

Status of Taal Lake Fishery Resources with Emphasis on the Endemic Freshwater Sardine, *Sardinella tawilis* (Herre, 1927)

Maria Theresa M. Mutia^{1,*}, Myla C. Muyot¹, Francisco B. Torres Jr.¹, Charice M. Faminialagao¹

¹National Fisheries Research and Development Institute, 101 Corporate Bldg., Mother Ignacia St., South Triangle, Quezon City

ABSTRACT

Assessment of fisheries in Taal Lake was conducted from 1996-2000 and 2008-2011 to know the status of the commercially important fishes with emphasis on the endemic freshwater sardine, *Sardinella tawilis*. Results of the fish landed catch survey in 11 coastal towns of the lake showed a decreasing fish harvest in the open fisheries from 1,420 MT to 460 MT in 1996 to 2011. Inventory of fisherfolk, boat, and gear also decreased to 16%, 7%, and 39%, respectively from 1998 to 2011. The most dominant gear is gill net which is about 53% of the total gear used in the lake with a declining catch per unit effort (CPUE) of 11kg/day to 4 kg/day from 1997 to 2011. Active gear such as motorized push net, ring net, and beach seine also operated in the lake with a CPUE ranging from 48 kg/day to 2,504 kg/day. There were 43 fish species identified in which *S. tawilis* dominated the catch for the last decade. However, its harvest also declined from 744 to 71 mt in 1996 to 2011. The presence of alien species such as jaguar fish, pangasius, and black-chinned tilapia amplified in 2009.

Population parameters of *S. tawilis* from 2009 to 2011 were estimated using the FISAT (FAO-ICLARM Stock Assessment Tool) software. The analysis of length frequency data showed an estimated L_{∞} of 15.40 to 16.36 cm and K value ranged from 0.53 to 0.73. The total mortality (Z) ranged from 3.01 to 5.03, natural mortality (M) from 1.44 to 1.75, fishing mortality (F) from 1.57 to 3.28 and exploitation rate (E) from 0.52 to 0.65. The high values of fishing mortality and exploitation rates indicate unsustainable fishing practices. Conservation and management measures of the fishery resources in the lake were recommended for appropriate action of the Protected Area Management Board (PAMB).

*E-mail: tmmutia@yahoo.com

Keywords: Taal Lake, *Sardinella tawilis*, fisheries, population parameters

Received: 23 March 2017

Accepted: 29 September 2017

1. INTRODUCTION

Taal Lake is the 3rd largest lake in the country with an area of 24,356.4 ha and bounded by nine towns and two cities. In its center lies the 23.8 km² Volcano Island which has a 1.9 km crater lake in the middle. The lake is very deep with a maximum depth of 180 m and an average depth of 65 m. There are 38 tributary rivers draining into the lake, some of which are spring waters in origin. Located in the southern portion of the lake is the 8.2 km Pansipit River which is the only drainage of the lake that empties into Balayan Bay. The lake has multiple-resource use and its dominant use is fisheries of which aquaculture has flourished rapidly over the years. The resource is also used for recreation, tourism, navigation, water source for Tagaytay and for agricultural fields, and source of feeds for ducks.

The lake fisheries provide livelihood to around 2,761 sustenance fisherfolk (BFAR 1998) who gather finfishes, crustaceans, and mollusks found in commercial quantities in the lake. Total fish production slowly declined from 8,792 MT in 1992 (Aypa 1993) to 882 MT in 2000 (Mutia 2004). Fish production of the open water fisheries has dwindled over the years as shown by the

continuous decline of fish caught by the fishermen. This may be attributed to illegal fishing, overfishing, pollution and the expansion of aquaculture activities in the lake.

Published literature on Taal Lake fisheries were very limited. A Rapid Resource Appraisal of Taal Lake was conducted by UPLB-FI in 1996. Status of freshwater fishes in major lakes was studied by Mercene in 1997. Villanueva et al (1996) determined the status of Taal Lake capture fisheries and the extent of exploitation of *S. tawilis*. Mutia et al (2004) reported a declining production of *tawilis* from 744 MT in 1996 to 294 MT in 2000 due to illegal operation of active gear (motorized push net and ring net) and pollution load contributed by improper aquaculture practices.

This paper aims to provide a reliable data on the present status of fishery resources in Taal Lake and recommend appropriate policy regulations on its conservation and management. Specifically, it aims to 1) make an inventory of fisherfolk, boat and gear, 2) know the catch and species composition, 3) provide estimates of fish harvests in the open water fisheries, 4) catch and effort of major gear and 5) provide estimates on growth, mortality and exploitation rates of *Sardinella tawilis*.

