Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution, in support of the

Global Nutrient Cycle

Chilika Lake (India) and Laguna de Bay (Philippines) Ecosystem Health Report Cards

Prepared by: Chilika Lake Development Authority, Laguna Lake Development Authority

Component D: Doc: D3-1

Partners:

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About the GEF-Global Nutrient Cycle Project

Project objective: to provide the foundations (including partnerships, information, tools and policy mechanisms) for governments and other stakeholders to initiate comprehensive, effective and sustained programmes addressing nutrient over-enrichment and oxygen depletion from land based pollution of coastal waters in Large Marine Ecosystems.

Core project outcomes and outputs:

- the development and application of quantitative modeling approaches: to estimate and map present day contributions of different watershed based nutrient sources to coastal nutrient loading and their effects; to indicate when nutrient over-enrichment problem areas are likely to occur; and to estimate the magnitude of expected effects of further nutrient loading on coastal systems under a range of scenarios
- the systematic analysis of available scientific, technological and policy options for managing nutrient over-enrichment impacts in the coastal zone from key nutrient source sectors such as agriculture, wastewater and aquaculture, and their bringing together an overall Policy Tool Box
- the application of the modeling analysis to assess the likely impact and overall cost effectiveness of the various policy options etc brought together in the Tool Box, so that resource managers have a means to determine which investments and decisions they can better make in addressing root causes of coastal over-enrichment through nutrient reduction strategies
- the application of this approach in the Manila Bay watershed with a view to helping deliver the key tangible outcome of the project – the development of stakeholder owned, cost-effective and policy relevant nutrient reduction strategies (containing relevant stress reduction and environmental quality indicators), which can be mainstreamed into broader planning
- a fully established global partnership on nutrient management to provide a necessary stimulus and framework for the effective development, replication, up-scaling and sharing of these key outcomes.

Project partners:

- Chilika Development Authority
- Energy Centre of the Netherlands
- Global Environment Technology Foundation
- Government of India - Lake Chilika Development Authority
- Government of the Netherlands
- Government of the Philippines
- Government of the United States
- Intergovernmental Oceanographic Commission of UNESCO
- International Nitrogen Initiative
- Laguna Lake Development Authority
- Partnerships in Environmental Management for the Seas of East Asia
- Scientific Committee on Problems of the Environment
- University of Maryland
- University of the Philippines
- University of Utrecht
- Washington State University
- World Resources Institute

Implementing Agency: United Nations Environment Programme
Executing Agency: UNEP- Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA)

Chilika Lake

2012 Ecosystem Health Report Card

NCSCM
National Centre for
Sustainable Coastal Management

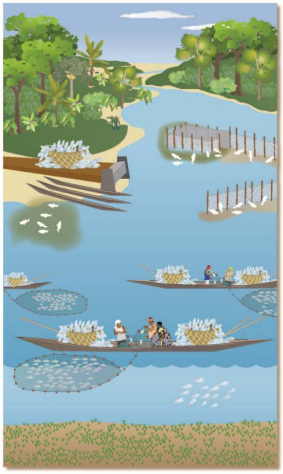
Chilika
Development Authority

Chilika Lake is rich in natural and cultural beauty, and important to local livelihoods

Chilika Lake stores monsoon flood waters and provides a level of salinity needed to sustain its amazing biodiversity of life. Local communities depend on the Lake to provide water for fish and shellfish for food and resale, village transport, and tourism income. It is for all these reasons that Chilika Lake needs our protection.

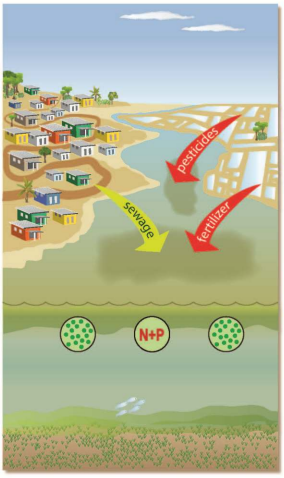
Pressures affecting the Chilika Lake ecosystem

Chilika Lake is subjected to constant pressures from both natural processes and human activities. The problems highlighted here are overfishing, pollution, tourism, and sedimentation, all of which can result in a degradation of the Lake. By identifying these pressures through efforts like this ecosystem health report card and subsequent management actions, the likelihood of Chilika Lake to sustain itself is improved.



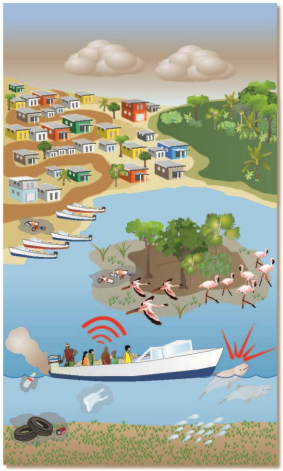
Fishing and Aquaculture

The recent abundance of fish stocks is not sustainable with overfishing and so many fishers. At landings, dead fish thrown back into the water contaminate the Lake. Active shrimp pens and abandoned nets trap sediment and kill juvenile fish.



Pollution

As land use changes from forest to settlements and paddy agriculture sewage, and fertilizer and pesticides runoff increases into the Lake. Algae blooms that float and sit on the bottom are the result of that extra nutrient input N+P.



Tourism

While tourism is providing welcome income to local communities, the activities, if not managed properly, adversely impact the environment. Air pollution, trash, wildlife disturbances, noise, and rapid village growth are increasing around and on the Lake.

Sedimentation

During monsoon season, an excess of sediment is deposited in the Lake, mostly from Mahanadi River tributaries, nearby settlements, and agricultural lands. As the Lake becomes more shallow and its sea outlets fill in with sediment, increased flooding occurs.

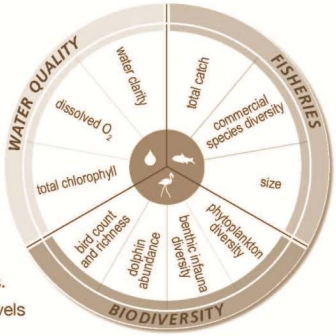
How the report card was prepared

This is the first of a proposed series of annual Ecosystem Health Report Cards for Chilika Lake. The report card was developed in order to enhance understanding and management of the Chilika Lake ecosystem through a collaborative, UNEP/GEF project on "Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution, in support of Global Nutrient Cycle" by Chilika Development Authority (CDA), National Centre for Sustainable Coastal Management (NCSCM), and UNEP/GPA facilitated Global Partnership on Nutrient Management (GPNM).

The CDA, in partnership with NCSCM and the Integration & Application Network from the University of Maryland Center for Environmental Science, convened a science workshop bringing together local, regional, and international experts and stakeholders, who together identified 10 indicators of ecosystem health currently monitored within the Lake, and developed thresholds for each. Due to data limitation, Nitrogen and Phosphorus were not considered in this report card. However, CDA is currently monitoring Nitrogen and Phosphorus, and this dataset will be included in the next Report Card. Additional indicators may be included in future once measures for data collection are in place. This first Report Card serves as a baseline that will be used as a point of comparison to measure progress towards Chilika Lake management goals and targets.

Measures of ecosystem health

Measuring the ecosystem health of Chilika Lake is conducted using 10 indicators organized into three main indices: Water Quality, Fisheries, and Biodiversity. Together, these indicators represent the ecosystem features of Chilika Lake that are valued (e.g., fishing, tourism, biodiversity); and represent the threats (e.g., overfishing and illegal aquaculture, pollution, and sedimentation) to these values.



WATER QUALITY

Water clarity — a measure of how much light penetrates though the water column which plays an important role in determining Lake grasses and phytoplankton distribution and abundance.

Dissolved oxygen — critical to the survival of Chilika Lake's aquatic life. The amount of dissolved oxygen needed before aquatic organisms are stressed, or even die, varies from species to species.

Total chlorophyll — a measure of phytoplankton (microalgae) biomass. Elevated phytoplankton levels can reduce water clarity and decomposing phytoplankton can reduce dissolved oxygen levels.

FISHERIES

Total catch — total catch of fish, prawns, and crabs recorded monthly at 27 landing stations around the Lake. Allows Lake managers to monitor annual yield in comparison to a calculated maximum sustainable yield.

Commercial species diversity — number of species landed each year that are commercially important for the livelihood of fishermen.

Size — body length of landed bagda 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. Chilika Lake is the largest wintering ground for migratory waterfowl found anywhere on the Indian sub-continent.

Dolphin abundance — count of the endangered Irrawaddy dolphins surveyed annually in the Lake.

Benthic infauna diversity — Simpson's Index of Diversity (D) is used to assess the condition of this community. Benthic infauna are organisms living in or on the soft bottom areas of the Lake (e.g., clams and worms) and are a key food source for many species.

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

Desired conditions guide ecosystem change

Desired conditions are based on available guidelines, current scientific knowledge, and/or historical data and trends, and take into account the influence of a variable climate from year to year. The table below outlines the desired condition developed or identified for each indicator and the source of this information.

