

POTENTIAL OF AFULILO RESERVOIR FOR FISH STOCKING

Prepared by

Yoshinobu Matsunaga¹ and Lui A.J. Bell²

¹UN Volunteer
Principal Fisheries Research Officer
Fisheries Division
Ministry of Agriculture, Forests, Fisheries and Agriculture
Apia
WESTERN SAMOA

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1. Introduction

In an effort to lessen pressure on the natural reef fishery resources, Fisheries Division has initiated an aquaculture programme assessing the potential of inland fish farming. Since reservoirs for electricity offers opportunity for fish stocking which can serve as a potential source of protein for local population, the construction of the Afulilo Reservoir was seen as offering a possibility for fish production.

In the Cabinet meeting on 23 February 1994, the Ministry of Agriculture, Forests, Fisheries and Meteorology was directed to submit a report within three weeks detailing the situation of the Afulilo Reservoir, including its potential, for fish farming. A report was prepared and submitted to Cabinet suggesting that the reservoir has the potential for aquaculture development. The report specifically recommended initial stocking of the reservoir with Nile Tilapia and then establish the site as the aquaculture centre. The Cabinet Decision, dated 21 April, 1994, was to with-hold a decision until details are finalised with a Chinese Government delegation that was expected at the time. The authors could not find any information pertaining to the Chinese Government delegation and any other further development except that the original report was submitted as a project on 6 February, 1995 to Foreign Affairs for submission to potential donors for funding.

A report from the Electric Power Corporation indicated that dissolved oxygen (DO) levels were low at the early times and therefore the reservoir was rated as not suitable for fish stocking. Accordingly, Fisheries Division devised and conducted a survey to properly assess the more important parameters that need to be considered before stocking fish. The parameters assessed included, dissolved oxygen levels, pH, temperature and phytoplankton presence. Between March 1996 and July 1996, Fisheries Division conducted 24-hour surveys at the Reservoir.

2. Material and Method

2.1 Survey and Measurement Frequencies

A total of six 24-hour surveys were conducted in March, May and July of 1996. Two surveys were conducted in each month, one during the first week and the other one, two weeks later. Three different stations were chosen within the reservoir where data were collected from. The locations are shown on Figure 1.

During each 24-hour survey, data were measured every six hours starting at 6:00 pm and finishing at 12:00 noon the following day. Thus data were collected at 18:00 hour, 12:00 mid-night, 06:00 hour and 12:00 noon.

2.2 Physical factors

Temperature

Surface temperature at the different stations was taken using a wristwatch with a thermometer. As with all other equipment used, sufficient time was given to allow the equipment to stabilize before a reading was taken.

Turbidity

Turbidity (as an indicator on plankton density) was measured using a secchi disc tied to the end of a graduated 5 mm rope. A small weight was attached to the bottom of the secchi disc to facilitate sinking. Measurements were only done at 12:00 noon for each station.

Depth
Water depth at each station was taken using a graduated 5mm rope. A small weight was tied to the end of the rope to facilitate sinking.

Rainfall and Reservoir water level
Rainfall data and water level within the reservoir were taken from data collected and compiled by EPC. The volume of water within the reservoir was calculated using a programme devised by EPC.

2.3 Chemical factors

Dissolved Oxygen (DO)
Dissolved oxygen measurements were taken using an M & M Marquillo Portable DO Meter. Surface and DO levels at 1.9 m deep were taken for each station.

pH
pH measurements were taken using a Hach Wide Range Indicator pH test kit. Only surface pH readings were recorded for each station.

Nutrients
Samples to determine Calcium, Potassium and Sodium were taken in 1994 and sent to the University of the South Pacific, Alafua Campus, for analysis (Fisheries Division, 1994). The results of these tests are not available yet.

2.4 Biological factors

Phytoplankton
Samples of phytoplankton were collected using a 100µ plankton net collected vertically through the water column.

3. Results and Discussions

3.1 Physical factors

Temperature

Tables 1a, 1b and 1c present the full set of data collected at the three stations during the survey days. The surface temperatures recorded range from the lowest, 24.3 °C, recorded in May at 06:00 am at Station 2, to the highest, 27.0 °C, recorded in March at 18:00 hour at Station 3. Overall, surface water temperatures throughout the study period was around 25.5 °C with daily variation of less than 2 degrees.

