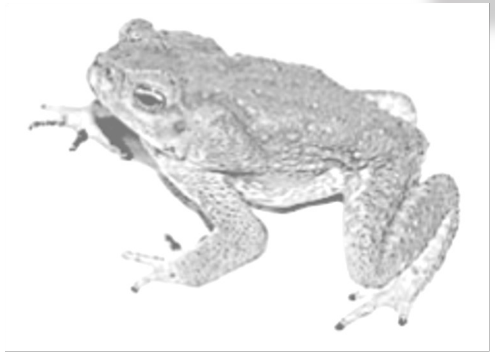
Unveiling the interplay between environmental pollutants, animal health, and sustainable ecosystems



Maria Claret Tsuchiya
Animal Biology Division, Institute of Biological Sciences
University of the Philippines Los Baños, College, Laguna, Philippines
Email: mblauan@up.edu.ph

Global water distribution

Earth

- ~71% water-covered
- <2% freshwater

Water source	Water volume, in cubic miles	Water volume, in cubic kilometers	Percent of freshwater	Percent of total water
Oceans, Seas, & Bays	321,000,000	1,338,000,000	--	96.54
Ice caps, Glaciers, & Permanent Snow	5,773,000	24,064,000	68.7	1.74
Groundwater	5,614,000	23,400,000	--	1.69
Fresh	*2,526,000*	*10,530,000*	*30.1*	*0.76*
Saline	*3,088,000*	*12,870,000*	--	*0.93*
Soil Moisture	3,959	16,500	0.05	0.001
Ground Ice & Permafrost	71,970	300,000	0.86	0.022
Lakes	42,320	176,400	--	0.013
Fresh	*21,830*	*91,000*	*0.26*	*0.007*
Saline	*20,490*	*85,400*	--	*0.006*
Atmosphere	3,095	12,900	0.04	0.001
Swamp Water	2,752	11,470	0.03	0.0008
Rivers	509	2,120	0.006	0.0002
Biological Water	269	1,120	0.003	0.0001

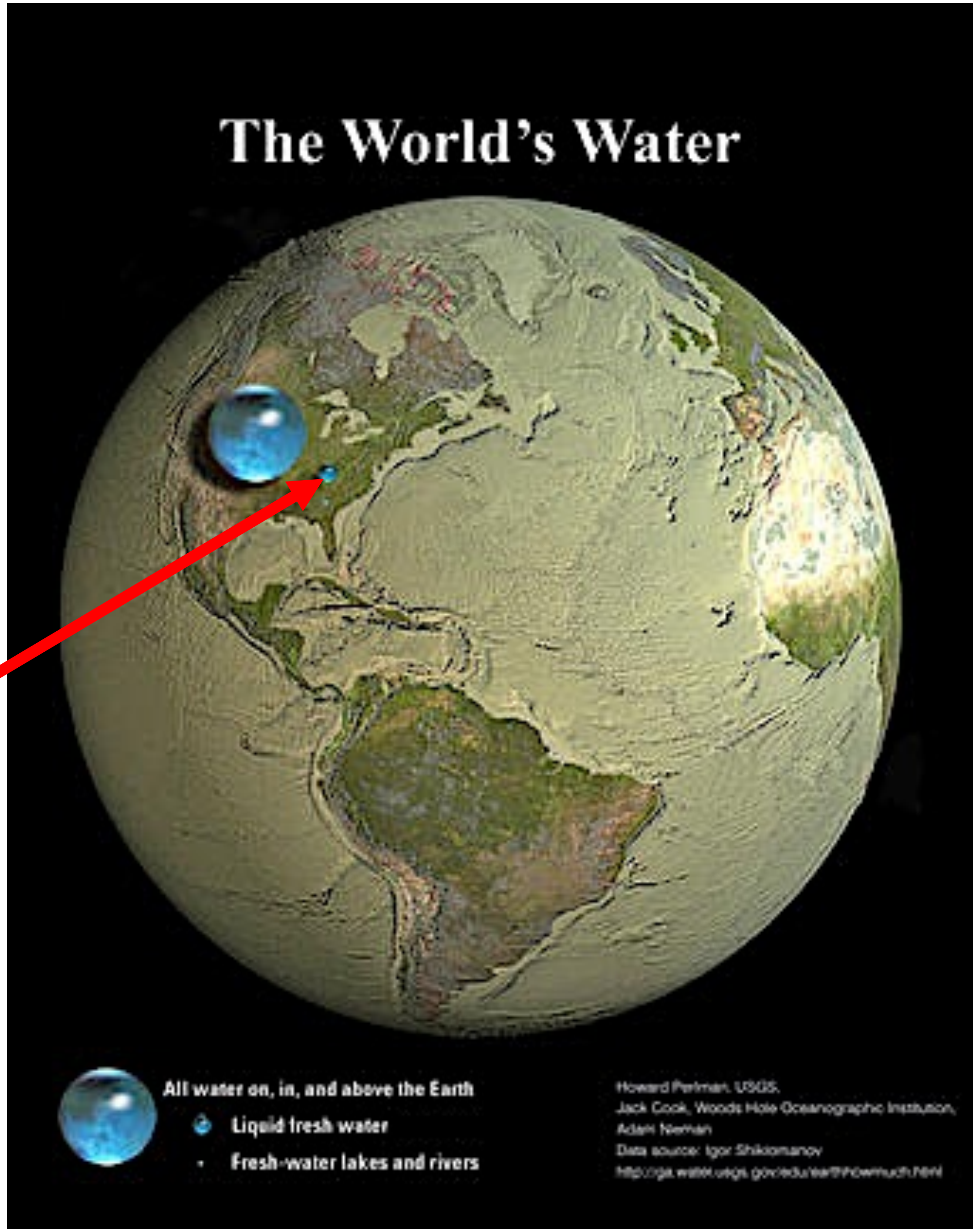
Water in Crisis: A Guide to the World's Fresh Water Resources, 2019

Global water distribution

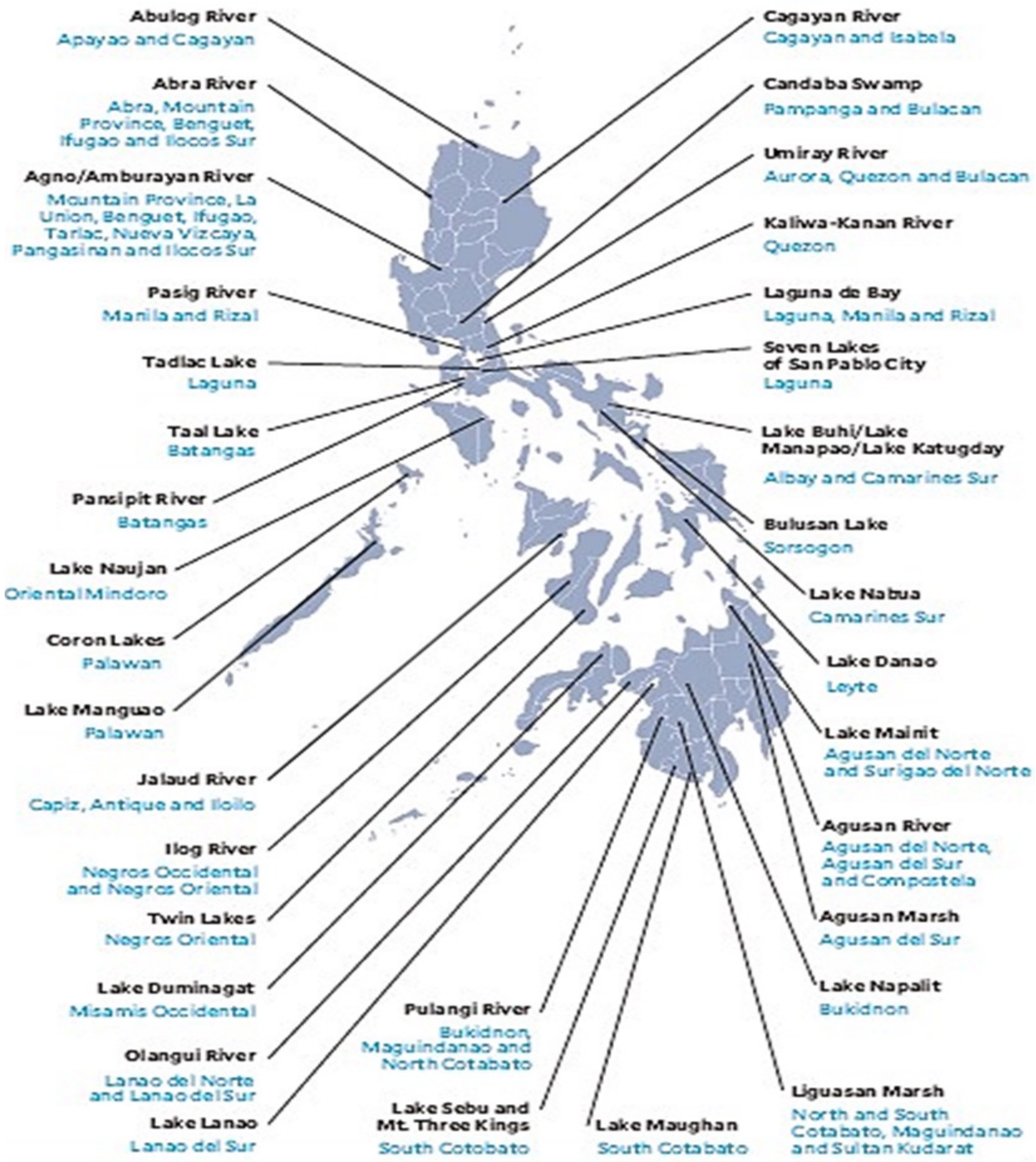
Earth

- ~71% water-covered
- <2% freshwater

Most of the water people and life on earth need every day comes from these surface-water sources.



Credit: Howard Perlman, USGS; globe illustration by Jack Cook, Woods Hole Oceanographic Institution (©); and Adam Nieman.



SAVING PHILIPPINE LAKES !

Philippines

- 266 natural inland wetland ecosystems
- over 70% are lakes

SOURCE: SAVING PH WETLANDS | FEBURARY 2019| INQUIRER.NET

TOP CONSERVATION AND RESEARCH AREAS FOR INLAND WATERS

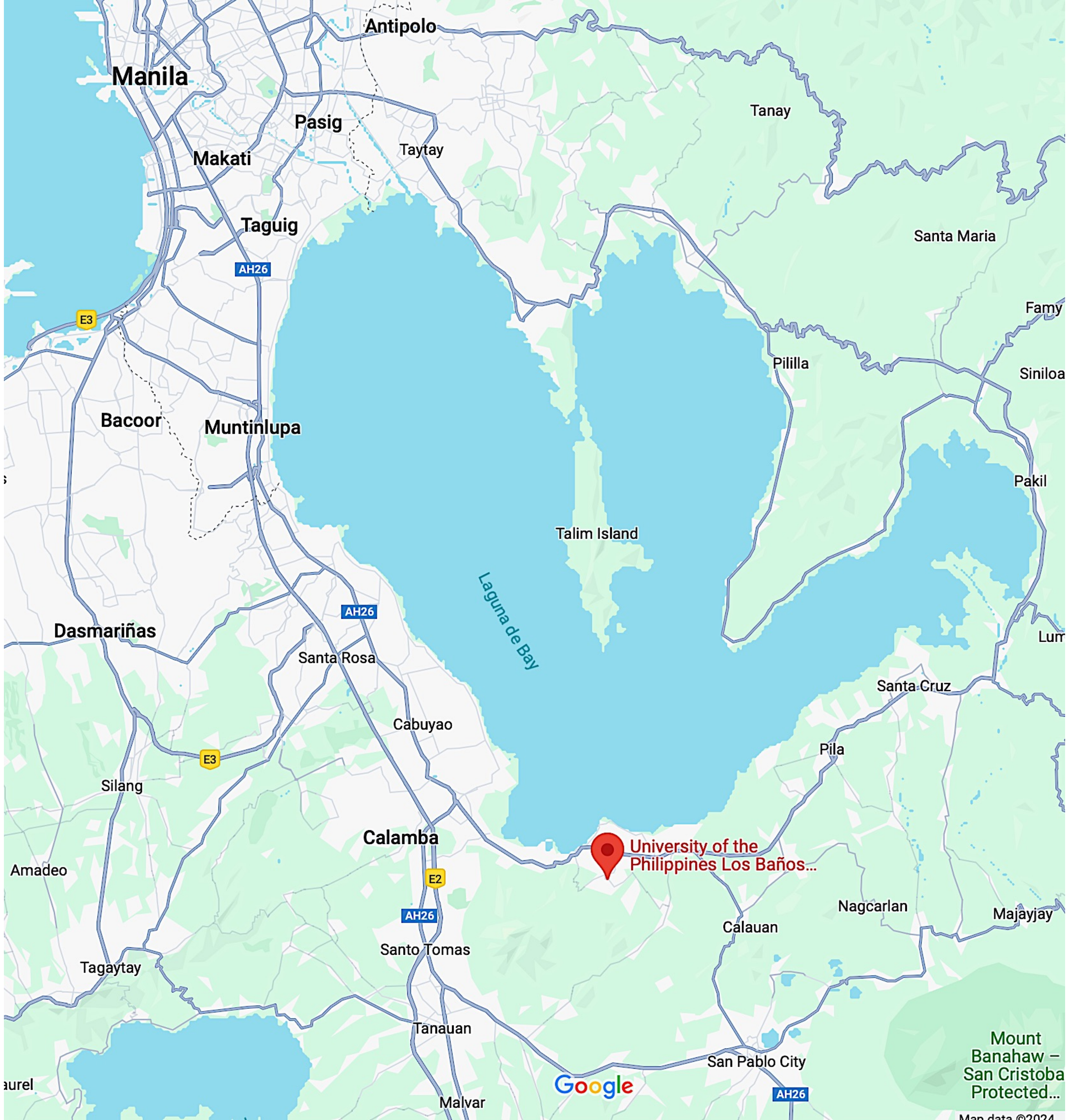
- Individual **assessments** on each inland water are still works in progress – status, resources, services, and threats

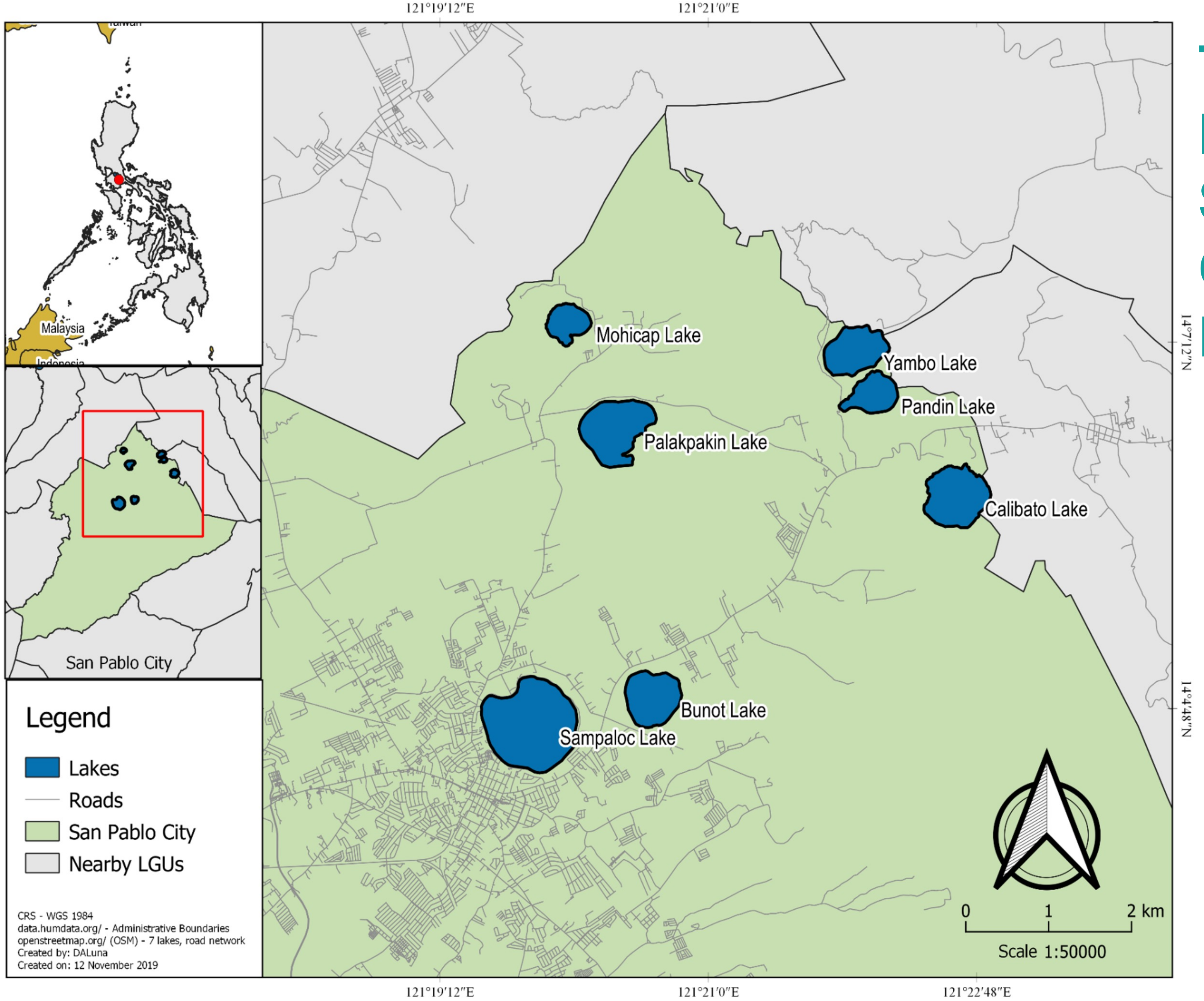
- More information needed to craft management plans to ensure **conservation and protection**

- The **assessment and monitoring** of the lakes need to be strengthened and assisted through identification of various factors that could contribute to their impairment.

Laguna Lake

Seven lakes of San Pablo



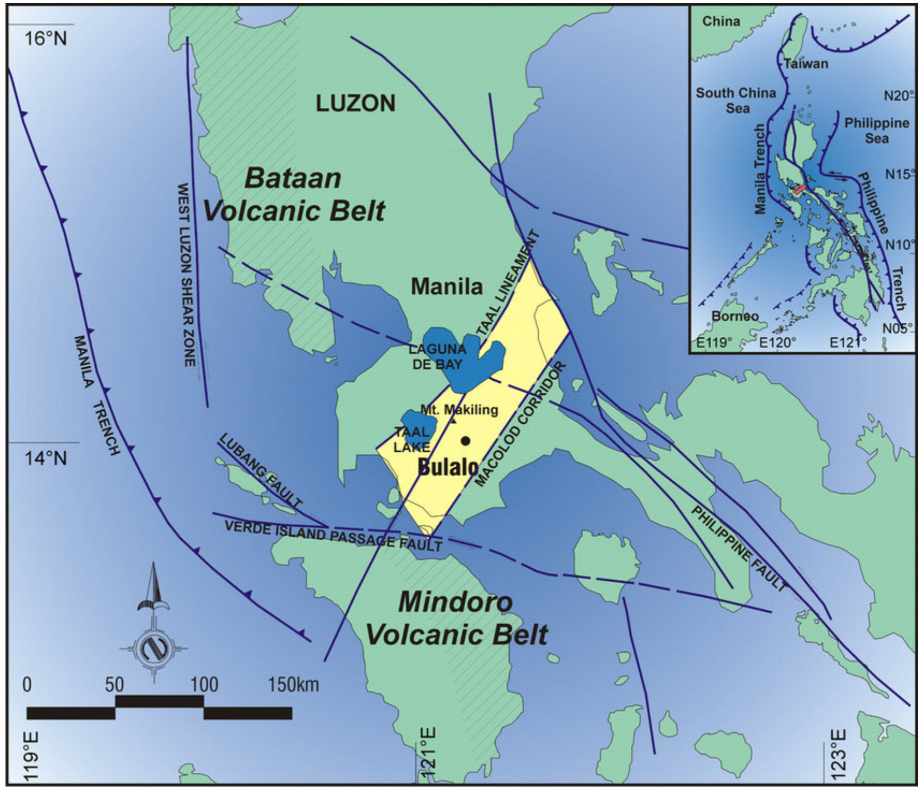


The Seven Maar Lakes of San Pablo City, Laguna, Luzon Island

- Crater lakes
- “Threatened Lakes of the Year 2014” by the Global Nature Fund

Maar Lakes of San Pablo City, Laguna, Luzon Island

- Geographically located in the **Macolod Corridor**
- **Volcanic origin:** formed through **phreatomagmatic eruptions** of Mt. Banahaw-San Cristobal

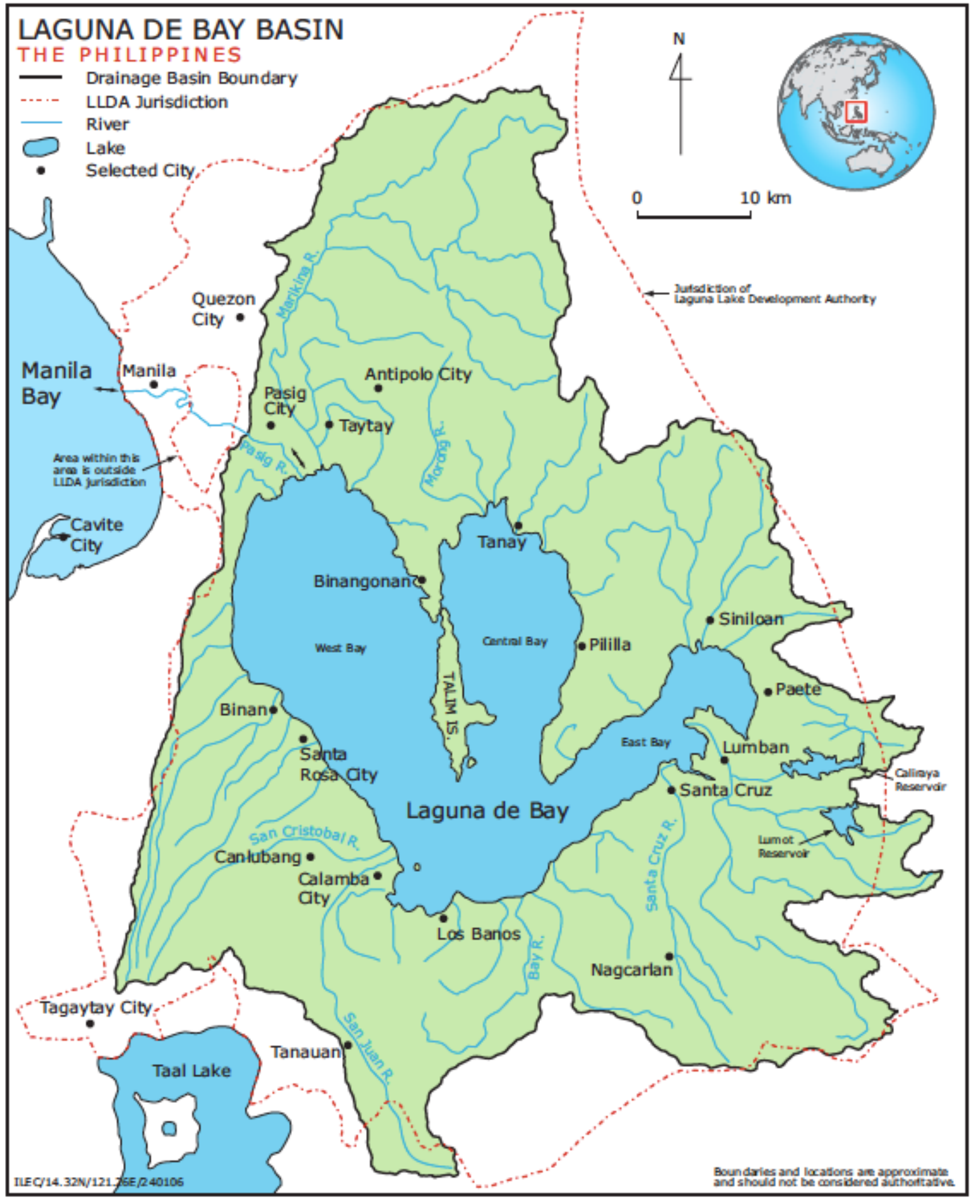


Vicedo et al., 2008

Laguna Lake

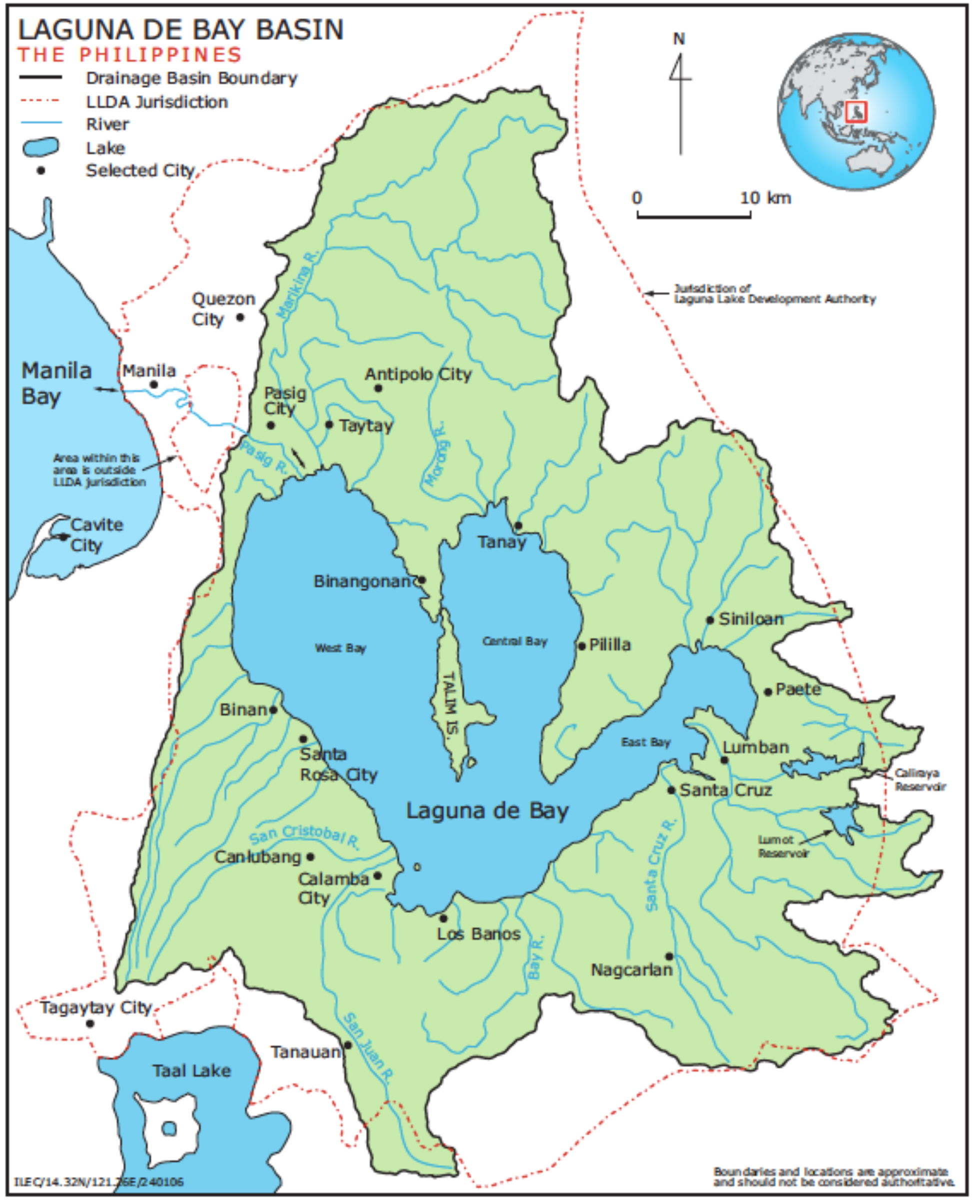
- Largest freshwater lake in the Philippines
  - Surface area 900 km^2
  - Water volume – 2.25 km^3
  - second largest in SouthEast Asia by surface area