Category	Indicator	Desired condition	Source of data
Water Quality	Water clarity	≤ 30 NTU	CDA
	Dissolved oxygen	≥ 5 mg/L or 60% sat.	ICMAM
	Total chlorophyll	≤ 5 µg/L	ICMAM
Fisheries	Total catch	% deviation above or below maximum sustainable yield (11,500 t/yr)	CDA
	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 - 461 mm; *P. monodon*: 116 - 197 mm; *S. serrata*: 87 mm	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
	Benthic infauna 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 reporting zones, each of which received a report card grade. The grades were calculated from the average of water quality, fisheries, and biodiversity indices, comprised of data collected over the 2011-2012 period. On-going monitoring will allow grades to be updated on a periodic basis, providing a means to track change over time.

What do the grades mean? *

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.

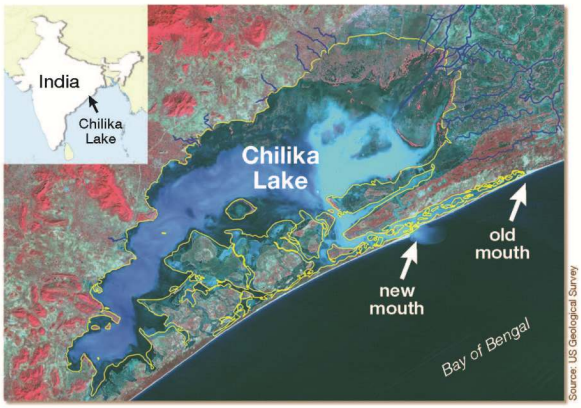
B — **60–80%**. Most water quality and biological health indicators meet desired levels. Quality of water in these locations tends to be good, often leading to good habitat conditions for fish and shellfish.

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.

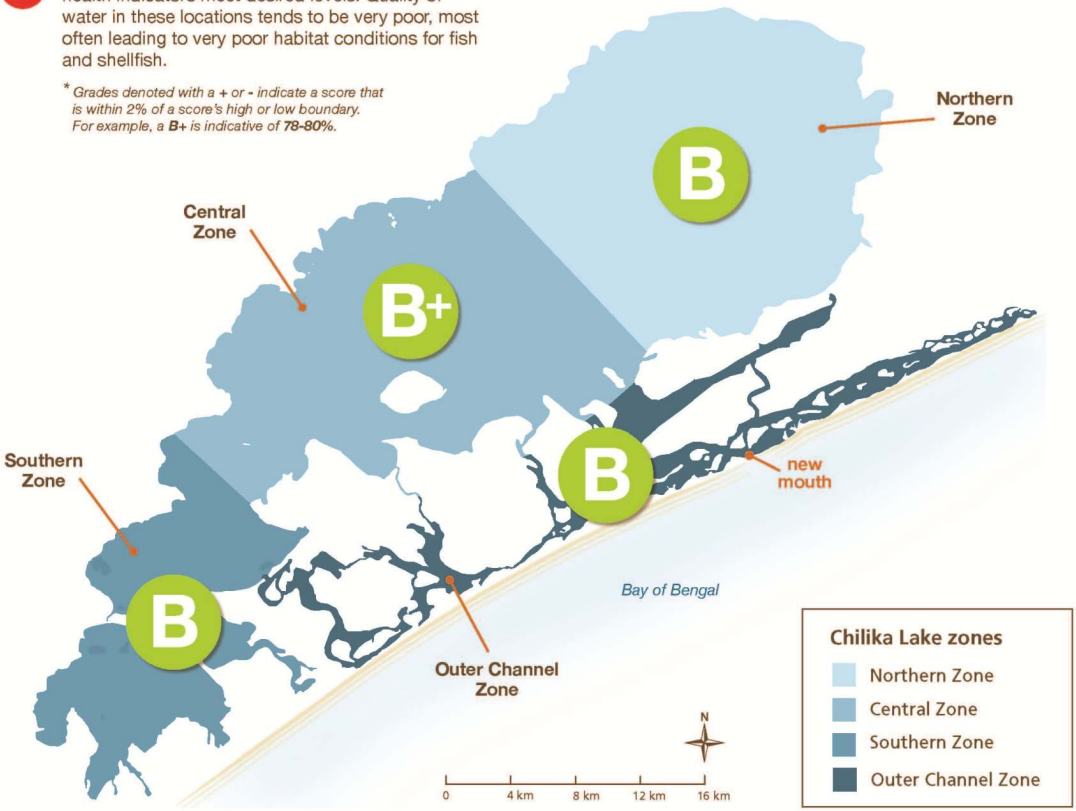
D — **20–40%**. Some or few water quality and biological health indicators meet desired levels. Quality of water in these locations tends to be poor, often leading to poor habitat conditions for fish and shellfish.

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.

* *Grades denoted with a **+** or **-** indicate a score that is within 2% of a score's high or low boundary. For example, a **B+** is indicative of **78-80%**.*



Until recently, Chilika Lake suffered from increasing sediment loads and reduced connectivity with the sea. In 2000, a new mouth to the Bay of Bengal was opened. This hydrological intervention helped improve salinity levels, enhance fish landings, decrease in the area of invasive species, as well as improve water quality overall.



Chilika Lake 2012 Report Card

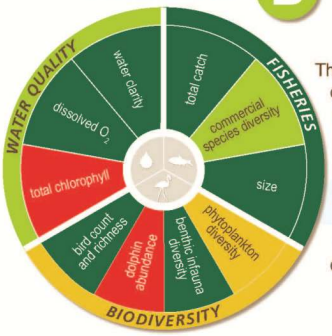
Overall, Chilika Lake scored a B for ecosystem health based on performance of water quality, fisheries, and biodiversity indices.

Grades

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

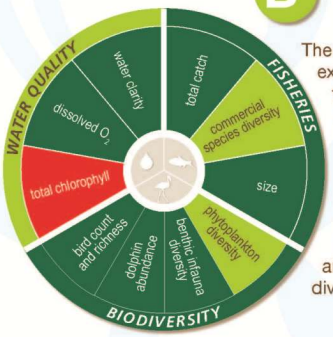
The Lake as a whole displayed excellent (**A**) dissolved oxygen concentrations, water clarity, total fishery catch and size, and benthic infauna diversity. The Lake failed, however, for total chlorophyll concentrations (**F**), based on desired conditions. Of the ten indicators that were assessed within water quality, fisheries, and biodiversity, 79% (**B+**) in the Central Zone, followed by 76% (**B**) in the Southern Zone, 71% (**B**) in the Outer Channel Zone, and 69% (**B**) in the Northern Zone. A breakdown of these indicators by zone is provided below.

Northern Zone B



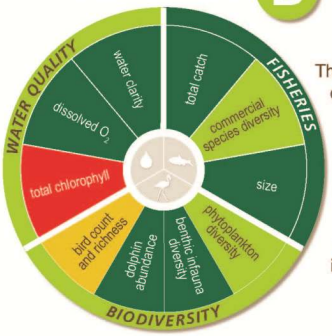
The Northern Zone displayed excellent results for fisheries, good water quality (with the exception of total chlorophyll), and average biodiversity largely due to an absence of dolphin sightings.

Central Zone B+



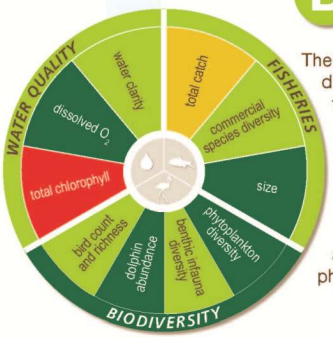
The Central Zone displayed excellent results for fisheries, good water quality (with the exception of total chlorophyll), and excellent biodiversity highlighted by bird count and richness, dolphin abundance, and benthic infauna diversity.

Southern Zone B



The Southern Zone displayed excellent results for fisheries, good water quality (with the exception of total chlorophyll), and good biodiversity highlighted by dolphin abundance and benthic infauna diversity.

Outer Channel Zone B



The Outer Channel Zone displayed good results for fisheries and water quality (with the exception of total chlorophyll), and excellent biodiversity highlighted by excellent dolphin abundance and phytoplankton diversity.

There's more to this story: Salinity

The four zones used in this Chilika Lake Report Card are based mostly on salinity variations that occur within the Lake. Salinity in the Lake is driven by freshwater river flow from the north and west, and tidal seawater from the east and south. This results in a variation of salinity in the Lake, from freshwater in the north, brackish waters in the center and south, and full saline waters to the east around the islands and outer channel. The boundaries between these zones shift throughout the year, driven by monsoonal rains and seasonal winds.

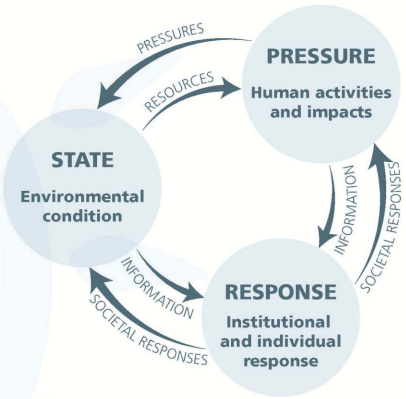
During the 1990s, extensive siltation in the Lake was limiting access to the sea, reducing tidal flushing and decreasing salinity to such an extent that biodiversity declined and invasive aquatic weeds proliferated. This had a highly negative impact on the Lake's habitat for wildlife and fishery resources. In 1992, it was included in the Montreux Record by Ramsar due to change in the ecological character. In 2000, CDA opened a new mouth to restore the lake ecosystem. This new opening increased salinities throughout the Lake, vastly improving water quality, recovering lost habitat for important species, enhancing fish resources, and controlling invasive species. Lake salinity and connectivity to the sea are now closely monitored to ensure that conditions do not return to those experienced prior to 2000. The lake was removed from the Montreux Record due to restoration of the lake ecosystem in 2002.