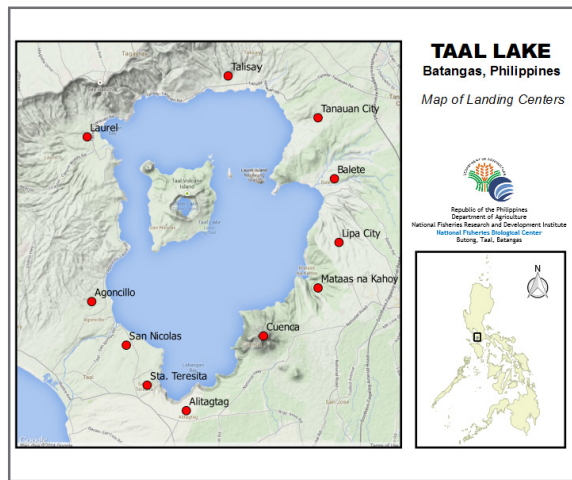


Figure 1. Location map of landing centers in Taal Lake.

2. METHODOLOGY

Landing centers/ sampling sites

The sampling stations were established in the fish landing sites of the eleven coastal towns of Taal Lake, namely Alitagtag, Agoncillo, San Nicolas, Sta. Teresita, Balete, Laurel, Tanauan, Lipa, Cuenca, Talisay and Mataas na Kahoy (Figure 1).

Data collection

Data on the number of fisherfolk, fishing boat and gear were collected and recorded by the enumerators from the fisherfolk registry of the Municipal Fisheries and Aquatic Resource Management Council (MFARMC) and the Office of the Municipal Agriculturist (MAO). The actual enumeration was also done to validate the records.

Fish landed catch survey was conducted by trained fisherfolk enumerators using a standard survey form on catch and effort. The survey was done in 2 days interval or a total of 20 days in a month including Saturdays, Sundays and Holidays. The survey form includes the following data gathered: landing site, fishing ground, volume of catch per species, type and number of gear and boat used, number of hours fishing, and number of people included in the fishing operation. All survey forms were submitted monthly for collation and processing.

Data analysis

Catch and species composition

The species composition caught by all gear in the lake were listed and identified up to species level. The fishery resources were categorized into fish, invertebrates and other organisms. These species were classified into endemic, introduced and migratory species. Total catch of each species by gear for the year was computed and

ranked from highest to lowest. Percentage composition of the major species from the total fish production was determined.

Production estimates

Fish production was estimated by extrapolation. Total catch for the day in kilograms (TCD) was computed by multiplying the total catch for the day (C) to a raising factor (RF) equivalent to the number sampled landings over total landings for the day. Monthly and annual productions were computed by raising the total catch for the day. Hereunder are the following computations:

(1) Total catch for the day (TCD) = Catch for the day (C) x raising factor (RF)

where: RF = number of total landing/sampled landings

(2) Total catch for the month (TCM) = TCD x RF

where: RF = number of days in a month/sampled days

(3) Total catch for the year (TCY) = TCM x RF

where: RF = number of months in a year/sampled months

Catch per unit effort

The different fishing gear used in the lake were identified and catch compositions by each gear were determined. The catch per unit effort (CPUE) of each gear was determined using a standardized unit of effort such as kilogram per day (kg/day). The CPUE is computed by taking the average catch for the day per gear. The annual mean CPUE was obtained by the summation of the monthly fish harvest over the summation of the number of fishing days in a month/year.

Population parameters

The analysis of length frequency data of *S. tawilis* was done. The total length (TL) of about 200-300 fish samples per month were measured to record length frequency data. The data were run using the FAO-ICLARM Stock Assessment Tool or FiSAT II version 1.2.2 software (Gayanalao et al. 1997). Powell Wetherall Plot was used in estimating the parameters L_{∞} (asymptotic length) and ELEFAN I was used to estimate K (curvature parameter) of growth formula while mortalities were estimated as the total mortality (Z) via catch curve method, natural mortality (M) using built-in empirical equation and fishing mortality (F) by getting the difference between Z and M. The exploitation ratio ($E=F/Z$) of the fish were derived using computed mortalities.

