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Fourth session**
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Ecosystem Health Report Cards for Chilika Lake, India and Laguna de Bay, the Philippines

Note by the Secretariat
The present document has been issued without formal editing.

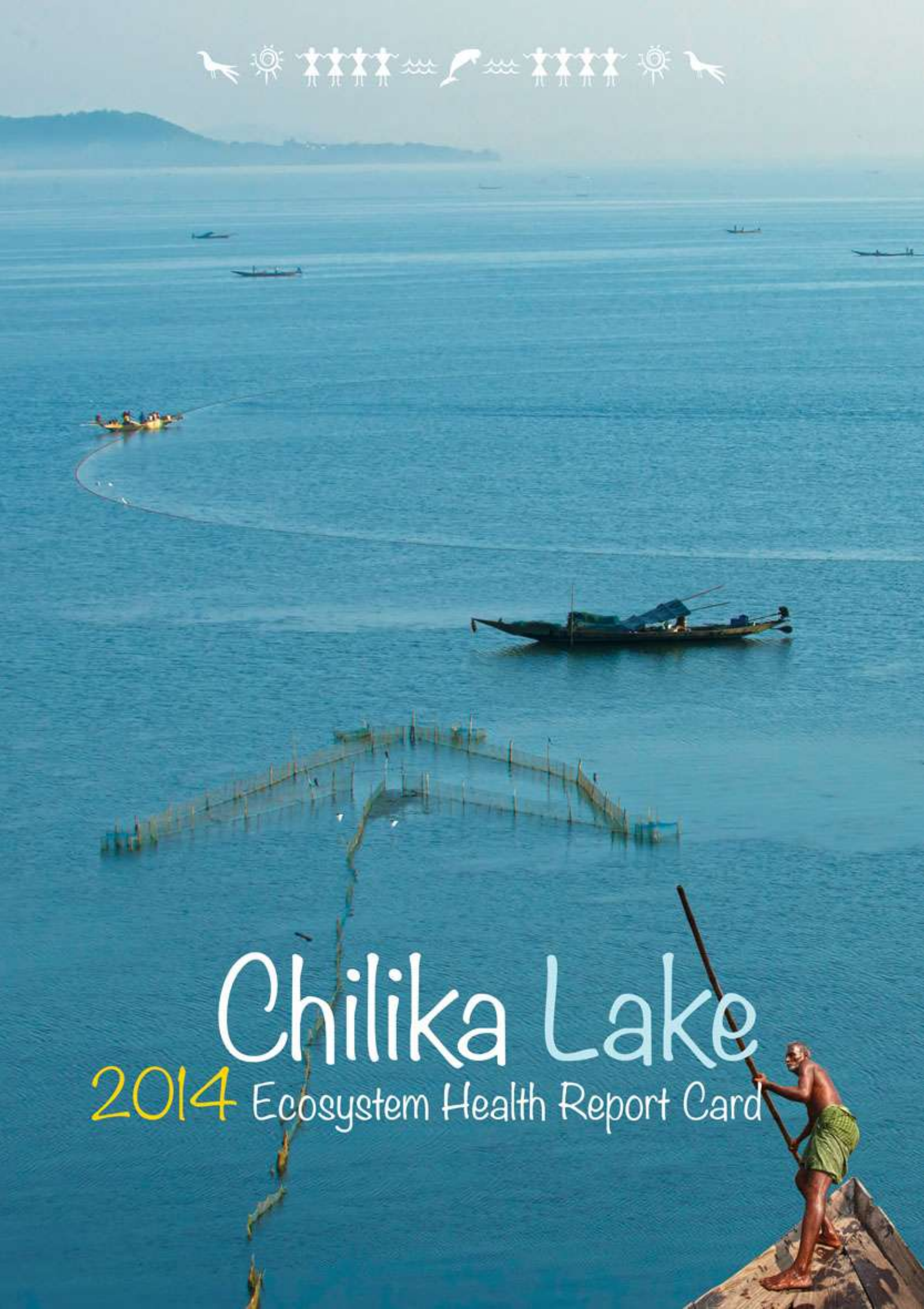
Background

The Global Environment Facility-funded 'Global foundations for reducing nutrient enrichment and oxygen depletion from land based pollution, in support of Global Nutrient Cycle Project' (GEF-Global Nutrient Cycle Project for short), executed by the Coordination Office of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, contributed to the development of Ecosystem Health Report Cards for Chilika Lake in India and Laguna de Bay in the Philippines.

