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Commercially Caught Freshwater Fishes in the Philippines: Status, Issues, and Recommendations

Rafael D. Guerrero III

Agricultural Sciences Division
National Academy of Science and Technology Philippines

ABSTRACT

The Philippines is endowed with 406,328 hectares of inland waters consisting of lakes, marshes, and reservoirs. In 2018, the production of inland fisheries in the country was 164,835 metric tons (3.8% of total fisheries production) with a value of PHP 5.8 billion. This study was conducted to determine the status of commercially caught freshwater fishes in major inland waters based on available data, literature, and information from key informants and personal observations, and identify issues and recommend strategies for the sustainability of such fishes.

Results of the analyses showed that the top 10 commercially caught freshwater fishes in 2017 were tilapia (50%), carp (16.4%), mudfish (11.0%), Asiatic catfish (6.6%), gourami (5.0%), white goby (3.8%), Manila catfish (2.6%), climbing perch (2.4%), silver perch (1.7%), and freshwater sardine (1.5%). Between 2005 and 2017, the highest increases in production were for the freshwater sardine (+49.7%), Asiatic catfish (+41.6%), and carp (+32.5%) while the highest decreases were for the silver perch (-69.8%), white goby (-39.5%), and Manila catfish (-26.6%). There was an average annual increase of 4.2% in the production of the 10 fishes for 2005-2017. The tilapia, mudfish, Asiatic catfish, and climbing perch were found in all regions of the country while the carp, gourami, white goby, Manila catfish, and silver perch were found in most regions. The freshwater sardine, on the other hand, was only found in the Lake Taal of Region IV-A (CALABARZON).

The major issues threatening the sustainability of freshwater fishes were identified as overfishing, water pollution, invasive fishes, and environmental degradation. Recommendations for addressing such issues include the imposition of a closed fishing season, strict implementation of water quality standards, firm enforcement of rules and regulations for foreign/exotic fishes, and the reforestation of denuded forests.

Keywords: freshwater fishes, inland waters, inland fisheries

Correspondence:
Rafael D. Guerrero III
rafaeldg7@gmail.com

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ORCID
Rafael D. Guerrero III
http://orcid.org/0000-0003-1822-6545

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Abbreviations: ARRM, Autonomous Region in Muslim Mindanao; BFAR, Bureau of Fisheries and Aquatic Resources; CALABARZON, Cavite, Laguna, Batangas, Rizal, Quezon; DA, Department of Agriculture; DENR, Department of Environment and Natural Resources; FAO, Food and Agriculture Organization; IUCN, International Union for Conservation of Nature; LGU, local government units; MMT, million metric tons; NFRDI, National Fisheries Research and Development Institute; NIA, National Irrigation Administration; NPC, National Power Corporation; PHP, Philippine Pesos; PSA, Philippine Statistics Authority.

INTRODUCTION

Freshwater fishes comprise 46% of about 32,500 species of fishes known (Nelson 2006). Globally, the total volume of fisheries from inland waters (i.e., lakes, reservoirs, rivers, and swamps) was 11.6 million metric tons (MMT) or 12.8% of the total fisheries volume of 90.9 MMT in 2016 (FAO 2020). The fisheries (i.e., fishes, mollusks, and crustaceans) of inland waters provide jobs, revenue, critical resources (biodiversity), and food security to communities around the world. More than 90% of the fisheries catch from inland waters, with a value of USD 26 billion, are used for human consumption. The Food and Agriculture Organization (FAO 2007) reported that about 94% of all freshwater fisheries occur in developing countries.

Freshwater fishes in inland waters are defined as those that live entirely in freshwater lakes, rivers, and other wetlands with a salinity of fewer than 1.05 parts per thousand (Reid et al. 2013). Mercene (1997) classified freshwater fishes in the Philippines into (a) primary fishes that have evolved in freshwater and cannot tolerate seawater (e.g., cyprinids) and (b) secondary fishes that are of marine origin, now confined in freshwater, and tolerant of seawater for short periods (e.g., gobies). In the Philippines, freshwater fishes are the major and often the only source of animal protein for low-income families (Briones et al. 2004). There are 359 freshwater fishes in the country consisting of nine endemic genera and more than 65 endemic species (Froese and Pauly 2022). Commercially caught freshwater fishes refer to those that have commercial value and are fished mainly for food in lakes, marshes, rivers, and reservoirs.

Compared to marine fishes, freshwater fishes are more vulnerable to extinction because of their proximity to man. Among the threats to their existence are pollution, drainage of wetlands, channeling of rivers, forest deforestation, sedimentation, invasive species, and overharvesting (Darwall et al. 2008).

The Code of Conduct for Responsible Fisheries (2005) of the Food and Agriculture Organization (FAO):

"Sets out principles and international standards or behavior for responsible practice for ensuring the effective conservation, management and development of living aquatic resource with due respect for the ecosystem and biodiversity, and provides principles and standards applicable to the conservation, management and development of all fisheries."

As a signatory to the FAO Code of Conduct for Responsible Fisheries that was adopted by the United Nations member-states in 1995, the Philippines is committed to voluntarily complying with the principles and standards of the Code.

In the Philippines, the Local Government Code of 1991 (Republic Act No. 7160) has empowered the municipal and city governments of local government units (LGUs) of the country to conserve, manage, utilize, and develop the coastal and inland waters (municipal waters) of the country. The Fisheries Code of 1998 (RA 8550 1998) has mandated the Bureau of Fisheries and Aquatic Resources (BFAR) of the Department of Agriculture (DA) to conserve, manage, utilize, and develop the country's fisheries and aquatic resources excluding municipal fisheries in municipal waters, which are under the jurisdiction of the local government units (LGUs).

Municipal fishing refers to the exploitation of the fisheries in municipal waters by fishers with or without fishing vessels of three gross tons or less using passive (non-active) fishing gears like gill nets, hooks and lines, and traps in lakes, rivers, and coastal waters within 15 kilometers from the coastline (RA 8550 1998). Relative to the conservation of inland fisheries in the country, the same law prohibits (a) fishing with explosives, noxious or poisonous substances, and electricity; (b) fishing with nets with mesh sizes smaller than what is legal; (c) use of active fishing gear in municipal waters; (d) use of "superlights"; (e) fishing in overfished areas and during closed seasons; (f) fishing in fisheries reserves, refuges, and sanctuaries; and (g) the obstruction to navigation or flow and ebb of the tide in any stream, river, lake, or bay.