3. RESULTS

Fisherfolk, fishing boat and gear inventory

Table 1. Number of fisherfolk by municipality in Taal Lake

Town	No. Coastal Barangay	Number of Fisherfolk		
		1998	2009	2011
Agoncillo	11	916	215	189
Alitagtag	10	22	71	72
Balete	6	89	246	132
Cuenca	1	89	89	107
Laurel	8	653	511	525
Lipa City	1	20	80	44
Mataas na Kahoy	3	91	119	123
San Nicolas	12	704	800	700
Sta. Teresita	3	60	68	30
Tanauan City	6	84	628	287
Talisay	11	33	133	102
TOTAL	72	2761	2960	2311

Table 2. Number of fishing boat by municipality in Taal Lake

Coastal Municipality	Number of Boat						
	1998		2009		2011		Raft
	Motorized Boat	Non-Motorized Boat	Motorized Boat	Non-Motorized Boat	Motorized Boat	Non-motorized Boat	
Agoncillo	124	618	47	74	57	33	26
Alitagtag	5	45	16	42	16	20	41
Balete	83	21	87	43	87	4	19
Cuenca	92	16	81	18	81	0	6
Laurel	116	317	203	136	203	0	26
Lipa	20	15	29	15	29	13	26
Mataas na Kahoy	61	12	-	58	92	13	5
San Nicolas	250	450	373	565	373	43	0
Sta. Teresita	25	55	24	60	24	4	20
Tanauan	24	33	96	139	96	34	5
Talisay	50	15	52	32	52	4	32
Total	850	1597	1008	1182	1110	168	206
	2,447		2,190		1,484		

There are 9 towns and 2 cities with 72 coastal barangays surrounding Taal Lake. The number of fisherfolk for the past 14 years declined from 2,761 to 2,311 (1998-2011). The latest record in 2011 showed that the highest number of fisherfolk was from the municipality of San Nicolas while the least number of fisherfolk was from Sta. Teresita (Figure 2 and Table 1). On the other hand, the number of fishing boat also decreased to about 7% or from 2,447 units to 1,484 boats operating in the lake, of which 1,110 were motorized, 168 non-motorized and 206 bamboo raft (Table 2 and Figure 3).

Fishing gear inventory in 2011 recorded a total of 2,375 units of 15 different types of fishing gear used in the lake (Table 3). These include gillnet, beach seine, fish corral, push net, hook and line, fish trap, scoop net, rake, spear gun, lift net, ring net, motorized push net, bamboo fish trap, fish spear, and cover net. The most number of gear is gill net with 1,258 units or 52.8% of the total number of gear in the lake (Figure 4 and Table 3). Other dominant gears were bamboo fish trap (16.8%), fish trap (15.7%), spear gun (5.5%), and hook and line (4.12%). Among the 15 gear identified, there were 3 active gear present in the lake, namely motorized push net, ring net, and beach seine. Although prohibited in the lake, these active gear were observed to have fish catch landings in

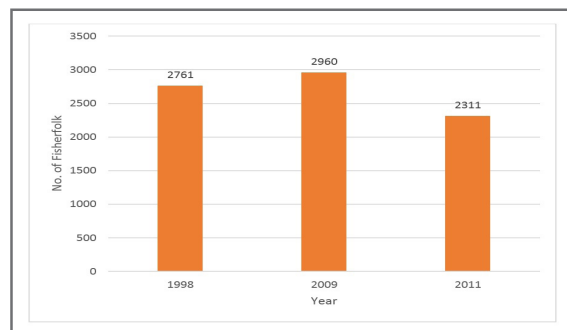


Figure 2. Number of fisherfolk in Taal Lake

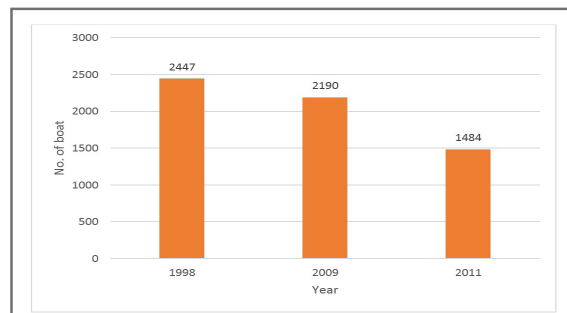


Figure 3. Number of boat in Taal Lake

Table 3. Number of fishing gear by municipality in Taal Lake

Gear	Number of gear		
	1998	2009	2011
Gill net (pante)	1616	1,770	1,258
Spear gun (pana)	237	291	132
Hook & Line (Kawil)	165	554	97
Fish trap (bubo)	253	250	375
Fish corral (baklad)	91	1	11
Lift net (pantaas)	49	-	1
Beach seine (pukot)	38	38	40
Scissors net (salap)	24	-	-
Crab lift net (bintol)	25	-	-
Motorized push net (suro)	15	17	17
Ring net (basnig)	15	7	4
Cover pot (saklob)	10	-	5
Fish shelter (paksol)	5	-	-
Drive-in net (sakag/paksol)	23	-	-
Bamboo fish trap (tukil)	-	-	401
Scoop net (sigpaw)	-	-	8
Fish spear (salapang)	-	-	3
Rake (balukay)	-	-	23
Cast net (dala)	-	5	-
19 gear	2,566	2,933	2,375

the lake.