Most fish suitable for stocking are tolerant of a fairly wide range of temperatures, but they can be stressed by sudden and wide changes. Temperature fluctuations within the reservoir are gradual and not wide. Experiences in other countries indicate that best growth of tilapia occurs between temperatures, 25-35 °C, with reproduction occurring at temperatures above 21 °C. Very slow growth occurs at temperatures below 20 °C and no growth at temperatures below 15 °C. Thus,

considering temperature alone, Afullo reservoir presents an ideal medium for tilapia growth.

Turbidity

The lowest secchi disc reading, 0.8 m, was recorded at Station 1 in July. Throughout the period, secchi disc readings were between 1 and 2 m for all Stations.

Turbidity may consist of a bloom of phytoplankton cells, of mineral particles in the water source, or of waste materials produced. The plankton tows conducted indicated that a fair amount of phytoplankton make up the turbidity of the water in the dam. Bloom turbidity is generally considered excessive and may endanger the animals by depleting the oxygen at night, if the secchi disc disappears at depth of 20 cm or less. Thus the turbidity by algal blooms in the Afullo dam does not present any problems with oxygen depletion at night. However, the rather light turbidity, thus low phytoplankton level indication, recorded could be a limiting factor in obtaining the full capacity production considering the volume of water and other factors in the reservoir.

Depth

All stations selected within the reservoir were less than 4 m in depth. The differences in depths for each station, as shown by the data collected on different survey dates, is probably due to differences of spots where depth measurements were taken and not indicative of fluctuations of water levels within the reservoir.

Rainfall and Reservoir Water Level

Table 2 presents monthly total rainfall, monthly average reservoir water level and estimated corresponding water volume recorded at Afullo by EPC for the September 1995/August 1996 period. These are graphically depicted on Figure 2.

Table 2: Monthly rainfall, average reservoir water level and corresponding water volume.

1995											
Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Rainfall (mm)	773.9	201.4	426.2	300.2	649.8	423.3	455.4	383.7	459.6	194.3	97.3
Reservoir water level (m)	314.89	313.97	313.48	313.99	314.60	316.11	316.18	316.51	317.15	316.47	314.98
Water volume 10 ⁷ cu m	47.63	29.17	19.43	29.67	41.81	62.04	73.61	80.13	92.98	79.33	49.43
											24.16

For the 12-month period, the lowest level, 313.48 m, occurred in November, 1995. This corresponds to a volume of 19.43 x 10⁷ cu m of water. The highest level was in May, 1996 which was 317.15 m, corresponding to 92.98 x 10⁷ cu m of water in the reservoir. The year data seems to indicate that the amount of water within the reservoir would not be prohibitive for fish growth.

3.2 Chemical factors

Dissolved Oxygen (DO)

Surface DO: The lowest surface DO recorded was 5.9 ppm in July at Station 1 at 06:00 hour. The highest, 11.5 ppm, was recorded in July at 18:00 hour at Station 2. As expected, the lowest DO readings were generally recorded at 06:00 hour. With the exceptions of a few cases, most of the DO levels were above 8 ppm. The average DO level for all three stations was around 8.6 ppm.

Fisheries Division has introduced a Thailand strain (Chitrakada) of the Nile Tilapia, *Oreochromis niloticus*, for aquaculture and stocking purposes. This species forms the basis of commercial fish farming in a lot of countries in the world including Fiji.

5. Recommendation

The results of the surveys conducted by Fisheries Division indicate that Afullio Reservoir has the capacity to support stocks of fish grown in it. This conclusion is reached after considering temperature, DO levels, pH, availability of natural food and volume of water. In fact, the parameters in the reservoir present an ideal situation for fish growth. The only limiting factor at this stage seems to be the density of phytoplankton within the water. However, this does not rule out the potential of the reservoir for stocking fish, but rather it limits the full capacity of the water available in terms of fish production.

4. Conclusion

The presence of phytoplankton, aquatic insects and leptocephalus is a positive indication of the presence of food for fish. Plankton tows were only conducted once, during the March survey. While it was not possible to estimate phytoplankton density, *Chroococcus* sp. was identified as the dominating phytoplankton in all three stations. In addition, many aquatic insects and leptocephalus were also found in the tows.

3.3 Biological factors

The results of the analysis for samples taken to USP, Alafua Campus, were not available.