The ecosystem heath report card has proven to be a very effective tool based on application in other parts of the world, to assemble environmental quality data and integrate into a coherent communication package that non-technical audiences can relate to, and provide the basis for assessment and feedback on results of efforts to combat pollution. The University of Maryland Centre for Environmental Science provided technical guidance to the development process based on their experience in application of the heath report card approach in other ecosystems across the globe.

The report card for Chilika Lake was developed under the leadership of the Chilika Development Authority, the entity with responsibility for the management of Chilika Lake. Based on this work, an ecosystem health report card was developed for Laguna de Bay. This was under the joint leadership of the Laguna Lake Development Authority and the Partnerships in Environmental Management for the Seas of East Asia (PEMSEA).

Chilika Lake 2014 Ecosystem Health Report Card



Chilika Lake

2014 Ecosystem Health Report Card

Introduction

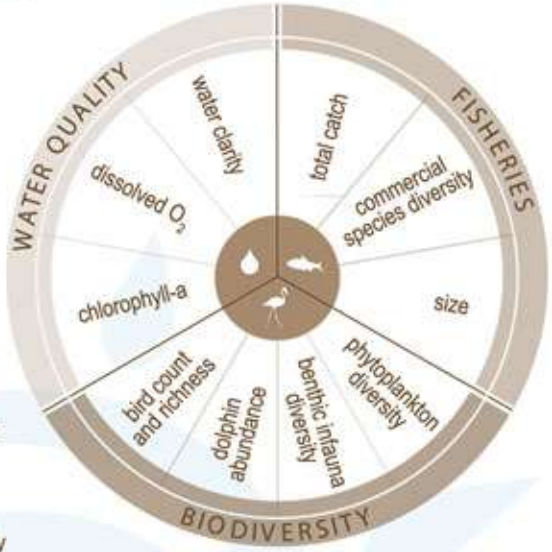
An ecosystem health report card emerged as an effective tool for tracking and reporting the ecological health of Chilika Lake. The report card has successfully communicated the complex volume of data and information gathered through the Lake monitoring program into a simple communicable format which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

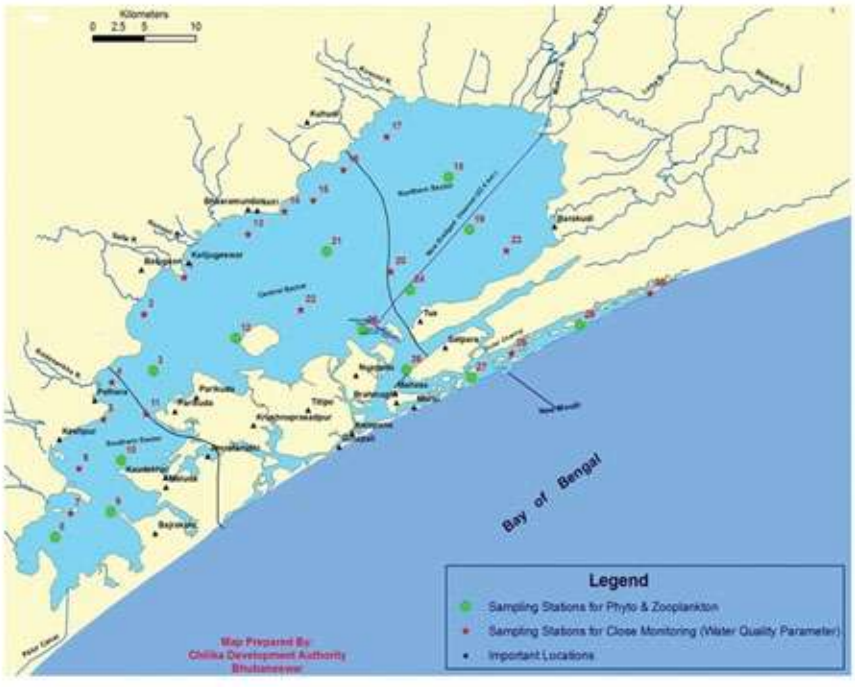
A 80–100%. All water quality and biological health indicators meet desired levels. Quality of water in these locations tends to be very good, most often leading to very good habitat conditions for fish and shellfish.