Catch/Species composition

A total of 52 species were caught at the different landing centers in the Taal Lake from 1996 to 2011. The species composition was comprised of 43 finfishes and 4 crustaceans, 3 mollusks and 2 reptiles belonging to 30 families (Table 4). Of the finfishes caught, 1 was endemic, 2 natives, 14 introduced, and 26 migratory species (Table 5).

The three endemic/native fishes recorded are *Sardinella tawilis*, *Glossogobius giuris*, and *Channa striata*. Introduced species were observed to increase in production starting 2009. A new record of introduced or alien species include *Parachromis managuensis* (jaguar guapote), *Pangasianodon hypophthalmus* (pangasius), *Colossoma macropomum* (red-bellied pacu), *Ptergoplichthys disjunctivus* (janitor fish), and *Sarotherodon melanotheron* (black-chinned tilapia). These species were not present in the previous assessment from 1996 to 2000. The introduction of janitor fish, jaguar guapote, red pacu and black-chinned tilapia were suspected to be unintentional and some unknown. However, pangasius was intended for aquaculture and its presence in the open waters was due to its escapement in cages during the strong typhoon in 2008. Migratory fishes were observed to increase in number in 2010-2011. This can be attributed to the clearance of Pansipit River from fish cages and fish corrals which allowed the different species from Balayan Bay to migrate to the lake.

Crustaceans, mollusks, and reptiles were also present in the landed catch survey. Four species of crustaceans, 3 species of mollusks, and 2 species of reptiles were recorded (Table 4). Among them, white

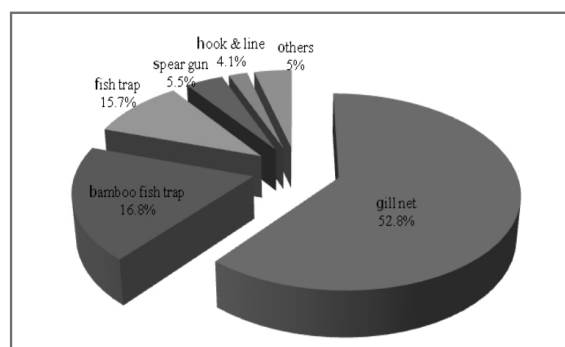


Figure 4. Percentage composition of major fishing gear in the lake

shrimp or *hipong puti* and freshwater clam or *tulya/peras* were caught in large quantities for human consumption only and sometimes for animal feed.

Total fish harvest estimates

Figure 5 shows the estimated total fish harvest in the open water fisheries of Taal Lake. There was an increasing fish harvest from 1,420 to 1,672 MT in 1996 to 1998, however, fish harvest declined to 460 MT in 2011. On the contrary, aquaculture production flourished from 3,140 to 6,000 cages from 1996 to 2010 (Municipal Agriculture Office) with an estimated production of 23,000 MT to 79,000 MT in 2001 to 2010 (BAS 2011).

Tawilis harvest estimates

Tawilis harvest increased from 744 MT to 1,120 MT in 1996 to 1998, however, suddenly declined to 674 MT in 1999. Tawilis harvest continued to decline up to

Table 4. Species composition of landed catch.