Nutrients

pH is the measure of the water's acid/base balance and neutral water has a pH of 7.0. For fish growth, pH 7.5 has been determined as the optimum pH. Accordingly, the pH recorded at Afullio is ideal for fish.

pH levels recorded at all stations throughout the survey ranged from 7.0 to 8.0, with an average of a little over 7.5.

pH

Dissolved oxygen is one of the most important factors for consideration in fish stocking. In warm waters, maximum or saturation point is about 8 ppm. Data presented in Tables 1a, 1b and 1c indicate that the DO levels in the water in the Afullio Reservoir is almost always saturated. In fact, in some incidences, oversaturation was the case. The average DO at surface as well as at 1.9 m deep were both above 8 ppm. Since the ideal DO level for fish growth is above 5 ppm, the DO levels in Afullio is certainly ideal for fish growth.

DO at depths of 1.9 m: Contrary to expectations, the lowest recorded DO level at depths of 1.9 m was higher than the lowest recorded for surface. The lowest recorded DO level at depths of 1.9 m was 6.2 ppm which was in July at 06:00 hour at Station 1, while the highest, 10.7 ppm, was also recorded in July at 18:00 hour at Station 2. The average DO level at 1.9 m depths for all three stations was around 8.4 ppm.

Contrary to the belief that tilapia is a "rubbish" fish, several studies conducted by Fisheries Division have indicated that tilapia is a well accepted food fish in Western Samoa. *O. mossambicus* introduced into Western Samoa in the 1950s, forms subsistence fisheries in several villages and an artisanal fishery in at least one village on Savaii. The results of taste tests conducted by Fisheries Division in 1994 and 1995, using *O. niloticus* (Thailand strain), indicated that the Nile Tilapia is well accepted by the local people and was even rated better than both reef fish and bottomfish for certain traditional method of cooking used.

Given the above, and the positive results of the survey conducted at the reservoir, it is recommended that fingerlings of the Thailand strain of the Nile Tilapia be stocked into the reservoir and that a monitoring programme be adapted. Additional stockings can be made after assessment by Fisheries Division depending on results of the monitoring programme. It is further recommended that fishing should only be allowed after the Fisheries Division has determined that stocks have been established, in sufficient numbers from the initial stockings, to accommodate fishing pressure.

It seems that a major concern of the EPC involves access to the reservoir by the public and safety. However, access can be regulated by opening fishing to the public at only certain sections of the reservoir, e.g. half side of the reservoir furthest (opposite) from the turbine, and allowing only certain fishing methods e.g. hook and line (including casting). Seasonal closures of the fishery can be decided upon by Fisheries Division and EPC when necessary.

Table 1a: Results of surveys conducted by Fisheries Division at Atulillo Reservoir, Station 1.

STATION 1	Parameter ↓↑	Date	Time				Temperature (°C)	DO1 (ppm)	DO2 (ppm)	pH	Secchi disc (m) (Turbidity)	Depth (m)
			18:00	24:00	06:00	12:00						
			25.8	25.5	25.0	25.6	25.5					
		6-Mar-96	26.9	26.7	25.5	25.8	26.2					
		20-Mar-96	25.1	24.9	24.5	24.5	24.8					
		8-May-96	25.8	25.2	25.1	26.3	25.6					
		22-May-96	25.8	24.9	25.0	26.1	25.5					
		10-Jul-96	25.6	25.0	25.0	25.5	25.3					
		25-Jul-96	25.6	25.4	25.0	25.6	25.5					
		Averages	8.4	9.0	7.7	8.4	8.4					
		6-Mar-96	10.6	9.4	8.4	9.8	9.6					
		20-Mar-96	9.5	8.9	-	-	9.2					
		8-May-96	9.3	8.1	8.1	8.8	8.6					
		22-May-96	10.4	7.8	8.1	9.6	9.0					
		10-Jul-96	9.3	7.9	5.9	8.2	7.8					
		25-Jul-96	9.6	8.5	7.6	9.0	8.8					
		Averages	8.3	9.2	7.8	7.8	8.3					
		6-Mar-96	9.5	8.4	7.3	6.3	7.9					
		20-Mar-96	9.3	8.9	-	-	9.1					
		8-May-96	9.1	8.1	8.1	8.7	8.5					
		22-May-96	9.7	9.0	8.1	9.0	9.0					
		10-Jul-96	9.0	7.5	6.2	6.2	7.2					
		25-Jul-96	9.2	8.5	7.5	7.6	8.3					
		Averages										
		6-Mar-96					7.0					
		20-Mar-96					8.0					
		8-May-96					7.5					
		22-May-96					7.5					
		10-Jul-96					7.5					
		25-Jul-96					7.5					
		Averages										
		6-Mar-96					1.5					
		8-May-96					1.1					
		22-May-96					1.3					
		10-Jul-96					1.2					
		25-Jul-96					0.8					
		Averages										
		6-Mar-96					2.8					
		8-May-96					3.8					
		22-May-96					2.2					
		10-Jul-96					1.2					
		25-Jul-96					1.2					
		Averages										
		25-Jul-96					2.5					

Notes: Temperature=Water Surface Temperature; DO1=Water Surface Dissolved Oxygen; DO2=Dissolved Oxygen at 1.9 m Depth.