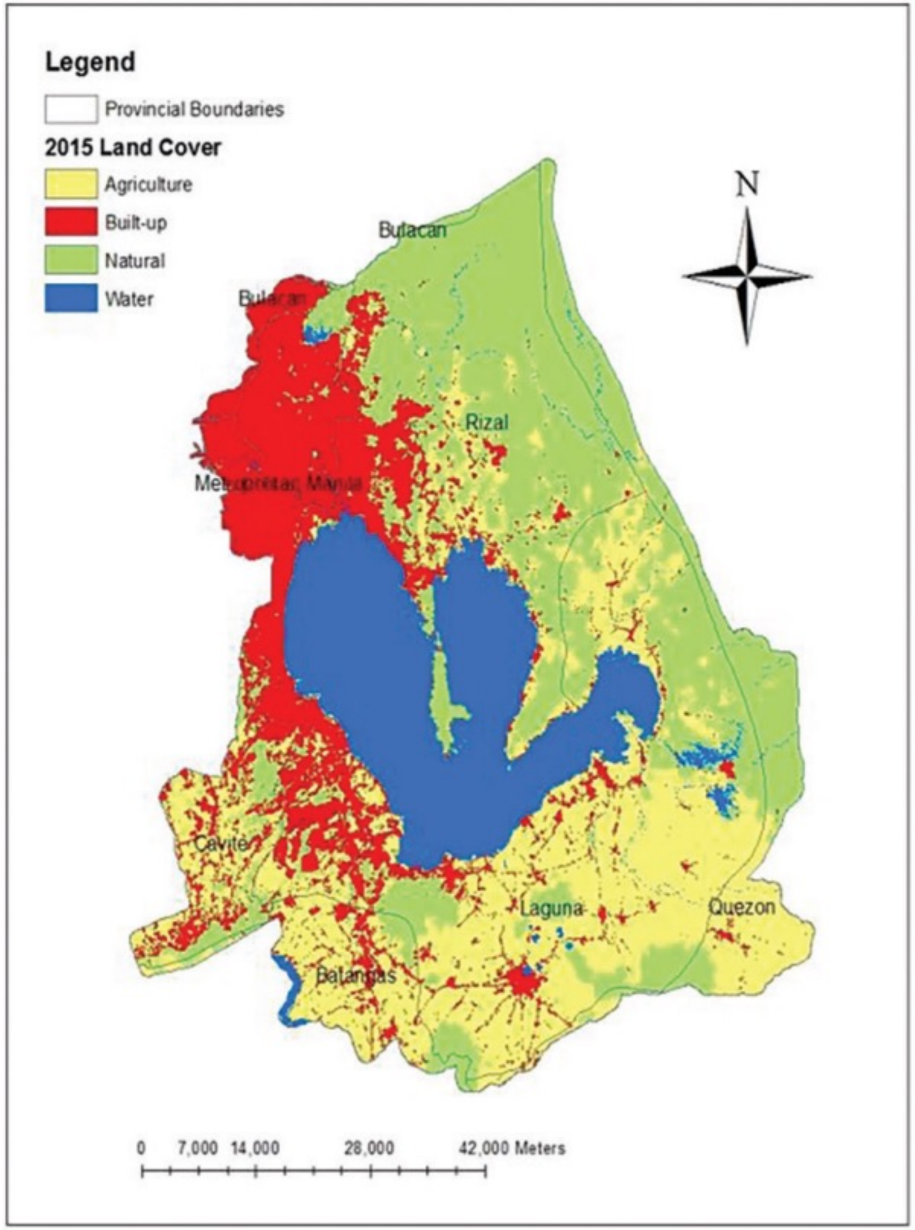
- 15 km southeast of the center of Metropolitan Manila
  - One of resource for drinking and irrigation water



Laguna Lake

- One of the shallowest lakes
  - Ave depth – 2.5 m
- Dominant use for fisheries
  - Open water fishing and aquaculture
- Serves as a sink for solid and liquid (treated and untreated) wastes from households (77%), cropland areas/agriculture (11%), and industries (11%)





PEMSEA; NAMRIA

- West Bay: Industries as extension of Metro Manila
  381-672 households/km^2 population density
  Highly Urbanized and Industrialized

- South and East Bays: Agricultural farms
  21-25 Households/km^2 population density
  Agro-industrialized

- Environmental contaminants detected and studied in Laguna de Bay

Heavy Metals
Xenoestrogens
Pharmaceuticals
Polyaromatic Hydrocarbons
Surfactants
Polychlorinated Biphenyls
Per- and polyfluoroalkyl substances
Organochlorine Compound
Polybrominated Diphenyl Ethers

Pollutant Contamination in Laguna de Bay

Year	Research Highlights	Authors
2005	**Heavy metal concentration (in mg/kg) in sediments:** **Ca, Cr, Co, Pb, Ni, Zn** **PAHs concentration (in ng/kg) in sediments:** **Flourene, Phenanthrene,** **Pyrene, Perylene** **NO PCB detected**	Hallare, Kosmeh, Schulze, Hollert, Kohler, Triebskorn
2006	**Lead and Cadmium contents in water spinach:** • Lead • Cadmium Edible portions < tolerable daily intake (WHO)	Baysa, Anuncio, Chiombon, Dela Cruz, Ramelb

Polycyclic Hydrocarbons (PAHs)

- organic compounds Used in dyes, plastics, pesticides

Pollutant Contamination in Laguna de Bay

Year	Research Highlights	Authors
2010	**PCB concentration of surface water samples: 3.0-10.9 ng/L** 5.5-fold higher than in Venice Lagoon (Moret et al., 2005) 25.17-fold higher than in Hongkong Coast (Worl et al., 2006) 7.4-fold higher than in Pearl River Delta (Guan et al., 2009)	Santiago C. and Rivas F.
2012	**Pesticide residues in surface waters of Pagsanjan-Lumban catchment** High level of PCB, PBDE, and organochlorines (e.g. dichlorodiphenyldichloroethylene (4,4' DDE), oxychlordane and *trans* nona-chlor)	Varca L.

Polychlorinated Biphenyl (PCB)

- organic chlorine compound
- hydrophobic with low water solubility

Pharmaceutical Pollution in the Philippines

Manila de Bay

Paraben
Triclosan
Triclocarban

Marikina and Pasig River

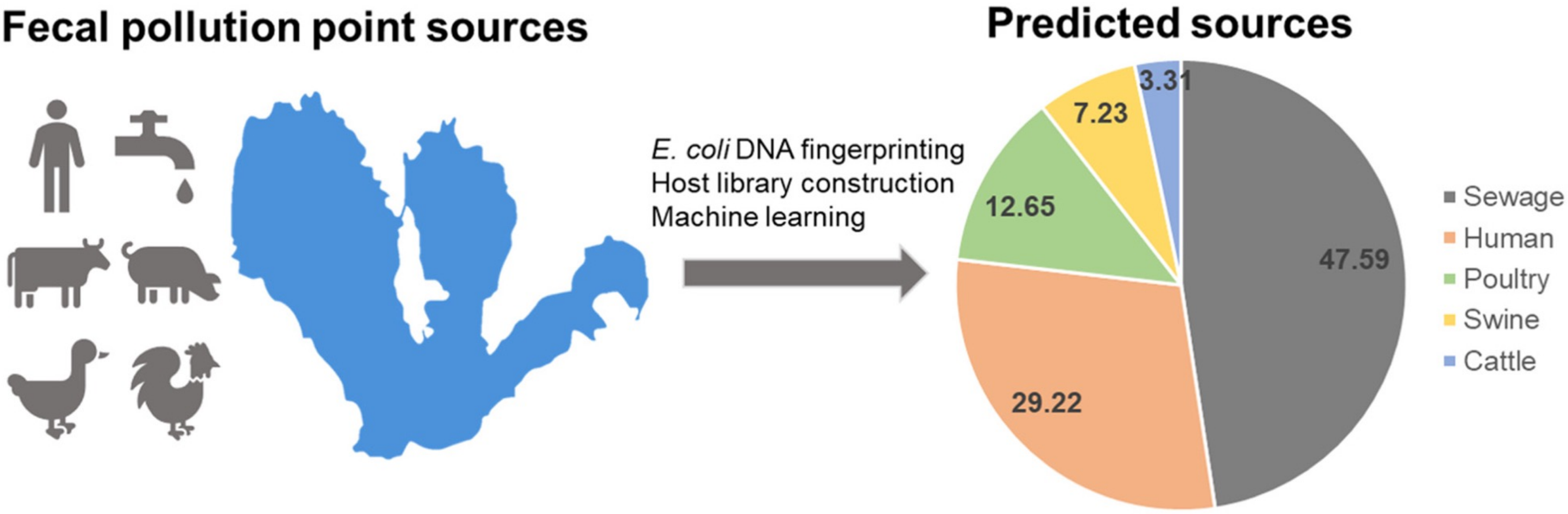
Caffeine
Mefenamic Acid
Sulfamethaxozole
Theophylline
Trimetroprim
Lincomycin
Carbamazepine

Laguna de Bay

Sulfamethoxazole
Trimethoprim
Lincomycin
Oxytetracycline
Quinolone
Ceftiofur
Florfenicol
Tetracycline

Shimizu et al., 2013; Ramaswamy et al., 2011; Revilleza et a., 2021; Van et al., 2021

Microbial source tracking of fecal contamination in Laguna Lake



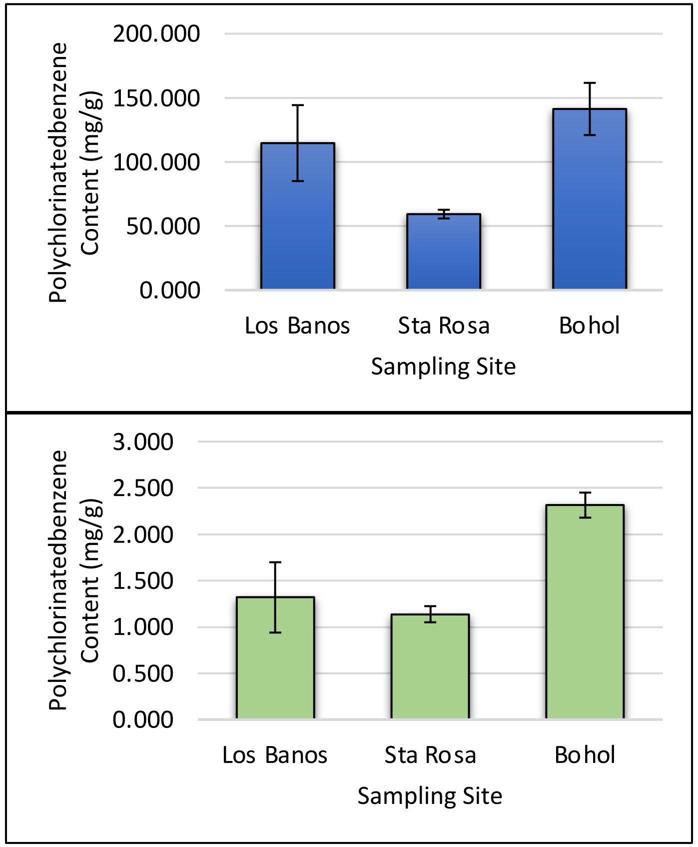
J Water Health. 2021;19(5):762-774. doi:10.2166/wh.2021.119

Levels of PCBs/PDBEs in Tilapia

Polychlorinated benzene

A

B

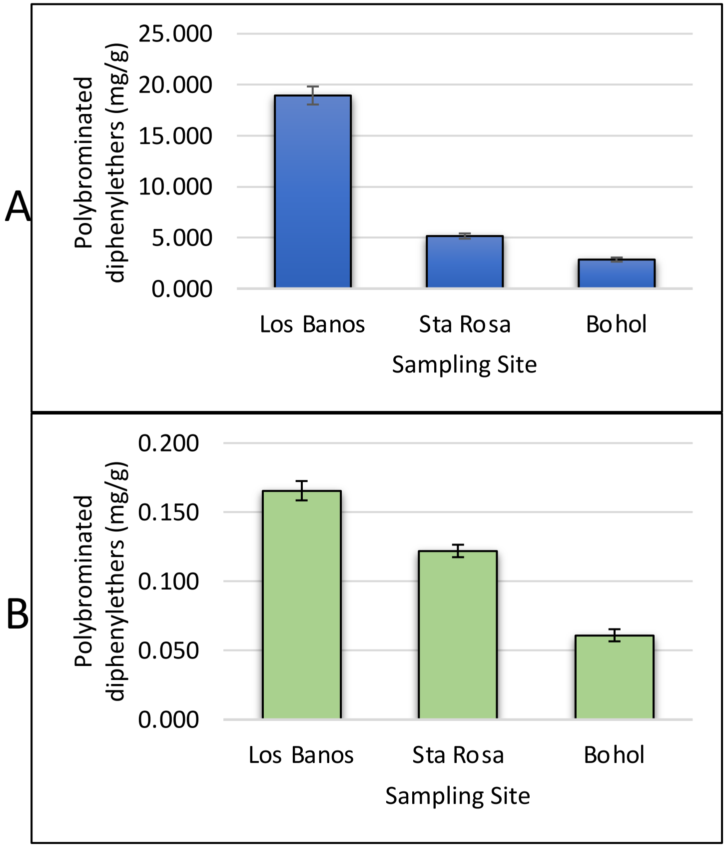


Polychlorinatedbenzene concentration (mg/g) in the liver of *Oreochromis niloticus* obtained from the three sampling sites according to (A) lipid weight and (B) wet weight.

Polybrominated Diphenylether

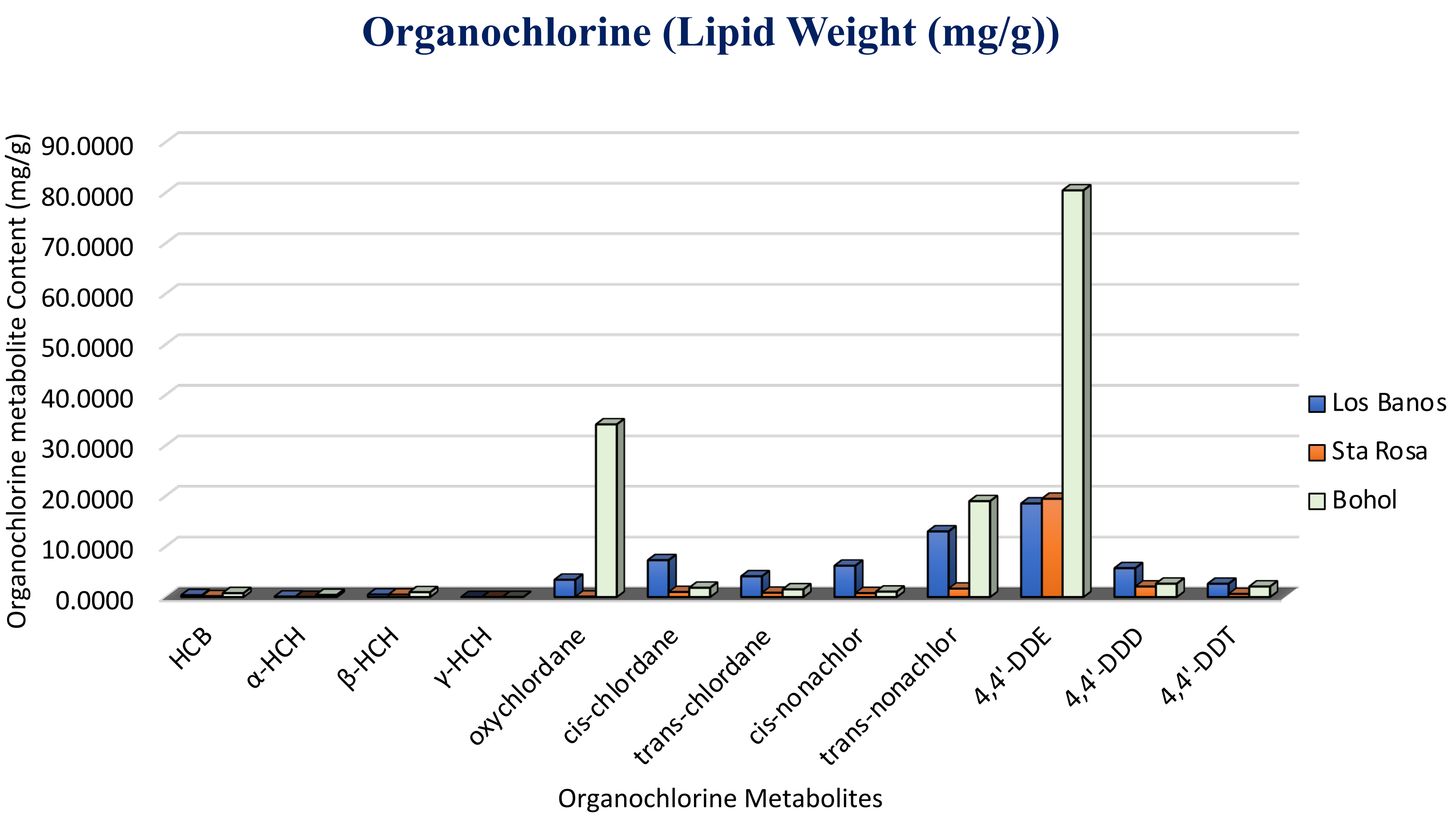
A

B

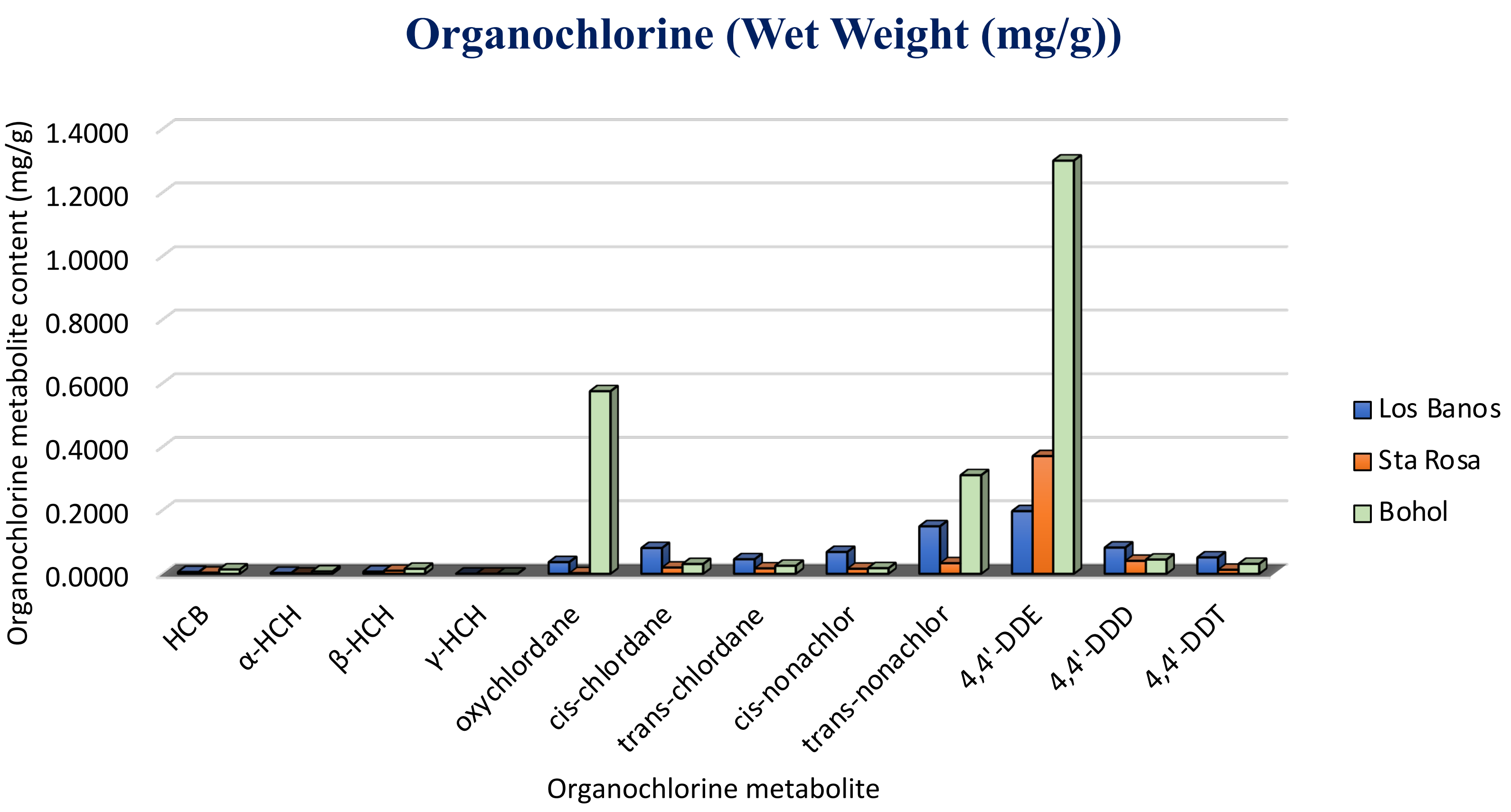


Polybrominated diphenylether concentration (mg/g) in the liver of *Oreochromis niloticus* obtained from the three sampling sites according to (A) lipid weight and (B) wet weight.

Levels of OCs in Tilapia



Organochlorine metabolites concentration (mg/g) in the liver of *Oreochromis niloticus* obtained from the three sampling sites based on lipid weight.