Where do we go from here?

This report card is a significant step in progressing our understanding of how human activities (or **Pressures**) affect the environmental condition (or **State**) of Chilika Lake within the **Pressure-State-Response** (PSR) framework for environmental management.

The Chilika Lake Development Authority has a **Response** plan which envisages ecosystem conservation and sustainable resource development and livelihood improvement supported by institutional development; communication, education and public policy; and institutional development as the key management response components.

The addition of this report card that assesses and monitors the **State** of Chilika Lake completes the PSR loop, and strengthens the framework that ultimately aims to reduce uncertainty in resource management decision-making for the sustainability of Chilika Lake and those that depend on it.



Key management **Response** strategies to be adopted include the following:

- **Ensuring hydrological connectivity** of Chilika with freshwater and coastal processes at the basin level.
- **Establishing hierarchical and multiscalar inventory** of hydrological, ecological, socioeconomic, and institutional features and ecosystem services to support management planning and decision-making.
- **Promoting sustainable catchment management practices** to manage inflow of silt and nutrients into the wetland system.
- **Adopting environmental flows** as a basis for water allocation for conservation and development activities.
- **Promoting biodiversity conservation** through habitat improvement of endangered and indigenous species.
- **Supporting ecotourism development** for enhancing awareness, income generation, and livelihood diversification.
- **Promoting sustainable fisheries** for maintaining nutritional security while ensuring maintenance of biodiversity and equitable sharing of benefits.
- **Reducing poverty** through sustainable resource development and utilization and livelihood diversification.
- **Promoting institutional arrangements** enabling integration of wetland management planning and river basin and coastal zone management.
- **Strengthening CDA** with adequate legal and administrative powers to regulate detrimental activities.
- **Building capacity at all levels** for technical and managerial skills for implementation of integrated management planning.

Workshop participants

Up to 45 participants attended the *Workshop on Coastal Ecosystem Heath Report Card of Chilika Lake*, 4-7 February, 2013, Bhubaneswar, Odisha, India, including scientists, managers, and graduate students from: Chilika Development Authority; National Centre for Sustainable Coastal Management; Government of Odisha; State Project Management Units of Gujarat and West Bengal; Indian Nitrogen Group; Gujarat Ecological Education and Research Foundation; International Lake Environment Committee Foundation; United Nations Environmental Programme; Society of Integrated Coastal Management; and FAO Bay of Bengal Large Marine Ecosystem.

The organizers of the workshop (front row, L to R) : Mr. Vivek Wadekar, SICOM, Government of India; Dr. Ramesh Ramachandran, NCSCM; Dr. Anjan Datta, UNEP; Mr. R.K. Sharma, Principal Secretary, Forest and Environment, Government of Odisha; Dr. Heath Kelsey, IAN/UMCES; and Dr. Ajit Pattnaik, CDA — and (back row) local civic leaders and fishing cooperative representatives.
Missing from photo: Dr. Paul Tapas, The World Bank.

Cover and page 2 photos courtesy of Chilika Development Authority; Photographer: K. Ramnath Chandrasekhrar

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An electronic copy of this report card and additional information can be found at: *http://www.chilika.com* and *http://www.ncscm.org/*.

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Kumar R, Pattnaik AK. 2012. *Chilika—An Integrated Management Planning Framework for Conservation and Wise Use*. Wetlands International-South Asia, New Delhi, India and Chilika Development Authority, Bhubaneswar, India.

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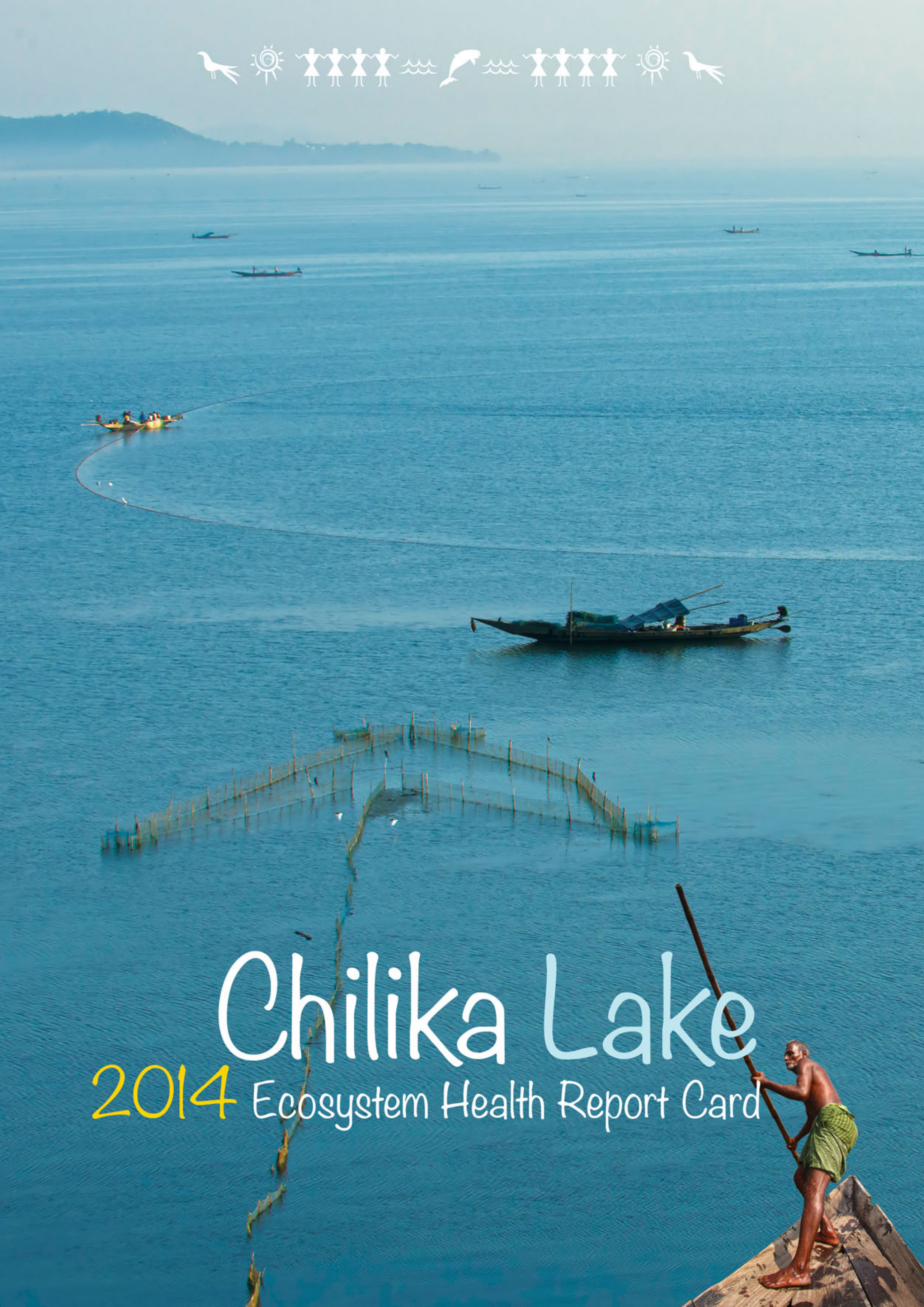


Chilika Lake

2014 Ecosystem Health Report Card

Introduction

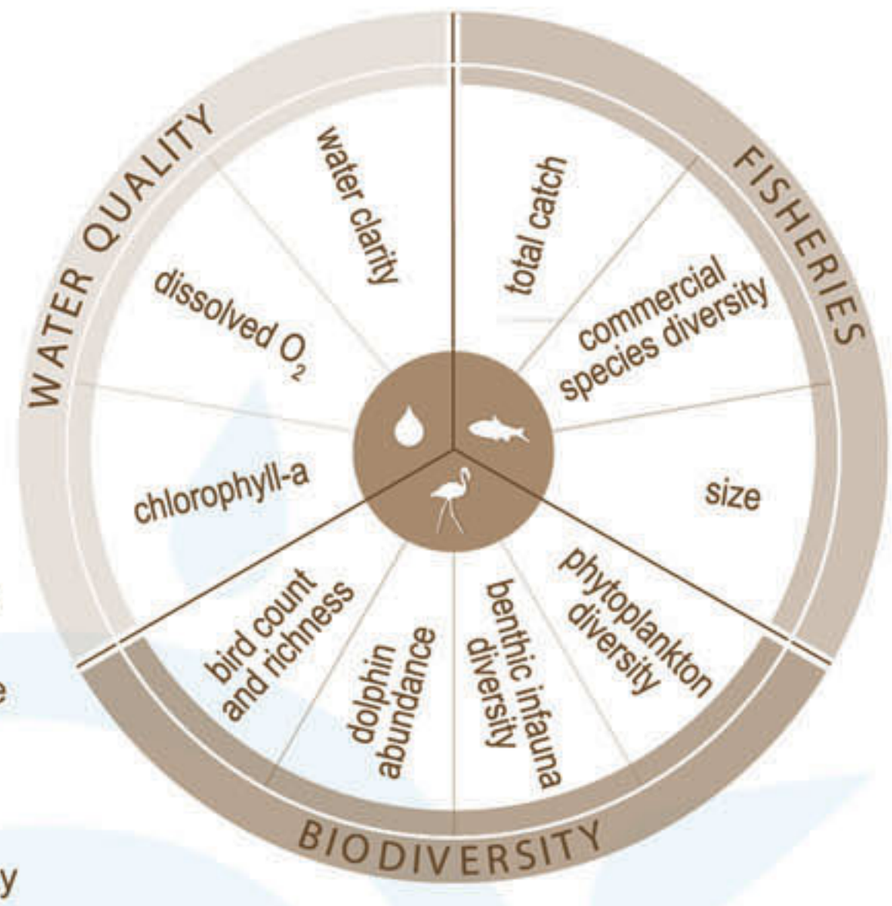
An ecosystem health report card emerged as an effective tool for tracking and reporting the ecological health of Chilika Lake. The report card has successfully communicated the complex volume of data and information gathered through the Lake monitoring program into a simple communicable format which 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?

