

**JOB PROGRESS REPORT  
RESEARCH PROJECT SEGMENT**

**STATE:** Territory of Guam

**PROJECT NO.:** F-1R-8  
**SUB-PROJECT NO.:** F-2  
**STUDY NO.:** 1  
**JOB NO.:** 1

**STUDY:** Monitoring of Guam's Freshwater Fisheries

**JOB TITLE:** Freshwater Monitoring Program (2440)

**PERIOD COVERED:** October 1, 1999 to September 30, 2000

**SUMMARY**

During FY00, the ongoing monitoring of four previously selected watersheds continued. Faunal counts and habitat characteristics recorded in FY00 are summarized in this report. The influence of Fena Reservoir on migrating fauna continues to be assessed. The results of the FY97 study were used as baseline data in comparative analyses with data collected in FY00. A local artist was commissioned to create a poster showcasing the native freshwater fauna of Guam. The working draft of a freshwater field guide continues to be updated.

**BACKGROUND**

- 1) Maintaining high quality watershed ecosystems is essential to protecting healthy coastal areas that support fisheries. In order to monitor the quality of Guam's watershed ecosystems, biological and physical baseline data were collected from the following four watersheds in FY97: 1) Fena; 2) Manenggon; 3) Ylig; and 4) Pago. Annual monitoring of these parameters is an important part of the effective watershed management that is necessary for the protection of Guam's coastal resources. Further explanation regarding the purpose of this project and additional background information can be found in Freshwater Monitoring Annual Report F-1R-5, F-2, 1-1.
- 2) Knowledge of and interest in freshwater species is limited on Guam. To increase awareness of these important organisms and their habitats, educational materials, such as a field guide and posters, need to be developed. Additionally, some native species, such as the flagtail *Kuhlia rupestris*, are ideal candidates for a recreational fishery.

**OBJECTIVES**

- 1) To implement a long-term freshwater monitoring program.
- 2) To heighten public interest in native species found in freshwater ecosystems and to develop a recreational fishery based on native species in Guam's rivers.

**PROCEDURES**

Species composition, organism density, and habitat characteristics were collected in the rivers identified as experimental and controls were chosen in FY97, using the methods described in the annual report of FY97. The experimental rivers, located above Fena Reservoir included: Almagosa; Maulap; and Sadog. The control rivers included: Maagas; Manenggon; Pago; and

Ylig. When possible, analysis of variance was used for data comparison of the streams. However, when the data did not conform to the assumptions of ANOVA, appropriate nonparametric tests were performed (StatView 4.51, Abacus Concepts, Inc., Berkeley, California, 94704-1014).

A scope of work for a freshwater poster was developed in February of FY00, and made available to 5 interested local artists. Four artists submitted examples of work and bids. An artist was chosen in March and began working with DAWR staff in April. The artist was taken into the field on 3 occasions, in order to view and photograph the fauna in their habitats. The artist was also provided live and dead specimens, and information on behavior and placement in a river setting. The painting is 75% complete and should be finished in early FY01. At that time, price quotations for the printing of posters will be solicited. The development of a more extensive freshwater field guide continued in FY00. A digital camera and software were utilized in producing and editing photos of freshwater fauna. Photos taken by a professional photographer were reviewed and the option of commissioning professional photos continues to be explored.

## RESULTS

Significantly fewer species per square meter were surveyed in FY00 than in FY97 ( $P < 0.01$ , Kruskal-Wallis; Figure 1). Additionally, there were significantly fewer individuals per square meter in FY00 than in FY97 and FY98 ( $P < 0.001$ ,  $P < 0.05$ ; 1-way ANOVA; Figure 2).

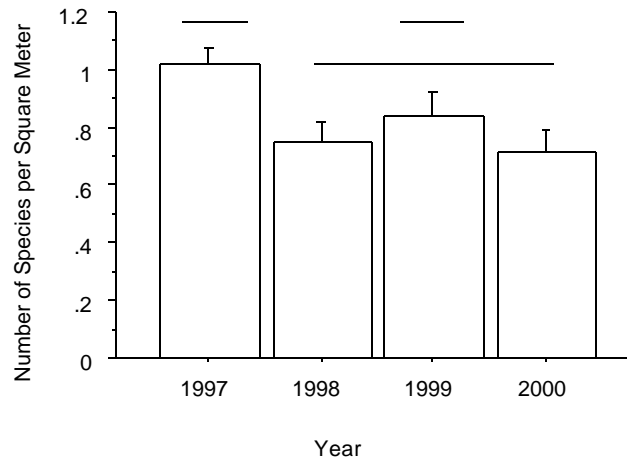


Figure 1. Mean number of species per square meter grouped by year. Densities are based on visual surveys. Nineteen ninety-seven (1997) serves as the baseline year. Error bars represent standard error of the means. Horizontal bars indicate no significant differences in densities between years.