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The Clean Water Act of the Philippines (RA 9275) was enacted in 2004 to protect the country's water bodies from pollution from land-based sources (i.e., industries and commercial establishments, agriculture, and community/household activities). It is the national policy for the protection, preservation, and revival of the quality of the country's waters (e.g., fresh, brackish, and marine).

A guidebook entitled "Basic Principles for the Management of Philippine Lakes" was published by Palma et al. (2005) for "the national regulatory framework for lake management, local development plans, and the need of development workers and stakeholder communities." It includes, among others, different strategies for the rehabilitation of lake resources. It also offers four training modules for local government units on (a) lake ecosystem, (b) man-environment interaction, (c) resource rehabilitation, and (d) social aspects of resource rehabilitation.

The DA-BFAR launched its *Balik Sigla sa Ilog at Lawa* (BASIL) Program in 2018 for reviving the fisheries of "lakes, rivers and reservoirs located in upland and land-locked areas where there is a deficiency of fish supplies." The five-year program (2018-2022) aims to (a) rehabilitate/restore the physical conditions of lakes, rivers, and reservoirs and (b) enhance the fisheries and repopulate indigenous species in support of biodiversity conservation, poverty alleviation, and food sufficiency. The program has the following components: (a) lake profiling (physical and biological); (b) social preparation by organizing fisherfolk; (c) lake rehabilitation (through clean-up activities and establishment of sanctuaries/ brush parks) and fish dispersal; and (d) lake management through ordinances of LGUs and monitoring/reporting of fish catch. The project cost for the dispersal of 126.82 million fingerlings for five years is PHP 209.28 million (BFAR 2020).

This paper presents the (a) status of fisheries in major inland waters (i.e., lakes, marshes, rivers, and reservoirs) in the country including the fisheries productions in the various regions of the country in 2005 and 2017 and (b) production data of the top ten commercially caught freshwater fishes in 2005 and 2017. It also discusses the (c) issues threatening the fishes and recommend (d) actions/strategies for their sustainability.

In the assessment of the status of commercially caught freshwater fishes in the major inland waters of the country, the fisheries production data of the Philippine Statistics Authority (PSA) were used and analyzed with percentages. Information from available literature (published and unpublished), key informants, and personal observations were also evaluated.

STATUS OF COMMERCIALLY CAUGHT FRESHWATER FISHES IN MAJOR INLAND WATERS

There are 406,328 hectares (ha) of inland waters in the Philippines (PSA 2020) consisting of lakes (61.5%), marshes/swamps (26%), rivers (7.6%), and reservoirs (4.7%). The major inland waters in the country are listed in Table 1 and shown in Figure 1.

Laguna de Bay

The largest lake in the country with an area of 90,000 ha and a mean depth of 2.5 m is Laguna de Bay. The multi-purpose lake is used for fisheries production, domestic water supply, navigation, hydropower generation, and irrigation. Its fisheries are from aquaculture (pens and cages) and open-water fishing (Lasco and Espaldon 2005).

Before the introduction of aquaculture in the lake in the 1970s, the production of the open-water fisheries was 86,282 metric tons (MT) in 1983 with the endemic silver perch or "ayungin" (*Leiopotherapon plumbeus*) as the most abundantly caught food fish in the lake. In 2015, the lake's total fisheries production was 156,832 MT with 61% (95,667 MT) from open-water fisheries and 39% (61,164 MT) from aquaculture (Guerrero 2017).

Palma (unpublished data) reported that there are 33 fishes, 11 mollusks, and three crustaceans recorded in the lake in 2016. The main freshwater fishes commercially caught by more than 3,000 fishers using passive fishing gear are the Nile tilapia (*Oreochromis niloticus*), Manila catfish or "kanduli" (*Arius manillensis*), white goby or "biyang puti" (*Glossogobius giuris*, and silver perch. Invasive fishes such as the janitor fish (*Pterygoplicthys dysjunctivus*) and the knife fish (*Chitala ornata*) have also been accidentally introduced into the lake.

The water quality of the lake has deteriorated due to the run-off of nutrients (nitrates and phosphates) from domestic, agricultural, and industrial sources, which have led to eutrophication and caused fish kills. Soil

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Table 1. Major inland waters in the Philippines.

Geographical Area	Inland Water	Province(s)	Category	Area (ha)
Luzon	Laguna de Bay	Laguna-Rizal	Lake	90,000
	Lake Taal	Batangas	Lake	24,356
	Lake Buhi	Camarines Sur	Lake	1,800
	Lake Naujan	Oriental Mindoro	Lake	8,125
	Cagayan River	Cagayan Valley	River	2,564,900 drainage area
	Pampanga River	Pampanga	River	975,900 drainage area
	Magat Reservoir	Isabela	Reservoir	11,700
	Angat Reservoir	Bulacan	Reservoir	2,360
Mindanao	Lake Mainit	Surigao del Norte	Lake	17,340
	Lake Lanao	Lanao del Sur	Lake	34,000
	Agusan Marsh	Agusan del Norte	Marsh	14,000
	Liguasan Marsh	Sultan Kudarat-Maguindanao	Marsh	43,930
	Rio Grande de Mindanao	Bukidnon-Davao del Norte	River	2,316,900 drainage area

(PSA 2020)

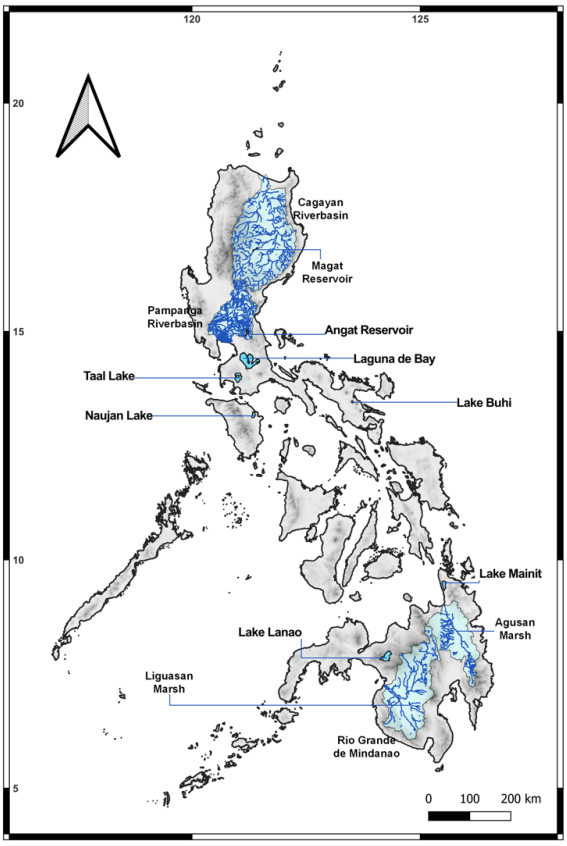

Figure 2. Map of the Philippines showing major inland waters.

