Tilapia Brackishwater Harvest Simulation System (TBHSS)

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Abstract— In the Philippines, tilapia is a significant fish species. It makes up more than half of the nation's entire aquaculture production, making it the most lucrative freshwater fish species. To provide a protein-rich diet that is comparable to its wild cousin, it is cultivated and bred in captivity. In both Asia and the United States, tilapia is also a common fish. It can be produced and farmed in freshwater, saltwater, or even the dark, demonstrating its adaptability. The goal of the study is to simulate the process of harvesting from the sea or buying fingerlings from another breeder and have those fingerlings grow to tilapias and be cultivated in a four month maturation period and be able to be harvested. A T-test is conducted in order to ensure accuracy and for validation purposes.

Keywords—*Tilapia, Arena, Aquaculture, Fisheries*

I. Introduction

The majority of the world's tilapia production, or 70.4% of all tilapia raised for food, is produced in Asia. In Asia, freshwater environments are where tilapia is primarily produced. In 2017, freshwater ecosystems accounted for around 96 percent of the overall production of farmed tilapia. In 2017, 31 Asian nations, mostly in South Asia and the Far East, reported producing tilapia.[2]

Aquaculture serves as a supplement to boost overall fish production and help support food supplies worldwide, by cultivating aquatic life. As the demand for fisheries products rises, aquaculture will continue to play a significant role in increasing global fish production. Capture fisheries output has plateaued and is no longer thought to be able to support the supply of fishery goods required to satisfy the rising global demand. Tilapias are increasingly becoming more important in aquaculture. [5]

TBHSS aims to provide a reliable simulation model with 90% accuracy for the production of the Top 10 Tilapia Aquaculture regions in the Philippines, generating a model that would show harvesting within a year's timespan. Because tilapia is harvested every 4 months, there will be three harvesting sessions overall. Brackishwater harvesting in Fishponds is the focus area of this study. Additionally, all tilapia values are measured in Metric Tons (MT).

II. REVIEW OF RELATED LITERATURE AND STUDIES

Tilapia

The most popular and economically significant fish in the Philippines are tilapia (Oreochromis niloticus) and milkfish (Chanos chanos). Numerous natural locations used for raising these fish are impacted by environmental emissions and climate change as a result of the industrialisation of the nation, and the likelihood of having an efficient and sustainable production may eventually decline. The weather system has a different impact on each geographical area of the Philippines[6].

With regard to the farming environment, there is a clear dominance of species. The dominant species in freshwater, brackishwater, and marine settings, respectively, continue to be tilapia, milkfish, and seaweeds. Filipinos like live tilapia and are unlikely to purchase the frozen variety. Given that there is currently essentially no market for (stockpiled) frozen tilapia, this seemingly minor difficulty with product presentation has a significant impact on output as a whole[4].

Aquaculture

Fish are raised in tanks or other enclosed aquaria through aquaculture. The most widely cultivated fish in aquaculture is the tilapia, which is prized for its high productivity and quick development [7]. As a freshwater species, tilapia can be maintained in a variety of aquatic environments, including brackish aquaculture systems, freshwater lakes and ponds, and even raised beds on the ground. With several aquaculture facilities producing the species for human consumption around the world, tilapia farming has emerged as one of the most popular methods for producing fish for food.[3]

Fisheries

Millions of people worldwide rely on the fishing industry as their main source of income and nourishment. People in industrialized nations are gradually shifting to tilapia as a source of protein [8]. Asia, particularly China and India, is where the majority of tilapia aquaculture is found. With the majority of its aquaculture output concentrated in the Gulf of Mexico, California, and Texas, the United States is the second-largest producer of tilapia in the world. An estimated four million people in the US depend on the fisheries for their subsistence, which also supports nearly two million jobs and an annual economic output of $35 billion. Over $35 billion is thought to be spent yearly on the aquaculture sector worldwide.[3]

As for the Philippines, it is noted to be one of the major contributors of fisheries worldwide. The ranking puts it at 13th highest producer for fish products in 2018, garnering around 4.36 Million Metric Tons. Tilapia is one of its leading fishes alongside the Milkfish. [1]

III. METHODOLOGY

The stages of research conducted at simulating the harvesting of Tilapia are as follows:

Data Collection

The purpose of data gathering is to determine the sort of distribution that exists in the tilapia harvesting system, which will be used as crucial data for simulation. The data used is the interval arrival of tilapia fingerlings, feeding of the fingerlings, the four months maturation period of tilapia, and the harvesting of the tilapia.