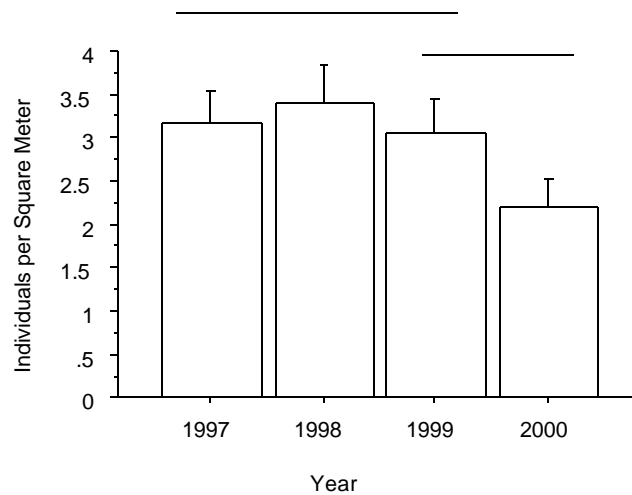


Figure 2. Mean number of individuals per square meter grouped by year. Densities are based on visual surveys. Nineteen ninety-seven (1997) serves as the baseline year. Error bars represent standard error of the means. Horizontal bars indicate no significant differences in densities between years.

Neither species density nor total density differed significantly between experimental and control streams ( $P > 0.05$ ; 1-way ANOVA, Mann-Whitney U) The gobies *Awaous guamensis* and *Stiphodon* sp. (formerly known as *Stiphodon elegans*), and the freshwater prawn *Macrobrachium lar* were seen in both control and experimental streams (Table 1).

Table 1. Species distribution in experimental and control streams determined by visual surveys. An "x" indicates the presence of a species and an empty cell indicates its absence.

Species	Experimental Streams			Control Streams			
	Almagosa	Maulap	Sadog	Maagas	Manenggon	Pago	Ylig
<i>Anguilla marmorata</i>	x						
<i>Awaous guamensis</i>	x		x	x	x	x	x
<i>Clarias</i> sp.				x			
<i>Eleotris fusca</i>							x
<i>Kuhlia rupestris</i>				x	x	x	x
<i>Macrobrachium lar</i>	x	x	x	x	x		
<i>Oreochromis mossambicus</i>	x		x				
<i>Stiphodon</i> sp.	x				x	x	x
<i>Tilapia zillii</i>				x			

Individually, densities of *A. guamensis*, *M. lar*, and *Stiphodon* sp. did not differ significantly between experimental and control rivers ( $P > 0.05$ ; 1-way ANOVA; Mann-Whitney U). The

flagtail *Kuhlia rupestris*, the walking catfish *Clarias* sp., the sleeper goby *Eleotris fusca*, and the tilapia *Tilapia zillii* were present only in control streams (Table 1). The eel *Anguilla marmorata* and the tilapia *Oreochromis mossambicus* were present only in experimental streams (Table 1). The gobies *Mugilogobius cavifrons*, *Sicyopus* sp. (formerly known as *Sicyopus leprurus*), *Sicyopterus macrostetholepis*, *Stenogobius* sp., and *Stiphodon percnopterygionus*, and the tucunare *Cichla ocellaris* were not recorded in any surveys. No single species was seen in all streams surveyed (Table 1).

## DISCUSSION

Although mean species density was significantly higher in FY97 than in FY00, a greater number of species were seen in FY00 (9) than in FY97 (8). Additionally, the number of species per square meter has not differed significantly for the past 3 years. Significantly fewer individuals per square meter were also seen in FY00 than in FY97, but total density did not differ significantly for the past 2 years. Although four years of data collection is not enough time to see broad trends, total densities and species composition appears relatively consistent.

Densities for the three species present in both experimental and control streams did not differ significantly between conditions. However, densities of *Stiphodon* sp. were significantly higher in control streams than in experimental streams in both FY99 and FY97. It is too soon to tell whether these data reflect general trends associated with the presence of the dam or if differences are due to natural variation.