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erosion due to deforestation of the lake's watershed has increased sedimentation to about 1.5 million cubic meters per year (Barril 1992). The proliferation of the predaceous knife fish has markedly reduced the population of the silver perch in the lake. The invasive fish became the second most abundantly caught fish (next to the Nile tilapia) with no commercial value in 2018 (Palma pers. comm.).

Lake Lanao

The second largest lake in the country with an area of 34,000 ha and a mean depth of 60 m is Lake Lanao. The lake is the source of water via the Agus River and is used by the National Power Corporation for hydropower providing more than 30% of the electricity supply of Mindanao (NPC 2017). It used to be the home of 18 endemic cyprinid species (Cyprinidae) (Herre 1933). The cyprinids (*Barbodes* spp.) were a major fishery in the lake that greatly contributed to the food and incomes of the Maranaos, the predominant ethnic group in the area.

In 1963-1964, the volume of cyprinids caught in Lake Lanao was 981.12 MT comprising 49% of the total catch by local fishers. In 1990-1991, however, only 22.74 MT of the cyprinids was caught, which was 9.1% of the total catch (Rosagaron 2001). The reason for the sharp decline in the catch of the cyprinids was the accidental introduction of the predaceous eleotrid, *Glossogobius margaritacea* (formerly *Hypseleotris agilis*), which was first noticed in the lake in 1977. It is believed that the indigenous eleotrid, inadvertently introduced with the Nile tilapia fingerlings from a government hatchery near Lake Mainit in Surigao del Norte, was stocked in Lake Lanao. The volume of the eleotrid caught in Lake Lanao in 1990-1991 was 78.94 MT or 31.5% of the total catch (Escudero 1995).

In 2001, only three cyprinids (i.e., *Barbodes lindog, B. sirang*, and *B. tumba*) of the original 18 species were found in Lake Lanao (Rosagaron 2001). In a survey in 2016-2017 conducted by Torres (2018), only *B. tumba* was collected. The other two species were reported as Critically Endangered or probably extinct by the International Union for Conservation of Nature (IUCN 2020).

The fishes of commercial value that are presently caught by local fishers in Lake Lanao are the Nile tilapia, mudfish (*Channa striata*), common carp (*Cyprinus carpio*), snake-skinned gourami (*Trichopterus pectoralis*), and Asiatic catfish (*Clarias batrachus*).

In 1994, Escudero reported the use of illegal fishing methods in catching fish in the lake such as electro-fishing. Indiscriminate logging as well as extensive land use and farming in the watershed of the lake have increased soil erosion and decreased its water level. Pollution of the lake from agriculture and domestic resources was also rampant.

Lake Taal

The third largest lake in the country with an area of 24,356 ha and a mean depth of 60 m is Lake Taal. It is the home of the only freshwater sardine in the world, the endemic "tawilis" (*Sardinella tawilis*), which is a commercially valuable species (Mutia et al. 2017).

A decline in the catch of the endemic "tawilis" was recorded from 8,792 MT in 1993 to 2,767 MT in 1995 due to overfishing with the use of active fishing gear such as the trawler and "superlights." The introduction of floating fish cages in the 1990s increased the fish production of the lake through aquaculture but reduced the fish catch of the small fisherfolk (Mercene-Mutia 2001). In 1993, the production of the cages in the lake was 41,000 MT and that of the open-water fish catch was 9,000 MT but in 1998, the production of the cages was 39,000 MT while that for the open-water catch was 2,000 MT (Visita and Norris 2005)

The other fishes of commercial value in the lake are the Nile tilapia, the silver perch, mudfish, common carp, and white goby, which are caught by the fisherfolk using traditional fishing gear. Massive fish kills in Nile tilapia cages have occurred in the lake due to wastes from the cages that settle in the bottom and cause oxygen depletion with lake overturns (Rosana and Salisi unpublished report 2001).

Mercene-Mutia (2001) reported that municipal ordinances of the lakeshore municipalities have been enacted to regulate the fish cages in Lake Taal, but no measures were taken to arrest the depletion of the "tawilis." In 2019, a closed fishing season banning the fishing of the "tawilis" in March and April in the lake was imposed by the Protected Area Management Board of the Department of Environment and Natural Resources, which manages the lake and provides "for the establishment and management of National Integrated

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Protected Areas System" under the Republic Act No. 7586 of 1992 (Mercene-Mutia pers. comm.).

Another major issue threatening the open-water fisheries of Lake Taal is the introduction (intentionally or unintentionally) of possibly invasive fishes such as the black-chin tilapia (*Sarotherodon melanotheron*), jaguar cichlid (*Parachromis managuensis*), and Midas cichlid (*Amphilophus citrinellus*). Such fishes have relatively low prices in local markets compared to those of commercially caught fishes. The possible adverse effects of the introduced fishes on the "tawilis" have yet to be ascertained.

In a fish stock assessment report of the National Fisheries Research and Development Institute (NFRDI) of the Department of Agriculture in 2018, the 883.91 MT of fishes caught in the lake consisted of tawilis (35%), Nile tilapia (35%), milkfish (*Chanos chanos*) (12%), black-chin tilapia (11%), Midas cichlid (2.3%), and jaguar cichlid (2.2%) (NFRDI unpublished data).

Lake Mainit

The fourth largest and deepest lake in the country with an area of 17,340 ha and a mean depth of 128 m is Lake Mainit. Uy et al. (2015) reported the presence of 41 fishes in the lake with the Nile tilapia, common carp, and Asiatic catfish as the main commercially caught fishes. In 1980-1981, the white goby and eleotrid were the most abundantly caught commercial fishes but have subsequently declined because of overfishing along with the catadromous giant mottled eel (*Anguilla marmorata*). Pollution from agriculture and mining is another issue threatening the fisheries of the lake (De Guzman 2008).

Lake Naujan

The fifth-largest lake in the country with an area of 8,125 ha and a maximum depth of 45 m is Lake Naujan. It was declared a National Park by Presidential Proclamation No. 282 in 1956.

The white goby is the most exploited indigenous fish in the lake. The other commercially caught fishes are the Nile tilapia, silver perch, common carp, mudfish, and gourami. In a fish stock assessment by Pasumbol and Perez (2001), 61% of the fishes caught in the lake were Nile tilapia, followed by silver perch (16%), white goby (4%), and mudfish (2%). The main issue threatening the fisheries of the lake is overfishing. In 1980 and 1990, 765 MT and 123 MT of fishes were caught, respectively.