Data was provided by the Bureau of Fisheries and Aquatic Resources (BFAR) in their 2020, 2019, and 2018 Final reports on all important Fishery/Aquaculture data, respectively. Once data gathering was concluded, the excel sheet was cleaned in order to ensure its accuracy.

B. Aquaculture Production by Region, Culture Environment, and Species, 2020

1. Production from Brackishwater (in MT)
a. Fishpond

Region	Total	Milkfish	Tiger Prawn	White Shrimp & Endeavor Prawn	Tilapia	Mudcrab	Grouper	Siganid	Others
NCR	150.82	2.00	..	0.00	..	..	..	..	148.82
I	28,303.11	23,251.31	1,147.34	48.59	3,129.14	10.00	..	44.08	672.65
II	4,936.85	553.55	47.89	79.62	2,174.82	42.78	..	16.03	2,022.16
III	89,399.33	51,008.24	22,852.82	528.94	7,022.88	5,097.29	..	..	2,889.16
IV-A	30,005.34	24,068.77	150.81	0.95	21.87	4,095.80	3.38	0.06	1,663.70
MIMAROPA	1,887.17	1,603.39	249.08	2.51	2.61	11.98	0.14	..	17.46
V	5,803.38	3,202.27	1,927.39	91.96	193.16	352.35	..	0.27	35.98
VI	103,886.23	97,577.99	763.87	177.66	2,142.45	2,009.43	0.06	..	1,214.77
VII	10,976.51	5,717.39	169.74	4.91	231.99	1.02	..	..	4,851.46
VIII	3,395.14	3,068.41	1.53	10.90	6.84	200.80	..	1.54	105.12
IX	8,165.55	5,894.08	844.72	237.44	438.18	748.60	..	..	2.53
X	35,283.57	13,326.18	13,542.13	53.90	579.25	7,759.36	..	0.01	22.74
XI	3,920.31	2,168.24	5.30	2.65	138.93	15.50	..	0.01	1,589.68
XII	9,726.49	2,254.82	0.40	0.04	2,150.77	0.29	..	..	5,320.17
XIII	2,646.60	1,783.09	90.11	4.37	8.34	301.07	..	..	459.62
BARMM	5,734.34	4,971.49	300.12	181.60	165.13	116.00	..	..	..
TOTAL	**344,220.74**	**240,451.22**	**42,093.25**	**1,426.04**	**18,406.36**	**20,762.27**	**3.58**	**62.00**	**21,016.02**

Source: Philippine Statistics Authority retrieved 04 June 2021

In brackishwater fish pond, the top produced species were Milkfish, Tiger Prawn, and Mudcrab, while the overall top producing region is Region VI with 30.2% of the total production.