Four species were seen only in control streams. The dam probably excludes flagtails because it is not morphologically adapted for climbing. It is also absent above natural waterfalls in most streams of Guam. The *Clarias* or Walking catfish, which is an introduced species, may have also been impeded by the dam. Alternatively, sleeper gobies can scale waterfalls and are certainly under-represented in our visual surveys due to their cryptic nature. *Tilapia zillii* have been seen above the dam in previous surveys. The snail family Neritidae has not been seen above the dam since surveys began in 1996. However, they are not prevented from scaling vertical heights anatomically. One individual was seen on the spillway in 1996 and nerites have been seen above waterfalls in other streams. Species of nerites often exhibit rheotaxis and thus may terminate their upstream migration in the absence of a perceptible current dampened by the presence of the lake (Barry Smith, personal communication). Nerite numbers may also be reduced by predation. The exposed surface of the spillway may leave the nerites more vulnerable to predation by migratory shorebirds. In FY00, a brief survey of the spillway was inconclusive. Neither adult snails nor egg sacs were seen at the upper edge of the spillway, and no shell fragments were seen on the spillway. Periodic surveys of both areas will be conducted in FY01. *Anguilla marmorata* and *Oreochromis mossambicus* were seen only in experimental rivers. However, they have not been restricted to areas above the dam. They were seen in control rivers in FY99. Eels were also under-represented in surveys due to their nocturnal activity.

## RECOMMENDATIONS

A new 5-year plan for this project commenced in FY00. Most of the objectives remained the same, but new emphasis was placed on increasing public interest in freshwater fisheries.

This study continues to suggest that dams and reservoirs in tropical streams may not have severe effects on most species. However, these ecosystems are complex and there can be high variability between streams and between years. Annual monitoring of these watersheds should continue in order to clarify ambiguous results seen so far.

Literature compiled for the freshwater field guide should continue to be condensed into a practical form. Digital technology can be utilized for production of the guide.

A poster showcasing the native freshwater fauna and habitats of Guam will be completed in early FY01. Plans for a follow-up poster showcasing freshwater fishing on Guam should be developed.

This project should continue integrating freshwater monitoring with coral reef protection. This entails investigating the rate of erosion and sediment loading in our streams in order to obtain a clearer understanding of depositional rates on adjacent coral reefs. Initial efforts have begun in the Ugum Watershed through a project initiated by the Guam Water Planning Committee. Various methods of monitoring by an interagency team, including measuring turbidity and soil depositional rates, will be implemented to test the effectiveness of a tree-planting project in the watershed. Two other projects, administered by the University of Guam Marine Laboratory and the U.S. Geological Survey, respectively, will focus on the dynamics of two additional watersheds. Information from all three projects will help to identify the magnitude of impacts on the reef and effective ways to mitigate them.

### **PROJECT COST**

The estimated cost of the project is \$50,000.

This report was prepared by Trina J. Leberer, Fisheries Biologist III.

**JOB PROGRESS REPORT  
RESEARCH PROJECT SEGMENT**

**STATE:** Territory of Guam

**PROJECT NO.:** F-1R-8  
**SUB-PROJECT NO.:** F-2  
**STUDY NO.:** 1  
**JOB NO.:** 2

**STUDY:** Monitoring of Guam's Freshwater Fisheries

**JOB TITLE:** Fisheries Studies in Fena Lake (2440)

**PERIOD COVERED:** October 1, 1999 to September 30, 2000

**SUMMARY**

A stock assessment of Fena Reservoir began in FY00. Several methods of fish capture were attempted and evaluated. Discussions with the Department of the Navy to allow public access to the lake are ongoing.

**BACKGROUND**

Fena Reservoir was completed in 1951 to provide a dependable water supply for the U.S. Navy on Guam (BioSystems Analysis, 1990). By 1955, pondweed (*Potamogeton crispus*) and bladderwort (*Utricularia* sp.) had become established near the banks and especially in the shallow waters at the back end of the reservoir in depths of 15 ft. or less (Brock and Yamaguchi, 1955). In order to control these plants, 2 species of tilapia (*Oreochromis mossambicus* in 1956, *Tilapia zillii* most likely in 1957) were introduced into the reservoir (Brock and Takata, 1956; Nelson and Eldredge, 1991). Between 1962 and 1968 other species, including tucunare (*Cichla ocellaris*), small mouth bass (*Micropterus dolomieu*), large mouth bass (*Micropterus salmoides*), and channel catfish (*Ictalurus punctatus*) were introduced to control the stunting of the tilapia and/or to increase angling opportunities. Mosquito fish (*Gambusia affinis*; some time before 1955) and guppies (*Poecilia reticulata*; in 1956) were also introduced to the reservoir for the control of mosquitoes (Brock and Yamaguchi, 1955; Brock and Takata, 1956). Surveys to monitor the status of the introduced species ended in 1969, and since that time, no stock assessments have been conducted in Fena Reservoir. Additionally, other species, such as unwanted aquarium pets, have been deposited in the lake over the years. In order to determine the status of both native and introduced species, an extensive stock assessment project was begun in FY00. Preparations began in FY98 and continued in FY99, with the research of various methods, the development of a project plan, and the design and purchase of the necessary equipment, including a weir-like net, electric trolling motors (gasoline powered motors are prohibited in the reservoir), and deep-cycle marine batteries.