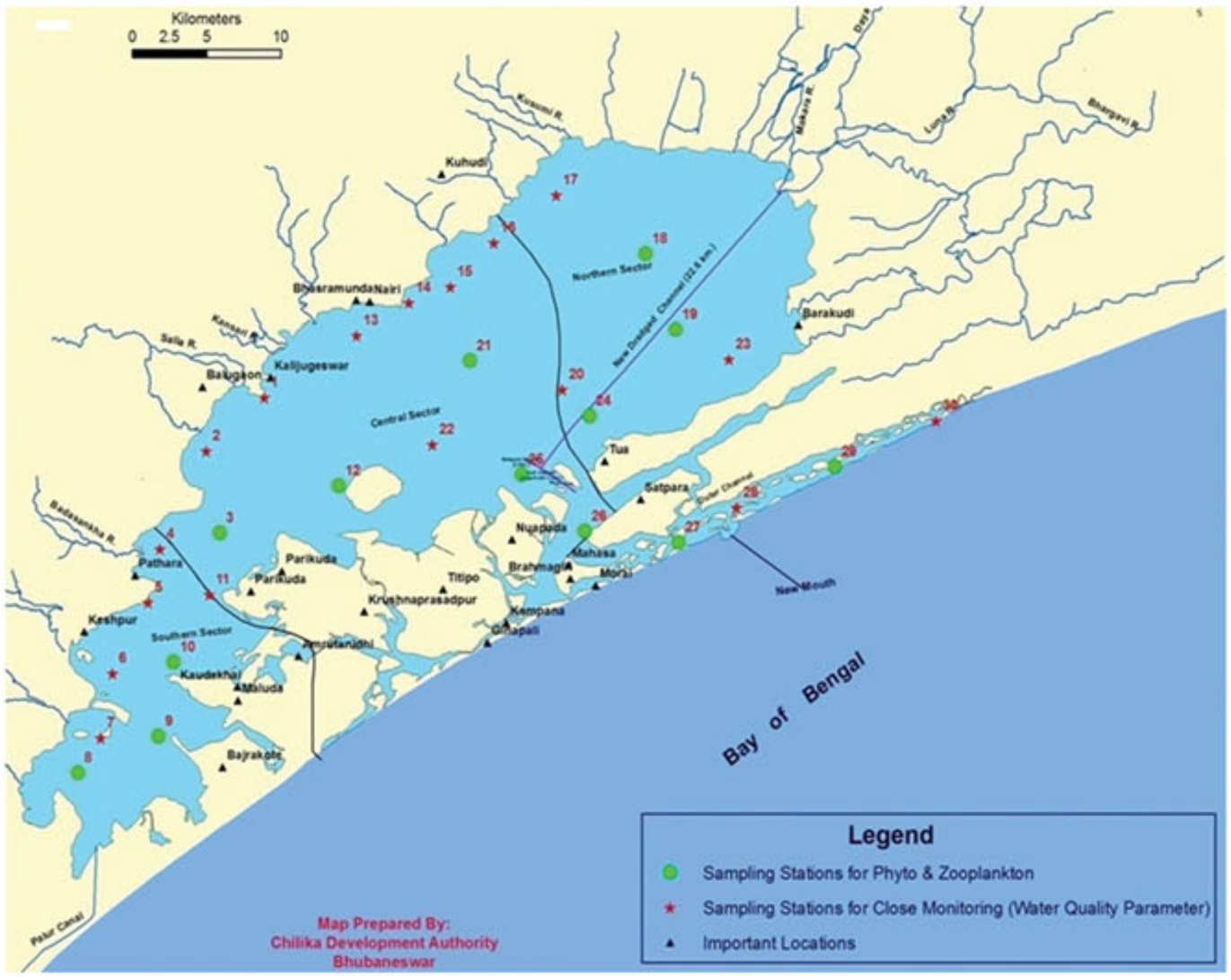
A 80–100%. All water quality and biological health indicators meet desired levels. Quality of water in these locations tends to be very good, most often leading to very good habitat conditions for fish and shellfish.

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.

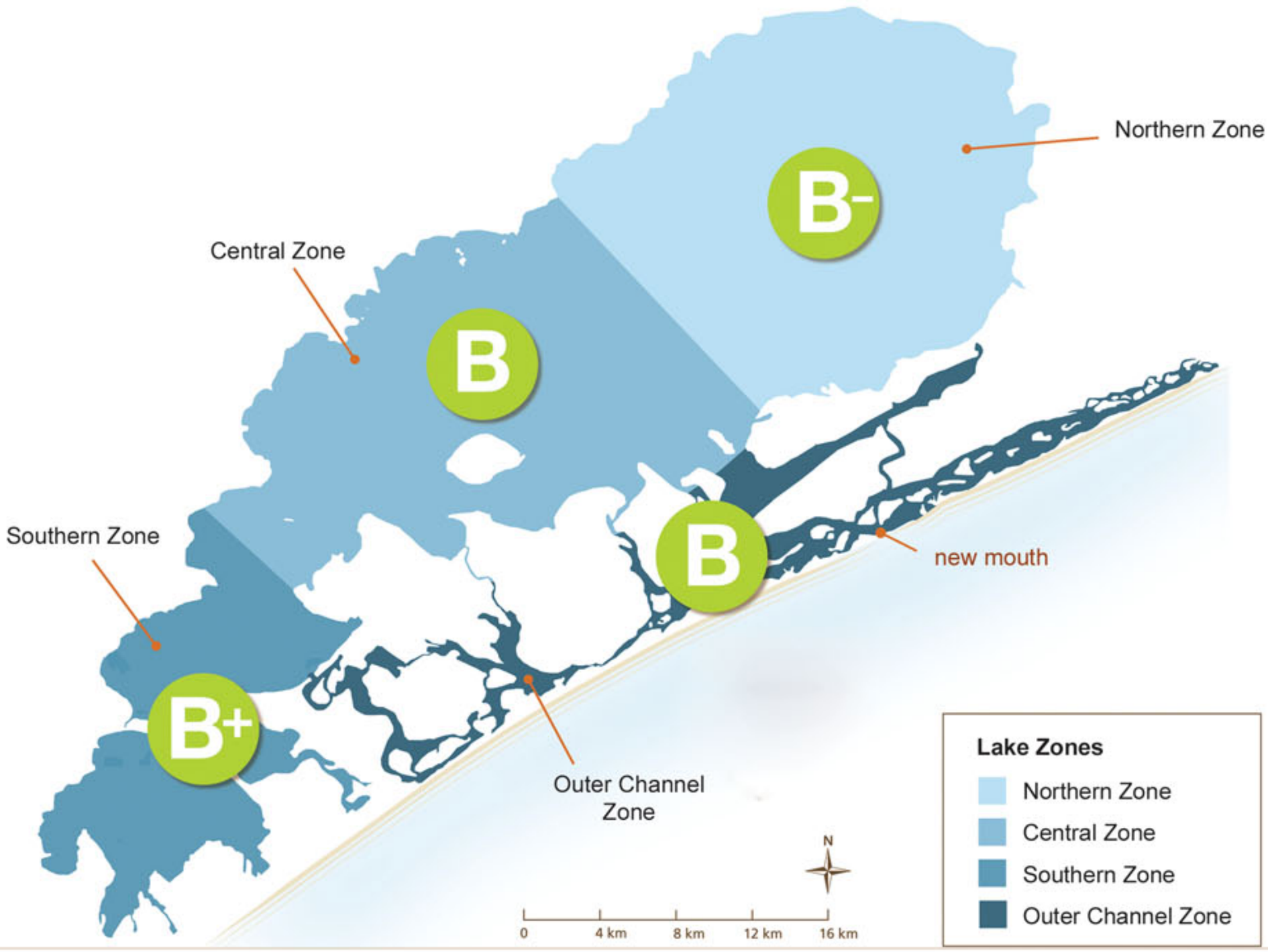
C 40–60%. There is a mix of good and poor levels of water quality and biological health indicators. Quality of water in these locations tends to be fair, leading to fair habitat conditions for fish and shellfish.