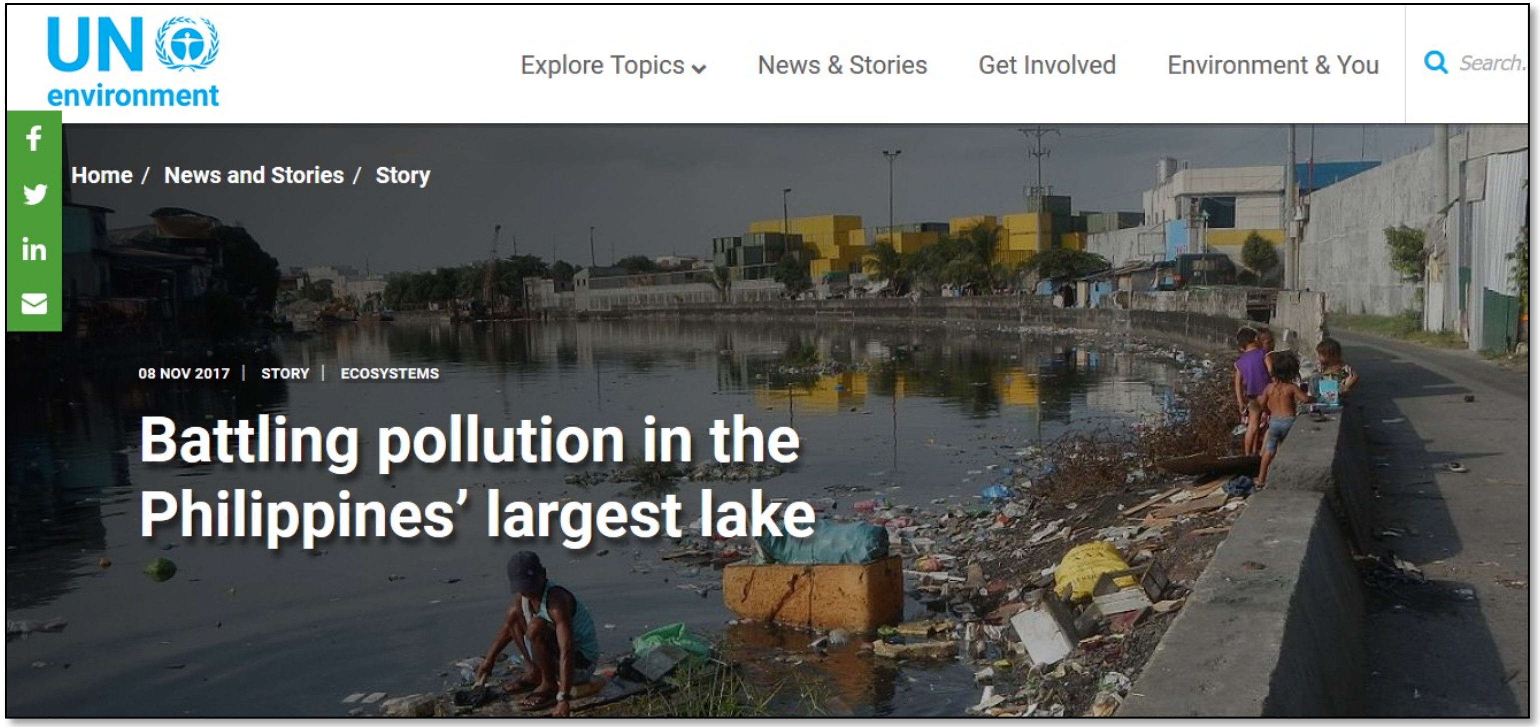


Organochlorine metabolites concentration (mg/g) in the liver of *Oreochromis niloticus* obtained from the three sampling sites based on wet weight.

HEADLINES SHARE THIS

Pollution, squatting, industries hasten death of Laguna de Bay

By: Maricar Cinco - Correspondent / @maricarcincoINQ Philippine Daily Inquirer / 12:28 AM January 05, 2017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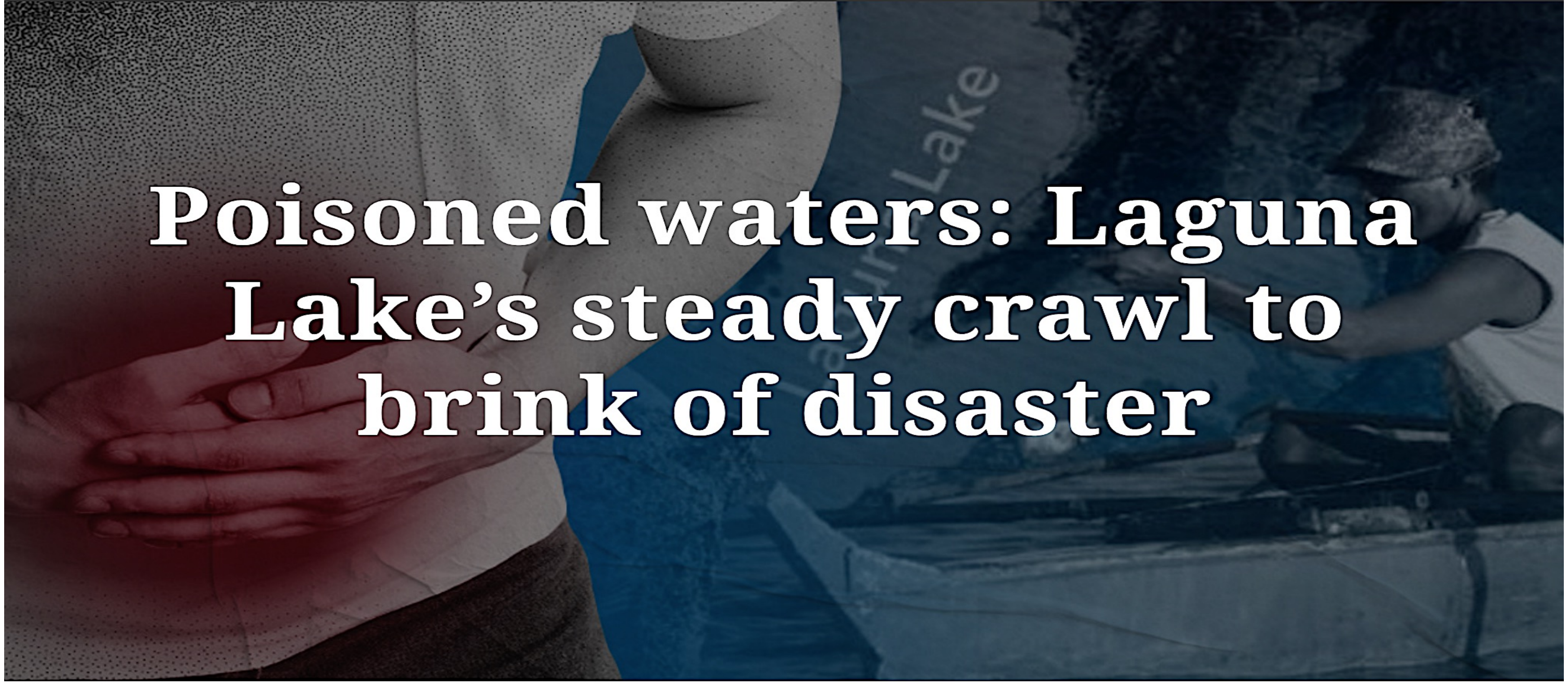
08 NOV 2017 | STORY | ECOSYSTEMS

Battling pollution in the Philippines' largest lake



Poisoned waters: Laguna Lake's steady crawl to brink of disaster

WRITTEN BY: CRISTINA ELOISA BACLIG

May 22, 2024

(Part 1 of 2)

MANILA, Philippines—Encircled by the contrast of verdant and urban landscapes, Laguna Lake is a silent witness to the environmental tug-of-war between progress and preservation, with few actors playing by the rules.

Nestled in the heart of the Philippines, Laguna Lake — also known as Laguna de Bay — holds the distinction of being the nation's largest freshwater lake and ranks as the third-largest in Southeast Asia by surface area.

Lakes	Measured Parameters	References
7 Lakes	pH, DO, BOD, NH3-N, NO3-N, PO4, Chloride, Turbidity, TDS, TSS, Total Coliform, Chlorophyll a, Phytoplankton, Zooplankton	Zapanta et al. (2008)
Pandin, Palakpakin, Sampalok	**Pesticides, Pharmaceuticals, Artificial sweeteners, Insect repellants and Fire retardants**	Dimzon et al. (2018)
7 Lakes	Plasma vitellogenin (VTG) levels, Hepatosomatic index (HSI) and Gonadosomatic index (GSI)	Mabansag et al. (2019)

Microplastics (MPs) are an **emerging pollutant** of freshwater.

(Qiu et al., 2020)

1.01Mt (2016) → 2.7Mt (2021) mismanaged plastic waste

Table 3. Countries with the highest mismanaged plastic waste generated by coastal populations in 2016. The two U.S. estimates (bold text) provide lower and upper bounds reflecting contributions from domestic litter (0.31 Mt), domestic illegal dumping (0.05 to 0.15 Mt), and inadequate management of plastic waste generated during the processing of imported U.S. plastic and paper scrap in countries with greater than 20% inadequately managed waste (0.15 to 0.99 Mt). Mt, million metric tons. HIC, high income; UMC, upper middle income; LMC, lower middle income.

Country	Mismanaged plastic waste (Mt)	Income status	Coastal population (millions)	Per capita plastic waste generation (kg/day)	% Plastic in solid waste	% Mismanaged waste
Indonesia	4.28	LMC	202.49	0.68	14.0	61
India	3.16	LMC	201.20	0.57	9.5	79
United States, upper bound	**1.45**	**HIC**	**117.94**	**2.72**	**13.1**	**2.98**
Thailand	1.16	UMC	26.73	1.08	17.6	62
China	1.07	UMC	270.94	0.44	9.8	25
Brazil	1.03	UMC	78.68	1.05	13.5	25
Philippines	1.01	LMC	92.06	0.39	10.6	74

Image from Law et al. (2020)

The Philippines is the **third** largest plastic contributor in the world.

(Jambeck et al., 2015; Law et al., 2020; Osorio et al., 2021)

Condition of the Seven Lakes of **San Pablo City, Laguna**

- Surrounded by illegal settlers, municipal establishments, fish cages, & commercial or industrial effluents
- All have aquaculture cages for **tilapia**
- Polluted with **plastics**

Images from City of Seven Lakes

Microplastic occurrence in rural and urban surface waters: the cases of Lake Sampaloc and Lake Yambo in San Pablo City, Laguna, Philippines

Fatima A. Natuel*[1,4], Damasa B. Magcale-Macandog[2], Decibel V. Faustino-Eslava[1], Loucel E. Cui[1], and Stefan Hotes[3]

- Only recent paper done on **microplastics in San Pablo lakes** (Feb 2023)
- Determined and compared **MP types and quantities in surface water** samples (from lakes Sampaloc and Yambo)

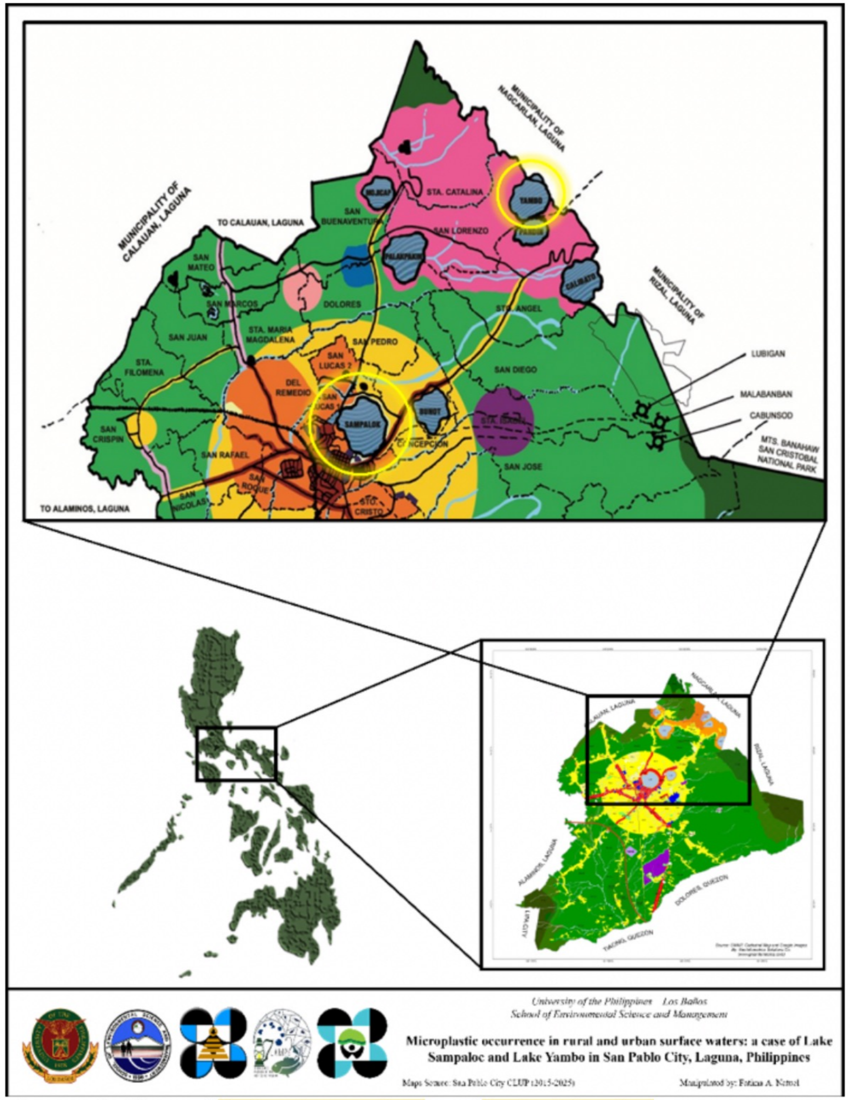
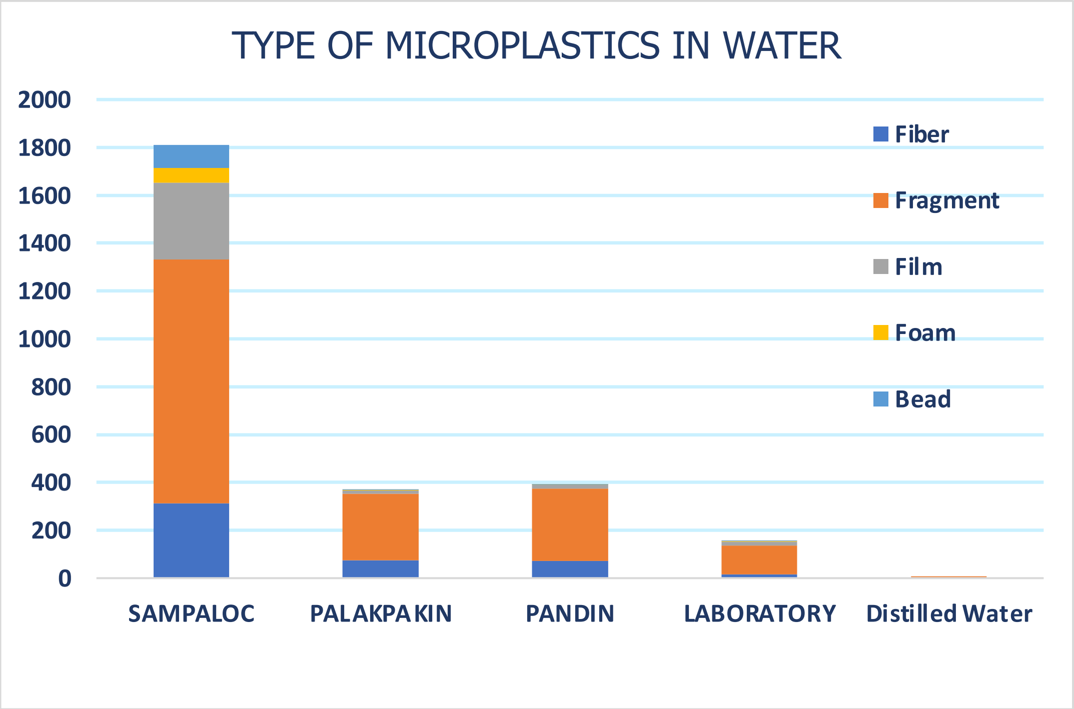
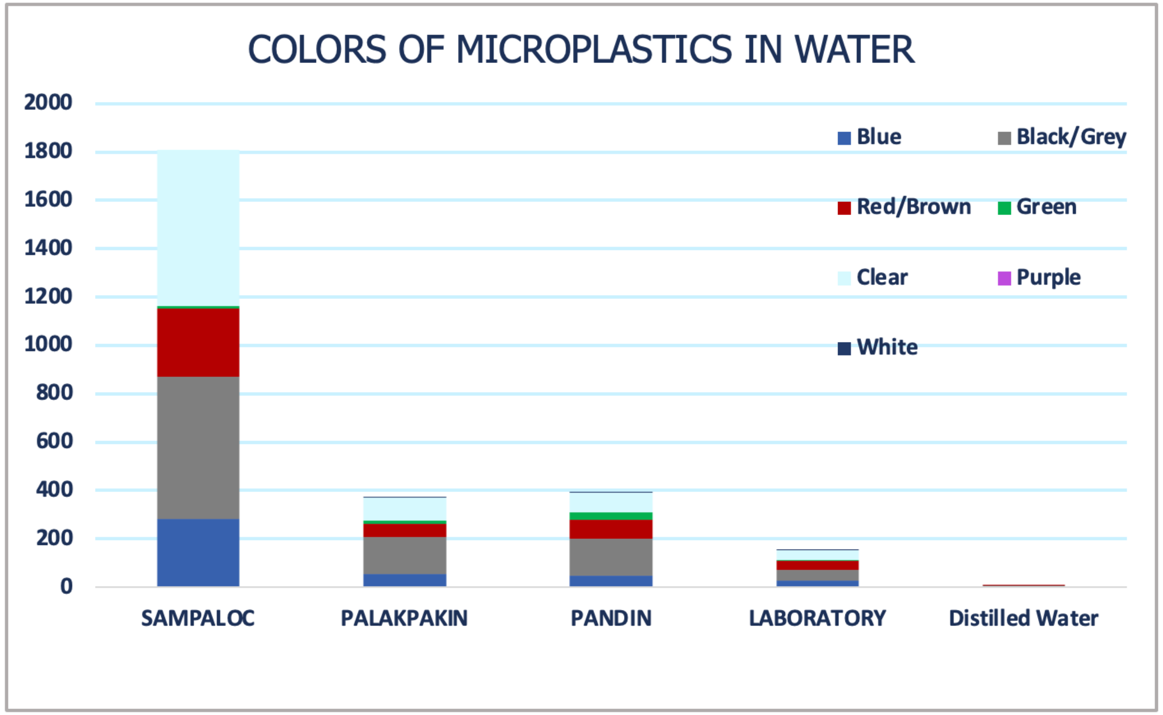


Figure 1: Map of Lake Sampaloc and Lake Yambo

Microplastics (MPs) in water



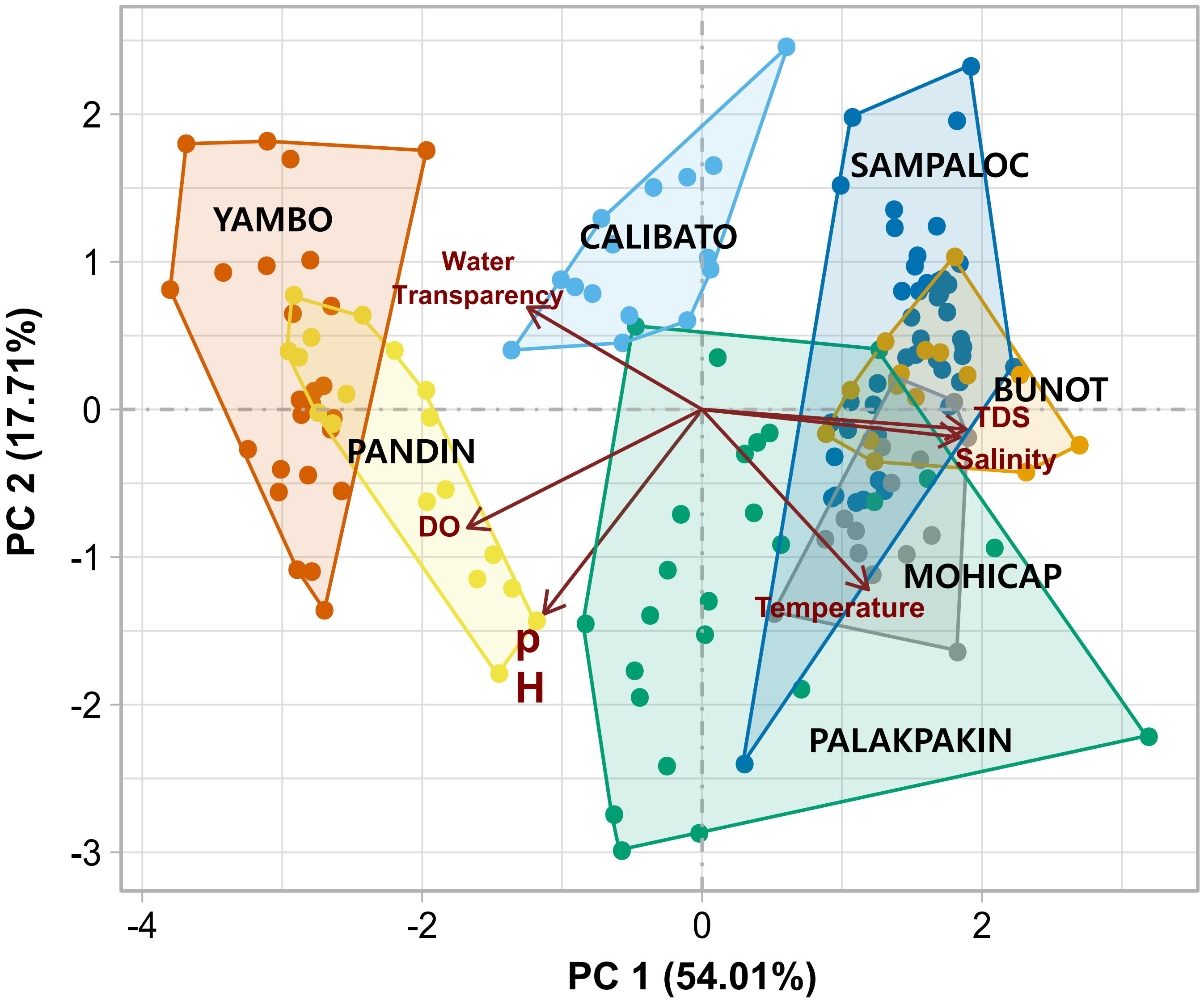


**Ongoing undergraduate thesis

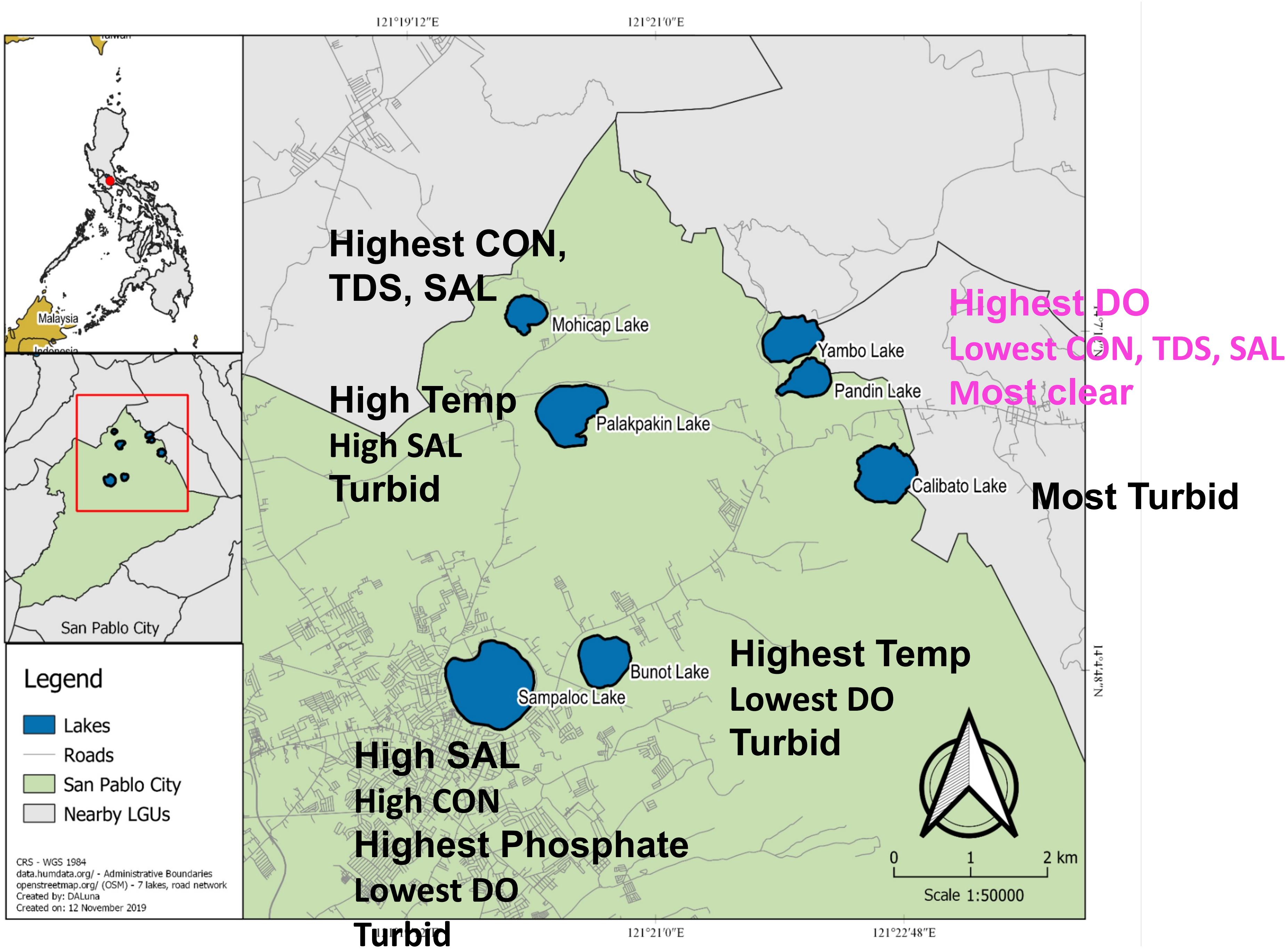
Environmental variables (average ± SD) in the Seven Lakes of San Pablo, Laguna. BUN – Bunot, CAL – Calibato, MOH – Mohicap, PAL – Palakpakin, PAN – Pandin, SAM – Sampaloc, YAM – Yambo. TEM – temperature, CON – conductivity, TDS – total dissolved solids, SAL – salinity, DO – dissolved oxygen, pH, TUR – Turbidity).