The program allowing limited recreational fishing at Fena Reservoir was suspended on February 21, 1998 due to a problem with program funds. Since that time, the Navy has been contacted periodically about reestablishing the program. At present, there are no plans to reinstate the program because of safety issues involving explosive arcs. However, there is a possibility that a waiver may be requested.

## OBJECTIVES

To work with the Department of the Navy to restore public access to Fena Lake, determine the species composition and status of stocks in Fena Lake, and develop a management plan for a recreational fishery on the lake.

## PROCEDURES

Preparations for the stock assessment of Fena Reservoir commenced in FY98 and continued in FY99. The stock assessment began in January of FY00. Because the lake is contained in a narrow, deep canyon, protecting it from wind-driven turnover, there is an anoxic layer on the bottom, averaging approximately 10 m (33 ft.) in depth. Thus, initial catch efforts were concentrated near the mouths of the Almagosa, Maulap, and Sadog Rivers, along the perimeter, and in the upper third of the lake, where oxygen was prevalent. Fish were caught in several ways. On 3 occasions, a weir-like net was set and baited minnow traps were placed on the bottom, both near shore and in deeper water. Both were left for approximately 2 hours and then checked for fish. On 4 occasions, we cast with hook and line and a talaya (cast net) near the river mouths for an average of 3 hours. Additionally, we trolled for fish in the main bowl of the reservoir and on the way to and from the rivers. Captured fish were weighed with a spring scale, measured with a ruler or measuring board, and sexed. Four to six scales were taken mid-body, from just above the lateral line, and placed in a plastic bag with an i.d. tag. One of the pelvic fins was then clipped (normally the left) and the fish was returned to the lake. Scales were examined with a dissecting scope and the average number of annuli was recorded. Statistical analyses were performed with Statview 4.51 (1995, Abacus Concepts, Inc., Berkeley, CA).

Negotiations with the Department of the Navy to restore public access to Fena Lake are ongoing. The situation is made difficult by security concerns, a high turnover of key personnel and an inability to secure a guarantee from the Navy to long-term public access. Until the question of reliable public access is resolved, the development of a management plan for a recreational fishery on the lake cannot proceed. However, a stock assessment of the reservoir, which is required for the development of a management plan, has already begun.

## RESULTS

A total of 75 fish were caught in Fena Reservoir between January 25 and August 14, 2000. Ninety-seven percent of those caught were the tilapia *Oreochromis mossambicus* and 3% were *Tilapia zillii*. The majority of individuals were < 125 mm in length and approximately 2 years in age. However, ages were difficult to determine using scale annuli and should be viewed as approximate. Females and males were not significantly different in length (1-way ANOVA,  $P = 0.425$ ) or weight (1-way ANOVA,  $P = 0.320$ ), but individuals whose sex was unidentifiable were significantly smaller than both sexes (1-way ANOVA,  $P < 0.001$ ). Individuals caught by nets (talaya and weir) were significantly smaller than fish caught by casting with hook and line and trolling (1-way ANOVA,  $P < 0.05$ ).

## DISCUSSION

Currently, no marked fish have been recaptured, so no population estimates can be made at this time. The stock assessment has been only moderately successful up to now. Although the two types of tilapia were the only species caught, several peacock bass (*Cichla ocellaris*) and native eels (*Anguilla marmorata*) were seen. New catch methods, such as electrofishing, and improvements to existing ones will continue to be explored in this ongoing project.

## **RECOMMENDATIONS**

The stock assessment begun in FY00 should continue and include the search for unknown species as well as the determination of densities of known species.

Discussion with the U.S. Navy must continue in FY01, in order to reestablish public access to fishing at Fena Reservoir.

## **PROJECT COST**

The estimated cost of the project is \$15,000.

This report was prepared by Trina J. Leberer, Fisheries Biologist III.

## **LITERATURE CITED**

- BioSystems Analysis, Inc. 1990. Natural Resources Management Plan, U.S. Naval Magazine, Guam. BioSystems Analysis, Inc., Tiburon, California. 230 pp.
- Brock, V.E. and M. Takata. 1956. A limnological resurvey of Fena River Reservoir Guam, Marianas Islands. Division of Fish and Game, Board of Commissioners of Agriculture and Forestry, Territory of Hawaii. 9 pp.
- Brock, V.E. and Y. Yamaguchi. 1955. A limnological survey of Fena River Reservoir Guam, Marianas Islands. Division of Fish and Game, Board of Commissioners of Agriculture and Forestry, Territory of Hawaii. 16 pp.
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