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

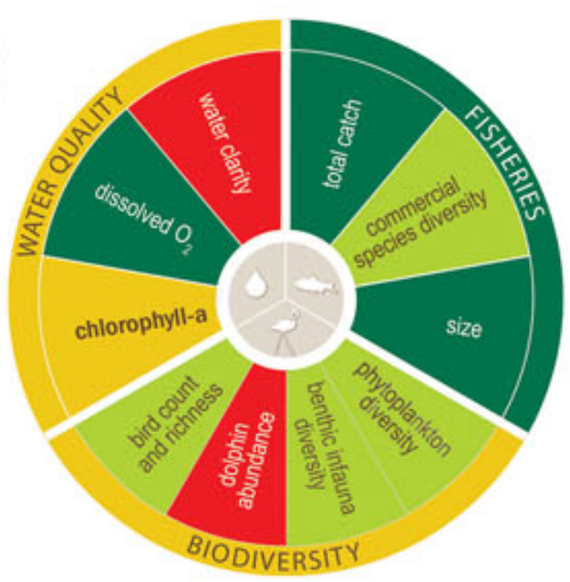
Overall, Chilika Lake scored a **B** for ecosystem health based on performance of water quality, fisheries, and biodiversity indices. The Lake as a whole displayed excellent (**A**) for dissolved oxygen concentrations, total fishery catch, and size. However, for chlorophyll-a concentrations,the Lake 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.

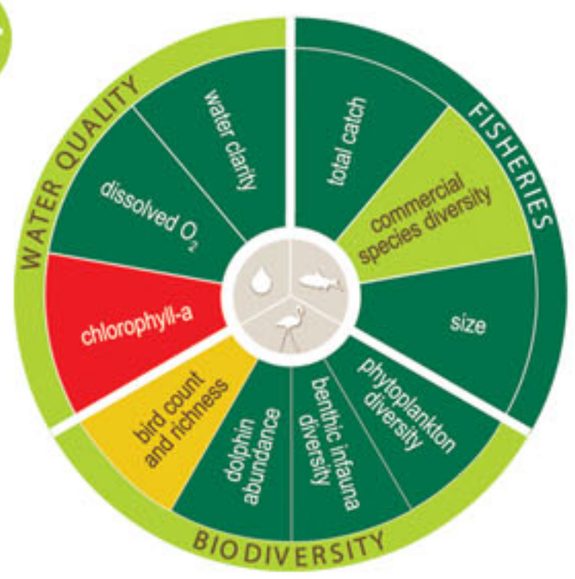


Central Zone B

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.

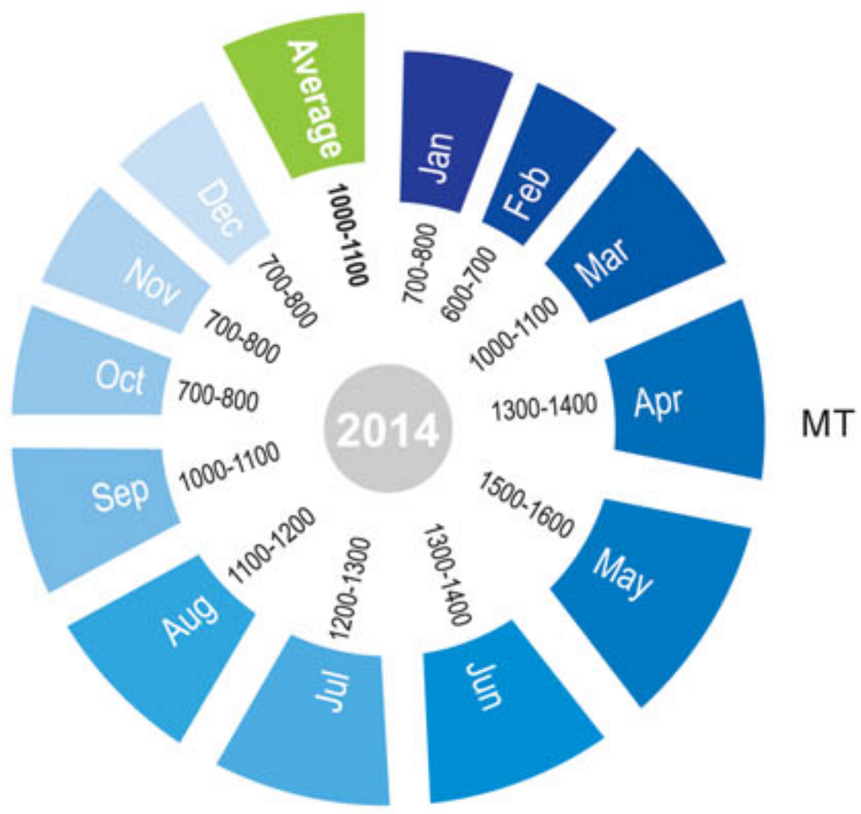
Over the last two years, systemic monthly monitoring of benthic faunal diversity indicated Chilika Lake is generally in good shape. Study of benthic macro fauna provided interesting insights of the resilient nature of Chilika Lake. The Lake was able to recover the diversity and abundance of macro fauna 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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An electronic copy of this report card and additional information can be found at: ***http://www.chilika.com***

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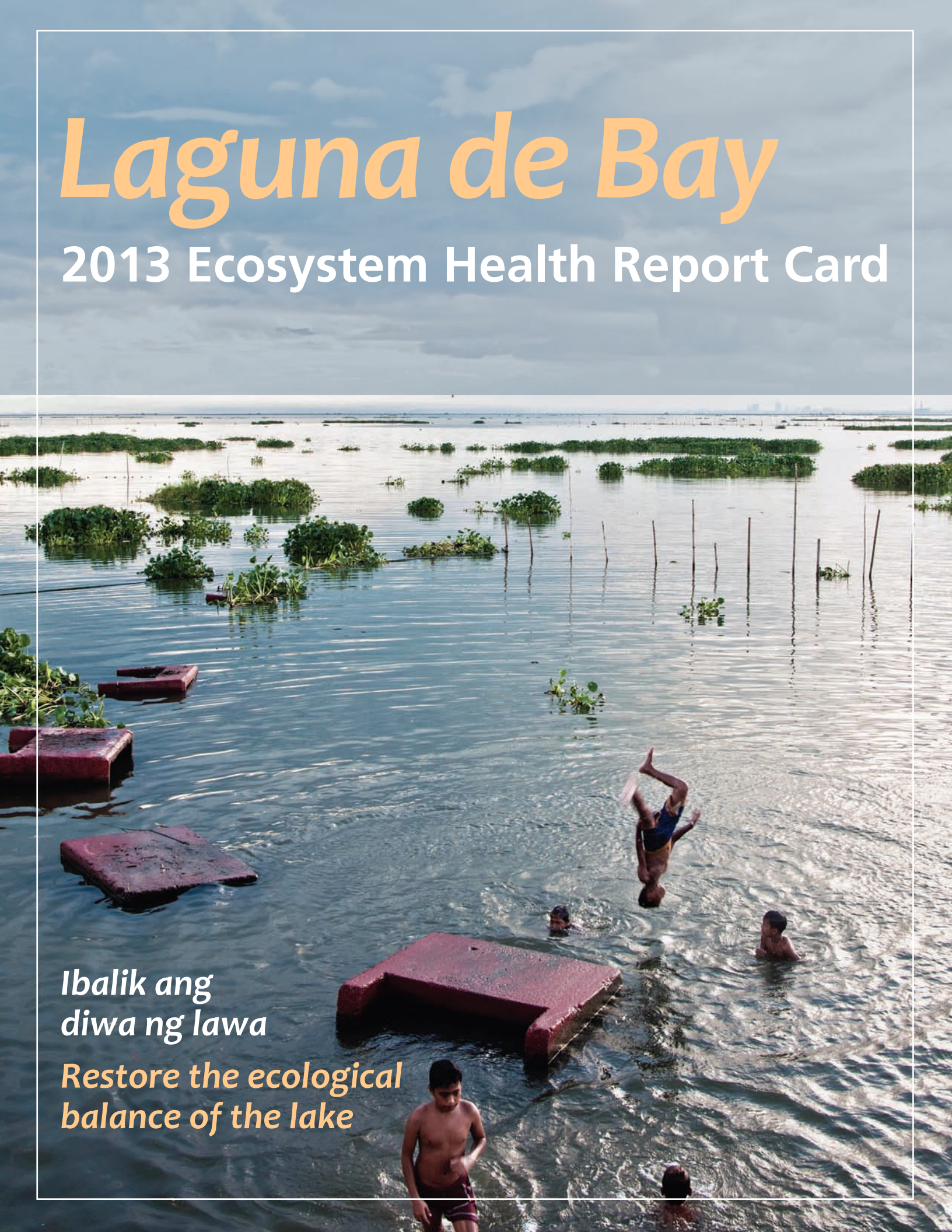
Release date: November 2015

Laguna de Bay

2013 Ecosystem Health Report Card



Ibalik ang diwa ng lawa

Restore the ecological balance of the lake

Laguna de Bay, a special ecosystem

Laguna de Bay is the largest inland water in the Philippines and the third largest in South East Asia. The lake has a surface area of 900 km², with an average depth of about 2.5 meters and an elevation of about 1 meter above sea level. It is bordered by the province of Laguna in the east, west and southwest, the province of Rizal in the north to northeast, and Metro Manila in the northwest. The lake features three distinct bays, the West Bay, Central Bay and East Bay that converge at the South Bay. The West Bay watershed is the most populated and heavily developed, mainly because it includes part of Metro Manila, while the East Bay, the least. The West and Central Bay are separated by Talim Island, the biggest and most populated island within the Lake. The lake's only outlet is the Napindan Channel which is connected to Manila Bay via the Pasig River.