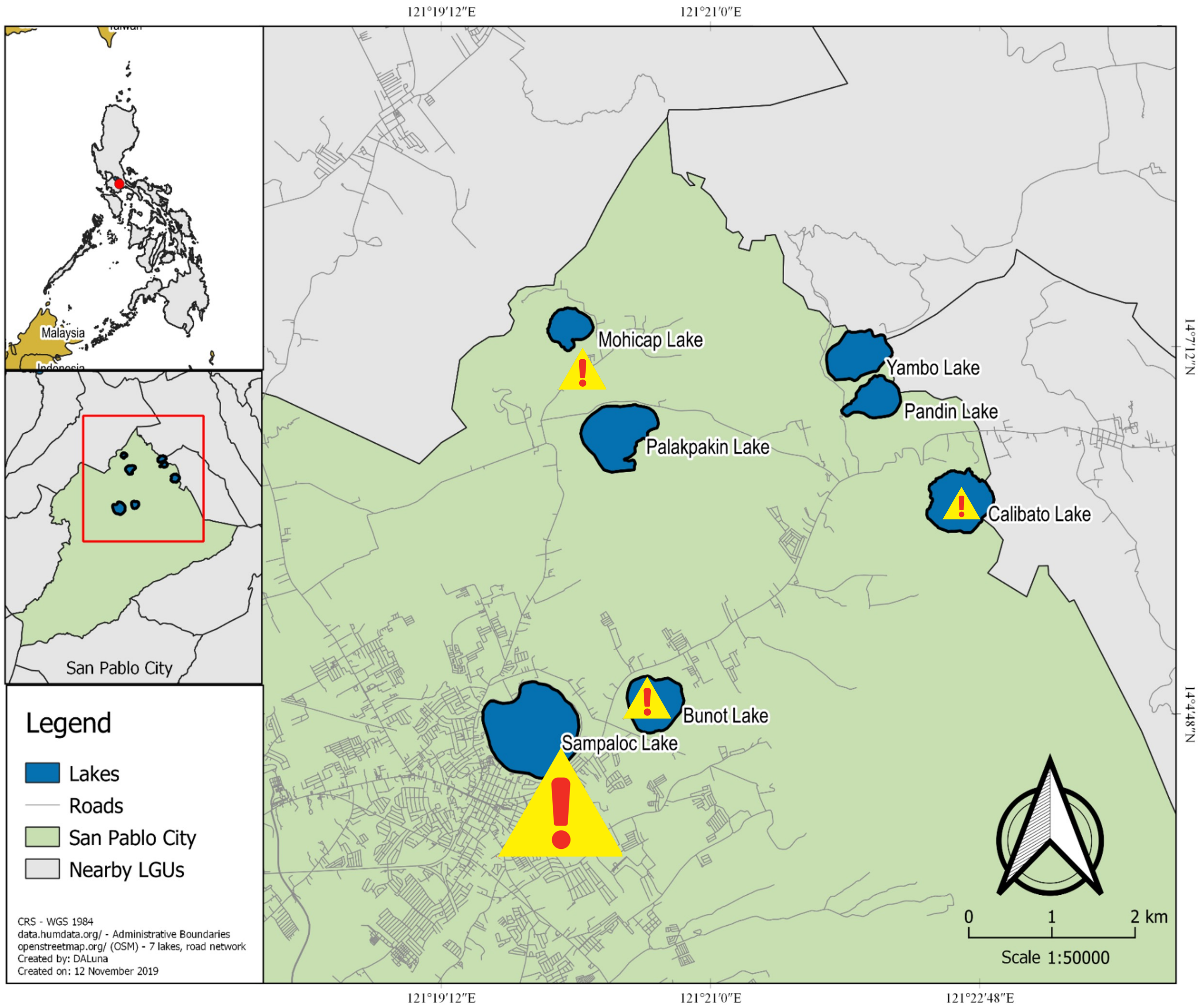
LAKES	TEM (°C)	CON (S/m]	TDS (mg/L)	SAL (ppt)	DO (mg/L)	pH	TUR (m)
BUN	**30.14 ± 0.49**	0.3009 ± 0.003	178.34 ± 1.30	0.13 ± 5.75E-17	2.585 ± 0.48	6.177 ± 0.04	1.042 ± 0.21
CAL	28.58 ± 0.28	0.272 ± 0.005	165.26 ± 2.69	0.12 ± 5.75E-17	4.20 ± 0.63	5.871 ± 0.15	**0.83 ± 0.33**
MOH	30.09 ± 0.15	**0.38 ± 0.0008**	**227.11 ± 0.59**	**0.16 ± 0.004**	4.17 ± 0.25	5.94 ± 0.21	2.15 ± 0.75
PAL	30.09 ± 0.55	0.303 ± 0.05	181.66 ± 22.75	0.15 ± 0.05	4.75 ± 0.87	6.01 ± 0.10	0.94 ± 0.20
PAN	29.49 ± 0.38	0.196 ± 0.003	120.84 ± 14.30	0.08 ± 0.002	**5.56 ± 0.47**	5.70 ± 0.11	2.31 ± 1.59
SAM	28.87 ± 0.33	0.366 ± 0.004	221.26 ± 1.22	**0.16 ± 8.42E-17**	2.74 ± 0.53	**6.34 ± 0.10**	1.57 ± 0.40
YAM	29.23 ± 0.20	0.188 ± 0.001	112.716 ± 0.79	0.08 ± 1.42E-17	5.28 ± 0.21	5.95 ± 0.37	3.44 ± 1.27

Environmental Variables



Water Parameters		
Temperature (°C)	0.317	**-0.570**
Dissolved Oxygen (mg/L)	**-0.448**	-0.374
pH	-0.302	**-0.647**
Water Transparency (m)	-0.333	**0.323**
Total Dissolved Solids (mg/L)	**0.504**	-0.062
Salinity (ppt)	**0.492**	-0.087
Variance explained by component	3.241	1.062
Total variance explained (%)	54.015	17.708


121°19'12"E
121°21'0"E
Malaysia
Indonesia
San Pablo City
Highest CON,
TDS, SAL
Mohicap Lake
Yambo Lake
Pandin Lake
Highest DO
Lowest CON, TDS, SAL
Most clear
High Temp
High SAL
Turbid
Palakpakin Lake
Calibato Lake
Most Turbid
14°7'1"N
14°4'48"N
Bunot Lake
Sampaloc Lake
Highest Temp
Lowest DO
Turbid
High SAL
High CON
Highest Phosphate
Lowest DO
Turbid
Legend
Lakes
Roads
San Pablo City
Nearby LGUs
CRS - WGS 1984
data.humdata.org/ - Administrative Boundaries
openstreetmap.org/ (OSM) - 7 lakes, road network
Created by: DALuna
Created on: 12 November 2019
0
1
2 km
Scale 1:50000
121°21'0"E
121°22'48"E


121°19′12″E
121°21′0″E
121°22′48″E
14°7′12″N
14°4′48″N
Malaysia
Indonesia
San Pablo City
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0
1
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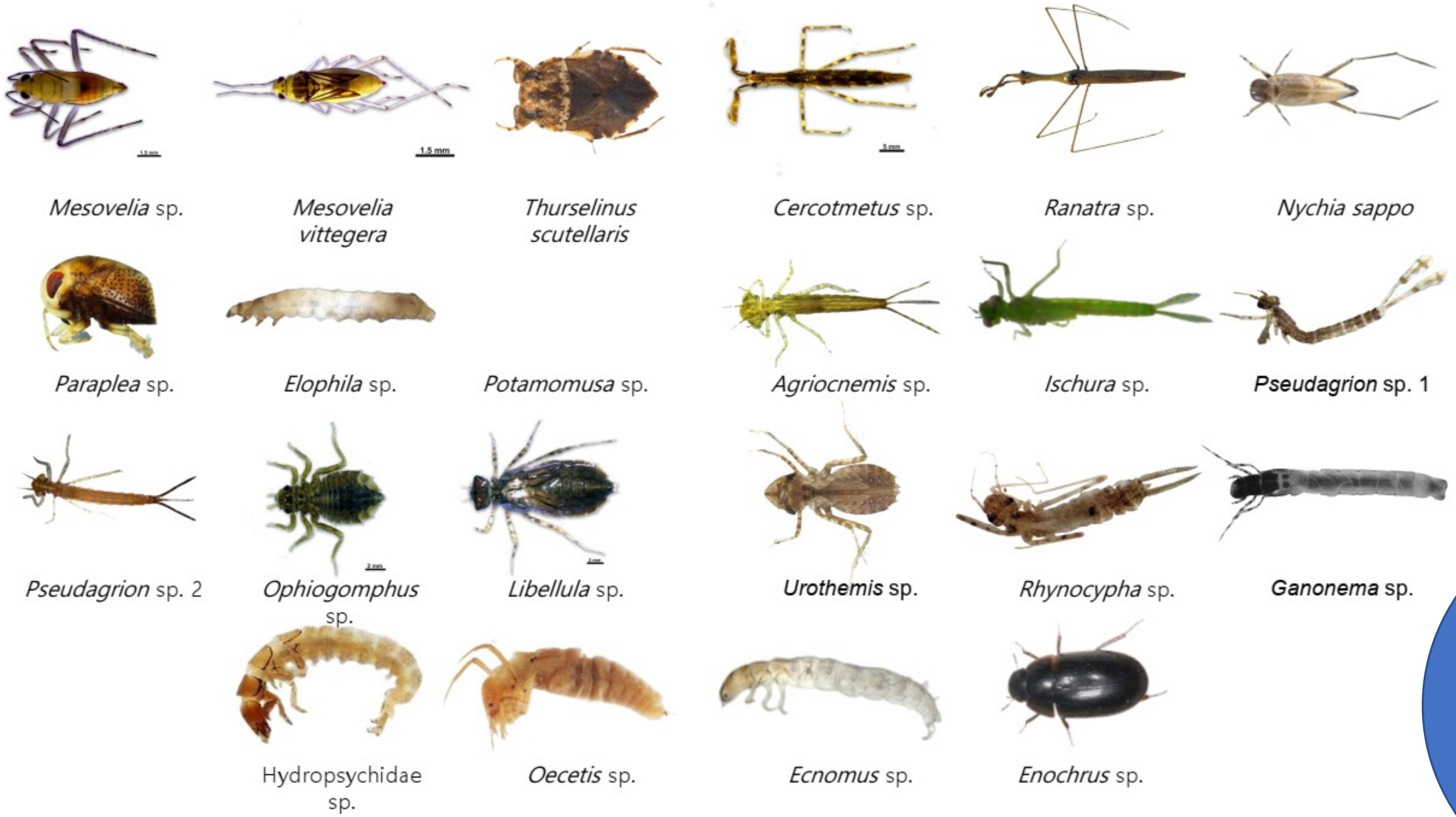
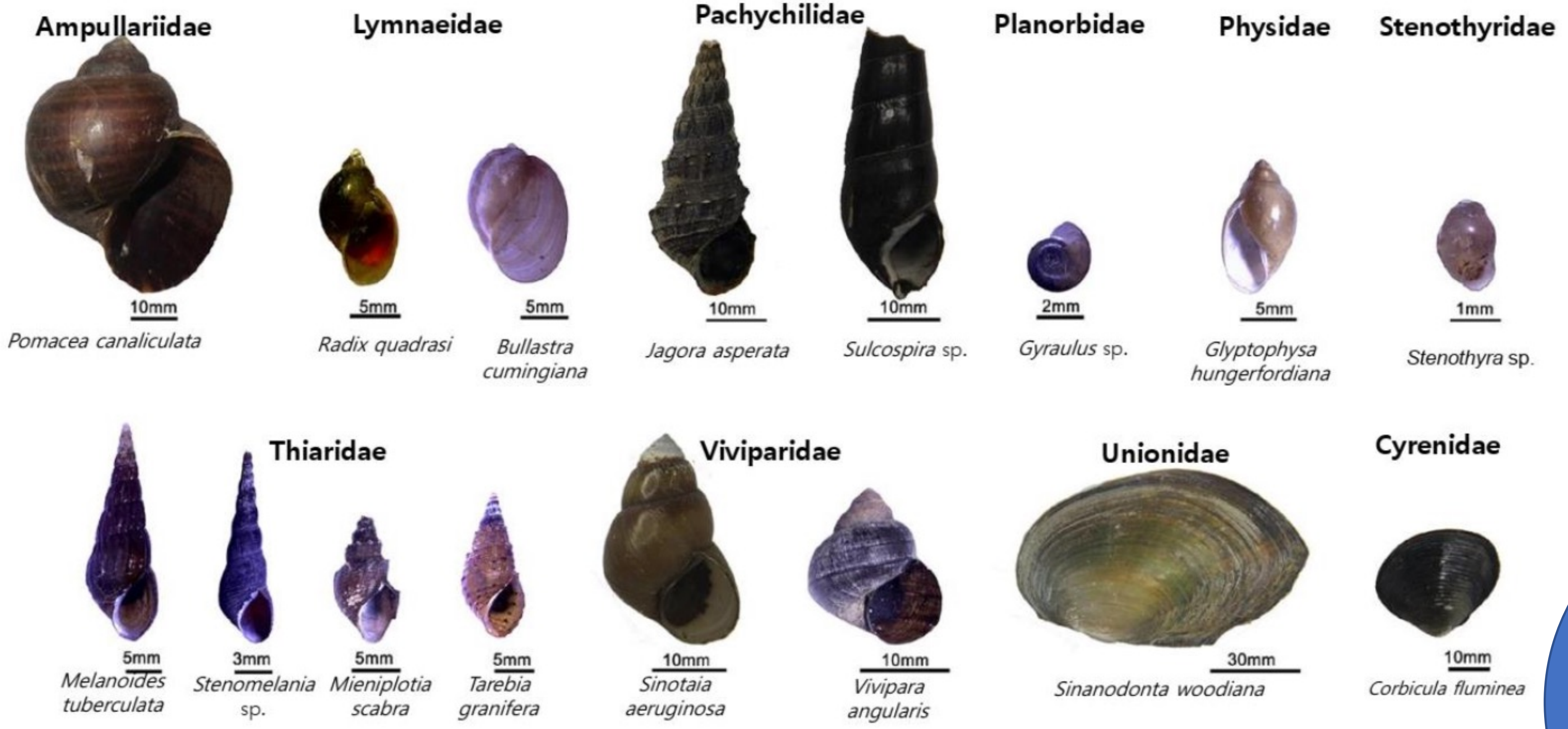
Diversity of insects across the seven lakes of San Pablo City



46
species

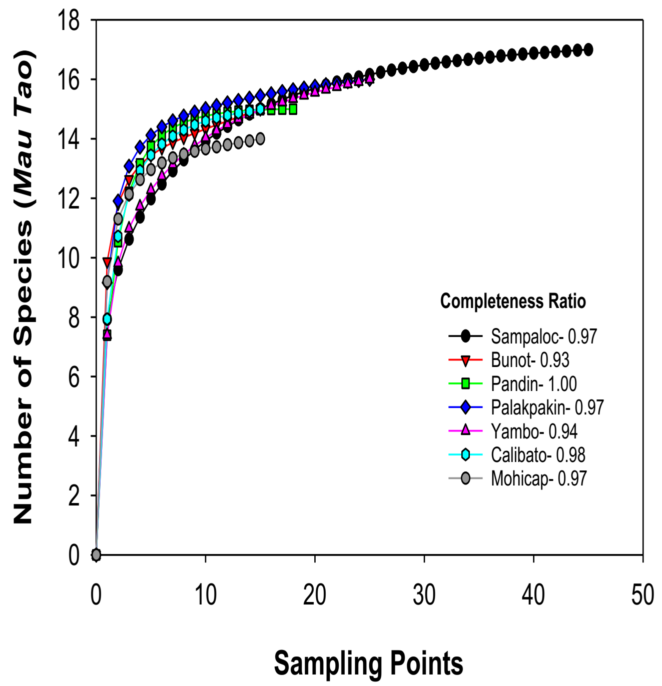
Mollusk diversity in the seven lakes of San Pablo City



17
species

Diversity indices of mollusks in the seven lakes of San Pablo City

Lake	Total Species Richness	Total Abundance	Shannon-Weiner Diversity Index (*H'*)	Evenness (*J'*)
Sampaloc	17	17,379	1.72	0.33
Bunot	15	1,792	2.10	0.54
Pandin	15	1,969	1.91	0.45
Palakpakin	16	3,543	2.06	0.49
Yambo	16	3,518	2.09	0.51
Calibato	15	1,013	1.95	0.47
Mohicap	14	2,538	1.73	0.40
TOTAL	**17**	**31,752**	**2.10**	**0.48**



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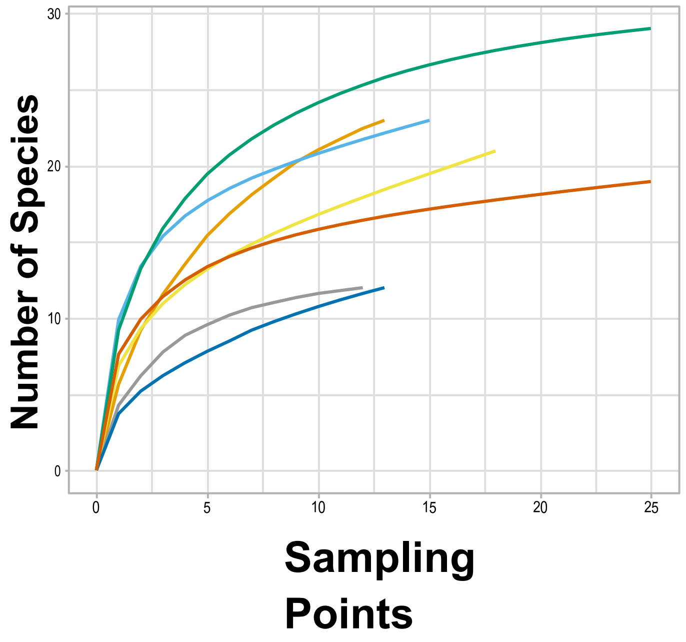


Biodiversity Findings

Mollusks	Insects
Lake Sampaloc has the highest species richness (17 species) while **Lake Bunot** the highest diversity index (*H*'= 2.10)	**46** species belonging to **26** families and **7** orders were identified
The most abundant species was ***Stenothyra* sp.** (n= 7, 758)	***Cleon* sp.** (Order Ephemeroptera, Family Baetidae) was the most abundant insect
Three invasive species, *Pomacea canaliculata*, *Sinotaia aeruginosa* and *Sinanodonta woodiana* were recorded.	**Pollution-tolerant species dominated Lakes Calibato, Bunot, Mohicap and Sampaloc**
Species accumulation curves demonstrated an **α-dominated community**, and **efficient sampling** marked by high completeness ratio (CR= 1.00).	

Animal health and Food safety

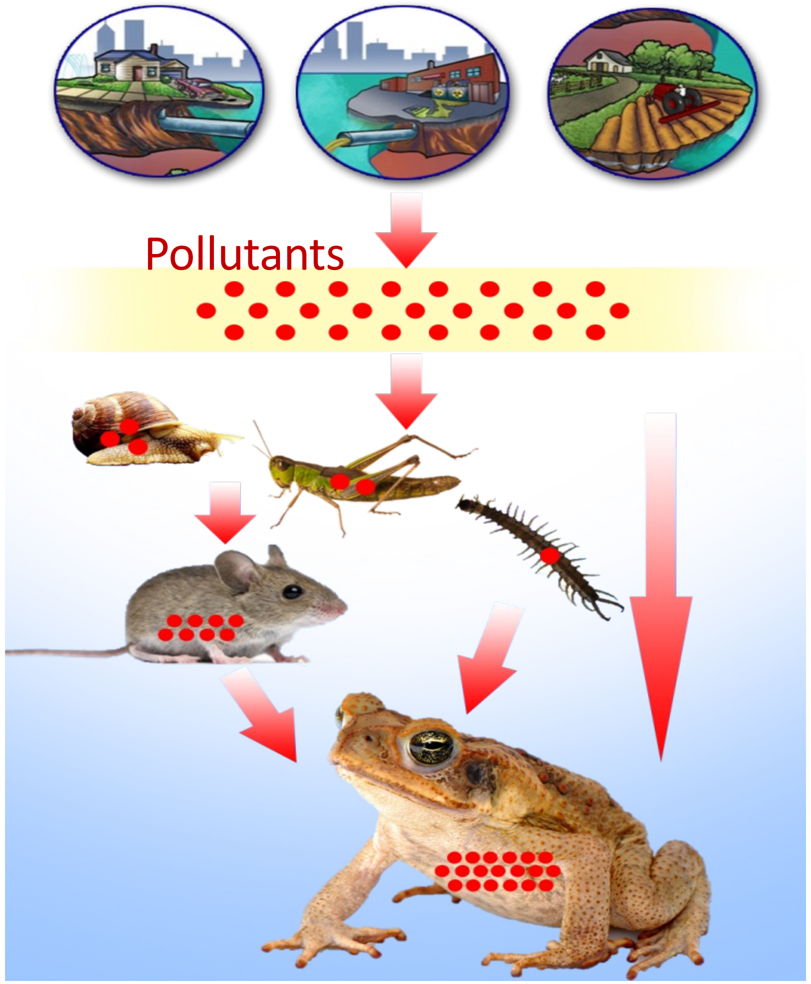


Image via The Guardian

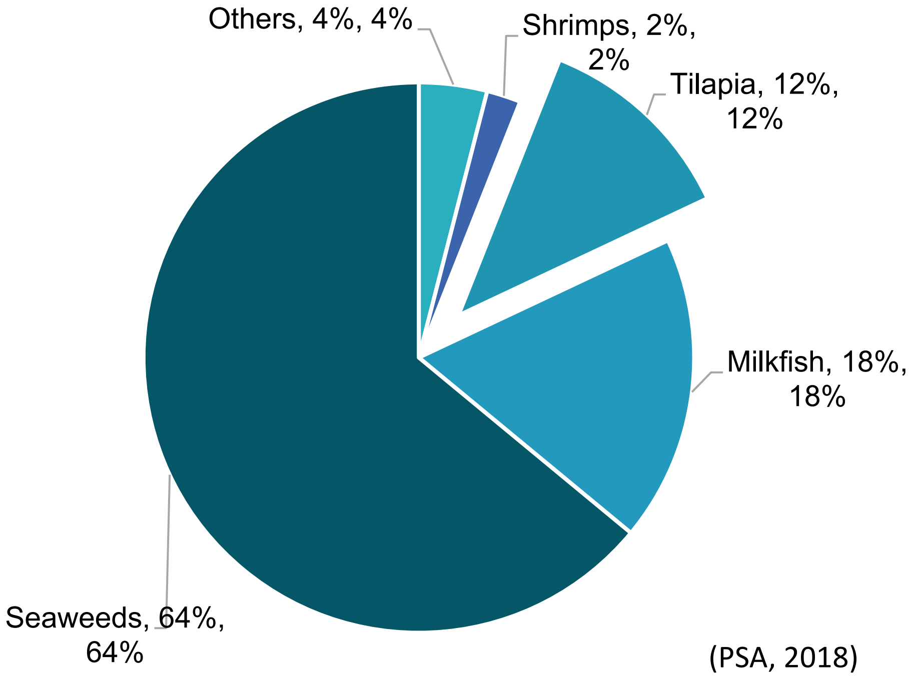
Food Sources in Laguna lake and San Pablo lakes