Lake Buhi

Lake Buhi is not one of the 10 largest lakes in the Philippines with an area of 1,800 ha and a mean depth of 8 m. However, it is special because it used to be the home of the world's smallest commercial fish, the "sinarapan" or pygmy goby (*Mistichthys luzonensis*) (Grutas and Noblefranca 2013).

The volume of "sinarapan" caught in the lake was 50-90 MT in 1983-1993 but dropped to almost nil in 1994 (Bagarinao 2001). The decline in the population of the fish was attributed to overfishing with the use of motorized fine-mesh push nets by unscrupulous fishers destroying the breeding, feeding, and refuge areas of the endemic goby (Gindelberger 1981; Soliman 2001).

In 1980, DA, through BFAR, issued Fisheries Administrative Order No. 121 that prohibited the catching of "sinarapan" in Lake Buhi. Fortunately, the fish was saved from extinction by its translocation to small lakes (i.e., Lake Katungay and Lake Manapao) in the highlands of Buhi, Camarines Sur, which were declared sanctuaries of the fish through the Buhi Municipal Ordinance No. 3 in 1981. The "sinarapan" has co-existed with other commercially important fishes such as the Nile tilapia, common carp, and mudfish in the small lakes (Soliman 1994).

The presence of floating tilapia cages in Lake Buhi with intensive feeding has resulted in fish kills in 1998-2018 similar to what occurred in Lake Taal. The need for a multi-sectoral management approach in lake management and sustaining the fish cage industry has been urged (Nieves et al. 2019).

Liguasan Marsh

Liguasan Marsh is the largest marsh in the country with an area of 43,930 ha, 30,000 ha of which are reserved for game refuge and bird sanctuary. It consists of a "vast complex of river channels, small freshwater lakes and ponds, extensive freshwater marsh, and arable land subject to seasonal flooding in the basin of the Mindanao River" (Viray 2019).

In a fish survey of the marsh by Donia et al. (2019) in 2015-2017, 13 fish species belonging to eight families and 11 genera were found. The mudfish is the most abundantly caught fish of high value with the use of

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12 types of fishing gear, with the fish trap as the most common. The other fishes caught were cyprinids, goby, indigenous catfish or "hito" (*Clarias macrocephalus*), gourami, and the climbing perch or "martiniko" (*Anabas testudineus*). The introduced Indian carp, rohu (*Labeo rohita*), also caught in the marsh is believed to be established or naturally bred (Palma pers. comm.). No major threats to the fisheries of the marsh have been reported.

Agusan Marsh

Agusan Marsh has an area of more than 14,000 ha with its forests as a protected wildlife sanctuary. As a fishing ground, it provides food and income to the indigenous local fishers (dela Peña et al. 2018).

There are 18 fish species belonging to 11 families and 13 genera in the marsh. In a fish survey in 2014-2016, the fishes of commercial value caught were mudfish (35%), Nile tilapia (27%), and common carp (26%). The fishers use fish pots and set gill nets, long lines, and electro-fishing using backpack batteries. There is a risk of overfishing the Nile tilapia and common carp (Baclayo et al. 2020).

Illegal logging of the forests, improper disposal of domestic wastes, and agricultural activities that pollute the fishing ground have been identified as threats to the fisheries of the ecosystem (Dela Peña et al. 2018).

Cagayan River

Cagayan River is the longest (350 km) and largest river in the country with a drainage area of 25,649 km2. There are eight freshwater fishes found in the river that include the Nile tilapia, indigenous catfish, gourami, white goby, common carp, mudfish, and the lobed river mullet or "ludong" (*Cestraeus plicatilis*). A major threat to the fisheries of the river is overfishing, especially for the "ludong" (Lagasca 2013). A ban on the fishing of the fish (closed fishing season) is implemented by the DA-BFAR from October 1 to November 15 (BFAR 2013).

Pampanga River

Pampanga River is the second longest river (260 km) in Luzon with a drainage area of 9,759 km2. The main freshwater fishes caught by fishers are the Nile tilapia, common carp, gourami, Asiatic catfish, and mudfish. A major threat to the fisheries of the river is pollution coming from domestic, agricultural, and industrial sources. High organic matter and high total levels of bacterial counts in the water and sediment have been reported (Reyes 2016).

Rio Grande de Mindanao or Mindanao River

Rio Grande de Mindanao or Mindanao River is the second longest river (373 km) in the country with a drainage area of 23,169 km2. In a fish survey of the Pulangi River, a major tributary of the Mindanao River, Cequinia and Amoroso (1998) reported that 95% of the total fish catch of fishers consisted of the Nile tilapia and red-belly tilapia (*Coptodon zillii*). The other 5% was composed of gourami, common carp, indigenous catfish, and mudfish. The main threats to the fisheries are unregulated fishing such as the use of fine-mesh nets and pollution from industries like the Bukidnon Sugar Company that has caused fish kills in the river.

Angat Reservoir

Angat Reservoir is a multi-purpose reservoir for hydropower generation, the domestic water supply of Metro Manila, and irrigation managed by the National Power Corporation (NPC). It has an area of 2,360 ha and a mean depth of 48.5 m.

The stocking of Nile tilapia fingerlings in the reservoir and enhancing the catch of stocked fish resulted in the catch of 781,783 kg of Nile tilapia (Balite 1993). With the stock enhancement, the catch of fisherfolk increased by 29% from 57,363 kg in 1983 to 81,172 kg in 1987. The NPC strictly enforces regulations for illegal fishing.

Magat Reservoir

Magat Reservoir is the second largest reservoir in the country with an area of 11,700 ha and a depth of 193 m. It is also a multi-purpose facility for hydropower generation and irrigation, managed by the National Irrigation Authority (NIA) (undated).

The main fishes caught by fisherfolk are Nile tilapia (31.8%), the silver perch (19.6%), white goby (14.2%), common carp (8.4%), and Manila catfish (7.7%) using traditional fishing gear.The fish catch of fishers decreased by 86% from 393,478 kg in 1984 to 54,823 kg in 1991 due to fluctuations in the water level of the reservoir and overfishing (de los Triños 1993).

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PRODUCTION OF THE TOP 10 COMMERCIALLY CAUGHT FRESHWATER FISHES

The production of the top 10 commercially caught freshwater fishes in the country's inland waters recorded by the Philippine Statistics Authority (2018) was 86,407.89 MT in 2017 with a value of PHP 3 billion. The Nile tilapia (*O. niloticus*) was the most abundantly caught with 50% of the total production, followed by the common carp (C. carpio) at 15.4% and the mudfish (C. striata) at 11% (Table 2). The 10 commercially caught freshwater fishes comprised 54% of the total production of fisheries caught in inland waters in 2017. The other 46% of inland fisheries production was composed of other fishes, mollusks, and crustaceans.