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.

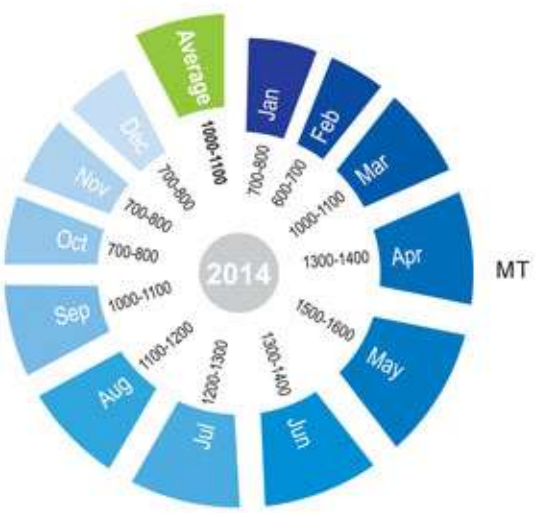
Over the last two years, systemic monthly monitoring of benthic faunal diversity indicated Chilika Lake is generally in good shape. Study of benthic macro fauna provided interesting insights of the resilient nature of Chilika Lake. The Lake was able to recover the diversity and abundance of macro fauna 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***

Acknowledgements

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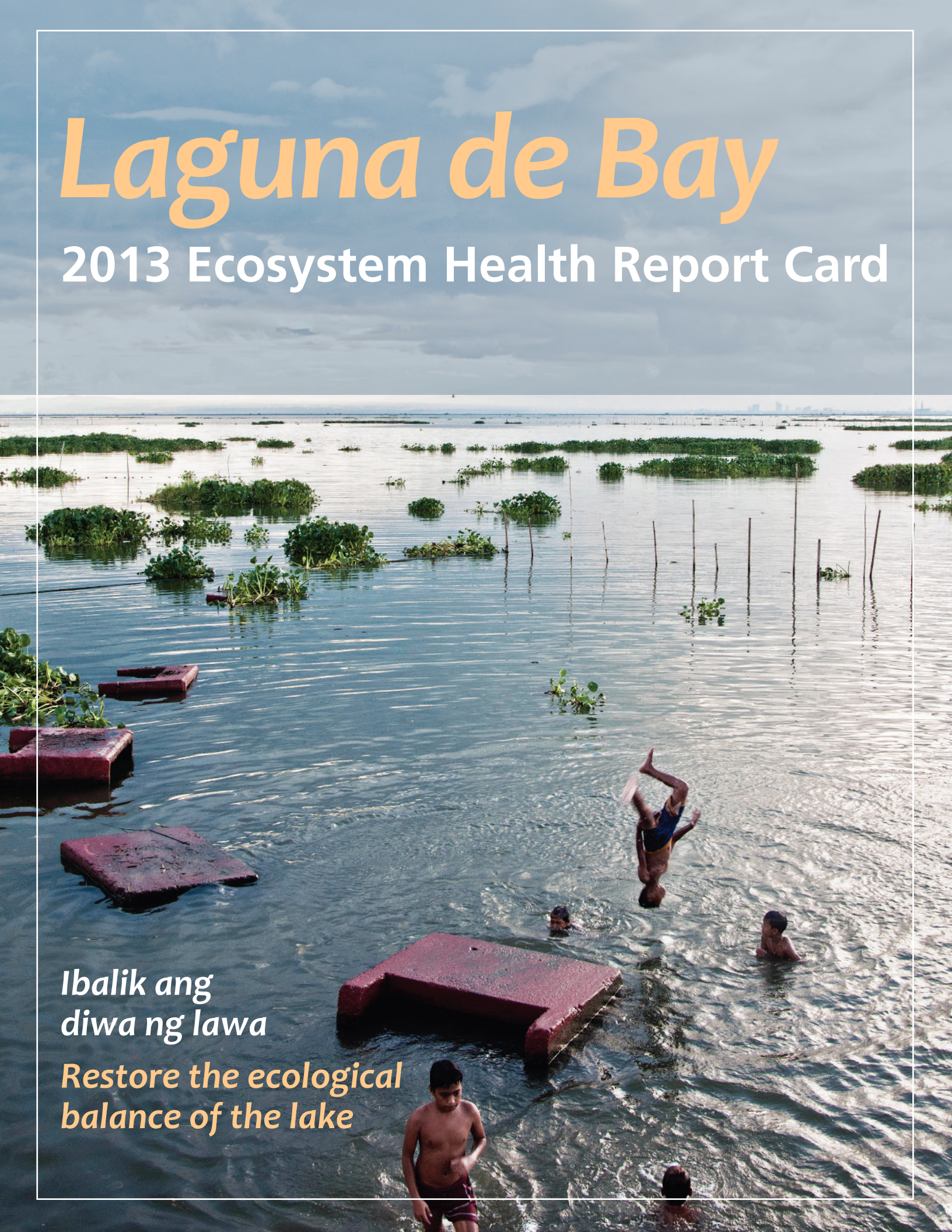
Laguna de Bay 2013 Ecosystem Health Report Card