Nile Tilapia
(*Oreochromis niloticus* L., 1758)
in San Pablo Lakes

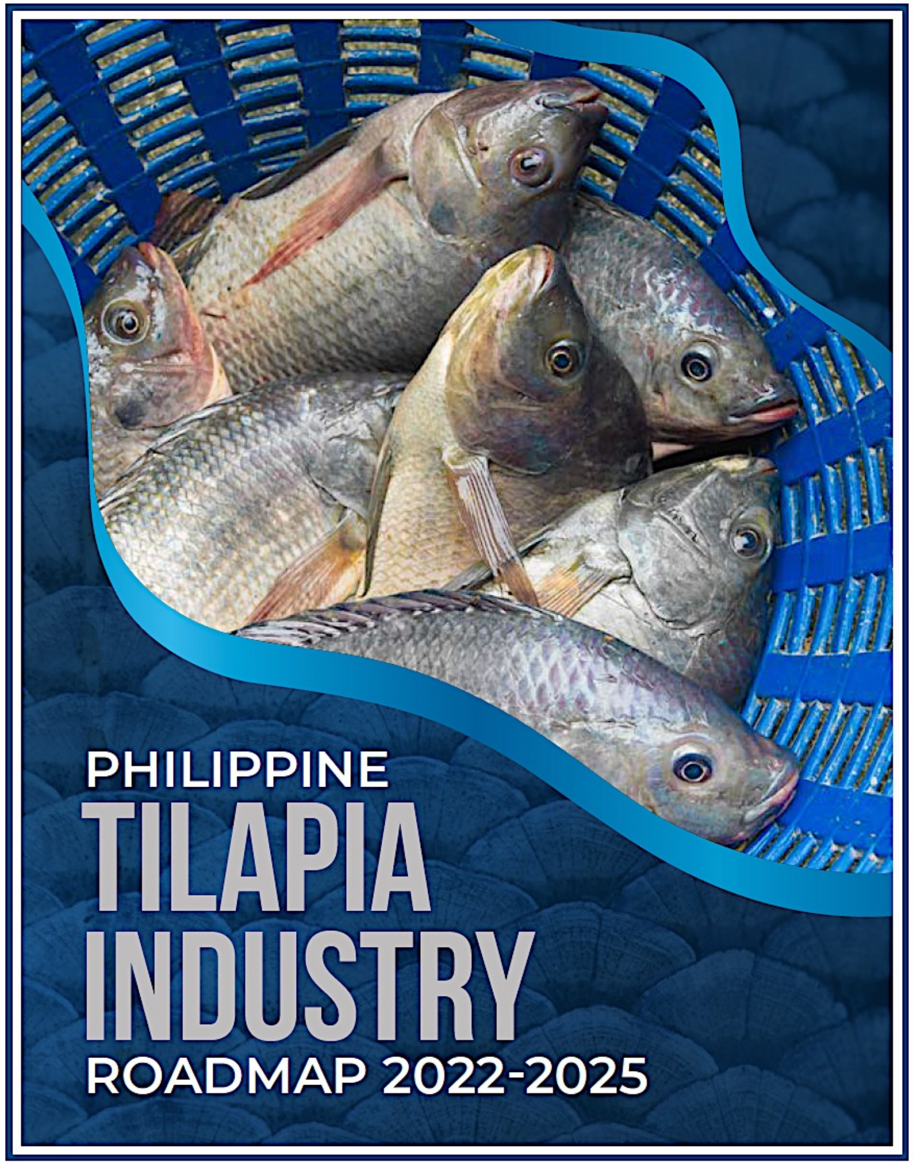
- Main **cultured** fish in all lakes
- Harvested and **sold** to communities
- Commodity and **food** source

Nile Tilapia in the Philippines

Species	Region	Volume of Production (metric tons)		
		2016	2017	2018
Tilapia				
	Central Luzon	127,241.91	133,882.74	136,819.49
	CALABARZON	92,372.73	91,866.80	92,136.28

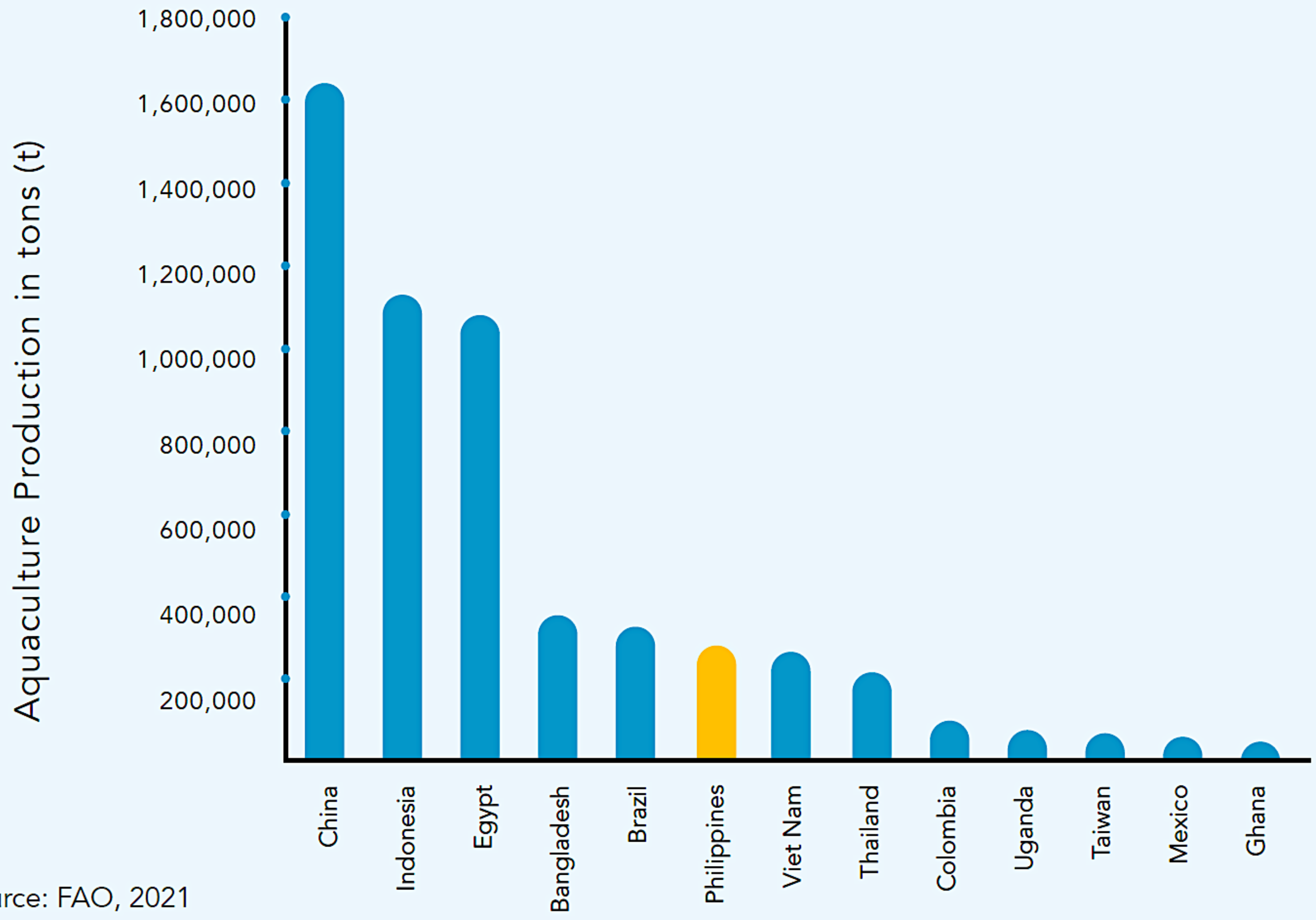


(PSA, 2018)



Department of Agriculture
BUREAU OF FISHERIES AND AQUATIC RESOURCES
"Tagapagtaguyod ng Malinis at Masaganang Karagatan"
ISO 9001:2015 | CIP 5387/19/12/1117

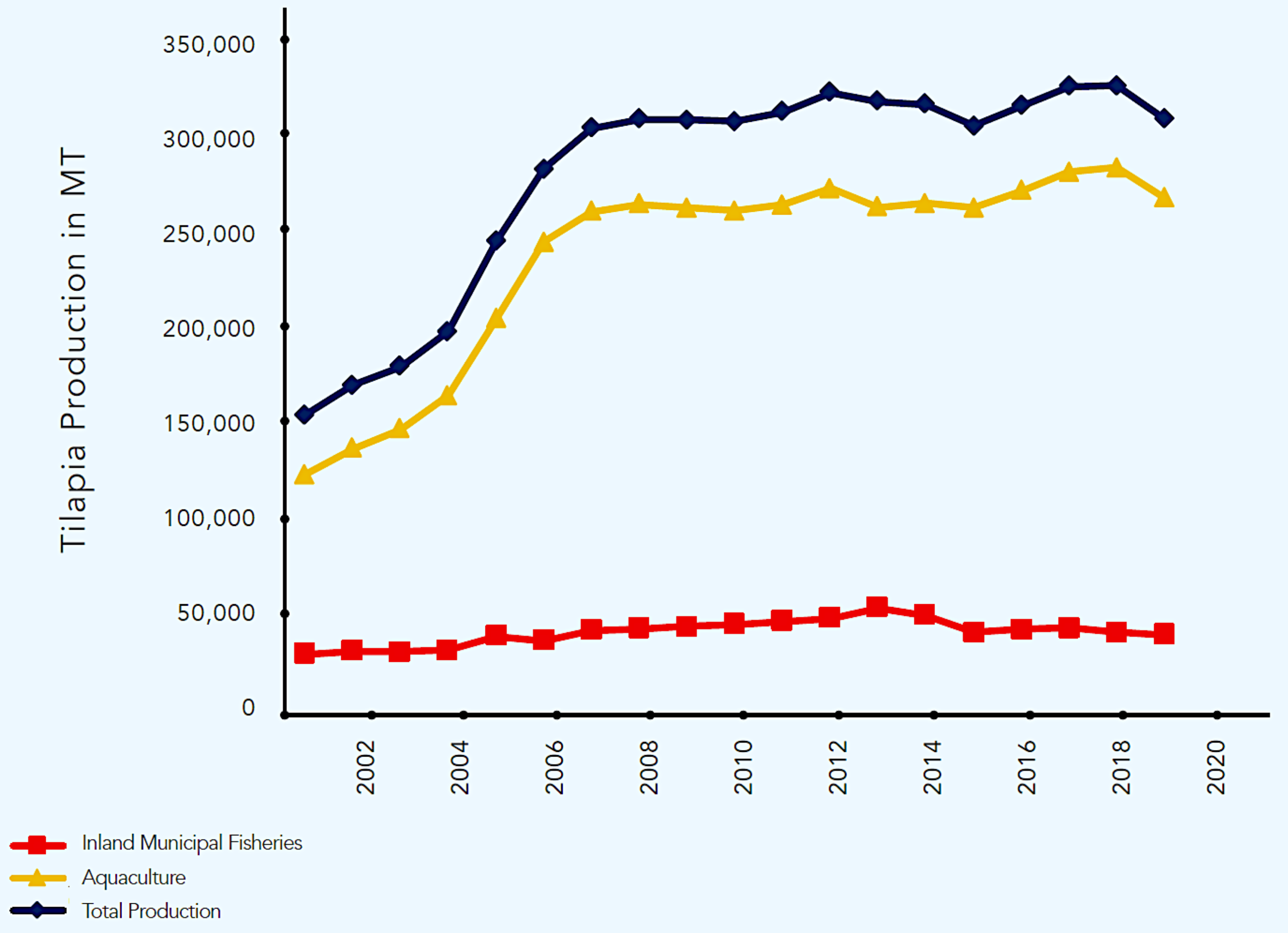
FIGURE 3: WORLD PRODUCER OF FARMED TILAPIA IN 2018



Source: FAO, 2021

Production

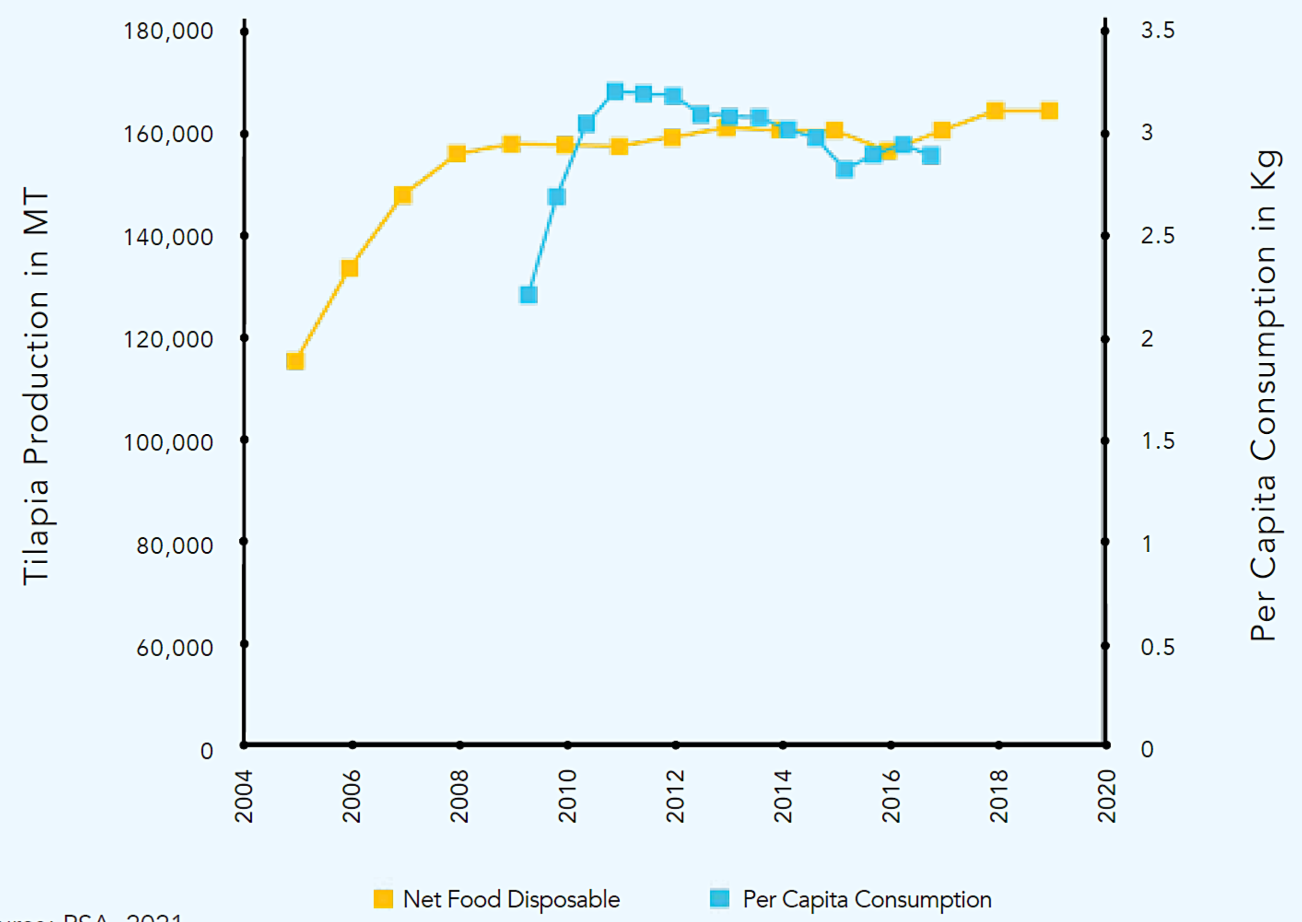
FIGURE 4: COUNTRY'S TILAPIA PRODUCTION (2002-2020)



Source: PSA, 2021

Consumption

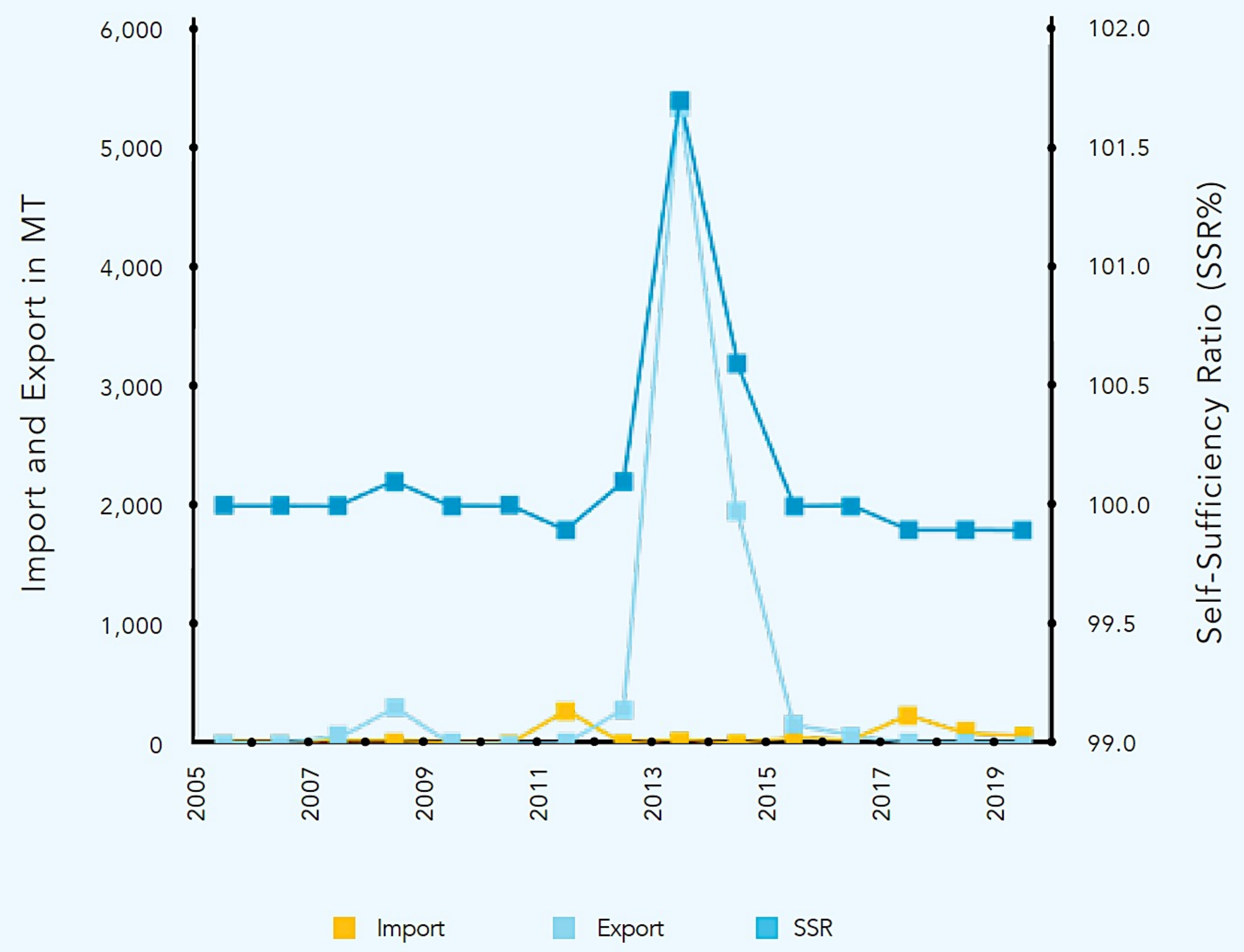
FIGURE 8: NET FOOD DISPOSABLE AND PER CAPITA CONSUMPTION OF TILAPIA (2005-2019)



Source: PSA, 2021

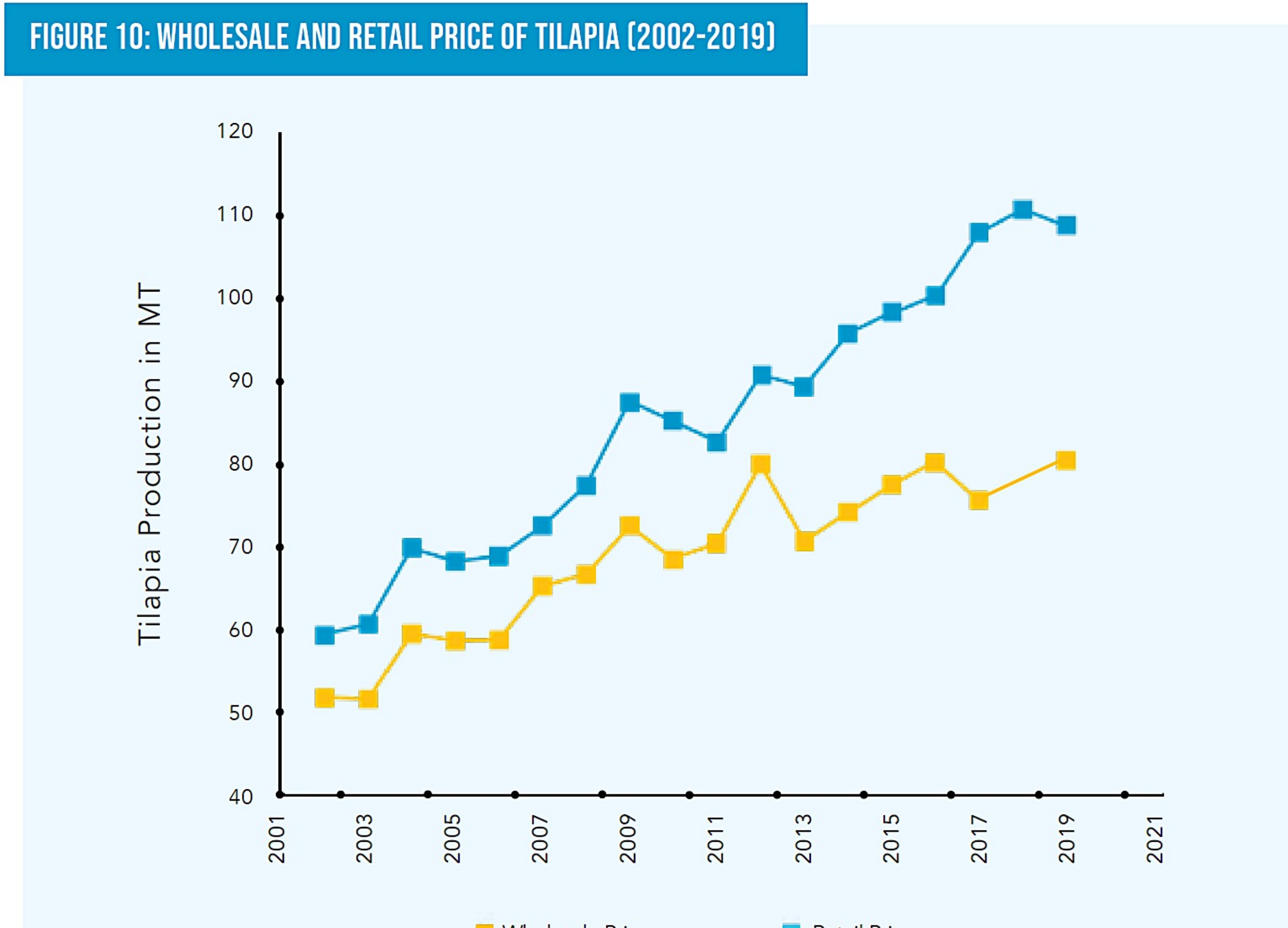
Self-Sufficiency ratio

FIGURE 9: IMPORT, EXPORT AND SELF - SUFFICIENCY RATIO OF TILAPIA (2005-2019)