Tilapia

This group of fish was the most abundant commercially caught (50%) freshwater fish in all the regions of the country in 2018. Mainly consisting of the Nile tilapia (*Oreochromis niloticus*), it was introduced into the country from Thailand in 1972 (Guerrero 2014). The species is also the most important cultured freshwater fish in the country. It feeds largely on blue-green algae (phytoplankton) in natural waters and breeds naturally throughout the year. The other minor tilapia species caught in inland waters are the red-belly tilapia (*Coptodon zillii*) and the black-chin tilapia (*Sarotherodon melanotheron*).

Carp

This fish was the second most abundant commercially caught (15.5%) freshwater fish in the country in 2018. The main species caught is the common carp (*Cyprinus carpio*), introduced from Hong Kong in 1915 (Guerrero 2014). It is a bottom feeder and breeds naturally throughout the year in the wild. It is also used for fish culture. The other minor carp species caught in some regions of the country are the Indonesian carp (*Puntius gonionotus*) and the Indian rohu (*Labeo rohita*) which breed naturally.

Mudfish

Also known as the striped snakehead or "dalag" in Pilipino, this fish (*Channa striata*) is the third most abundant commercially caught (11%) fish in all regions of the country in 2018. A native of Asia, it was introduced from Malaysia in 1908 (Guerrero 2014). It is a predaceous fish that feeds on other fishes and breeds naturally in the wild. Due to its delectable taste, it commands a higher price in the market compared to the other common freshwater fishes. It is commercially cultured in Vietnam and India. Ocean microplastic pollution has attracted much attention due to the potential harm that such pollutants may cause to marine organisms and to humans who consume the fish. Numerous studies have suggested that these small plastic particles may

Table 2. Production of the top 10 commercially caught freshwater fishes in 2017.

Species	Production (mt)	% Contribution
Tilapia (*O. niloticus*)	43,240.00	50.0
Common carp (*C. carpio*)	13,319.67	15.4
Mudfish (*C. striata*)	9,512.30	11.0
Asiatic catfish (*C. batrachus*)	5,669.80	6.6
Gourami (*T. pectoralis*)	4,286.31	5.0
White goby (*G. giuris*)	3,278.30	3.8
Manila catfish (*A. manillensis*)	2,243.94	2.6
Climbing perch (*A. testudineus*)	2,072.38	2.4
Silver perch (*L. plumbeus*)	1,438.83	1.7
Freshwater sardine (*S. tawilis*)	1,355.53	1.6

Source: PSA (2020a)

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cause complex and diverse detrimental health effects, from cancer (Gruber 2022) to obesity (Kannan 2021). The size, shape, chemical composition, surface charge, and hydrophobicity of microplastics may influence their toxicity.

Gourami

This generic group of fishes is found in most regions of the country. The most caught species with commercial value is the snake-skinned gourami (*Trichogaster pectoralis*) which was introduced from Thailand in 1938 (Guerrero 2014). The fish feeds on aquatic plants and breeds throughout the year naturally. The other introduced species are the pearl gourami (*Trichogaster leeri*) and the giant gourami (*Osphronemus gouramy*).

Asiatic catfish

The two Asiatic catfishes in the country are the indigenous or native *Clarias macrocephalus* and the *Clarias batrachus*, introduced from Thailand in 1972 (Guerrero 2014). In areas where the *C. batrachus* is present, the *C. macrocephalus* has been displaced. Found in all regions, the catfishes are bottom feeders but can predate on other fishes. They also breed naturally in the wild.

White goby

This is an indigenous fish known locally as "puting biya" (*Glossogobius giuris*) which is native to Asia specifically to Southeast Asia. Found in most regions of the country, it is a predaceous fish feeding on shrimps and other fishes. It breeds naturally in the wild throughout the year.

Manila catfish

This is also known as the "kanduli" (*Arius manillensis)* which is endemic to the country and found in most regions (9 of 16). It is a bottom feeder and breeds naturally in the wild. There are other Arius species in the country like the *A. dispar* in Laguna de Bay and the *A. magatensis* in the Magat Reservoir.

Silver perch

This is also the "ayuñgin" (*Leiopotherapon plumbeus*), an endemic fish that is found in most regions of the country (12 of 16). It feeds on shrimps and other fishes and breeds throughout the year in the wild. It is the most vulnerable commercially caught freshwater fish to overfishing in the country with the highest decrease of -69.8% in production in 2018 from 2005. Fortunately, techniques for its induced breeding and larval rearing have been developed locally to ensure its sustainability (PCAARRD 2012).

Climbing perch

This is also known as the "martiniko" (*Anabas testudineus*), an indigenous commercially caught freshwater fish found in all regions of the country. It feeds on aquatic insects and shrimps and breeds naturally in the wild.

Freshwater sardine

This is the "tawilis" (*Sardinella tawilis*) that is endemic in the country and found only in Lake Taal of CALABARZON (Region IV-A). It feeds on zooplankton (floating minute animals in the water) and breeds throughout the year in the lake. Due to heavy overfishing, it has been included in the "red list" of critically endangered species by the International Union for Conservation of Nature (IUCN 2018).

In summary, of the 10 commercially caught freshwater fishes in the Philippines, five are introduced (i.e., tilapia, carp, mudfish, Asiatic catfish, and gourami), three are endemic (i.e., Manila catfish, silver perch, and freshwater sardine), and two are indigenous or native (i.e., freshwater goby and climbing perch). With the highest decrease in the production of silver perch between 2005 and 2017, there is an urgent need for reducing the fishing pressure on the species for its sustainability.

There was an average increase of 4.2% to produce the top 10 commercially caught freshwater fishes in the country between 2005 and 2017. The freshwater sardine had the highest increase of +49.7% during the period, followed by the Asiatic catfish with +41.6%, and the common carp with +32.5%. The silver perch had the highest decrease of -69.8%, followed by the white goby with -39.5%, and the Manila catfish with -26.6% (Table 3).

Of the top 10 commercially caught freshwater fishes, tilapia, mudfish, Asiatic catfish, and climbing perch are found in all regions of the country. The common carp, gourami, white goby, Manila catfish, and silver perch are found in most regions of the country. The ARMM had the highest production for the common carp, Asiatic catfish, and white goby. Freshwater sardine is only found in Lake Taal in CALABARZON (Table 4).