Philippine Fisheries Profile 2020 29

B. AQUACULTURE PRODUCTION BY, CULTURE ENVIRONMENT, BY REGION AND SPECIES, 2019

1. Production from Brackishwater (in MT)
A) Fishpond

Region	Total	Milkfish	Tiger Prawn	White Shrimp & Endeavor Prawn	Tilapia	Mudcrab	Grouper	Siganid	Others
NCR	91.27	87.80	-		2.6	0.86	-	-	
CAR	-	-	-	-	-	-	-	-	-
I	28,521.81	23,340.26	1,278.5	49.42	3,842.2	9.60	-	0.75	-
II	2,797.19	542.34	46.0	97.15	2,063.3	48.45	-	-	1.06
III	84,411.25	49,484.36	22,703.9	527.14	7,074.5	4,621.35	-	-	-
IV-A	26,885.56	23,502.70	112.2	44.23	16.4	3,210.08	-	-	-
IV-B	1,634.10	1,331.55	282.0	1.06	3.7	15.80	-	-	-
V	8,585.47	3,993.75	3,730.7	102.45	205.5	553.16	-	-	-
VI	101,262.17	96,345.23	792.8	188.99	1,883.3	2,051.72	0.23	-	-
VII	4,770.37	4,266.57	287.8	3.27	211.0	1.78	-	-	-
VIII	7,473.92	6,865.04	8.6	1.50	4.5	594.22	-	-	-
IX	8,756.77	6,213.44	918.4	409.95	422.8	792.14	-	-	-
X	36,996.54	12,883.02	15,050.4	59.28	553.8	8,450.10	-	-	
XI	2,858.58	2,373.05	84.2	3.67	382.1	15.34	-	0.08	0.12
XII	3,623.00	2,136.06	0.2	-	1,486.5	0.20	-	-	-
CARAGA	2,589.13	2,139.12	142.8	4.33	9.2	293.27	-	-	-
ARMM	4,177.87	3,435.79	293.7	181.24	160.9	106.27	-	-	-
									0.12
TOTAL	325,435.00	238,940.08	45,732.12	1,673.68	18,322.00	20,764.34	0.23	0.833	-

Region III is the top producer of tiger prawn and tilapia, while Region X tops in mudcrab production. As for milkfish species, Region VI has the highest production of this commodity.

Philippine Fisheries Profile 2019 29

B. AQUACULTURE PRODUCTION BY, CULTURE ENVIRONMENT, BY REGION AND SPECIES, 2018

1. Production from Brackishwater (in MT)
A) Fishpond

Region	Total	Milkfish	Tiger Prawn	White Shrimp & Endeavor Prawn	Tilapia	Mudcrab	Grouper	Siganid	Others
NCR	192.79	16.37	0.30		1.51	0.09			174.52
CAR									
I	27,864.45	21,194.70	1,586.47	41.81	4,510.38	9.76		46.67	474.66
II	4,059.01	526.11	44.36	105.69	2,098.87	50.12		13.45	1,220.41
III	87,777.22	51,503.62	21,990.55	549.63	7,710.89	4,338.02	0.50	0.82	1,683.19
IV-A	19,670.64	15,906.32	294.34	40.89	35.94	2,751.19	13.3		628.66
IV-B	1,779.94	1,441.07	271.15	0.48	5.31	33.07			28.86
V	8,048.41	3,780.86	2,586.13	218.08	219.71	1,202.95	4.45	0.38	35.85
VI	93,830.56	88,681.14	890.73	156.38	1,325.36	2,239.32	0.07		537.56
VII	8,385.51	4,594.47	444.46	6.03	136.59	2.12			
VIII	7,413.60	6,672.79	278.75	1.07	6.68	358.78	2.00	1.83	3,201.84
IX	9,950.06	6,676.54	1,153.21	916.42	500.48	702.00			1.70
X	36,593.93	12,652.47	14,599.58	60.65	673.11	8,602.61			1.41
XI	3,717.50	2,472.07	110.26	10.20	493.51	51.89		0.17	5.51
XII	7,980.12	3,566.39	0.67	0.02	661.71	0.14			633.40
CARAGA	3,398.12	2,191.94	246.85	4.18	32.25	322.31			3,751.66
ARMM	4,841.70	4,140.72	282.41	167.98	152.92	97.67			600.59
TOTAL	325,504.03	226,107.58	44,780.22	2,279.51	18,511.22	20,762.04	20.32	63.32	12,979.82

Region III is the top producer of tiger prawn and tilapia, while Region X tops in mudcrab production. As for milkfish species, Region VI has the highest production of this commodity.

Philippine Fisheries Profile 2018 29

Simulation Application

The researchers have used Arena Simulation Software to create the model for simulating the Tilapia Brackish Water Harvest Simulation to create processes. Which has a click and drag system, and little to none value assignment. This makes it easier to operate and it only requires the minimum system requirements to run the program. The recommended system only needs to be running at Windows 7, with 2GBs of ram available, and Adobe Acrobat pre-installed to a user's pc.

Arena Simulation is also able to provide easy-to-access data gathered from the simulation. Data that can be converted to other more feasible files such as Excel and PDF files. The researchers will now be able to gather data with ease.