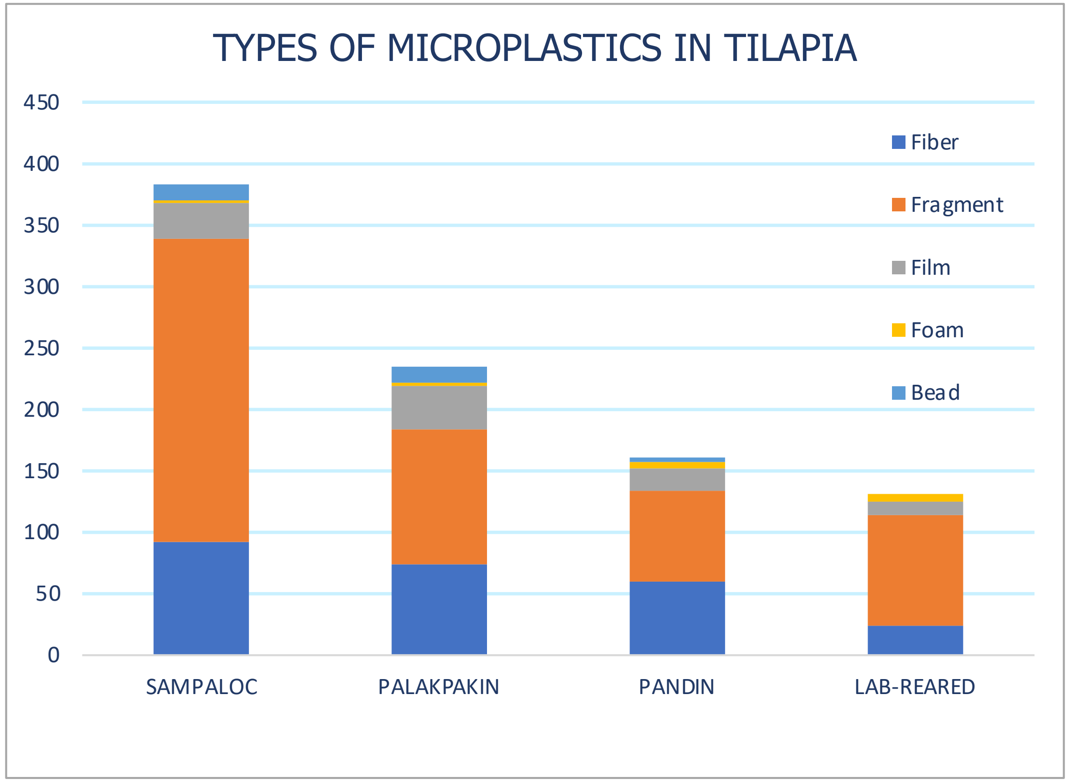
Source: PSA, 2021

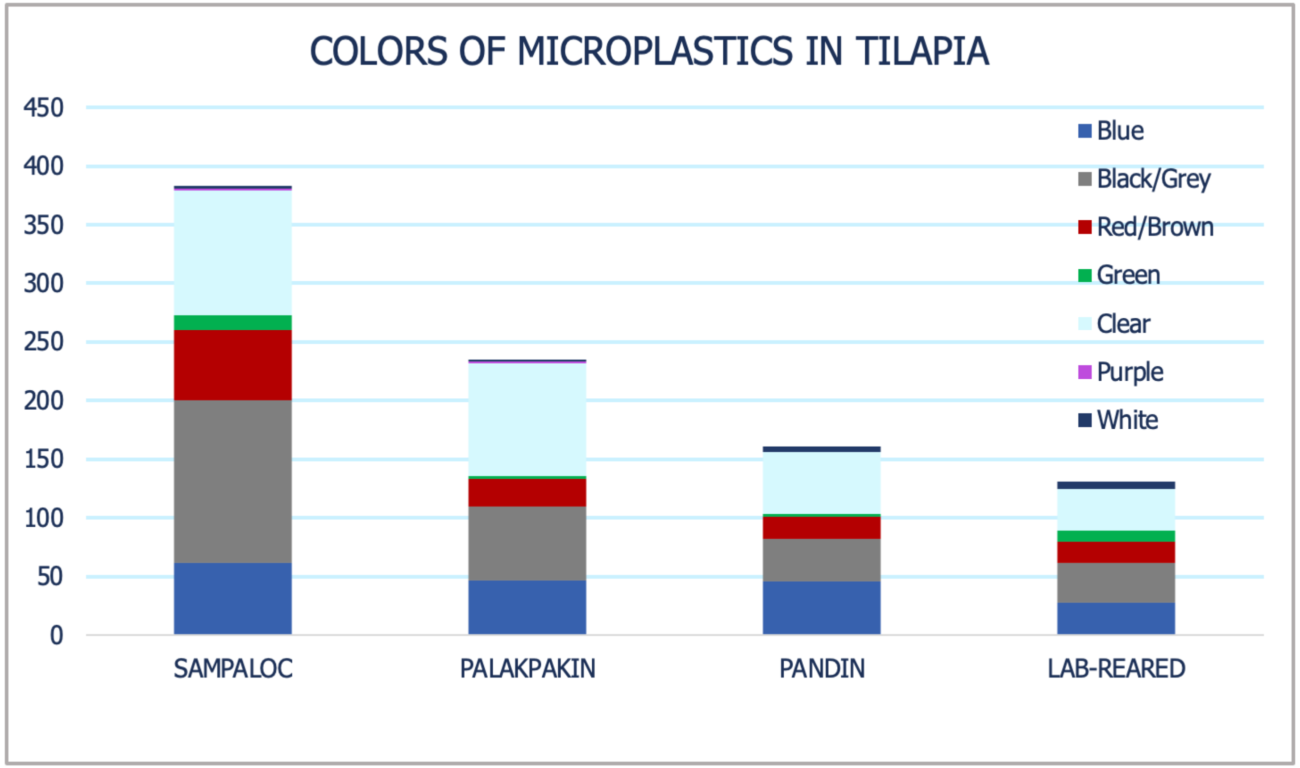
Price



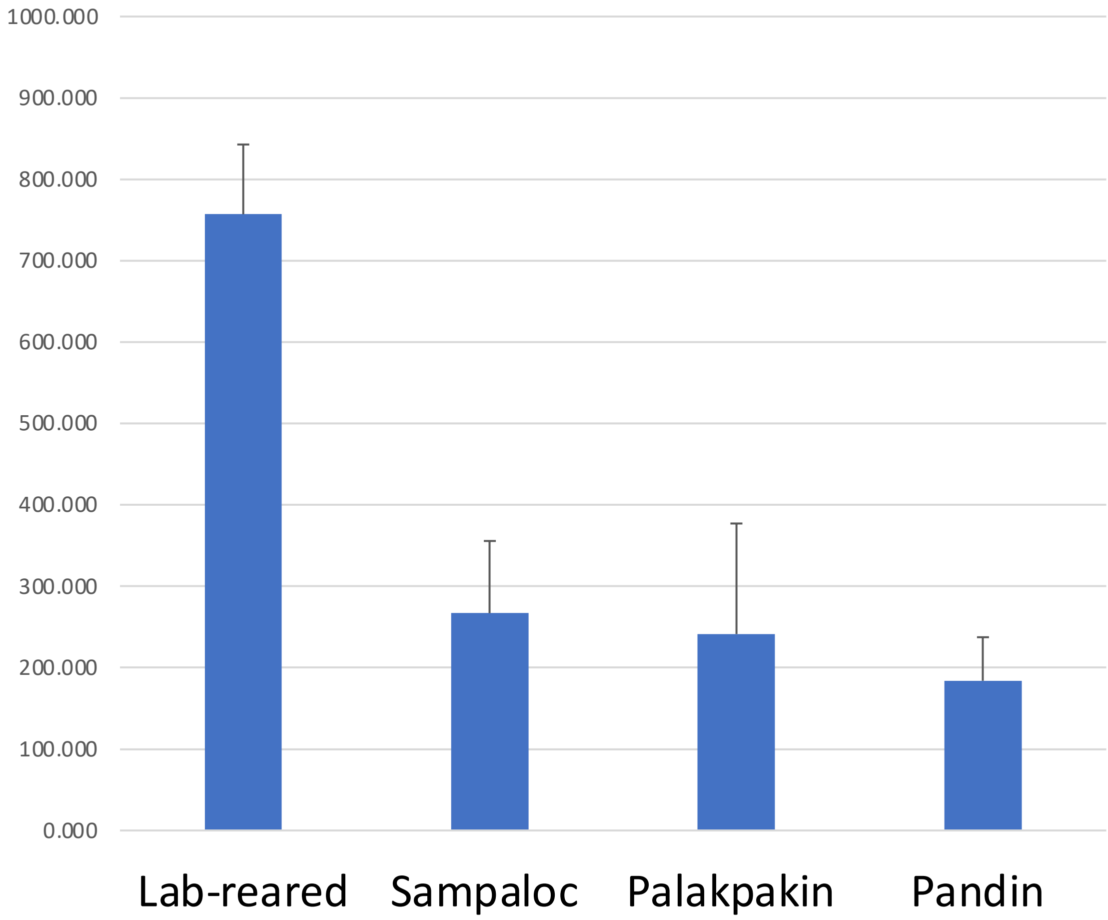
Source: PSA, 2021

Microplastics in Nile tilapia muscle



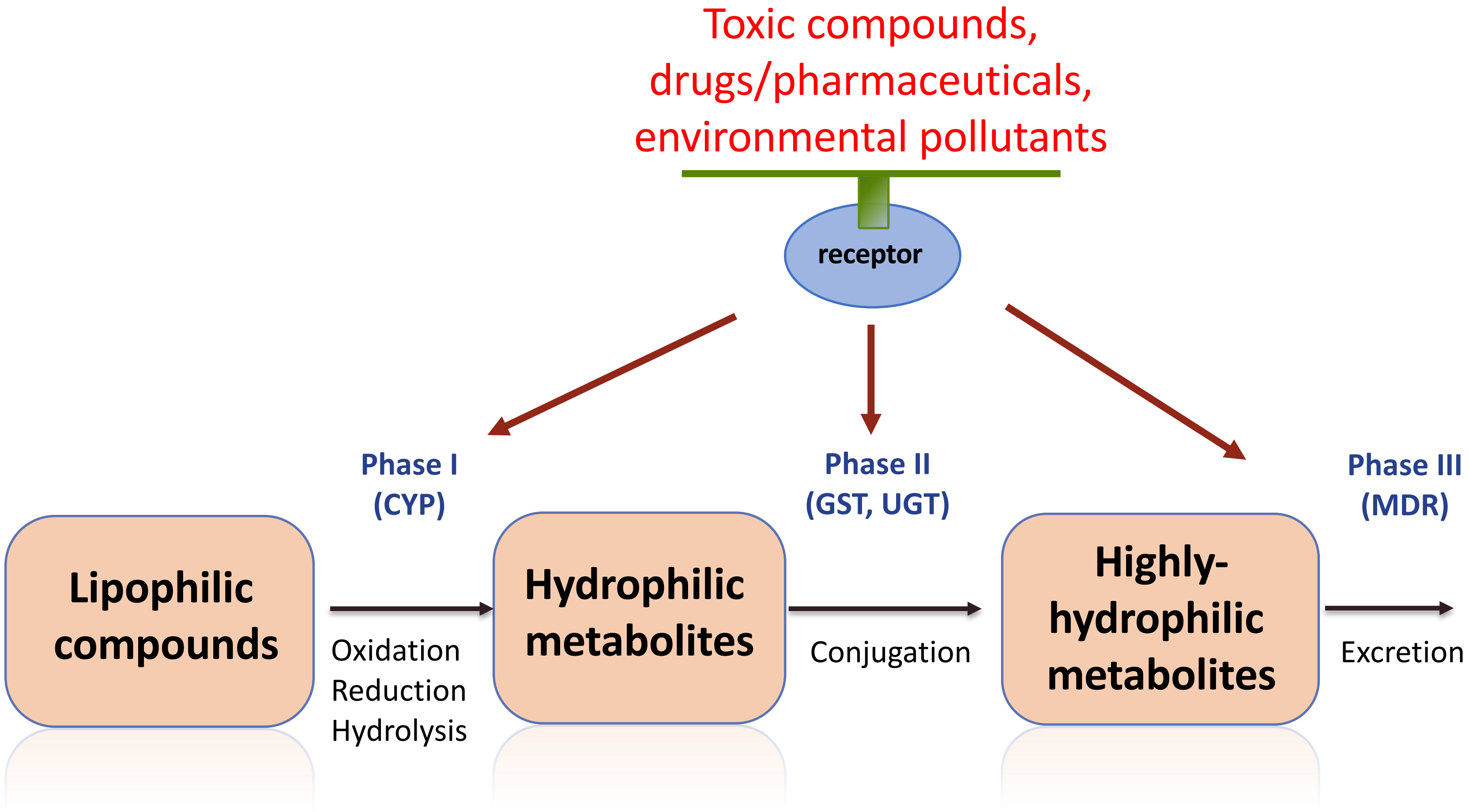


Malondialdehyde (MDA) Protein
- biomarker of oxidative stress



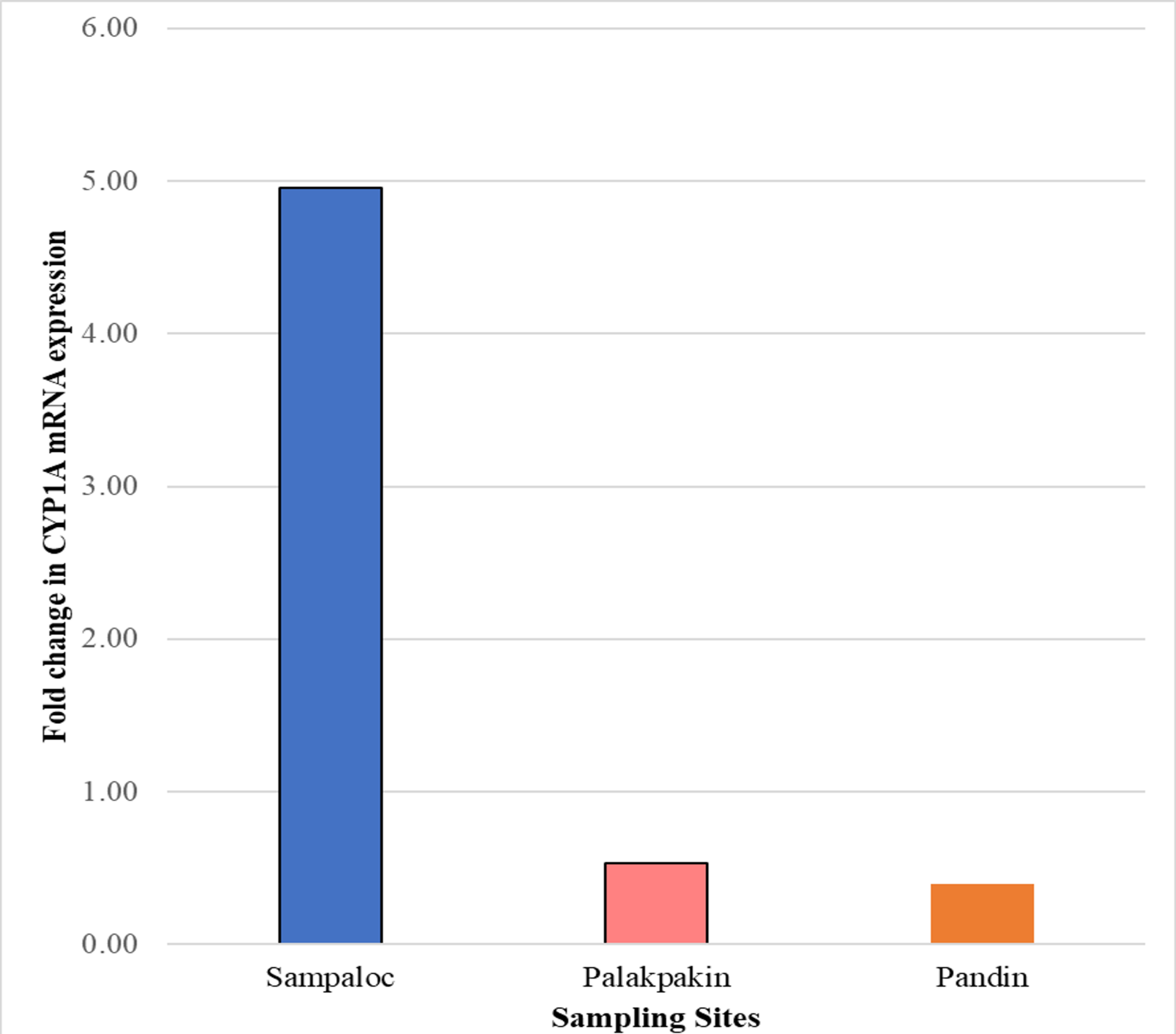
- decreased MDA protein in the Nile tilapia from the lakes

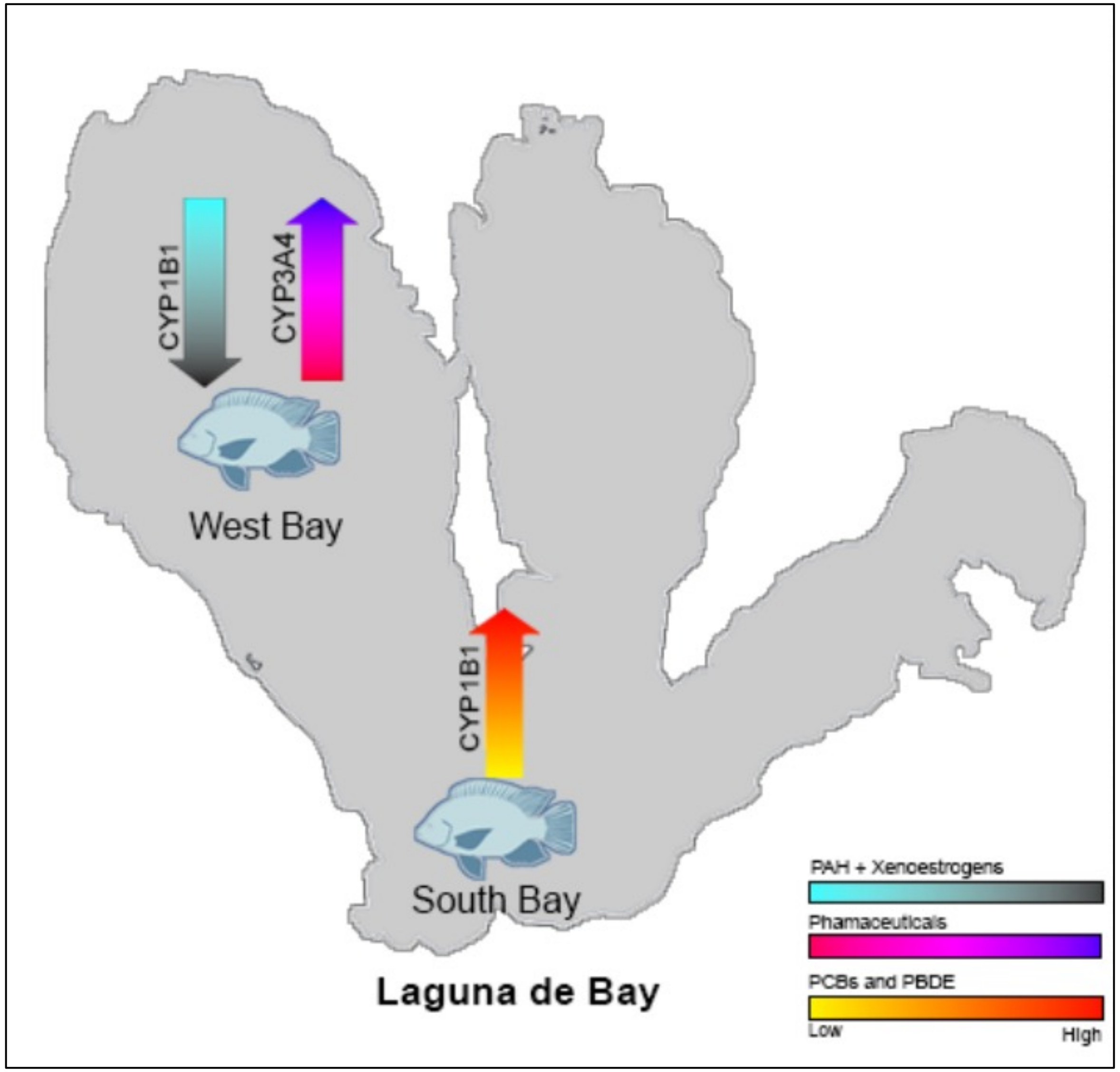
Cytochrome P450 Enzymes
- biomarker of environmental pollutants



CYP1A (San Pablo Lakes samples)

Sampling sites	Average	SD
Sampaloc	4.95	3.29
Palakpakin	0.53	1.19
Pandin	0.40	1.91





CYP450 Gene Expression and Contaminants in Laguna Lake

- **West Bay:**

  a) Lower CY1B1 gene expression might be associated with PAH-Xenoestrogen

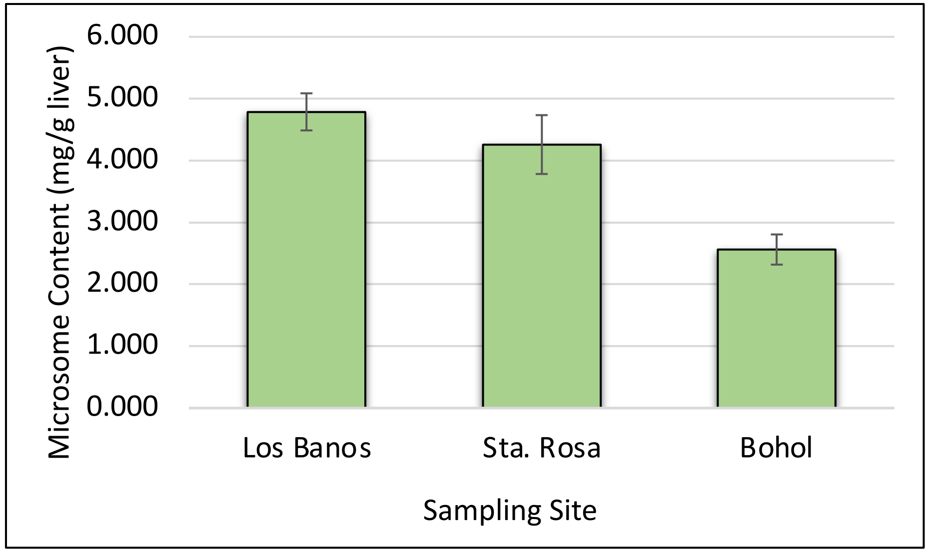
  b) Higher CYP3A4 gene expression might be associated with pharmaceutical

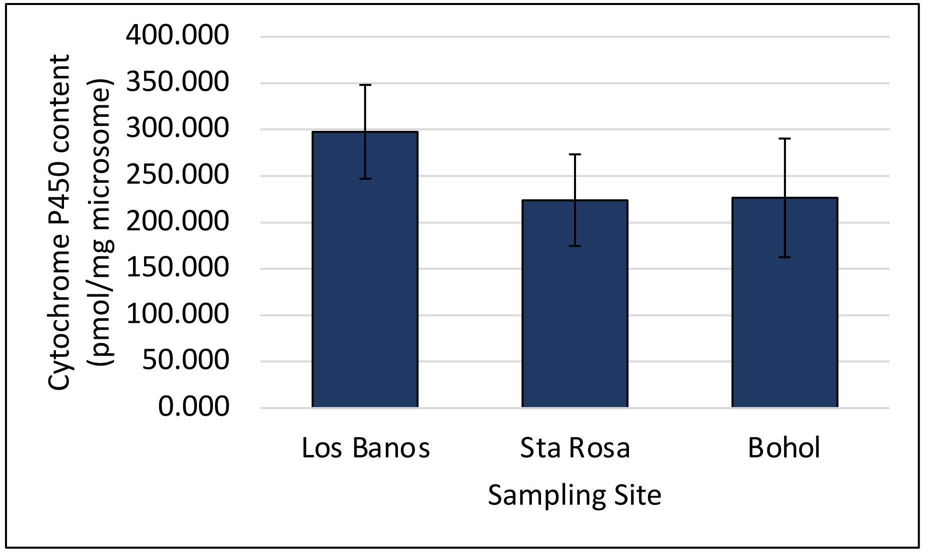
- **South Bay:**

  a) Higher CYP1B1 gene expression might be associated with PCBs and PBDE

Biochemical Assays in Tilapia

Microsome and Total CYP contents





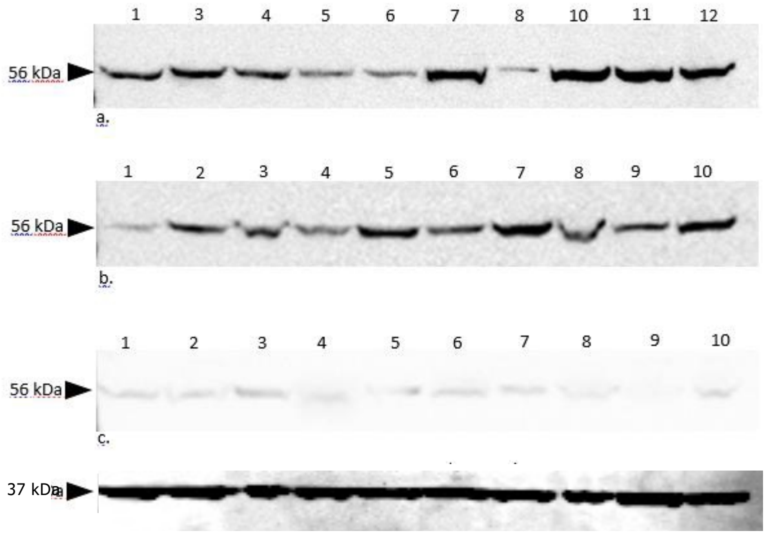
Microsome content of tilapia liver obtained from the three sampling sites. The three sampling sites are significantly different from each other (*p = 0.0003*)

Cytochrome P450 content of the liver microsomes from the tilapia samples obtained from the three sampling sites.