Natural resource values and human activity threats

VALUES: Laguna de Bay is a multi-use water resource, supporting agriculture, livestock and poultry , and various industries . Local populations rely on both aquaculture in fish pens and cages and traditional fishing for commerce and food. Water extraction provides drinking water, industrial cooling and hydroelectric power generation . The lake provides transportation and recreational opportunities for the general public. Laguna de Bay and its watershed are rich in biodiversity, serving as a flyway sanctuary for migratory birds .

THREATS: The impacts of rapid population growth and urbanization are causing severe stress to the lake environment and the watershed. Untreated domestic sewage (i.e., informal waterway settlements), sediment and nutrients from agricultural, industrial, and mining activities flow into either the lake or its many tributaries, leading to poor water quality and ultimately, harmful algal blooms , and fish kills. Invasive species such as the clown knife fish threaten native fish stocks. To attempt to regulate saltwater intrusion , flooding, and pollution flowing between the Pasig River and the lake, the Napindan Hydraulic Control Structure was constructed in 1983. However, it was not operated to regulate saltwater intrusion due to strong protest from the Fisheries sector since periodic salt water intrusion is favorable to fisheries.

How ecosystem health is measured

Recognizing the importance of Laguna de Bay, this first ecosystem health report card is designed to provide a better understanding of the current ecosystem health, particularly as water quality improvement strategies are developed.

View of the West Bay. Photo: Vanessa D. Vargas

Two workshops were conducted. The first workshop iin December 2013 discussed the framework for the report card; identified the target audience and proposed indicators, sub-indicators and thresholds; and, determined the key messages.

During the second workshop in June 2015, the initial grades for the four sections of the bay were calculated and the report card framework was drafted. Indicators for **Water Quality** and **Fisheries** were selected to measure the ecosystem health of Laguna de Bay. Taken together, these indicators stand for the values of the lake and the threats that it is currently faced with.

Participants of the Second Laguna de Bay Report Card Workshop. *List of participants: Nancy Bermas and Daisy Padayao (Partnerships in Environmental Management for the Seas of East Asia); the Laguna Lake Development Authority Technical Working Group: Adelina Santos-Borja, Jocelyn Sta. Ana, Rose Bonifacio, Neil Varcas, Ireneo Bongco, Rosemary Cabrera, Gregory Ongjoco, and Marilyn Apacionado; Dr. Adelaida Palma (Bureau of Fisheries and Aquatic Resources); Dr. Gil Jacinto (University of the Philippines-Marine Science Institute); Dr. Macrina Zafaralla (University of the Philippines-Los Baños); Dr. Rey Papa and Milette Mendoza (University of Santo Tomas); and the Science communication team: Dave Nemazie, Dr. Simon Costanzo, and Vanessa Vargas (University of Maryland Center for Environmental Science).*

Water quality indicators

NO_3^-

Nitrates in excess amounts cause dramatic increases in aquatic plant growth and changes in the types organisms that live in the lake. Sources include fertilizers, drainage from livestock feeds, as well as domestic and industrial discharges.

PO_4^{-3}

Phosphates come from agricultural runoff, animal waste and sewage. Phosphorous is also one of the main component of synthetic detergents.

Chlorophyll a measures the amount of phytoplankton that can cause algal blooms. Algal blooms by blue-green algae are an indicator of deteriorating water quality and pollution.

DO

Dissolved oxygen (DO) is vital for the survival of fish and benthic organisms in the lake.

BOD

Biological oxygen demand (BOD) is the amount of oxygen required by microorganisms for stabilizing biologically decomposable organic matter in water under aerobic conditions. High BOD levels are associated with organic pollution, such as sewage.

Total coliforms is a measure of animal bacteria that enter the lake by direct deposition of waste in the water and runoff from areas with high concentrations of animals or humans.

Fisheries Indicators

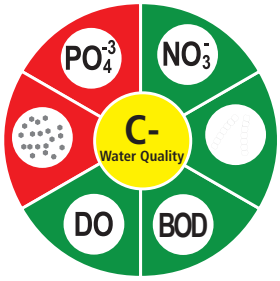
Zooplankton ratio can be used to indicate changes in the trophic state of the lake, level of eutrophication and warming history. Decreasing calanoid to cyclopoid ratio indicates deteriorating trophic state; the lower the calanoids, the higher the trophic state of the lake. In Laguna de Bay, the only remaining calanoid copepod is the invasive *Arctodiaptomus dorsalis*, which has already displaced previously recorded native calanoid species in the lake.

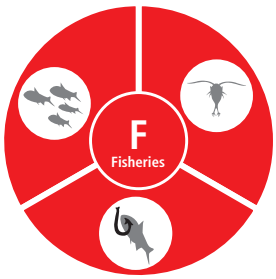
Native fish species composition measures the proportion of native against introduced/invasive species in major catch composition.

Catch per unit effort is computed from the average total daily catch and the total number of fishing hours.

2013 Laguna de Bay ecosystem health

LAGUNA DE BAY

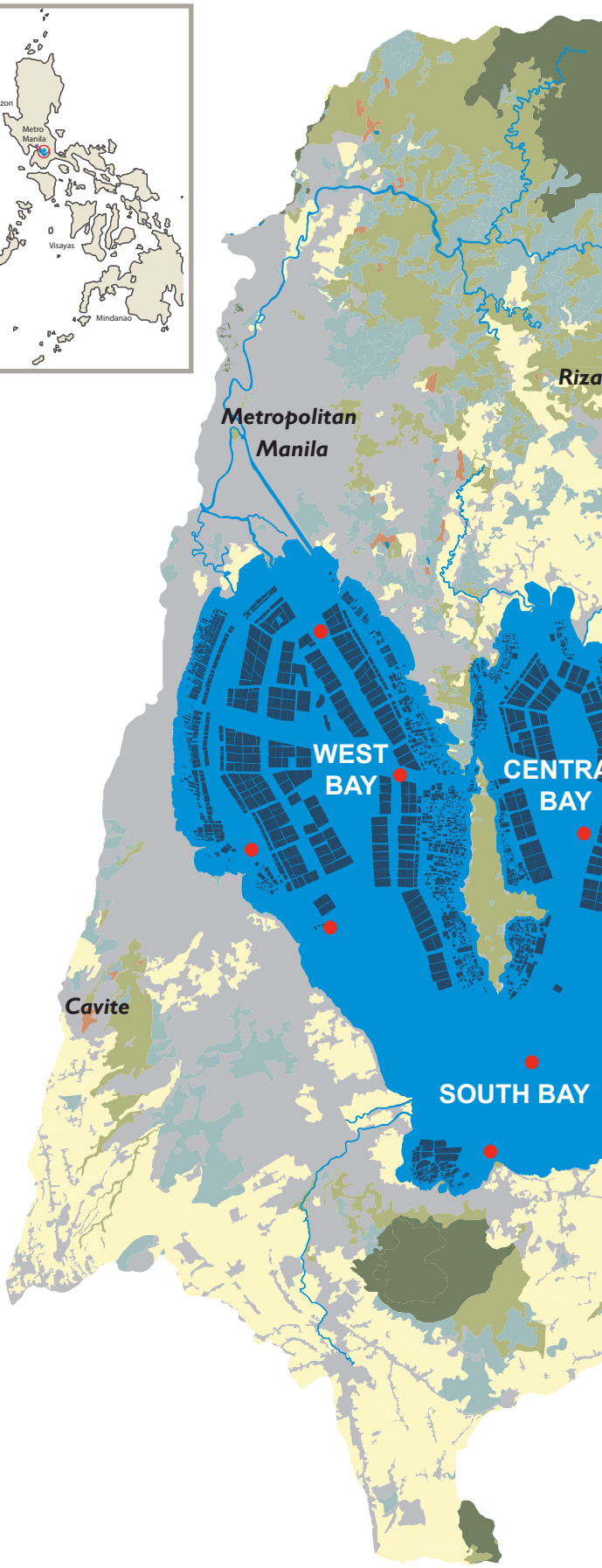




Laguna de Bay scored a low passing mark, 76%, a C-, in water quality. The bay consistently is within the Department of Environment and Natural Resources (DENR) guidelines for class C waters in DO, BOD, Nitrate, and Total Coliforms. However, it scored 0% in Cholorophyll and 59% in Phosphate. Water quality was affected by high population and industralization.

The lake received an F in Fisheries (48%), with a 53%, 68%, and 22% scores in fish native species composition, zooplankton ratio, and catch per unit effort (CPUE), respectively. Invasive fish species and competition among fisher folks contributed to the low scores.