No.	Scientific name	Family	English name	Local name	Classification
FINFISHES					
1	<i>Sardinella tawilis</i>	Clupeidae	Freshwater sardine	Tawilis	E
2	<i>Oreochromis niloticus</i>	Cichlidae	Nile tilapia	Tilapia	I
3	<i>Atherinomorus lacunosus</i>	Atherinidae	Wide-banded Hardyhead Siverside	Guno	M
4	<i>Chanos chanos</i>	Channidae	Milkfish	Bangus	M
5	<i>Caranx ignobilis</i>	Carangidae	Giant trevally	Maliputo	M
6	<i>Carassius auratus</i>	Cyprinidae	Carp	Karpita	I
7	<i>Glossogobius giuris</i>	Gobiidae	Tank goby	Bia	N
8	<i>Leiopotherapon plumbeus</i>	Terapontidae	Silver perch	Ayungin	I
9	<i>Pangasianodon hypophthalmus</i>	Pangasiidae	Iridescent shark	Pangasius	I
10	<i>Ostorhinchus thermalis</i>	Apogonidae	Half-barred Cardinal fish	Dangat	M
11	<i>Apogon hyalosoma</i>	Apogonidae	Humpbacked cardinal fish	Muang	M
12	<i>Parachromis managuensis</i>	Cichlidae	Jaguar guapote	Dugong	I
13	<i>Anguilla marmorata</i>	Anguillidae	Giant mottled eel	Igat	M
14	<i>Channa striata</i>	Channidae	Striped snakehead	Dalag	N
15	<i>Glossogobius celebius</i>	Gobiidae	Celebes goby	Pauto/Biyang tulog	M
16	<i>Caranx sexfasciatus</i>	Carangidae	Bigeye trevally	Muslo	M
17	<i>Giuris margaritacea</i>	Eleotridae	Snakehead gudgeon	Palawon	M
18	<i>Carassius carassius</i>	Cyprinidae	Crusian Carp	Karpita	I
19	<i>Toxotes jaculatrix</i>	Toxotidae	Banded Archerfish	Kataba	M
20	<i>Clarias batrachus</i>	Clariidae	Philippine catfish	Hito	I
21	<i>Lutjanus argentimaculatus</i>	Lutjanidae	Mangrove red snapper	Also	M
22	<i>Hypophthalmichthys nobilis</i>	Cyprinidae	Bighead carp	Bighead carp	I
23	<i>Scatophagus argus</i>	Scatophagidae	Spadefish	Kitang	M
24	<i>Mugil cephalus</i>	Mugilidae	Flathead grey mullet	Banak	M
25	<i>Megalops cyprinoides</i>	Megalopidae	Indo-Pacific Tarpon	Buan-buan	M
26	<i>Lutjanus malabaricus</i>	Lutjanidae	Malabar red snapper	Maya-maya	M
27	<i>Ambassis miops</i>	Ambassidae	Flag-tailed glassfish	Ning-ning	M
28	<i>Ctenopharyngodon idella</i>	Cyprinidae	Grasscarp	Karp	I
29	<i>Caranx sp.</i>	Carangidae	Cavalla	Pepikat	M
30	<i>Sarotherodon melanotheron</i>	Cichlidae	Black chin tilapia	Tilapiang arroyo	I
31	<i>Hyporhamphus quoyi</i>	Hemiramphidae	Quoy's garfish	Siliw	M
32	<i>Zenarchopterus buffonis</i>	Zenarchopteridae	Buffon's river- garfish	Siliw	M
33	<i>Caranx sp.</i>	Carangidae	Cavalla	Karis-karis	M
34	<i>Acentrogobius suluensis</i>	Gobiidae	Sharptail goby	Tunghod	M
35	<i>Oreochromis niloticus x O. hornorum</i>	Cichlidae	Red tilapia	Red Tilapia	I
36	<i>Elops machnata</i>	Elopidae	Tenpounder	Kanoping/ Bidbid	M
37	<i>Colossoma macropomum</i>	Serrasalmididae	Cachama	Pacu	I
38	<i>Chelon melinepterus</i>	Mugilidae	Otomebora Mullet	Aligasin	M
39	<i>Pterygoplichthys disjunctivus</i>	Loricariidae	Spotted catfish	Janitor fish	I
40	<i>Gerres filamentosus</i>	Gerreidae	Whipfin silver biddy	Balabatuhan	M
41	<i>Trichopodus trichopterus</i>	Osphronemidae	Three spot Gourami	Gourami	I
42	<i>Terapon jarbua</i>	Terapontidae	Convex-lined grunt	Bagaong	M
43	<i>Lates calcarifer</i>	Latidae	Giant seaperch	Apahap	M
Others					
Crustacean					

No.	Scientific name	Family	English name	Local name	Classification
44	<i>Macrobrachium sp.</i>		White shrimp	Hipon	
45	<i>Atya sp.</i>		Atyid prawn	Apta	
46	<i>Potamon sp.</i>			Katang	
47	<i>Macrobrachium sp.</i>		Freshwater prawn	Ulang	
	<i>Molluscs</i>				
48	<i>Cristaria plicata</i>		Freshwater clam	Peras	
49	<i>Melania blatta</i>			Suso	
50	<i>Pomacea canaliculata</i>		Golden apple snail	Kuhol/sihe	
	<i>Reptile</i>			Parus	
51	<i>Pelodiscus sinensis</i>		Soft shelled turtle	Pawikan	
52	<i>Hydrophis semperi</i>		Seasnake	Dohol	E