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 waterbody 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 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 is the least. The West and Central Bays 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 watershed. Photo: Vanessa Vargas

Two workshops were conducted. The first workshop in 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 facing.

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 components 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

Biochemical 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

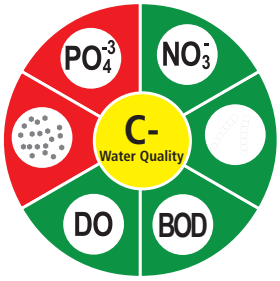
Zooplankton ratio can be used to indicate changes in the trophic state of the Lake, level of eutrophication and warming history. A decreasing calanoid to cyclopoid ratio indicates deteriorating trophic state; the lower the calanoids, the higher the trophic state of the Lake. In Laguna de Bay, the only 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.

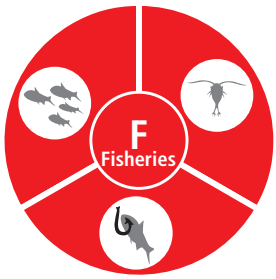
Catch per unit effort (CPUE) is computed from the average total daily catch and the total number of fishing hours.

2013 Laguna de Bay ecosyste

LAGUNA DE BAY



Laguna de Bay scored a low passing mark, 76%, a C-, in water quality. The Lake 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 chlorophyll *a* and 59% in phosphates. Water quality was affected by high population and industralization.



The Lake received an F in Fisheries (48%), with 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 fisherfolk contributed to the low scores.

Even though the DENR guidelines are met in most water quality indicators, the chlorophyll *a*, phosphates, and zooplankton ratio 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) guidelines for class C waters (suitable for fisheries and recreation) which were then combined and represented as a percent score for each bay. The three fisheries indicators were calculated as ratios or percentages that are then combined as a percent score for each bay. The grading scale follows the typical scale used in Philippine universities.