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Table 3. Production (MT) of the top 10 commercially caught freshwater fishes in 2005 and 2017.

Species	2005	2017	%Variation (increase/decrease)
Tilapia	35,200.00	43,240.00	+16.6
Carp	8,981.14	13,310.67	+32.5
Mudfish	8,125.50	9,512.30	+14.6
White goby	5,415.18	3,278.83 (2016)	-39.5
Silver perch	4,764.69	1,438.03	-69.8
Gourami	3,831.70	4,286.31	+11.6
Asiatic catfish	3,313.60	5,669.80	+41.6
Manila catfish	3,055.58	2,243.94	-26.6
Climbing perch	1,534.71	2,072.38	+26.0
Freshwater sardine	682.30	1,355.63	+49.7

Source: BAS (2008); PSA (2020a).

Table 4. Regional distribution of the top ten commercially caught freshwater fishes.

Species	Regional Distribution
Tilapia	All regions with the highest production in CALABARZON (IV-A)
Carp	Most regions except in SOCCSKSARGEN (XII) with the highest production in the ARMM
Mudfish	All regions with the highest production in the ARMM
Gourami	Most regions except in Bicol (V) and Zamboanga Peninsula (IX)
Asiatic catfish	All regions with the highest production in the ARMM
White goby	Most regions except in Central Mindanao (XI) with the high-est production in the ARMM
Manila catfish	Most regions except in Ilocos (I), Central Visayas (VII), Zamboanga Peninsula (IX), Northern Mindanao (X), SOCCSKSARGEN (XII), CARAGA (XII), and the ARMM with the highest production in CALABARZON (IV-A)
Silver perch	Most regions except in Western Visayas (VI), Central Visayas (VII), Eastern Visayas (VIII), and the ARMM with the highest production in CALABARZON (IV-A)
Climbing perch	All regions with the highest production in Bicol (V)
Freshwater sardine	Only in CALABARZON (IV-A) in Lake Taal

Source: PSA (2020b).

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MAJOR ISSUES AND RECOMMENDATIONS

The major issues threatening the sustainability, particularly of the endemic freshwater fishes of commercial value in the Philippines are overfishing, water pollution, invasive fishes, and environmental degradation.

Overfishing

This is defined as the harvesting of commercial fishes in aquatic ecosystems at rates that are higher than the ability of the stocks to replenish themselves (McKeever 2022). It is the most serious issue found in most regions of the country adversely affecting the populations of commercially caught endemic freshwater fishes such as the "tawilis" of Lake Taal and the silver perch.

Recommendations

a. The imposition of a closed fishing season for the "tawilis" of Lake Taal is a positive step towards its conservation. Further measures such as catch and size limits may be considered to restore the abundance of the fishery.

b. For the silver perch, conservation measures such as closed season and catch/size limits may also be considered for inland water where the fishery has declined. The setting up of hatcheries for the species applying the techniques for induced breeding and larval rearing of the species available can help in restocking depleted populations (BFAR 2022).

c. Strict enforcement of fisheries laws for the protection and conservation of overfished commercially caught freshwater fishes should be done.

Water Pollution

The intensive culture (with feeds and high stocking densities) of the Nile tilapia in the floating cages of Lakes Taal and Buhi has brought about heavy organic loading in the lakes causing oxygen depletion and fish kills (Bongco 2016). The indiscriminate dumping of organic/toxic wastes from domestic, agricultural, and industrial sources into rivers has also resulted in fish kills.

Recommendations

a. The number of fish cages and fish stocking densities should be regulated to keep them within the carrying capacities of lakes where aquaculture is done.

b. Strict implementation of the water quality standards and enforcement of the rules, regulations, and penalties provided for by the Clean Water Act should be done by the Environmental Management Bureau of the Department of Environment and Natural Resources in coordination with the concerned LGUs and their respective Fisheries and Aquatic Resources Management Councils.

Invasive Fishes

The accidental introduction of invasive fishes of local or foreign origin can be a serious threat to endemic freshwater fishes, especially in lakes (Tamayo-Zafaralla 2016). The inadvertent stocking of the indigenous eleotrid (a predaceous fish) from Lake Mainit to Lake Lanao in Mindanao which decimated the endemic cyprinids in the latter lake is a case in point. Another case is the unintentional release of the highly predaceous knife fish, an aquarium fish, into Laguna de Bay which has reduced the population of the silver perch in the lake.

Recommendations

a. The dispersal of fingerlings (mainly the Nile tilapia) for enhancing the catch of fishers in lakes should be done with utmost care and good practice to ensure that no other species are stocked with it.

b. The impacts of invasive fishes already established in Laguna de Bay such as the knife fish and in Lake Taal such as the jaguar cichlid and the Midas cichlid (aquarium fishes accidentally or deliberately introduced) should be fully assessed not only for their possible negative effects on the endemic and indigenous fishes but also for their control and possible benefits.

c. Strict implementation of the rules and regulations for the introduction of foreign/exotic fishes, particularly by the aquarium fish industry, including import risk analysis, quarantine, and proper containment to avoid escapes into the wild should be done (Guerrero 2014).

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Environmental Degradation

The siltation/sedimentation of reservoirs and shallow rivers and lakes due to heavy soil erosion of deforested watersheds has reduced the capacities for fish production of such water bodies. Suspended solids in the water also limit the productivity of natural waters by blocking the sunlight essential for photosynthesis and smothering the breeding/feeding areas of fishes.

Recommendations

a. The restoration of the forest cover in deforested areas of critical watersheds of the country's inland waters should be given priority in the DENR's "National Greening Program" (DENR 2019).

b. The Integrated Water Resources Management approach, which is "coordinating the development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems," as defined by the United Nations Environment Programme (UNEP undated), should be adopted and applied by LGUs in their Comprehensive Land Use Plans (CLUPs).

CONCLUSION

Commercially caught freshwater fishes in the Philippines contribute to the food security and livelihoods of a multitude of the country's population living particularly near inland waters. An assessment of the top 10 important fishes showed that their production in 2017 was 86,407.89 MT with a value of PHP 3 billion, which was 53% of the total inland fisheries of the country. There was an average annual increase of 4.2% in the production of freshwater fishes between 2005 and 2017. There is a need to address the issues of overfishing, water pollution, invasive species, and environmental degradation to ensure their sustainability.

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REFERENCES

Baclayo JM, Alcantara MT, Haloyohoy LM, & Alaba LA. 2020. Status of fisheries in Agusan Marsh: La Paz and Talacogan, Agusan del Sur, Mindanao. The Philippine Journal of Fisheries 27(1):54-82.