Legend : E- endemic; I – introduced, M-migratory

Table 5. Endemic, introduced, migratory species in Taal Lake

Year	Endemic	Introduced	Migratory	Total	Source
1997	5	4	16	25	Villanueva 1996
2000	4	6	16	27	Mutia, et al 2004
2009	3	6	17	27	Mutia, et al 2011
2010	3	10	23	37	Mutia, et al 2011
2011	3	14	26	42	Mutia, et al 2011

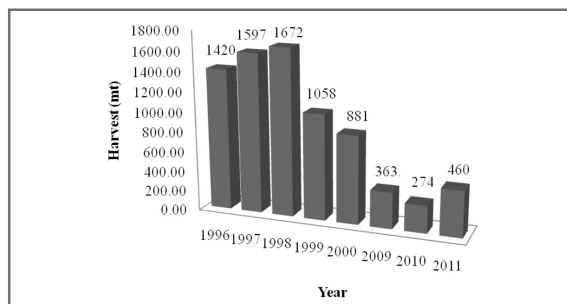


Figure 5. Fish harvest trend in the open fisheries of Taal Lake.

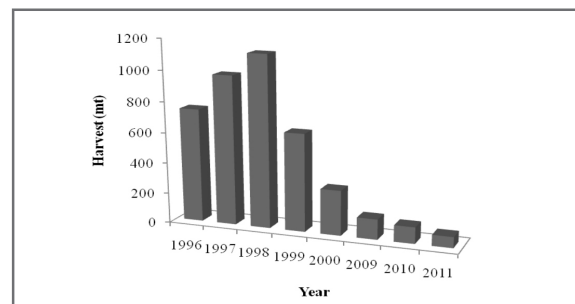


Figure 6. Estimated Tawilis harvest in the lake.

71 MT in 2011 or about 89% reduction in 12 years.

Dominant species

The top 10 major fish species caught in the lake from 1996-2000 and 2009-2011 are as follows: *Sardinella tawilis*, *Oreochromis niloticus*, *Atherinomorus lacunosus*, *Chanos chanos*, *Caranx ignobilis*, *Carassius auratus*, *Glossogobius giuris*, *Leiopotherapon plumbeus*, *Pangasianodon hypophthalmus*, and *Ostorhinchus thermalis* (Figure 7). *S. tawilis* has been consistently the most dominant species in the open water fisheries, however, in 2011 *P. hypophthalmus* dominated the catch with 148 MT.

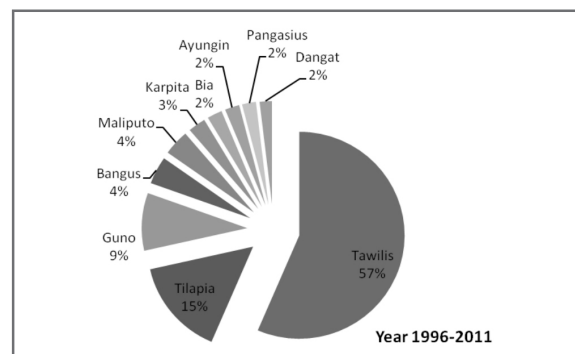


Figure 7. Dominant species in Taal Lake

Catch per unit effort

The catch per unit effort (CPUE) of the major fishing gear in the lake is shown in Table 6. The active gear such as ring net, motorized push net, and beach seine have the highest CPUE. These gear are prohibited to operate in the lake. The CPUE of ring net increased tremendously from 143 to 2,504 kg/day from 1997 to 2011. CPUE of motorized push net and beach seine

continued to increase in the past 14 years. However, the CPUE of gill net which is the most dominant passive gear continued to decline from 11 kg/day to 4.4 kg/day in 1997 to 2011.