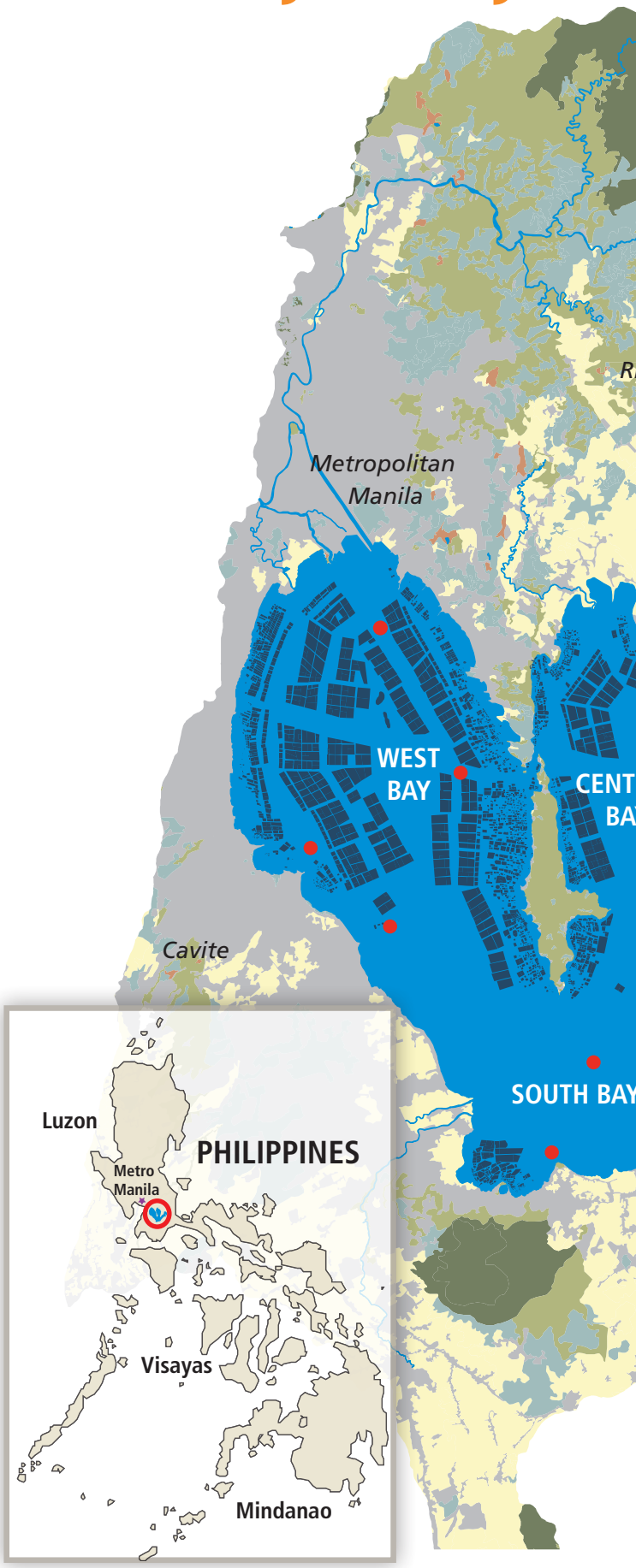
A 91–100%: All the indicators meet desired levels. Quality of water in these locations tends to be very good, most often leading to preferred habitat conditions for aquatic life.

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.