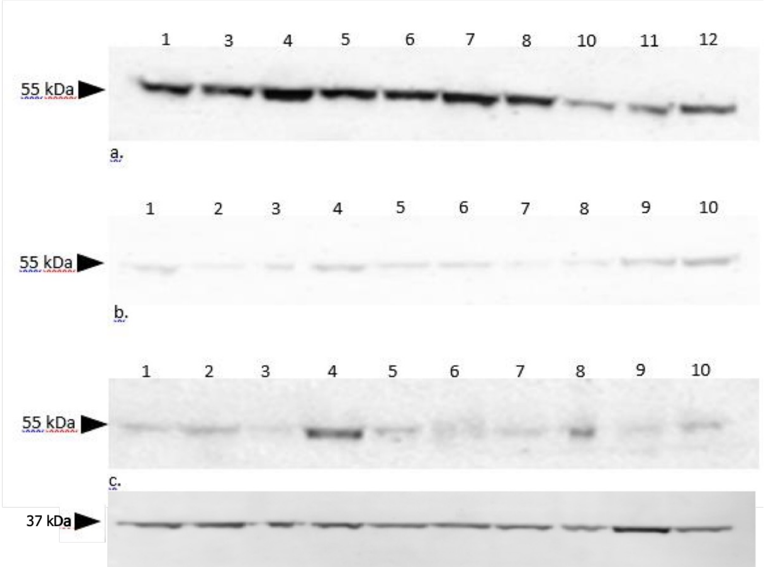
Protein Expression and Validation in Tilapia
(2019)

Western Blot analysis

CYP1A1



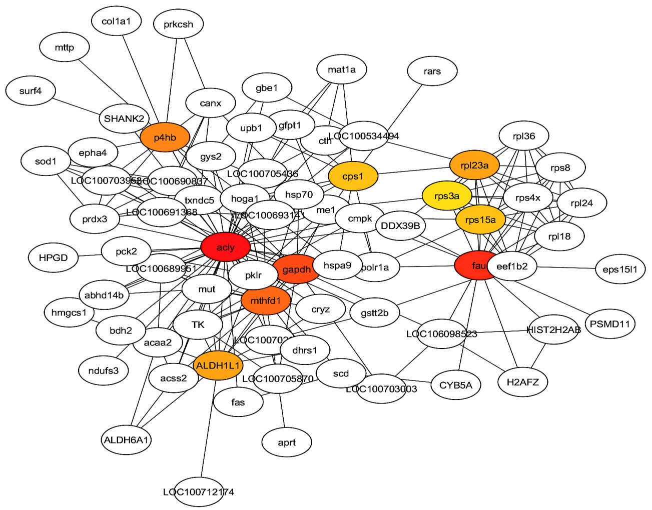
CYP1B1



Western blots analysis of CYP1A1 and CYP1B1 proteins. Representative immunoblots of from Nile tilapia in (A) Site 1 Laguna Lake South Bay (A) Site 2 Laguna Lake South West Bay, and (C) Bilar, Bohol. Total protein (48 µg) was loaded in each lane. The levels of GAPDH (loading control) at 37kDa were analyzed to ensure samples' loading amount.

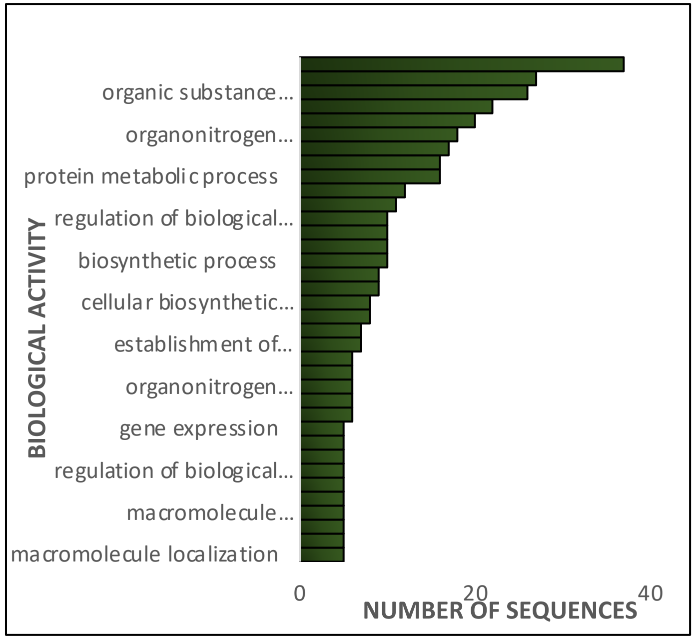
CYP3A: no specific binding

Protein Profiling in Tilapia

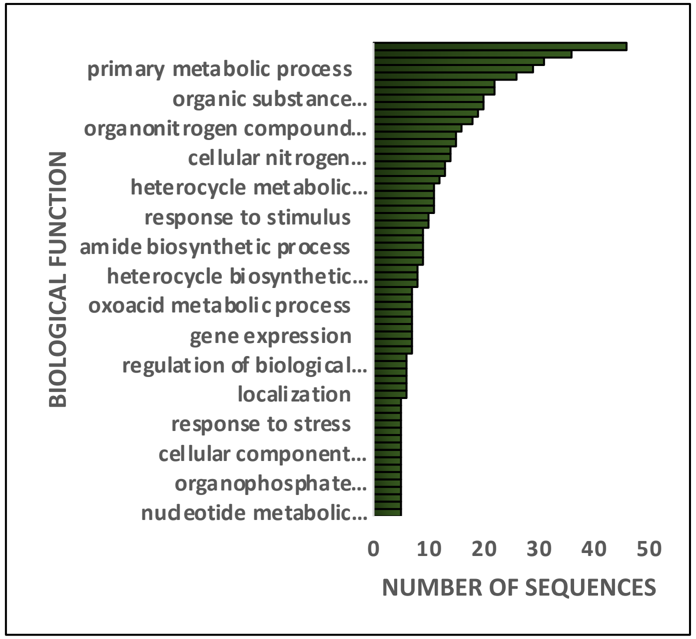


Gene Symbol	Protein Name	Betweenness Centrality	Degree	Fold Change
acly	ATP citrate lyase	0.569183	44	-1.7717
fau	40S ribosomal protein S30	0.130853	17	-1.7775
gapdh	Glyceraldehyde-3-phosphate dehydrogenase	0.224083	15	-1.83394
mthfd1	C-1-tetrahydrofolate synthase, cytoplasmic	0.053591	14	-1.78574
p4hb	Protein disulfide-isomerase	0.108836	13	1.65987
rpl23a	Ribosomal protein L23a	0.032682	12	1.79353
ALDH1L1	10-formyltetrahydrofolate dehydrogenase	0.049572	12	1.88041

Upregulated Proteins



Downregulated Proteins



Protein Profiling in Tilapia

List of differentially expressed protein biomarkers

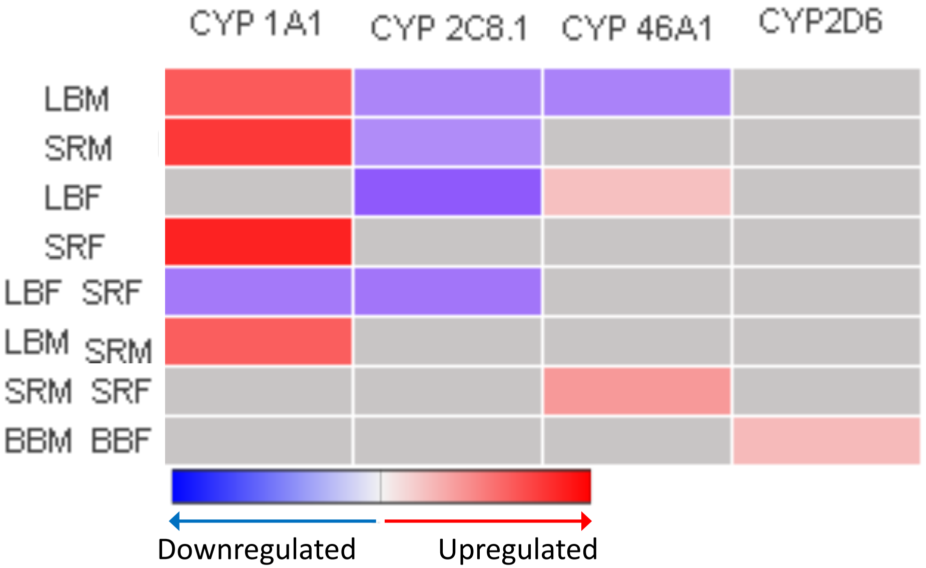
involved in stress and detoxification

SITE	UPREGULATED		DOWNREGULATED
Site 1	Male	cyp3a27, rpl23a, mgst, sult1a4, srd42e, CYTB5, BCHE, gsta	ephx2, ABHD14B, UGT, aoc1, calcoco1, gstt2b, dhrs1, ALDH91A.1, ADH1, ADH5, hsp70
	Female	FMO1, abhd14b, mgst1, sult1a4, calcoco1	ephx, UGT, pter, CYB5R2, gstt2b, dhrs1, hagh, ADH5
Site 2	Male	FMO1, hao1, ABHD14B, UGT, rpl23a, pter, CYB5R2, cat, sdr42e1, aox5	CTYB5, BCHE, hagh, PIEZO2
	Female	hao1, ABHD14B, UGT, CYB5R2, sdr42e1, ALDH9A1A.1, aox	BCHE, gsttb, ndrg1, PIEZO2

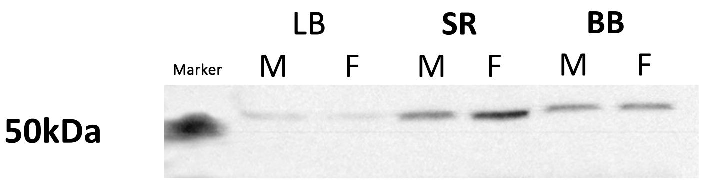
Other organisms living in the lake are also affected.

Toad Hepatic Protein Profile

Identified differentially expressed CYP450



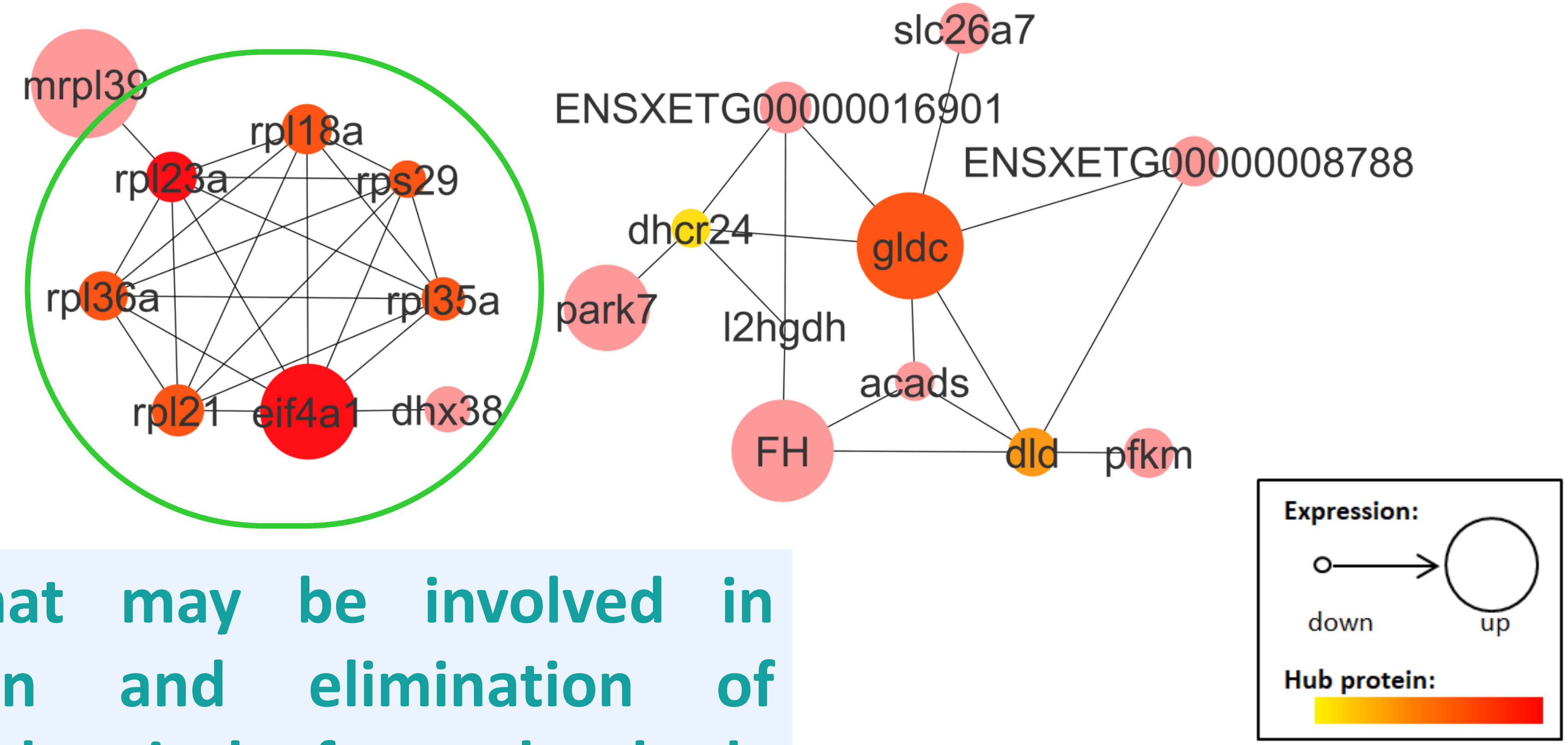
CYP1A1 Western Blot analysis



LBM- Site 1 Male
LBF – Site 1 Female
SRM – Site 2 Male
SRF – Site 2 Female
BBM – Site 3 Male
BBF – Site 3 Female

Toad Hepatic Protein Profile

Site 3 Differentially expressed proteins

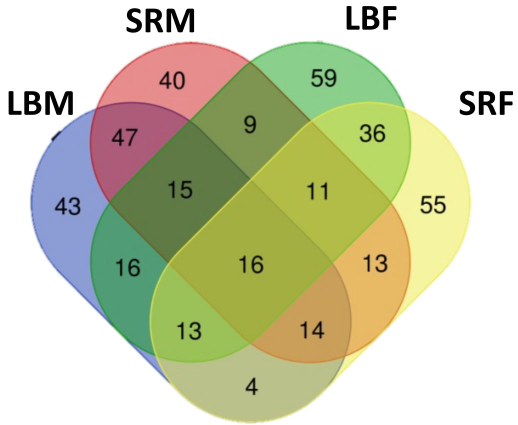


Enzymes that may be involved in detoxification and elimination of exogenous chemicals from the body are downregulated

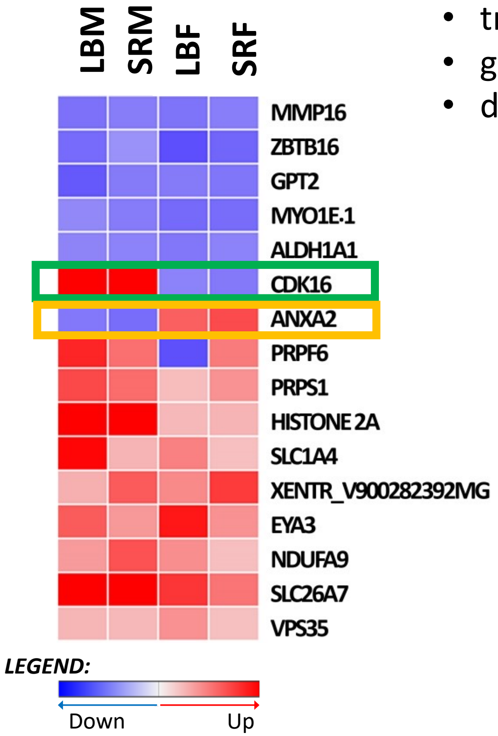
Toad Hepatic Protein Profile

Differential Expression of Proteins

Number of Common proteins in Sites 1 and 2



Expression of Common proteins in Sites 1 and 2



Upregulated Proteins

- metabolism
- transport
- gene expression
- development

Downregulated Proteins

- metabolism
- intracellular movement
- binding
- stimulus recognition

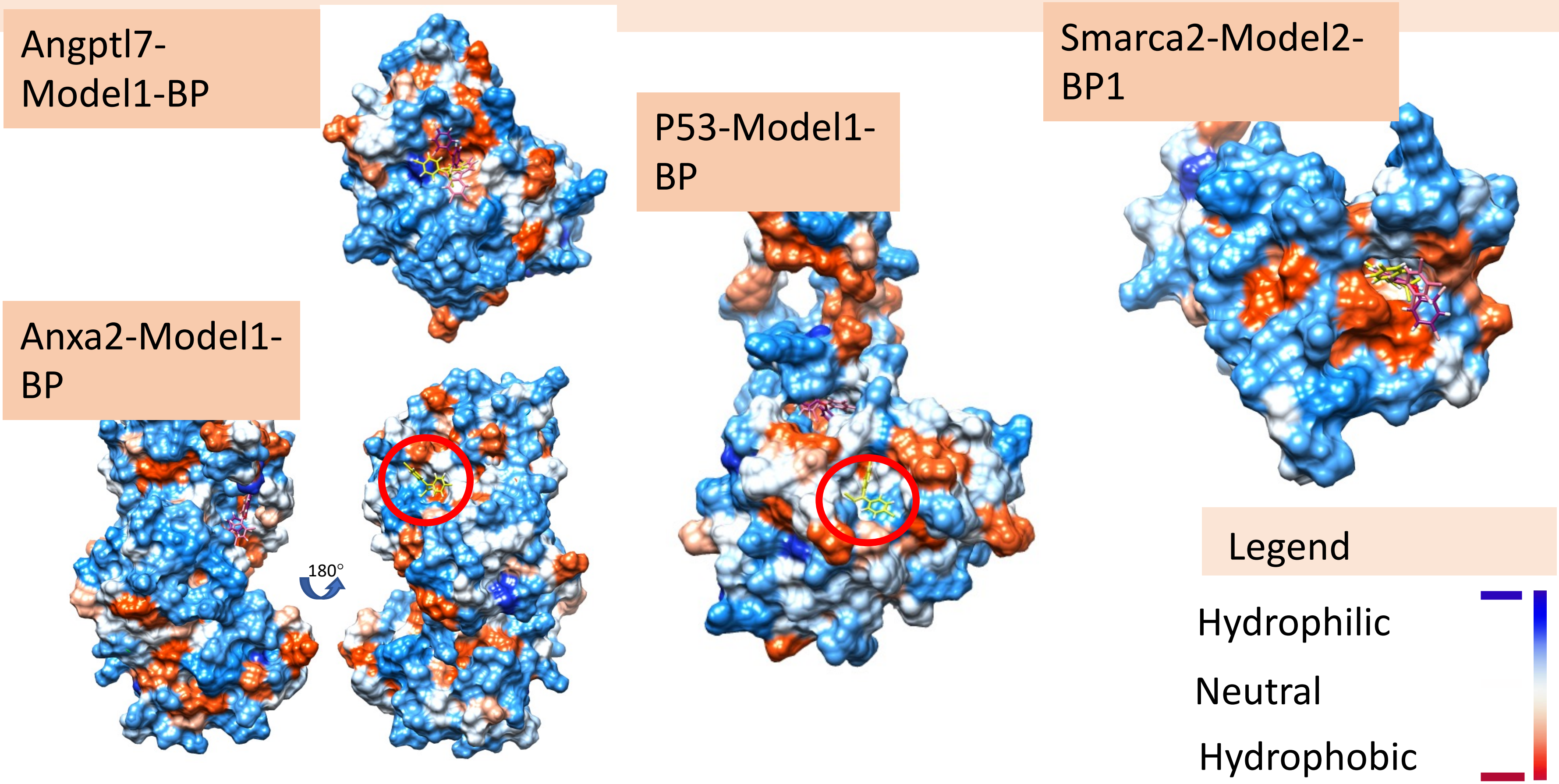
CDK16	**Annexin**
-G1 to S phase transition **-DNA damage response**	**-signal transduction** **-cell growth regulation**

Proteins involved in cancer are affected.

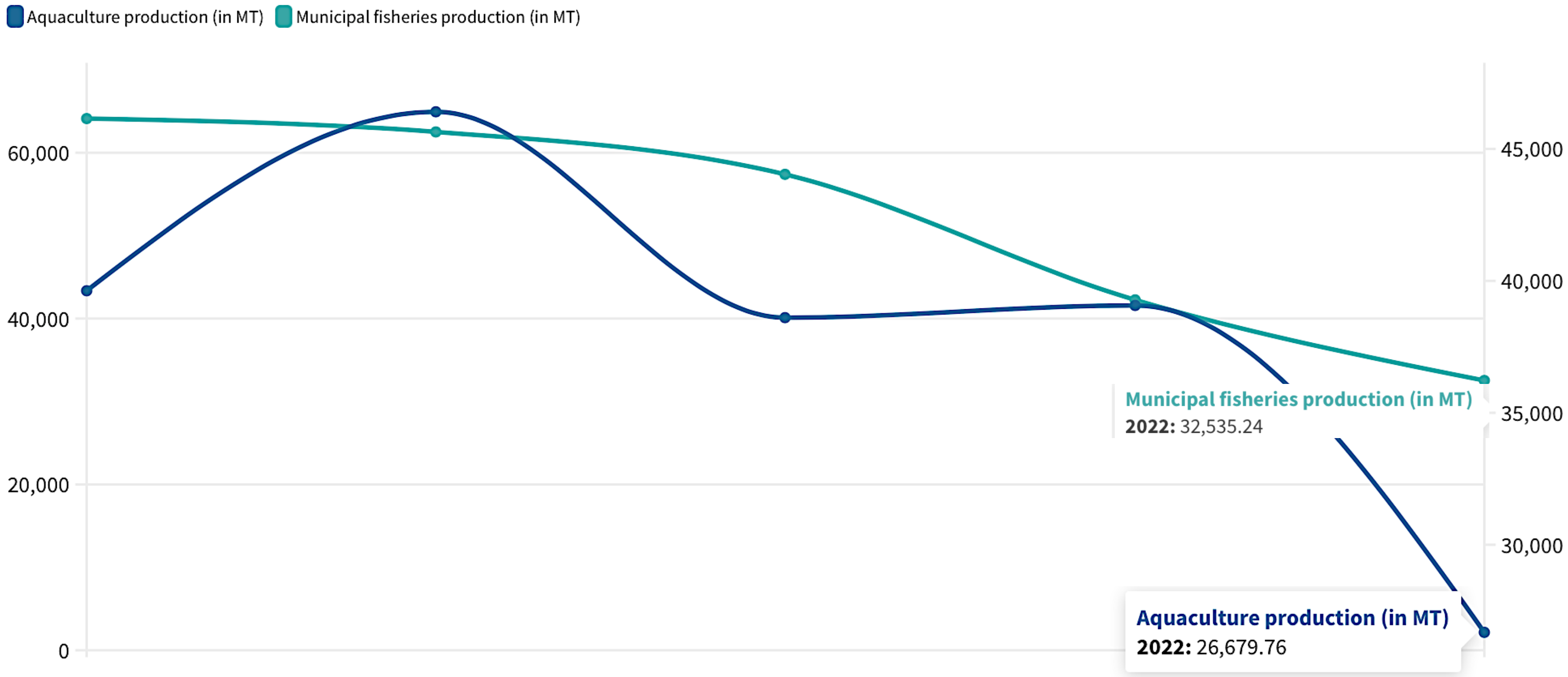
LBM- Site 1 Male
LBF – Site 1 Female
SRM – Site 2 Male
SRF – Site 2 Female

In silico Approaches

Docking Poses of Persistent Organic Pollutants against the 3D Models of Cancer-linked proteins



Declining fish catch in Laguna Lake

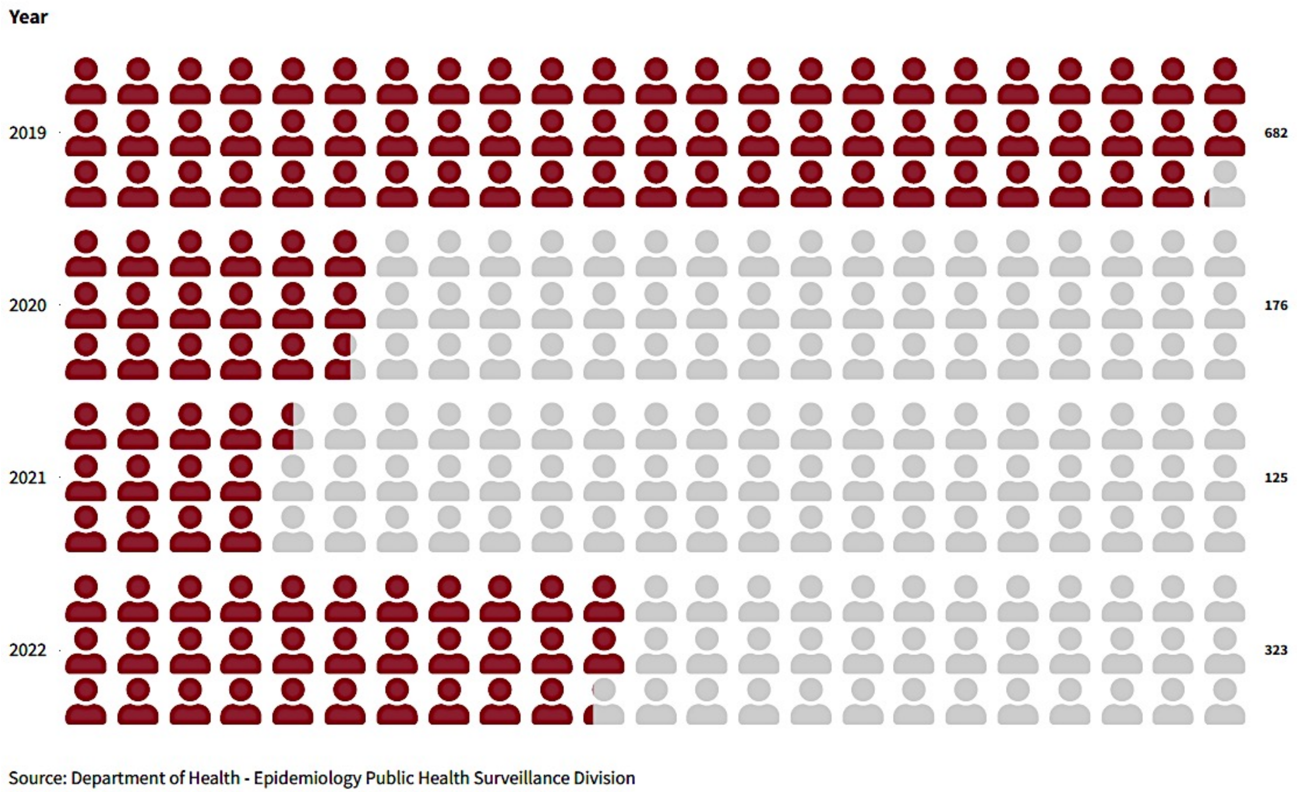


Source: Laguna Lake Development Authority , Philippine Statistics Authority •

Aquaculture Production: The controlled farming of aquatic organisms, including fish and shellfish, in designated water enclosures, aimed at enhancing seafood production.