Making the Harvesting System Simulation

The researchers created the simulation by considering the following steps on how a regular harvest of an aquaculture plant works. Essentially the fingerling tilapias go straight into the aquaria, but since the pandemic happened, there has been difficulty in demand of the tilapias as trading overseas has been undoable as a lockdown was issued in the Philippines making the breeders unable to sell their tilapia overseas. The fingerling tilapias continued to be fed in a four month maturing period and occasional checks to see if there are any diseased tilapias. The breeders then see if they are the right size to be sold off and that is where simulation ends.

Model Run Documentation

The researchers provided a model for the aquaculture of tilapias. In which it simulates the growth of tilapias from raising them into the time for them to be harvested. The simulation model for the TBHSS can be seen in figure 1.

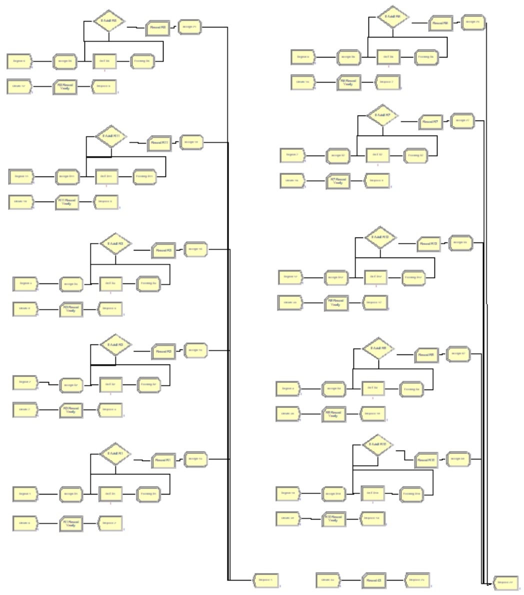

Figure 1: Simulation Model of Brackishwater Aquaria raised Tilapia

IV. RESULTS AND DISCUSSION

The results of the simulation model for the TBHSS is close to the actual real life data that was acquired from BFAR. The simulation achieved 88% in comparison to the data. The replications can be seen in the figures below.

Tilapia AquaCulture Farm Simulation Replications: 3

Replication 1 Start Time: 0.00 Stop Time: 365.00 Time Units: Days

Tally

Expression	Average	Half Width	Minimum	Maximum
Overall Total Weight	18,159.67	(Insufficient)	18,159.67	18,159.67
Region 1 Weight	1,275.42	(Insufficient)	1,267.89	1,280.63
Region 1 Yearly Weight	3,826.27	(Insufficient)	3,826.27	3,826.27
Region 10 Weight	199.29	(Insufficient)	198.87	199.82
Region 10 Yearly Weight	597.87	(Insufficient)	597.87	597.87
Region 11 Weight	111.70	(Insufficient)	110.09	113.19
Region 11 Yearly Weight	335.10	(Insufficient)	335.10	335.10
Region 12 Weight	479.32	(Insufficient)	468.54	485.41
Region 12 Yearly Weight	1,437.97	(Insufficient)	1,437.97	1,437.97
Region 2 Weight	699.40	(Insufficient)	699.13	699.58
Region 2 Yearly Weight	2,098.21	(Insufficient)	2,098.21	2,098.21
Region 3 Weight	2,411.25	(Insufficient)	2,410.16	2,412.51
Region 3 Yearly Weight	7,233.76	(Insufficient)	7,233.76	7,233.76
Region 5 Weight	68.3479	(Insufficient)	68.2052	68.4417
Region 5 Yearly Weight	205.04	(Insufficient)	205.04	205.04
Region 6 Weight	593.81	(Insufficient)	588.71	598.18
Region 6 Yearly Weight	1,781.44	(Insufficient)	1,781.44	1,781.44
Region 7 Weight	63.7426	(Insufficient)	63.3035	64.1190
Region 7 Yearly Weight	191.23	(Insufficient)	191.23	191.23
Region 9 Weight	150.93	(Insufficient)	150.86	151.02
Region 9 Yearly Weight	452.78	(Insufficient)	452.78	452.78