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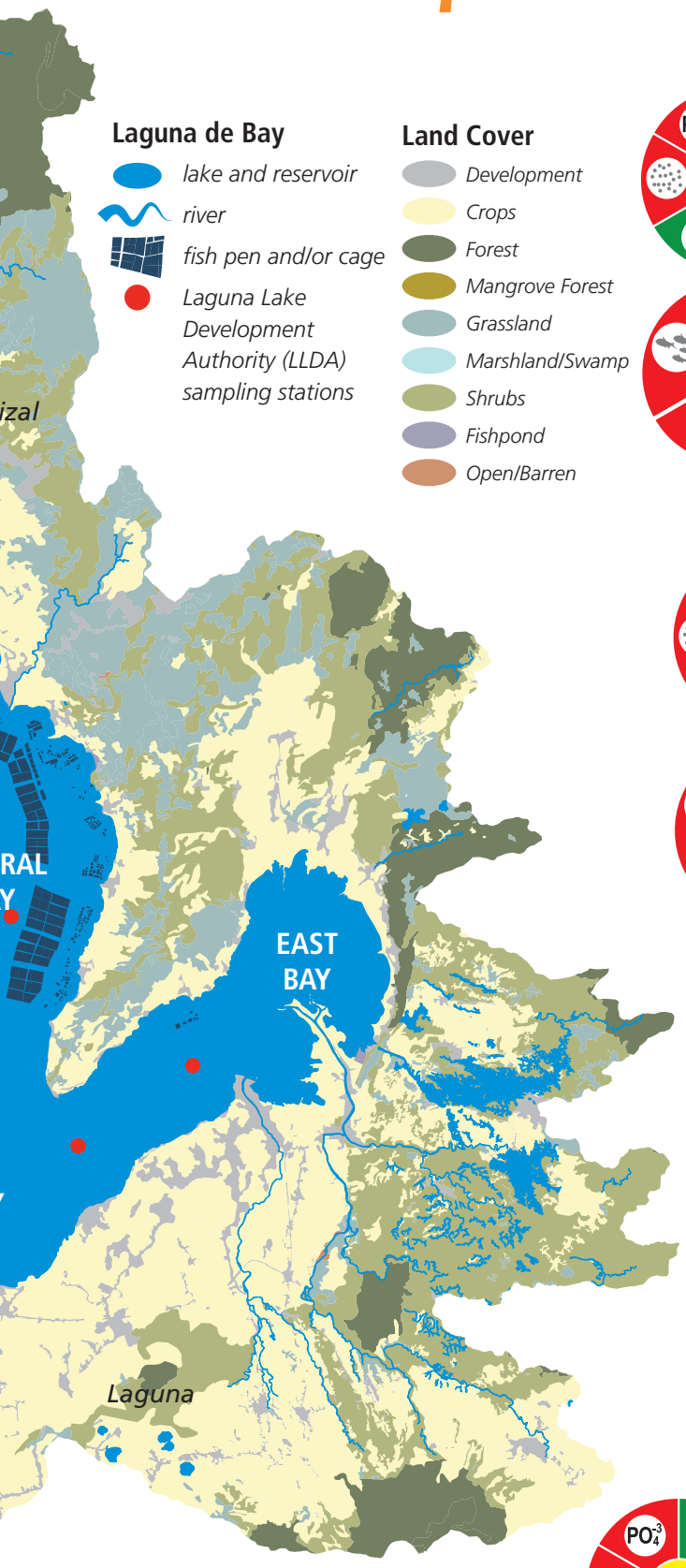
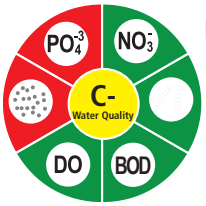
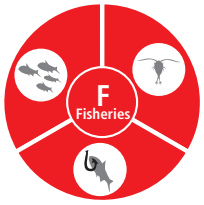


WEST BAY

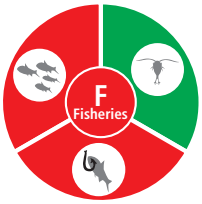




The West Bay has the second lowest water quality score, 76%. It is the most heavily developed side of Laguna de Bay and most populated. For 2013, its DO, BOD and nitrate were within DENR's guideline for class C waters (100%) and its total coliforms at 98%. However it has the second lowest score in phosphates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

The West Bay has the second highest fisheries score of 55% (F), with a 62% score in zooplankton ratio, 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 hectares (ha).

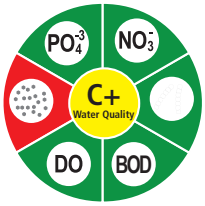
CENTRAL BAY



The Central Bay has the lowest water quality score at 71%, however, its 65% score in Fisheries is the highest of all bays. Although it scored 100% in nitrate, DO, BOD, and total coliforms, it had the lowest score in phosphates with 25%, and a 0% in chlorophyll a.