Even though the DENR guidelines are met in most water quality indicators, the chlorophyll a, phosphate, and zooplankton scores show that the lake is highly eutrophic. These results have a negative impact on the fisheries of Laguna de Bay. Overall, these scores are not only a cause of concern for fisheries, but the whole community and all the industries supported by the lake.



How are the scores calculated and what do they mean?

The 2013 Laguna de Bay report card measured indicators for water quality and fisheries for the West, Central, East, and South bays. Six water quality indicators were compared to the Department of Environment and Natural Resources (DENR) guideline for class C (suitable for fisheries and recreation) waters which were then combined and then represented as a percent score for each bay. The three fisheries indicator were calculated as ratios or percentage that are then combined as a percent score for each bay.

The grading scale follows the typical scale used in Philippine schools.

A 91–100%: All the indicators meet desired levels. Quality of water in these locations tends to be very good, most often leading to preferred habitat conditions for aquatic life.

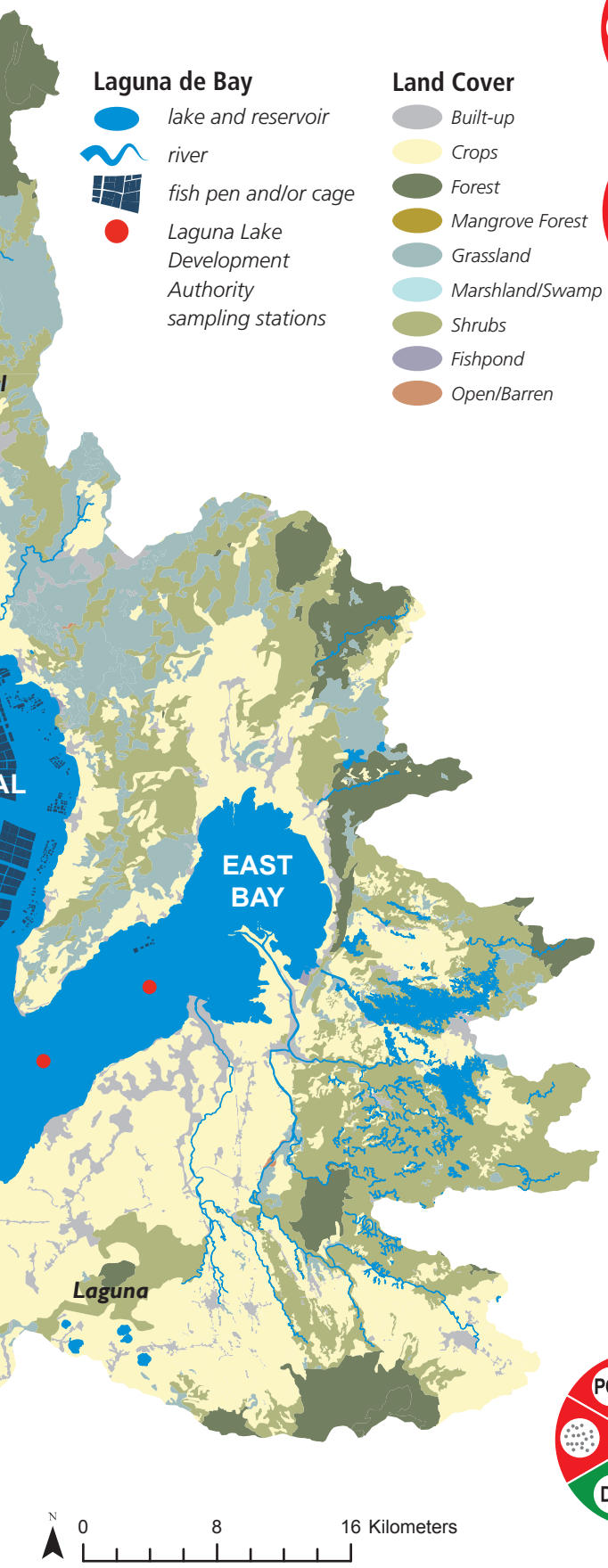
B 83–91%: Most indicators meet desired levels. Quality of water in these locations tends to be good, often leading to acceptable habitat conditions for aquatic life.

C 75–83%: There is a mix of good and poor levels of indicators. Quality of water in these locations tends to be fair, leading to sufficient habitat conditions for aquatic life.

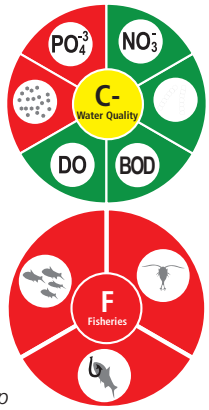
D 70–74%: Some or few indicators meet desired levels. Quality of water in these locations tends to be poor, often leading to degraded habitat conditions for aquatic life.

F 0–70%: Very few or no indicators meet desired levels. Quality of water in these locations tends to be very poor, most often leading to unacceptable habitat conditions for aquatic life.

report card



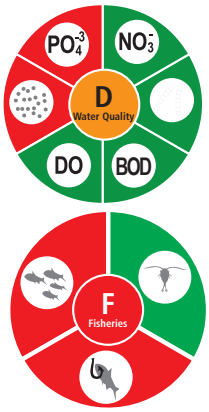
WEST BAY



The West Bay has the second lowest water quality score (76%). It is the most heavily developed side of Laguna de Bay and most populated. For 2013, its DO, BOD and Nitrate were within DENR's guideline for class C waters (100%) and its total coliform at 98%. However it has the second lowest score in phophate (56%) and like all the bays, received a 0% in chlorophyll. This scores reflect its high population density and the need to reduce phosphorus runoff into the lake..

The West Bay also has the second highest fisheries score of 55% (F), with a 62% score in zooplankton ratio, and CPUE (35%) and the second highest score in native fish species composition at 68%. This region has the highest concentration of commercial fish pens and cages, and an estimated fishing ground allocation of 1 fisher/101 ha.

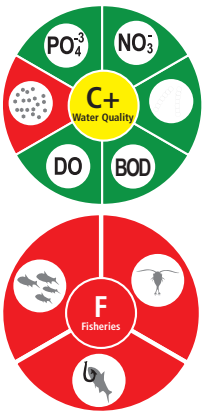
CENTRAL BAY



The Central bay has the lowest water quality score at 71%, however, its 65% score in Fisheries is the highest. Although it scored 100% in nitrate, DO, BOD, and total coliform, it had the lowest score in phospate with 25%, and a 0% in chlorophyll a.

The Central Bay has the highest in percentage of native fish in catch composition and zooplankton, with a score of 69% and 100%, respectively. It has approximately 1 fisher/110 ha of fishing ground allocation.

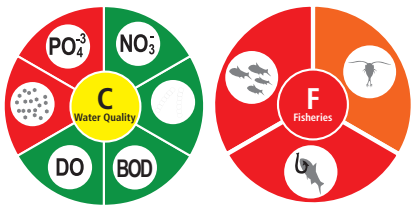
EAST BAY



The East Bay has the highest water quality score at 81%. It received an A in all water quaity indicators except for cholorophyll a (0%, an F). However, the East Bay scored the lowest in fisheries with 28% scoring a mere 3% in CPUE.

East Bay has a higher number of fishermen operating in a smaller fishing area with a fishing ground allocation of only 1 fisher/28 ha and the highest concentration of the invasive clown knife fish. This species was introduced in the lake through the East Bay and most likely propagated faster because of the East bay's water quality.

SOUTH BAY

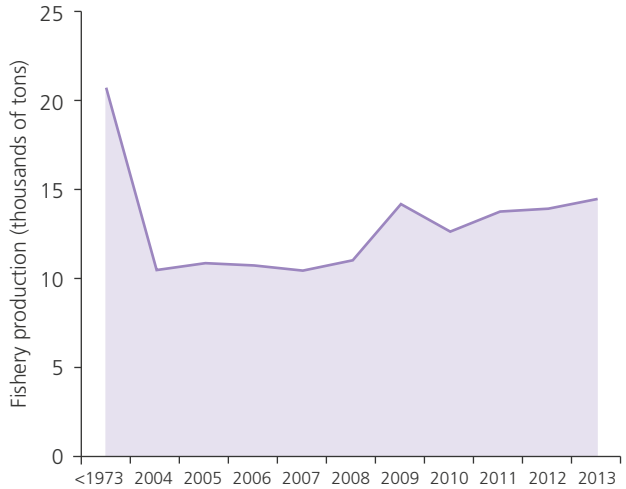


The South Bay has the second best score in water quality at 77%, with 100% in nitrate. DO, BOD, and total coliform. Like all the bays, it has a 0% in chlorophyll a and an F in phosphate at 63%. However, it had the second lowest score in fisheries, 43%, with the lowest score in native fish species composition at 37% even though a designated fish sanctuary is located within the South Bay.

Fishery production is in trouble

In 2013, Laguna de Bay accounts for 3.1% of the national fisheries production, 2.5% of the national production for aquaculture, and 6.8% of the national production for municipal fisheries (BFAR). The major commercial species caught in the lake included milkfish (bangus), tilapia, bighead, silver perch, and goby (biya).