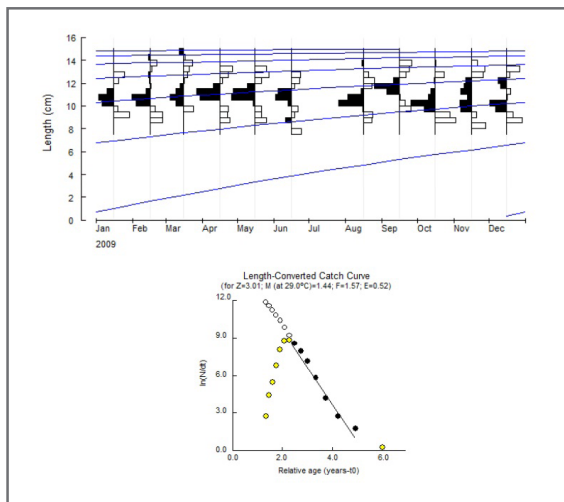
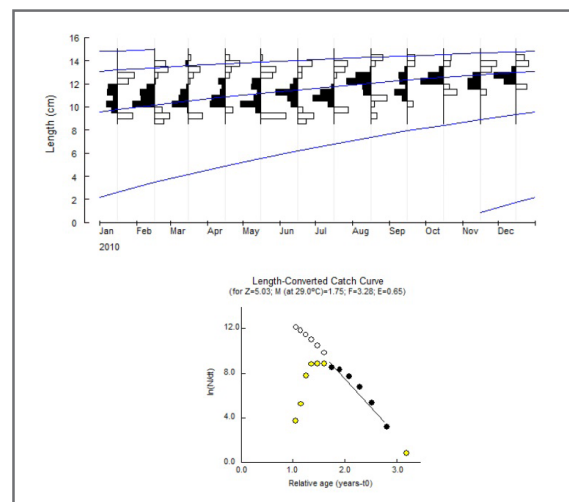
Despite the effort to fish in both active and passive gear, the fish harvest remained to decline especially the endemic freshwater sardine and all other

Table 6. Catch per unit effort (kg/day) by gear in Taal Lake, Batangas from 1997-2000 & 2010.

Fishing Gear	Local Name	1997	1998	1999	2000	2010	2011
Gill net	Pante	11	12	6	8	6.6	4.4
Beach seine	Pukot	48	68	66	34	25.6	72.9
Ring net	Pangulong/basing	143	276	43	-	30	2504.5
M.push net	Suro	379	327	168	111	544.3	222.2

Table 7. Tawilis population parameters

Year	L_{∞}	K	Z	M	F	E
2009	15.40	0.53	3.01	1.44	1.57	0.52
2010	16.36	0.73	5.03	1.75	3.28	0.65
2011	15.76	0.63	3.55	1.61	1.94	0.55

Figure 8. Length frequency and Length-converted catch curve of *Sardinella tawili* in Taal Lake from 2009.Figure 9. Length frequency and Length-converted catch curve of *Sardinella tawili* in Taal Lake from 2010.

indigenous fishes of the lake.

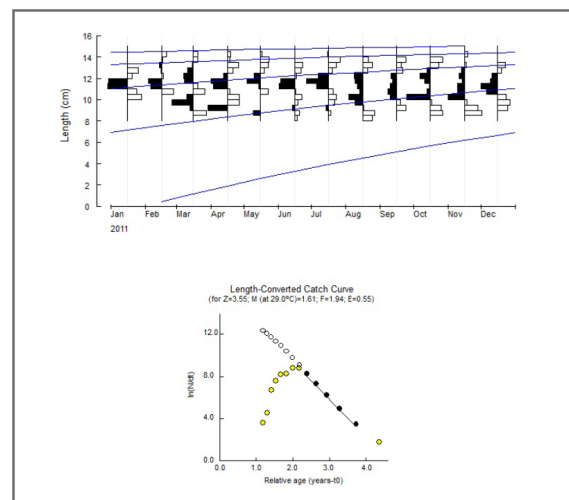
Tawilis population

The length frequency data of tawilis caught by combined gill net and beach seine from 2009 and 2011 has an estimated range of L_{∞} from 15.40 to 16.36 (Table 7). The L_{∞} is the mean length of the fish in the population that will be reached if they grow indefinitely. The K value obtained ranged from 0.53 to 0.73. It is the rate of dimension time at which L_{∞} is approached.

The total mortality (Z) obtained ranged from 3.01 to 5.03, natural mortality (M) from 1.44 to 1.75 and fishing mortality (F) from 1.57 to 3.28. The exploitation rate (E) obtained ranged from 0.52 to 0.65. The high fishing mortality and exploitation rates imply unsustainable fishing practice (Figures 8-10).