Figure 2: Replication 1

Replication 2 Start Time: 0.00 Stop Time: 365.00 Time Units: Days

Tally

Expression	Average	Half Width	Minimum	Maximum
Overall Total Weight	18,132.75	(Insufficient)	18,132.75	18,132.75
Region 1 Weight	1,273.03	(Insufficient)	1,267.15	1,277.25
Region 1 Yearly Weight	3,819.10	(Insufficient)	3,819.10	3,819.10
Region 10 Weight	199.04	(Insufficient)	198.92	199.20
Region 10 Yearly Weight	597.11	(Insufficient)	597.11	597.11
Region 11 Weight	111.89	(Insufficient)	110.31	114.77
Region 11 Yearly Weight	335.68	(Insufficient)	335.68	335.68
Region 12 Weight	475.46	(Insufficient)	466.87	482.23
Region 12 Yearly Weight	1,426.37	(Insufficient)	1,426.37	1,426.37
Region 2 Weight	699.75	(Insufficient)	698.39	700.62
Region 2 Yearly Weight	2,099.24	(Insufficient)	2,099.24	2,099.24
Region 3 Weight	2,411.38	(Insufficient)	2,410.82	2,411.84
Region 3 Yearly Weight	7,234.13	(Insufficient)	7,234.13	7,234.13
Region 5 Weight	68.3661	(Insufficient)	68.3096	68.4416
Region 5 Yearly Weight	205.10	(Insufficient)	205.10	205.10
Region 6 Weight	590.89	(Insufficient)	587.45	594.30
Region 6 Yearly Weight	1,772.68	(Insufficient)	1,772.68	1,772.68
Region 7 Weight	63.9610	(Insufficient)	63.7332	64.0945
Region 7 Yearly Weight	191.88	(Insufficient)	191.88	191.88
Region 9 Weight	150.48	(Insufficient)	150.34	150.69
Region 9 Yearly Weight	451.45	(Insufficient)	451.45	451.45

Figure 3: Replication 2

Replication 3 Start Time: 0.00 Stop Time: 365.00 Time Units: Days

Tally

Expression	Average	Half Width	Minimum	Maximum
Overall Total Weight	18,104.64	(Insufficient)	18,104.64	18,104.64
Region 1 Weight	1,269.11	(Insufficient)	1,263.31	1,274.47
Region 1 Yearly Weight	3,807.34	(Insufficient)	3,807.34	3,807.34
Region 10 Weight	199.30	(Insufficient)	199.14	199.57
Region 10 Yearly Weight	597.89	(Insufficient)	597.89	597.89
Region 11 Weight	112.09	(Insufficient)	111.55	112.45
Region 11 Yearly Weight	336.27	(Insufficient)	336.27	336.27
Region 12 Weight	472.04	(Insufficient)	468.89	475.65
Region 12 Yearly Weight	1,416.12	(Insufficient)	1,416.12	1,416.12
Region 2 Weight	700.12	(Insufficient)	699.45	700.98
Region 2 Yearly Weight	2,100.37	(Insufficient)	2,100.37	2,100.37
Region 3 Weight	2,407.30	(Insufficient)	2,399.57	2,413.12
Region 3 Yearly Weight	7,221.90	(Insufficient)	7,221.90	7,221.90
Region 5 Weight	68.3131	(Insufficient)	68.0704	68.6812
Region 5 Yearly Weight	204.94	(Insufficient)	204.94	204.94
Region 6 Weight	592.19	(Insufficient)	590.85	594.78
Region 6 Yearly Weight	1,776.58	(Insufficient)	1,776.58	1,776.58
Region 7 Weight	63.8940	(Insufficient)	63.2434	64.2251
Region 7 Yearly Weight	191.68	(Insufficient)	191.68	191.68
Region 9 Weight	150.52	(Insufficient)	150.16	150.78
Region 9 Yearly Weight	451.55	(Insufficient)	451.55	451.55

Figure 4: Replication 3

The average number out for the model is to signify the harvest per year in each region. Every region conducts three harvests per year every four months, that is why the number out is 30.

V. CONCLUSION

In conclusion, the agricultural activity of breeding, feeding, and farming the local Tilapia of our country is an integral part of the Philippine economy and ecosystem. This model proves to be an accurate and realistic simulation of how the usual process of breeding and harvesting tilapia in brackish water fish ponds through aquaculture is conducted.

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