Bagarinao TU. 2001. The decline of native fishes and fisheries and the rise of aquaculture in lakes and rivers in the Philippines, p. 51, In CB Santiago, MLC Aralar, & ZU Basiao (Eds.), Conservation and Ecological Management of Philippine Lakes in Relation to Fisheries and Aquaculture (187p). Bureau of Fisheries and Aquatic Resources, Quezon City, Philippines.

Balite LR. 1993. Status of fish production and management of fisheries in the reservoirs of the NPC Hydroelectric Power Plants (HEPs), p.11-20, In RC Sevilleja, EV Manalili, & RD Guerrero III (Eds.), Reservoir Fisheries Management and Development in the Philippines, PCAMRD Book Series No. 17/ 1993 (155p).

Barril CR. 1992. Sustainable development of Laguna de Bay: prospects and problems. Philippine Technology Journal, XII(2): April-June.

Bongco IG. 2016. Water quality of Laguna de Bay and sources of pollution, p. 44-46, In Lake Ecosystem Assessment in the Philippines: Science and Policy Forum Proceedings, SESAM. UPLB, Los Baños, Laguna. 98p.

Briones M, Dey MM, & Ahmed M. 2004. The future of fish in the food and livelihoods of the poor in Asia. WorldFish Center Quarterly, 27(3-4):48-50.

Bureau of Agricultural Statistics. 2008. Fisheries statistics of the Philippines 2005-2007. 407 p. (psa.gov.ph)

Bureau of Fisheries and Aquatic Resources. 2013. BFAR Administrative Circular No. 247 (bfar.da.gov.ph)

Bureau of Fisheries and Aquatic Resources. 2020. Balik Sigla sa Ilog at Lawa (BASIL). (beta.bfar.da.gov.ph)

Bureau of Fisheries and Aquatic Resources. 2022. BFAR Press Release: DA-BFAR Revives Native Fish Species (bfar.da.gov.ph)

Cequinia EV, & Amoroso VR. 1998. Aquatic and terrestrial resources assessment for the NPC Pulangi IV Reservoir, p. 45-57, In RB Edra, EV Manalili, & LC

Transactions NAST PHL Vol. 44: (2022)
doi.org/10.57043/transnastphl.2022.2568

Darvin (Eds.), Riverine Resources in the Philippines, PCAMRD Book Series No. 22/1998 (141 p).

Darwall W, Smith K, Allen D, Sheldon M, McGregor Reid G, Clausnitzer V, & Kalkman V. 2008. Freshwater biodiversity – a hidden resource under threat. In JC Vie, C Hilton-Taylor, & SN Stuart (Eds.), The 2008 Review of the IUCN Red List of Threatened Species. IUCN, Gland, Switzerland.

De Guzman AB. 2008. The sustainable fisheries management program for Lake Mainit. The Lake Mainit Chronicle, August 2007-2008, 3p.

Dela Peña GD, Gomez-Ramos P, Acuña RE, & Abrea RA. 2018. Agusan Marsh finfish: current trend, threats and sustainable development, Book of Abstracts Trans. of the Nat. Acad. of Sci. & Tech., 40(1):47.

De los Trinos RA. 1993. Reservoir fisheries aspects of Magat Dam, p.79-88, In RD Guerrero III, AT Calpe, & LC Darvin (Eds.), Proc. First National Symposium-Workshop on Aquatic Biology. PCAMRD, Los Baňos, Laguna.

Department of Environment and Natural Resources. 2019. Enhanced National Greening Program (denr.gov.ph) https://www.denr.gov.ph/priority-programs/national-greening-prog

Donia EA, Cecilio MAF, & Pautong AAT. 2019. Assessment of freshwater species in Liguasan Marsh, North Cotabato, Region XI. Paper presented at the 12th Asian Fisheries and Aquaculture Forum, Iloilo City, Philippines.

Escudero PET. 1994. Lake Lanao fisheries: problems and recommendations. The Philipine Biota, 27(1):8-18.

Escudero PET. 1995. Lake Lanao fisheries: problems and recommendations, p. 75-93, In RB Edra, EV Manalili, & RD Guerrero III (Eds.), Lake Fisheries Management in the Philippines, PCAMRD Book Series No. 19/1995 (125 p).

Food and Agriculture Organization. 1995. Code of Conduct for Responsible Fisheries, UNFAO, Rome, Italy. 41 p.

Food and Agriculture Organization. 2005. The state of world aquaculture and fisheries. UNFAO, Fisheries and Aquaculture Department, Rome, Italy. (https://www.fao.org)

Food and Agriculture Organization. 2007. The state of world aquaculture and fisheries 2006. UNFAO, Fisheries and Aquaculture Department, Rome, Italy. 180 p.

Food and Agriculture Organization. 2020. The state of world fisheries and aquaculture production. UNFAO, Rome, Italy. 227 p.

Froese R, & Pauly D (Eds.). 2022. FishBase World Wide Web electronic publication (www. fishbase.org)

Gindelberger B. 1981. Fishery management in Camarine Sur, Philippines: why "sinarapan" almost disappeared from Lake Buhi. ICLARM Newsletter, 4(3)3-5.

Grutas MB, & Noblefranca LP. 2013. Save lake Buhi now, p. 321-322, In MLC Aralar, AS Borja, AL Palma, MM Mendoza, PC Ocampo, EV Manalili, & LC Darvin (Eds.), LakeCon 2011: Building on the Pillars of Integrated Lake Basin Management (Second National Congress on Philippine Lakes). PCAARRD-DOST, Los Baños, Laguna.

Guerrero RD. 2014. Impacts of introduced freshwater fishes in the Philippines (1905-2013): a review and recommendations. Phil. Journ. of Sci. 143(1):49-59.

Guerrero RD. 2017. Fishpens have enhanced the fisheries of Laguna de Bay in the Philippines. Agriculture Monthly Magazine XX(10):30-31.

Herre AW. 1933. The fishes of Lake Lanao: a problem in evolution A.Nat. 67:54-162.

International Union for the Conservation of Nature. 2018. The IUCN Red List of Threatened Species. Available at: www.iucn.redlist.org

International Union for the Conservation of Nature. 2020. The IUCN red list of threatened species. Version 2020-1. https://www.iucnredlist.org

Lagasca C. 2013. 8 Cagayan Valley freshwater species threatened (https://www.philstar.com)

Lasco RD, & Espaldon MVO (Eds.). 2005. Ecosystems and People: The Philippine Millennium Ecosystem Assessment (MA) Sub-global assessement, Environmental Forestry Programme, College of Forestry and Natural Resources, University of the Philippines Los Baños. 233p.