4. DISCUSSION

The assessment of fisheries in Taal Lake revealed a continued decline in fish harvest in the open waters. The decline in harvest may be attributed to unsustainable

Figure 10. Length frequency and Length-converted catch curve of *Sardinella tawili* in Taal Lake from 2011.

fishing practice and proliferation of aquaculture activities. The operation of the three active gear such as the beach seine, motorized push net, and ring net worsened the condition of the open water fisheries.

The growing number of aquaculture activities in the lake also contributed to the declining population and displacement of indigenous fishes as well as introduction of more aggressive aliens species. These alien species may become invasive and disrupt the ecological balance of the lake. The continued operation of the active gear and the prevalence of introduced species reflect the laxity in the implementation of fishery laws and ordinances. To address the issue, Protected Area Management Board (PAMB) and Taal Lake Task Force should strictly implement the Unified Rules and Regulations for Fisheries (URRF) under the TVPL management plan. Specifically, on the establishment of fish sanctuary area, prohibiting the introduction of alien species in the lake, banning the operation of active gear, mesh size regulation of fishing gear, and support to R & D programs are necessary for the conservation and management of indigenous fishes in the lake.

5. ACKNOWLEDGEMENT

We would like to express our gratitude to the following for their big contribution to this research project: National Fisheries Research and Development Institute, for funding the Project; Local Government Units (LGUs) for allowing us to conduct the survey in their respective municipalities; the fishermen and other respondents for sharing their knowledge and time; and our enumerators for their hard work and reliable survey data.

6. REFERENCES

- Aypa SM, Galicia AM Jr., Lapasaran ES. 1991. A contribution to the biology of *Herengula tawilis* in Taal Lake, Batangas. Bureau of Fisheries and Aquatic Resources, Project Completion Report to the DA of Agricultural Research, 12 pp., 2 tables, 3 figures.
- Castillo BB, Castillo AS, Gonzales CL. 1975. Tawilis fishery resources investigation of Taal Lake. Report to the Bureau of Fisheries and Aquatic Resources, p. 16. FishBase. 2012. <http://www.fishbase.org/>
- Hargrove TR. 1991. The mysteries of Taal. A Philippine volcano and lake, her sea life and lost towns. Book-Publishing, Manila, p. 204.
- Herre AW. 1927. Four new fishes from Lake Taal (Bombon). Philippine Journal of Science 34(3): 273-278.
- Mercene EC. 1997. Freshwater fishes of the Philippines. Proc. First National Symposium on Aquatic Biology R&D PCAMRD, No.20.
- Mercene-Mutia MT. 2001. Assessment of local government's implementation of open access policy in Taal Lake, Philippines: effects on lake conservation and management, pp 123-132. In CB Santiago, ML Cuvin-Aralar and ZU Basiao (eds). Conservation and Ecological Management of Philippine Lakes in Relation to Fisheries and Aquaculture. SEAFDEC, Iloilo; PCAMRD, Los Banos, Laguna and BFAR, Quzon City, Philippines. p. 187.
- Mutia MT, Magistrado ML, Muyot MC. 2004. Status of *Sardinella tawilis* in Taal Lake, Philippines. Proceedings of the 8th Zonal Center II Research and Development Review. De La Salle University, Taft, Manila. p. 14.
- Mutia MT, Muyot MC, Torres FB, Faminialagao CM. 2011. Seasonality, Abundance and Biology of Tawilis (*Sardinella tawilis*) in Taal Lake, Batangas. 2nd National Congress on Philippine Lakes. SEARCA, UP Los Banos, Laguna. April 27-29, 2011.
- Presidential Commission on Tagaytay-Taal. 1993. Agriculture and fisheries program, Vol. 1, p. 21-24 and 2.1.2 Fisheries, Vol. 4, p. 30-72 and 101-110. In Tagaytay-Taal Integrated Master Plan, 20 Year Timeframe 1994-2014, PCTT, Department of Tourism, Manila, Philippines.
- Rosana MR, et al. 2006. *Parachromis managuensis* (Gunbther, 1867) in Taal Lake. Philippine Journal of Environmental Science and Management 9(2): 1-19.
- UPLB Foundation, Inc. 1996. Rapid resource appraisal of Taal Lake. Terminal report submitted to Bureau of Fisheries and Aquatic Resources.
- Villadolid DV. 1937. The fisheries of Taal Lake, Pansipit River and Balayan Bay, Batangas Province, Luzon. Philip. J. Sci. 63(2): 191-225
- Villanueva LS, Luistro AP, Calabig CS. 1996. Assessment of Taal Lake capture fisheries with emphasis on the exploitation of *Herengula tawilis*. STIARCH.