Table 1b: Results of surveys conducted by Fisheries Division at Afulilo Reservoir, Station 2.

STATION 2		Parameter ↓↓		Date		Time		Average	
Temperature (°C)		DO1 (ppm)		DO2 (ppm)		pH		Secchi disc (m)	
Depth (m)		Turbidity		Average		Average		Average	
6-Mar-96	25.6	6-Mar-96	9.3	6-Mar-96	10.2	6-Mar-96	7.0	6-Mar-96	1.5
20-Mar-96	26.2	20-Mar-96	11.0	20-Mar-96	9.1	20-Mar-96	7.5	20-Mar-96	1.1
8-May-96	24.6	8-May-96	9.1	8-May-96	8.8	8-May-96	8.0	8-May-96	1.3
22-May-96	25.9	22-May-96	8.7	22-May-96	8.5	22-May-96	8.0	22-May-96	1.4
10-Jul-96	25.6	10-Jul-96	11.5	10-Jul-96	10.7	10-Jul-96	7.5	10-Jul-96	1.3
25-Jul-96	25.7	25-Jul-96	9.6	25-Jul-96	9.7	25-Jul-96	7.6	25-Jul-96	1.1
Average	25.9	Average	9.3	Average	9.6	Average	7.9	Average	1.3
6-Mar-96	25.4	6-Mar-96	9.1	6-Mar-96	8.7	6-Mar-96	7.0	6-Mar-96	1.5
20-Mar-96	26.4	20-Mar-96	9.3	20-Mar-96	9.2	20-Mar-96	7.5	20-Mar-96	1.1
8-May-96	24.8	8-May-96	8.0	8-May-96	8.5	8-May-96	8.0	8-May-96	1.3
22-May-96	25.9	22-May-96	8.6	22-May-96	8.3	22-May-96	8.0	22-May-96	1.4
10-Jul-96	25.1	10-Jul-96	9.4	10-Jul-96	8.3	10-Jul-96	7.5	10-Jul-96	1.3
25-Jul-96	25.2	25-Jul-96	7.5	25-Jul-96	7.2	25-Jul-96	7.6	25-Jul-96	1.1
Average	25.6	Average	7.9	Average	8.8	Average	7.9	Average	1.3

Notes: Temperature=Water Surface Temperature; DO1=Water Surface Dissolved Oxygen; DO2=Dissolved Oxygen at 1.9 m Depth.

Table 1c: Results of surveys conducted by Fisheries Division at Afulilo Reservoir, Station 3.

STATION 3		Date	18:00	24:00	06:00	12:00	Average
Parameter	Unit						
Temperature (°C)			25.5	25.2	24.9	26.2	25.5
			27.0	26.5	25.9	26.6	26.5
			24.8	24.7	24.8	24.8	24.8
			26.1	26.1	25.9	26.8	26.2
			26.5	24.8	25.5	26.2	25.8
			25.7	25.3	25.2	25.6	25.5
Average			25.9	25.4	25.4	26.0	25.7
DOI (ppm)		6-Mar-96	8.0	7.3	7.7	9.4	8.1
		20-Mar-96	10.5	9.3	9.0	10.5	9.8
		8-May-96	6.6	7.8	-	-	7.2
		22-May-96	8.5	9.1	8.4	9.3	8.8
		10-Jul-96	10.8	8.0	8.5	9.4	9.2
		25-Jul-96	9.1	6.8	6.4	7.8	7.5
DO2 (ppm)		Average	8.9	8.1	8.0	9.3	8.4
		6-Mar-96	6.8	7.2	6.8	9.6	7.6
		20-Mar-96	9.1	8.8	8.9	10.2	9.3
		8-May-96	6.5	7.6	-	-	7.1
		22-May-96	8.3	8.9	8.0	8.9	8.5
		10-Jul-96	10.6	6.9	7.6	9.0	8.4
pH		25-Jul-96	9.4	7.9	7.2	9.0	8.4
		Average	8.5	7.9	7.7	9.3	8.2
		6-Mar-96				7.0	7.0
		20-Mar-96				8.0	8.0
		8-May-96				7.5	7.5
		22-May-96				8.0	8.0
Secchi disc (m)		25-Jul-96				7.5	7.5
		10-Jul-96				7.5	7.5
		Average				7.6	7.6
		6-Mar-96				>1.3	
		8-May-96				1.0	1.0
		22-May-96				1.4	1.4
Depth (m)		10-Jul-96				>1.0	
		25-Jul-96				1.1	1.1
		Average				1.2	1.2
		6-Mar-96				1.5	1.5
		8-May-96				3.5	3.5
		10-Jul-96				>1.0	
		25-Jul-96				2.9	2.9
		Average				2.6	2.6