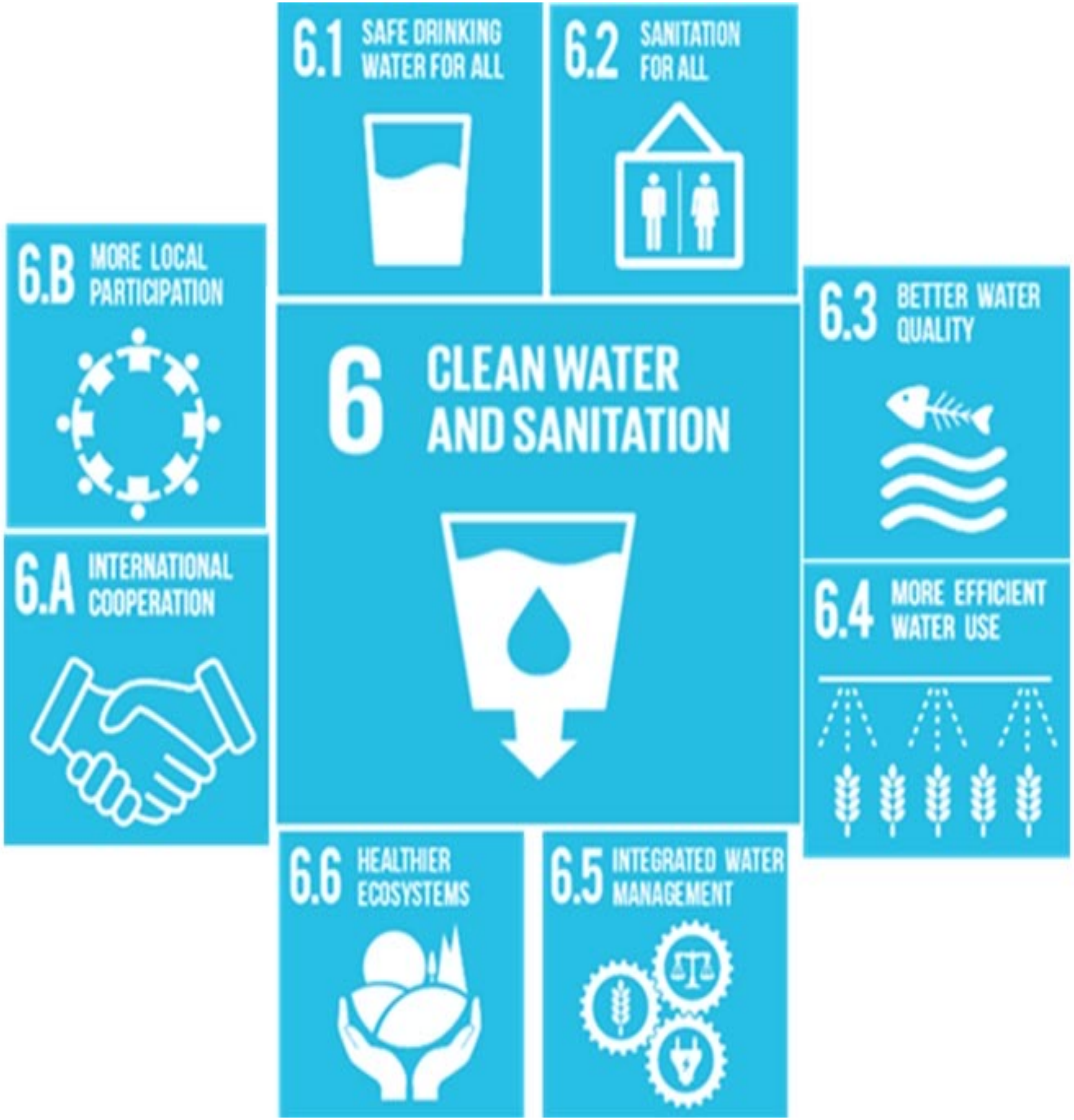
Municipal Fisheries: Small-scale fishing activities conducted near the coast, primarily for local consumption, involving community-managed, less industrialized methods.

Water-borne diseases in the region around lakes



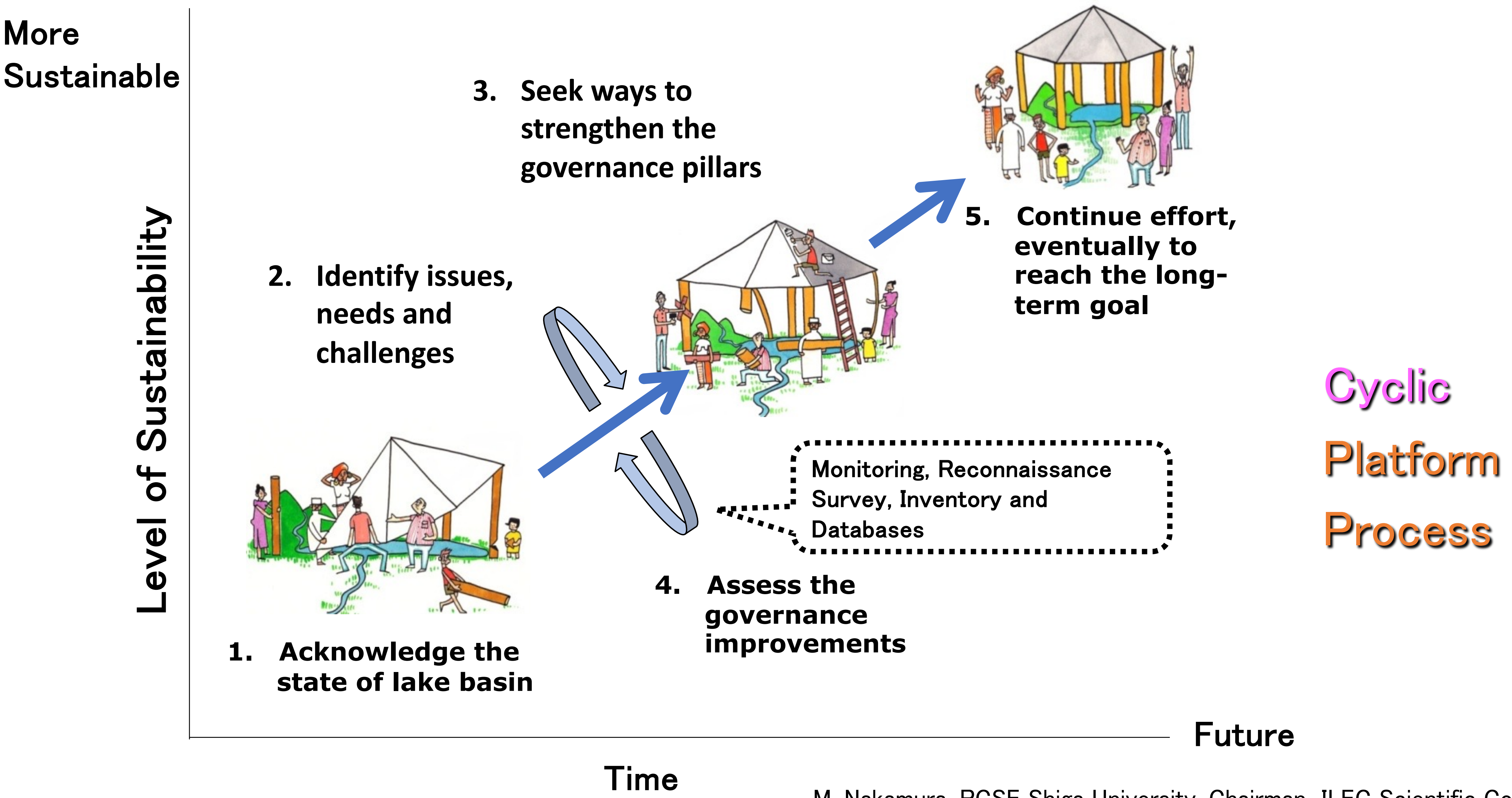
Department of Health (DOH) noted a reduction in the morbidity rate due to diarrhea from 1,520 per 100,000 population in 1990 to 347.3 per 100,000 population in 2010

Recent years have seen notable outbreaks, which health authorities attribute to a combination of socio-cultural factors and environmental issues.



Water quality have far-reaching critical role in the interplay among environmental pollution, biodiversity, aquatic and terrestrial ecosystem function, food production, and human health.

Lake Governance



M. Nakamura, RCSE Shiga University, Chairman ILEC Scientific Committee

PREMISE: The **City Tourism Master Plan** was formulated by the City Government of San Pablo to develop Sampaloc Lake and its environs as a premier eco-adventure tourist destination which was adopted and approved on 07 April 2015 by the Sangguniang Panlungsod.

Approval and Implementation of LLDA Memorandum Circular No. 2017-03:

"Guidelines in Implementing the Zoning of Aquaculture Structures in Sampaloc Lake by Amending Certain Provisions of Memorandum Order No. 2005-43 and Inclusions of Other Rules and Regulations"

25 July 2017 *- Signing by GM Jaime Medina in San Pablo City*

08 September 2017 *- Orientation of Operators*

26-27 November 2017 *- Cluster Demarcation*

26 June 2018 *– Awarding of Lake Occupancy Permit*

Recent Developments:

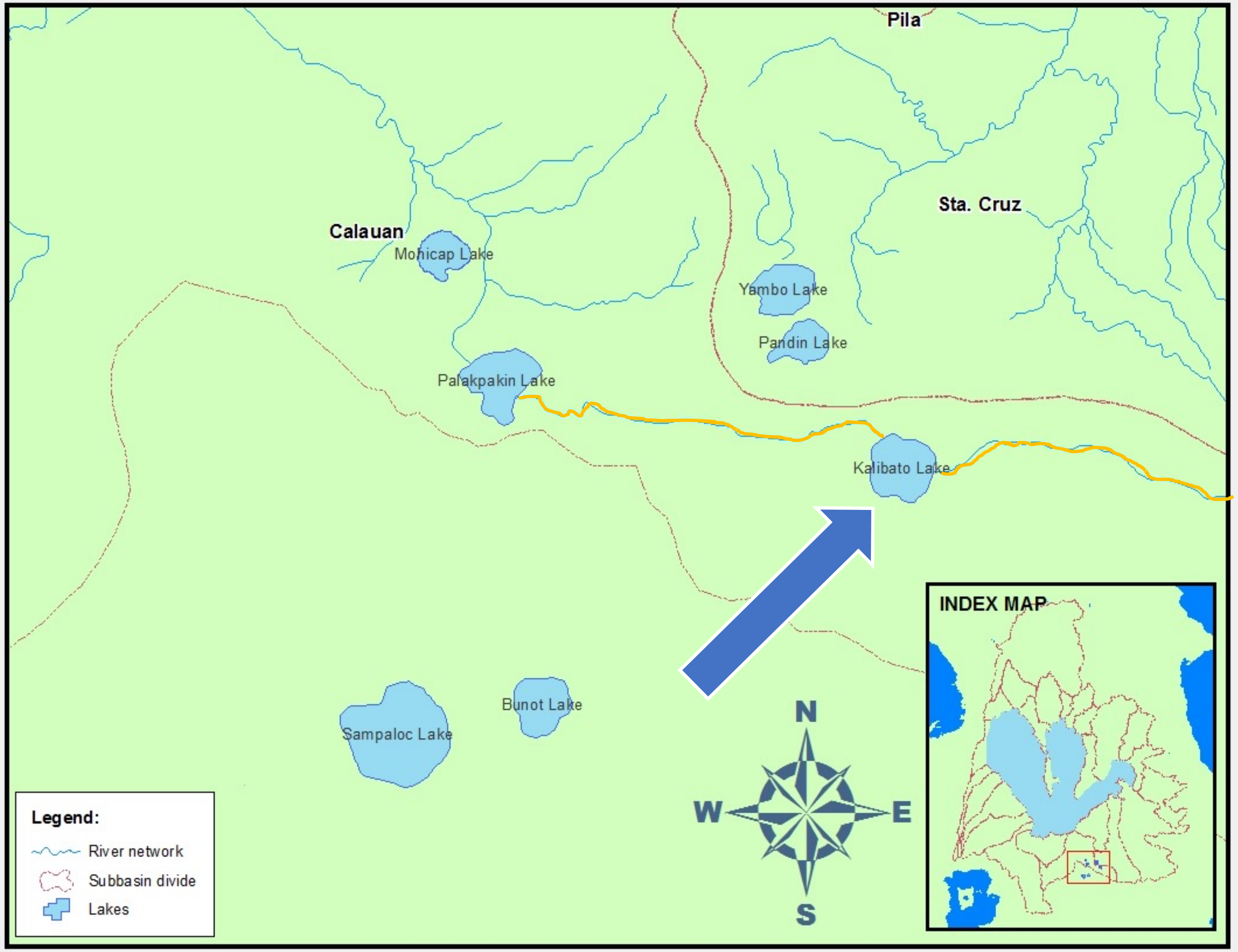
- ***January-March 2018*** *- Continuous consultation with City Government and fish cage operators on clustering and agreed specific location of fish cages in the lake*
- ***April to May 2018*** *– Actual application for LLDA Permit by fish cage operators*
- ***June 2018*** *- Demarcation of Actual Relocation Sites of Fish Cages/Ceremonial Transfer*
- ***3rd Quarter 2018*** *- Actual Transfer of Fish Cages According to MC No. 2017-03*
- ***December 2018*** *– 100% completion on the transfer/zoning of fish cages*

Research Dissemination to Local Stakeholders

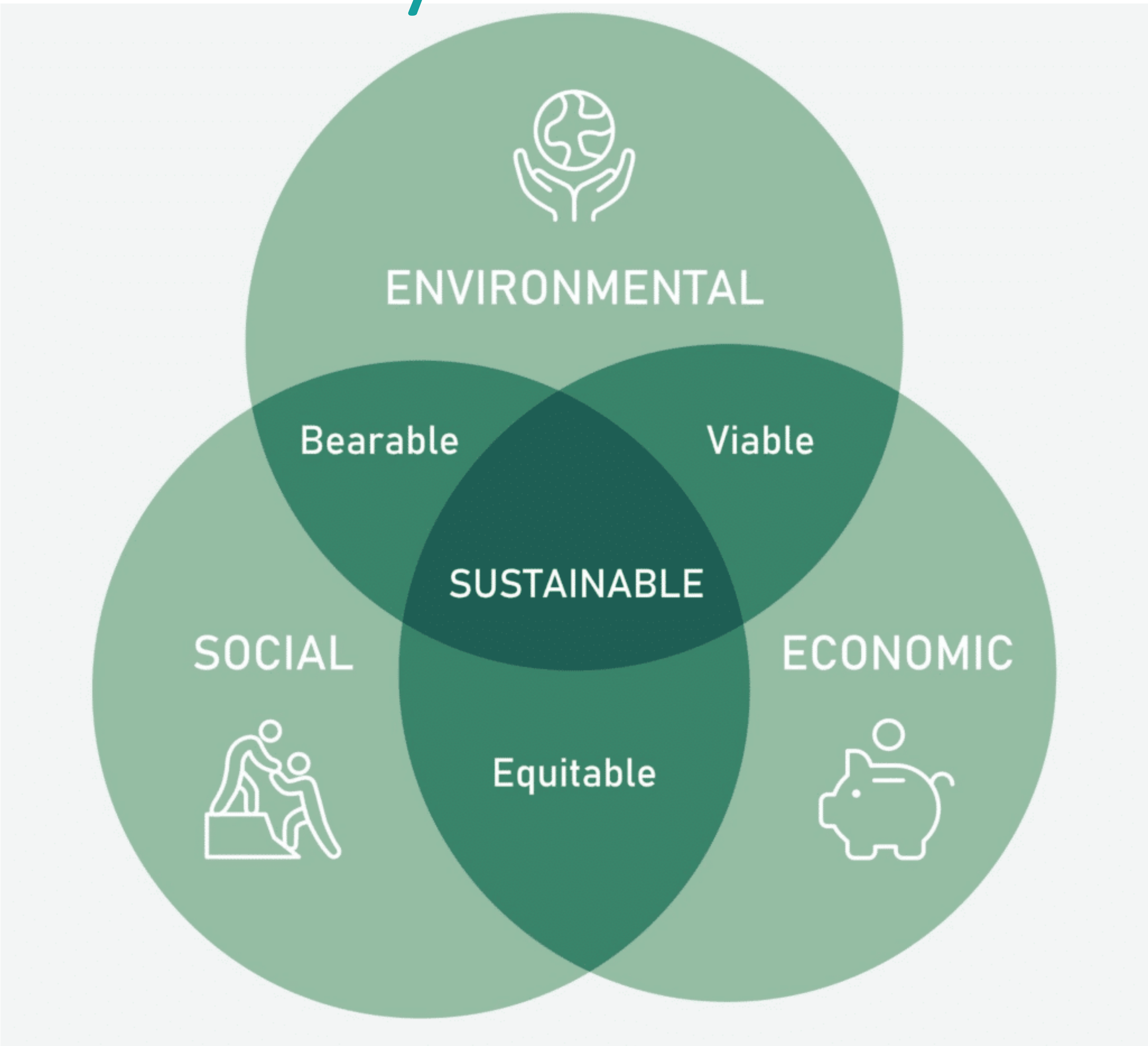
SCAN ME

Stakeholders forum among local communities of the 7 Lakes of San Pablo City

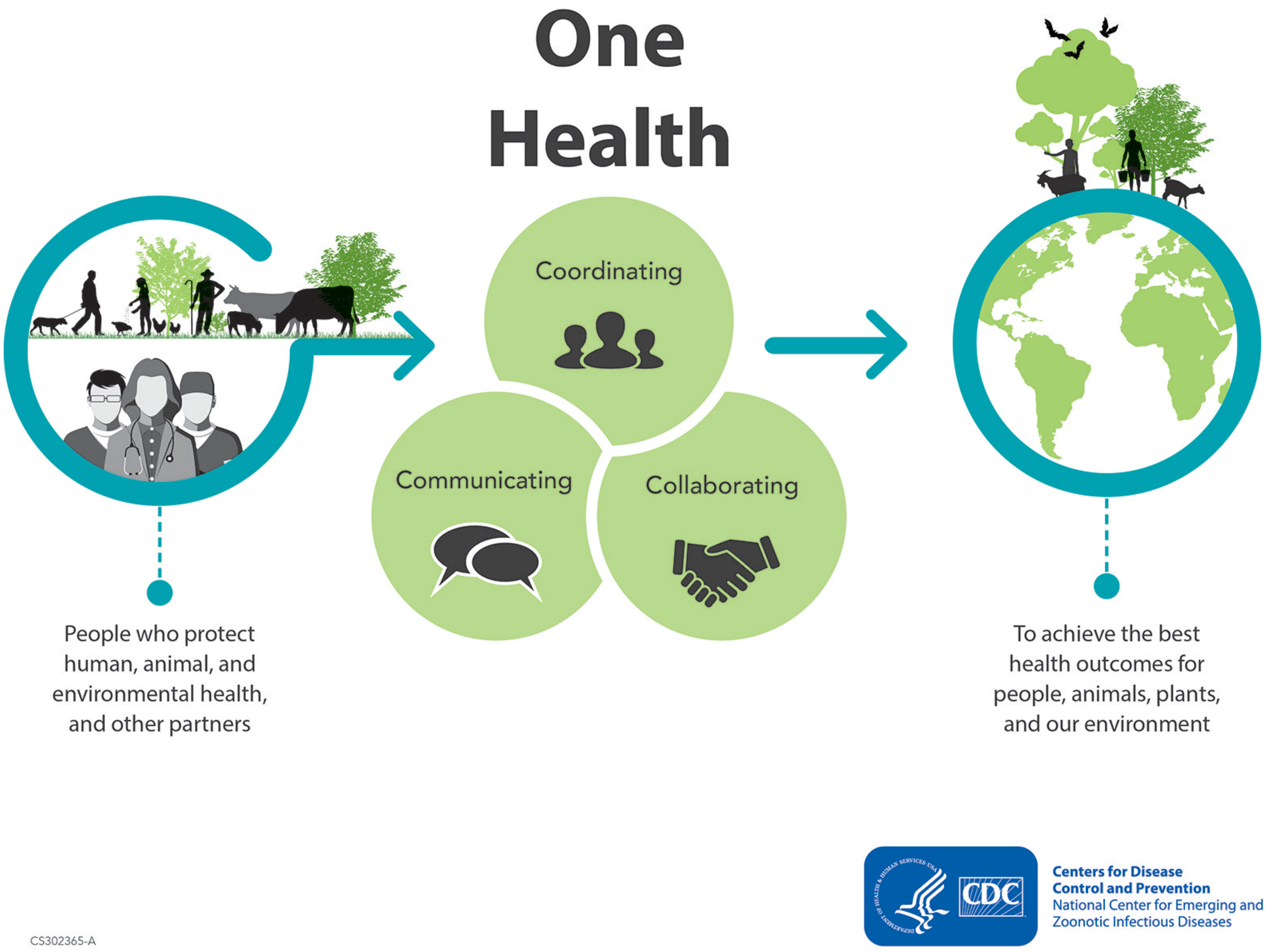
Ecosystem Services Shared Value Assessment



Sustainability



One Health Approach



One health, one earth.

Acknowledgment

Research Mobility Grant, Meiji University

Dr. Takamitsu Kai
Kurokawa Field Center, Meiji University

Seven Lakes Assessment and Monitoring Program: Strategies toward a Sustainable Lake Ecosystems (7 LAMPS)
Department of Science and Technology, Philippines

Leading Academia in Marine and Environment Pollution Research (LaMer)
Ehime University, Matsuyama, Japan