Fisheries production prior to the introduction of fish pens in 1973 was at 20,700 T/yr. Catch data in 1995 was at 8,146 T/yr before the reported sightings of invasive species. In 1996, catch was at 3,055 T/yr when there were two strong typhoons and catch data were most likely from natural recruitment.



Ten year production trend in Laguna de Bay. Data source: Bureau of Agricultural Statistics.

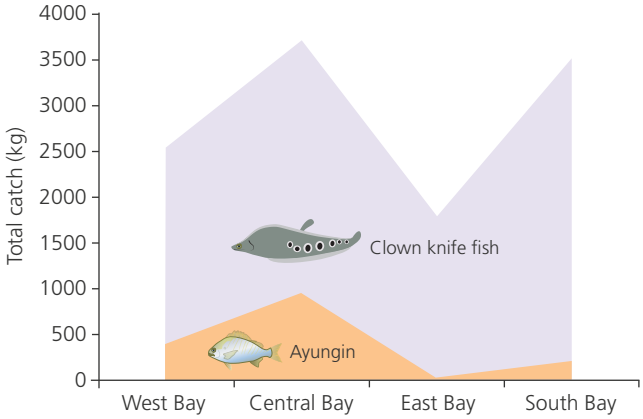
Declining water quality and invasive species affect fisheries

Both cultured and native fish species utilize the nutrients productivity of Laguna de Bay. However, lake water quality has been declining due to:

- land use change from agricultural to industrial and residential;
- industrial pollution, agricultural fertilizer run-off, siltation, and sedimentation; and,
- algal blooms and fish kill events in the Lake.

One of the most important native fishes in the Lake is the ayungin (*Leipotherapon plumbeus*). The highest total catch in 2013 is in the Central Bay, while the lowest is in the East Bay. This can be attributed to the high concentration of the invasive clown knife fish (*Notopterus chitala*) in the East Bay, which prey on ayungin. Clown knife fish eggs also attach to cultured fish cages and pens and once hatched, will feed on the fry and fingerlings of big head carp and bangus. The proliferation of knife fish has caused significant declines in cultured and native fish production.

*Bighead carp (*Hypophthalmichthys nobilis*). Photo: Ramon F Velasquez.*



Comparison of clown knife fish and ayungin catch from actual sampling in Laguna de Bay in 2013. Data source: Bureau of Fisheries and Aquatic Resources

Algal bloom in tilapia fish pens. Photo: Mark Anthony Salvador

People can make a difference

Youth education and involvement

The Laguna Lake Development Authority (LLDA) has a 14-year partnership with the Society for the Conservation of Philippine Wetlands, Inc. and Unilever Philippines called CLEAR (Conservation of Laguna de Bay's Environment and Resources). CLEAR was responsible for the acceptance of Laguna de Bay in the Living Lakes Network and aims to ensure the sustainability of initiatives towards a unified effort to conserve the Lake through awareness campaigns.

CLEAR and its various partners have conducted 16 ecological camps benefitting students from 100 high schools in 13 lakeshore municipalities. At these Eco-Camps, students are taught basic ecological principles and experienced actual rapid wetland assessment and water quality monitoring. To date, the network is composed of about a thousand youth members doing projects in their schools and communities that promote community resilience, climate change mitigation measures and climate change adaptability.

An annual CLEAR Youth Network Congress is being held for participants to report on their accomplishments and plan activities for the ensuing year. It has become a venue for the youth to exchange ideas and information on practices and activities on lake conservation.

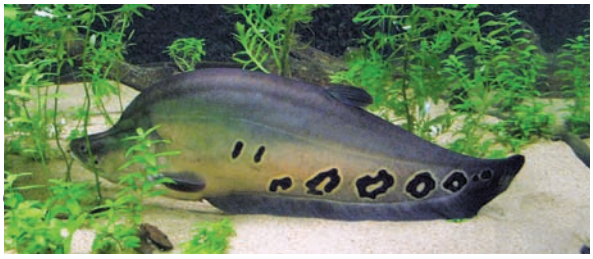
Students learn to value Laguna de Bay. Photos: Conservation of Laguna de Bay's Environment and Resources

Government agencies and local communities work together

An inter-agency technical working group (TWG) was formed to harmonize efforts for the implementation of projects and strategies for the containment of clown knife fish (*Notopterus chitala*) in Laguna de Bay and the preventive measures for further spread into other inland waters. With the theme "Panganib ng Knife Fish Sugpuin; Laguna de Bay Muling Pasiglahin" and "Mapanganib na Dayuhang Isda Pigilang Makawala sa mga Ilog at Lawa", the TWG:

- mobilized fishing communities to participate in the massive retrieval of knife fish;
- conducted experiments to intervene in the life cycle through salinity manipulation and electrocution of eggs;
- provided livelihood opportunities through development of value adding technology for the economic utilization of knife fish;
- conducted an extensive educational campaign; and,
- established and maintained a BFAR (Bureau of Fisheries and Aquatic Resources) interactive invasive fishes webpage for information dissemination and participatory citizen science.

Efforts are paying off—the 2013 fisheries survey showed that knife fish in the total catch was reduced to 10.53% compared to 40.34% in 2011!



Knife fish collection and creating new knife fish products such as sausages and burger patties. Photos: Bureau of Fisheries and Aquatic Resources

A new technology helps restore water quality

A simple, cost-effective filtration system is a promising solution to pollution, fish production, and biodiversity problems in Laguna de Bay. It is centered on the University of the Philippines (UPLB) Los Baños' phytoremediation system called the UPLB Aquatic Macrophyte Biosorption System (AMBS). It aims to restore degraded water quality of Laguna de Bay tributaries.

The AMBS system is made of bamboo and water hyacinth (*Eichhornia crassipes*) or kang kong (*Ipomoea aquatica*). Initial data showed visible evidence of habitat restoration, i.e., clearer water after filtration and robust populations of native fish fingerlings in 1–2 weeks. Stream cleanup before installation is needed, thus requiring community cooperation.

Molawin Creek is declared a biopark as water quality improves by the AMBS. Photos: Dr. Macrina Zafaralla (Los Baños Times)

You can help save the Lake!

Photo: LLDA.

Youths participate in tree planting activity.

Be conscientious

Properly dispose your household waste and maintain a clean surrounding. Organize and participate in community clean-up and tree planting activities.

Photo: sercul.org

Phosphate free detergents are now available.

Be proactive

Support environmentally friendly products. Join the campaign to encourage the use of phosphate-free detergents and household cleaners.

Photo: BFAR

Invasive knife fish forum.

Be informed

Learn about the status of the lake, and existing and future projects of governmental and non-governmental agencies that you can participate in.

Photo: LLDA.

Polluting industry is closed.

Be vigilant

Report illegal activities and malpractices of the aquaculture, agricultural, and industrial sectors.

Moving forward with LLDA

The Laguna Lake Development Authority faces a range of daunting challenges that go beyond land degradation, water pollution, and ecological degradation. The interlocking concerns- land use, water quality, reforestation, settlements and shorelines, regulation of fisheries and industries - run into the even larger imperatives of social and institutional reform.

The Lake basin of twenty four (24) sub-basins and river systems encompass close to a half-million hectares, which could not be effectively managed if stakeholders from all sectors - local governments, fisherfolk, the private sector, civil society - are not able to work together, with a shared vision of a re-imagined future for this most critical ecosystem of the country. For this to be sustained as a course of action, sound, science-based governance and new, innovative institutional arrangements - LLDA fully engaging with the widest array of interests and stakes - must be in place. In this day and age of climate change, we can do no less.

As we say, we cannot protect that which we do not value, we cannot value that which we first do not understand. This Ecosystem Health Report Card aids us all in the deeper appreciation of what ails the Laguna Lake - and more importantly, helps us understand how we can all the more value its beauty and bounties, and commit ourselves to restoring, enhancing, and protecting, its ecological wealth.

The Laguna Lake Development Authority (LLDA), headed by Sec. Nereus Acosta, is tasked with managing the Laguna de Bay region. Photo: Mark Anthony Salvador

- HON. J.R. NEREUS O. ACOSTA, Ph.D., Secretary/Presidential Adviser for Environmental Protection, LLDA General Manager

About the report card

The development of the first ecosystem health report card for Laguna de Bay was jointly implemented by the Partnerships in Environmental Management for the Seas of East Asia Resource Facility and the Laguna Lake Development Authority (LLDA), under the UNEP/GEF Project on Global Foundations for Reducing Nutrient Enrichment and Oxygen Depletion from Land-based Pollution in Support of Global Nutrient Cycle.

PEMSEA LLDA UNEP gef GPA Global Programme of Action for the Protection of the Marine Environment from Land-based Activities

Key partners

Key partners include the LLDA Technical Working Group, the external experts from the University of the Philippines-Marine Science Institute (UPMSI), University of the Philippines-Los Baños (UPLB), University of Santo Tomas (UST), and the Bureau of Fisheries and Aquatic Resources (BFAR), and the Science communication team from the Integration and Application Network, University of Maryland Center for Environmental Science.

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For more information, visit http://llda.gov.ph

Front cover: Local children playing when the lake overflowed in Wawa, Rizal. Photo: Jon Aguirre.