Notes: Temperature=Water Surface Temperature; DOI=Water Surface Dissolved Oxygen; DO2=Dissolved Oxygen at 1.9 m Depth.

Figure 2: Afullio Reservoir: Rainfall, Water Level and Water Volume

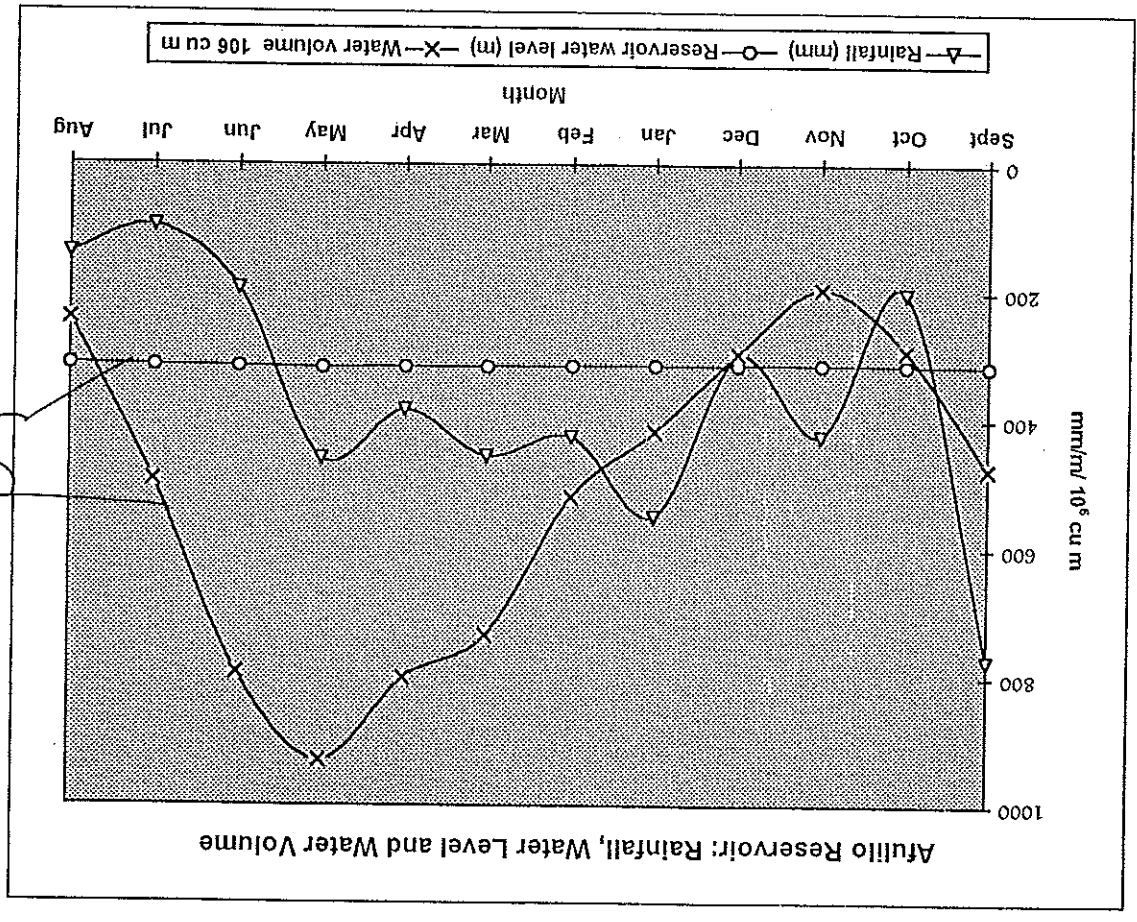


Figure 3: Various parameters recorded at Afullio Reservoir at Different Stations