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

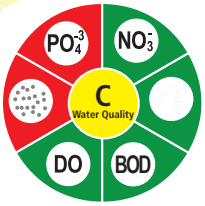
EAST BAY



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

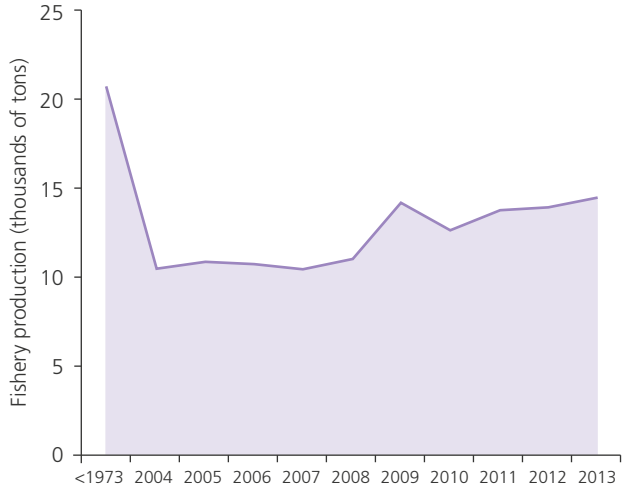


The South Bay has the second highest score in water quality at 77%, with 100% in nitrates, DO, BOD, and total coliforms. Like all the bays, it has a 0% in chlorophyll *a* and an F in phosphates at 63%. It had the second lowest score in fisheries, 43%, with the lowest score in native fish species composition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

Fishery production is in trouble

In 2013, Laguna de Bay accounted 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, 2013). 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 ton per year (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

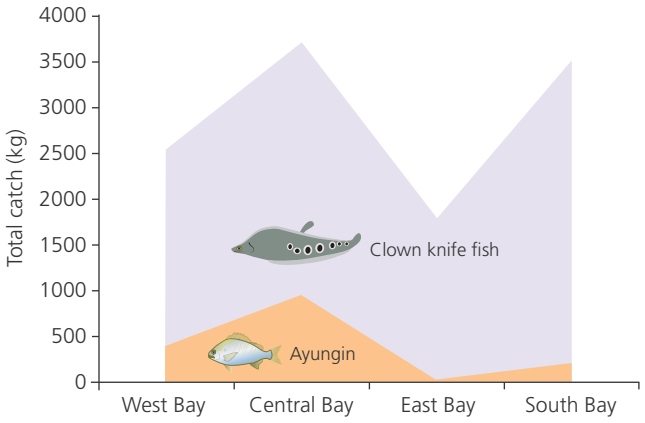
Declining water quality and invasive species affect fisheries

Both cultured and native fish species utilize nutrient productivity of Laguna de Bay. However, the Lake's 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 (BFAR)

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 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 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 upcoming year. It has become a venue for the youth to exchange ideas and information on practices and activities in lake conservation.

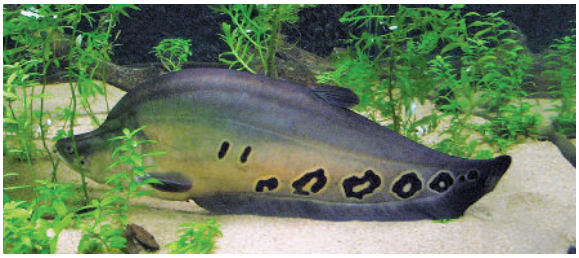
Students learn to value Laguna de Bay. Photos: Conservation of Laguna de Bay's Environment and Resources

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 themes "*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;
- organized 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!



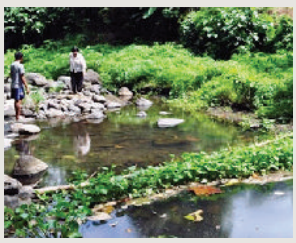
Clown knife fish (Notopterus chitala). *Photo: Daniel Arndt*

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. Community cooperation is developed through stream clean-up before installation.



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

You can help save the Lake!

Photo: LLDA

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: Laboko

Phosphate-free detergents.

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 was stopped.

Be vigilant

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

Moving forward with LLDA

"The Laguna Lake Development Authority (LLDA) 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."

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

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

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.