macrobenthos and phytoplankton communities

The output from these studies would be incorporated into the ecological and mathematical modeling with a decision support system for the Lake. Once baseline information is generated for additional indicators, these would be incorporated in subsequent version of Health Report Cards. Further studies in the area of sea-grasses their distribution and diversity would be taken in subsequent years.

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