Transactions NAST PHL Vol. 44: (2022)
doi.org/10.57043/transnastphl.2022.2568

McKeever A. 2022. How overfishing threatens the world's oceans and why it could end in catastrophe. Retrieved 10 March 2022, from National Geographic: https://www.nationalgeographic.com/environment/article/criticalissues-overfishing

Mercene EC. 1997. Freshwater fishes of the Philippines, p. 81-105, In R Guerrero III, A Calpe, & L Darvin (Eds.), Proc. First National Symposium on Aquatic Biology Research and Development. PCARMD, Los Baños, Laguna, Book Series No. 20/1997.

Mercene-Mutia M. 2001. Assessment of local government's implementation of open access policy in Lake Taal, Philippines effects on lake conservation and management, p. 123-132, In CB Santiago, ML Cuvin-Aralar, & ZU Basiao (Eds.), Conservation and Ecological Management of Philippine Lakes in Relation to Fisheries and Aquaculture 187p). BFAR, Quezon City, Philippines.

Mutia MTM, Muyot MC, Torres FB Jr., & Faminialagao CM. 2017. Status of Taal Lake fishery resources with emphasis on the freshwater sardine Sardinella tawilis (Herre, 1927), The Philippine Journal of Fisheries 25(1):128-135.

National Irrigation Administration (undated). Magat River Integrated Irrigation System (mariis, nia.gov.ph)

National Power Corporation. 2017. Lake Lana- Agus River Watershed (napocor.gov.ph)

Nelson JS. 2006. Fishes of the world. John Wiley & Sons, Hoboken. 601 p.

Nieves PM, Mendoza AB Jr., Bradecinia SRB, & Bonaos RB. 2019. Occurrence and recurrence: the fish kill story in Lake Buhi, Philippines, p.52, Book of Abstracts of the 12th Asian Fisheries and Aquaculture Forum, Iloilo City, Philippines.

Palma AL, Bartolome B, Castillo L, & Darvin L. 2005. Basic principles on the management of Philippine Lakes, Bureau of Fisheries and Aquatic Resources, Quezon City and Philippine Council for Aquatic and Marine Research and Development, Los Baňos, Laguna. 154 p.

Pasumbol RA, & Perez CT. 2001. Stock assessment of commercially important fishes in Naujan Lake, p. 99-107, In CB Santiago, MLC Cuvin-Aralar, & ZU Basiao (Eds.), Conservation and Ecological Management of the Philippine Lakes in Relation to Fisheries and Aquaculture (187p). Bureau of Fisheries and Aquatic Resources, Quezon City, Philippines.

Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development. 2012. Induced spawning and larval rearing of ayuñgin (Leiopotherapon plumbeus Kner). PCAMRD-DOST, Los Baňos, Laguna. 1 p.

Philippine Statistics Authority. 2020a. Fisheries statistics of the Philippines 2017-2019. Vol. 28, 321p. (psa.gov.ph)

Philippine Statistics Authority. 2020b. Fisheries statistics of the Philippines 2018-2020. Vol. 29 320 p. (psa.gov.ph)

Presidential Proclamation No. 282. 1956. Naujan Lake National Park (officialgazette.gov.ph)

Republic Act 8550. 1998. AN ACT PROVIDING FOR THE DEVELOPMENT, MANAGEMENT AND CONSERVATION OF THE FISHERIES AND AQUATIC RESOURCES INTEGRATING ALL LAWS PERTINENT THERETO, AND FOR OTHER PURPOSES (https:/www.bfar.da.gov.ph/bfar/download/ra8550/RA8550.pdf) Retrieved on 13 March 2022

[RA 9275] Republic Act 9275. 2004. AN ACT PROVIDING FOR A COMPREHENSIVE WATER QUALITY MANAGEMENT AND FOR OTHER PURPOSES. Available at emb.gov.ph

Reid GT, Contreras T, MacBeath T, & Satadi K. 2013. Global challenge in freshwater fish conservation related to public aquarium and the aquaculture industry. International Zoo Yearbook 47(1):6-45.

Reyes AT. 2016. Development of comprehensive geo-referenced database for ecological risk analyses in tilapia pond culture in Pampanga. Terminal Report Program 13 – Innovative Approaches in Nile tilapia culture. National Research and Development Program. PCAARRD, Los Baňos, Laguna. 81p.

Rosagaron RP. 2001. Lake Lanao: its past and present status, p. 29-40, In CB Santiago, MLC Cuvin-Aralar and ZU Basiao (Eds.), Conservation and Ecological Management of the Philippine Lakes in Relation to Fisheries and Aquaculture (187p). Bureau of Fisheries and Aquatic Resources, Quezon City, Philippines.

Transactions NAST PHL Vol. 44: (2022)
doi.org/10.57043/transnastphl.2022.2568

Soliman VS. 1994. Conservation and management of Lake Manapao (Philippines), a "sinarapan" (Mistichthys luzonensis) sanctuary: status, problems and solutions. Mitt. Internat. Verein. Limnol. 24:179-283

Soliman VS. 2001. Exploitation rate, yield per recruit and virtual population of sinarapan (Mistichthys luzonensis) in Lake Manapao, Buhi, Camarines Sur. Transactions of the 9th Scientific Meeting of the National Academy of Science and Technology, Philippines XIII:701-716.

Tamayo-Zafaralla M. 2016. Water quality of Laguna de Bay in relation to biological pollution, p. 42-43, In Lake Ecosystem Assessment in the Philippine: Science and Policy Forum Proceedings, SESAM, UPLB, Los Baños, Laguna. 98p.

Torres AG. 2018. An assessment of the fish diversity and environmental conditions of Lake Lanao (Philippines) with emphasis on the endemic fishes (Cyprinidae) and integrated strategies for their conservation. Ph.D. Dissertation, University of the Philippines Los Baños, Laguna. 252p.

United Nations Environment Program (undated). Integrated Water Resources Management (unep.org)

Uy NH, de Guzman AB, Acuña RE, & Roa RL. 2015. Aquatic biodiversity of Lake Mainit, Southern Philippines. Journal of Environmental Science and Management 3(201):1-15.

Viray JM. 2019. The Liguasan Marsh. The Maritime Review (https//maritimereview.ph)

Visita AB, & Norris PE. 2005. Back to basics: institutional and behavioral perspectives on the Taal Lake fish cage industry, p. 134-144 In ML Cuvin-Aralar, RS Pununbayan, A Santos-Borja, LV Castillo, EV Manalili, MM Mendoza (Eds.), Proc. of the First National Congress on Philippine Lakes (339p). SEARCA, Los Baños, Laguna, Philippines.