JOB PROGRESS REPORT
RESEARCH PROJECT SEGMENT

STATE: Territory of Guam

PROJECT NO.: F-1R-7
SUB-PROJECT NO.: F-2
STUDY NO.: 1
JOB NO.: 1

JOB TITLE: Freshwater Monitoring (2440)

PERIOD COVERED: October 1, 1998 to September 30, 1999

SUMMARY

During FY99, the ongoing monitoring of four previously selected watersheds continued. Faunal counts and habitat characteristics recorded in FY99 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 FY99. Preparations were completed in FY99 for a stock assessment of Fena Reservoir to begin in FY00. A weir-like net, trolling motors, and deep-cycle marine batteries were purchased and tested. The working draft of a freshwater field guide continues to be updated. A digital camera and software purchased in FY99 will be used to produce and edit photos for the field guide. The option of commissioning photos from a professional photographer is also being explored.

BACKGROUND

1-2. 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 essential for the effective watershed management 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).

3. Fena Reservoir was completed in 1951 to provide a dependable water supply for the U.S. Navy on Guam (BioSystems Analysis, 1990). By 1955, pond weed (*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 (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 will commence 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.

4. 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.

OBJECTIVES

1. Continue to survey the four watersheds chosen in FY97 in order to monitor the health of stream ecosystems on Guam.

2. Continue to monitor the effect of Fena Reservoir on faunal migration.

3. Continue preparations for a stock assessment of Fena Reservoir.

4. Continue the development of a more extensive freshwater field guide, building on information collected in FY97 and FY98.

PROCEDURES

1-2. Species composition, organism density, and habitat characteristics were collected in the experimental and control rivers chosen in FY97, using the methods described in the annual report of FY97. The experimental rivers, located above Fena Reservoir, are: the Almagosa River, the Maulap River, and the Sadog River. The control rivers are: the Maagas River, the Manenggon River, the Pago River, and the Ylig River. 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).

3. Preparations for the stock assessment of Fena Reservoir commenced in FY98 and continued in FY99. Various methods were researched and potential sites were explored. A mark-recapture method was chosen and some of the required materials were procured. The stock assessment was to have commenced in the dry season of FY99 (January - May) but was delayed because of problems with the availability of required watercraft. Methods and materials were tested in the clear water of Cocos Lagoon prior to implementation of the project in the murky waters of Fena Reservoir. The stock assessment will commence in January of FY00.

4. The development of a more extensive freshwater field guide continued in FY99. A digital camera and software were purchased for use in producing and editing photos of freshwater fauna. Photos taken by a professional photographer were reviewed and the option of commissioning professional photos is being explored.

RESULTS

Significantly fewer species per square meter were seen in all rivers in FY99 than in FY97 ($P < 0.05$; Mann-Whitney U) (no significant difference between species density in FY98 and FY99; $P > 0.05$, 1-way ANOVA). However, the number of species seen in FY99 was higher than in FY97. Eleven species were seen in surveys in FY99 (Table 1), while 8 species were seen in surveys in FY97 (8 species were also seen in FY98). Additionally, there was no significant difference between FY99 and both FY97 and FY98 for total density in all rivers ($P > 0.05$; 1-way ANOVA). The gobies *Mugilogobius cavifrons*, *Sicyopus* sp. (formerly known as *Sicyopus leprurus*), and *Sicyopterus macrostetholepis*, and the tucunare *Cichla ocellaris* were not recorded in any surveys. No single species was seen in all streams surveyed.

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.

	Experimental Streams			**Control Streams**			
Species	Almagosa	Maulap	Sadog	Maagas	Manenggon	Pago	Ylig
Anguilla marmorata				x	x		
Awaous guamensis	x	x	x	x		x	x
Caranx sexfasciatus						x	
Eleotris fusca							x
Kuhlia rupestris				x	x	x	x
Lutjanus argentimaculatus						x	
Macrobrachium lar	x	x	x		x		x
Oreochromis mossambicus			x	x		x	
Stenogobius sp.						x	
Stiphodon sp.	x		x		x	x	x
Tilapia zillii			x				

Although species density did not differ significantly between experimental and control streams ($P > 0.05$; 1-way ANOVA), the total densities in experimental and control streams were significantly different ($P < 0.001$; Mann-Whitney U) (Fig. 1). The gobies *Awaous guamensis* and *Stiphodon* sp. (formerly known as *Stiphodon elegans*), the tilapia *Oreochromis mossambicus*, and the freshwater prawn *Macrobrachium lar* were seen in both control and experimental streams. Individually, densities of *A. guamensis*, *O. mossambicus* and *M. lar* did not differ significantly between experimental and control rivers ($P > 0.05$; Mann-Whitney U) but densities of *Stiphodon* sp. were significantly higher in the control streams ($P < 0.01$; Mann-Whitney U). The flagtail *Kuhlia rupestris*, the eel

Anguilla marmorata, the sleeper goby *Eleotris fusca*, the goby *Stenogobius* sp., two primarily marine species, the jack *Caranx sexfasciatus* and the snapper *Lutjanus argentimaculatus*, and neritid snails were present only in control streams. The tilapia *Tilapia zillii* was present only in experimental streams.

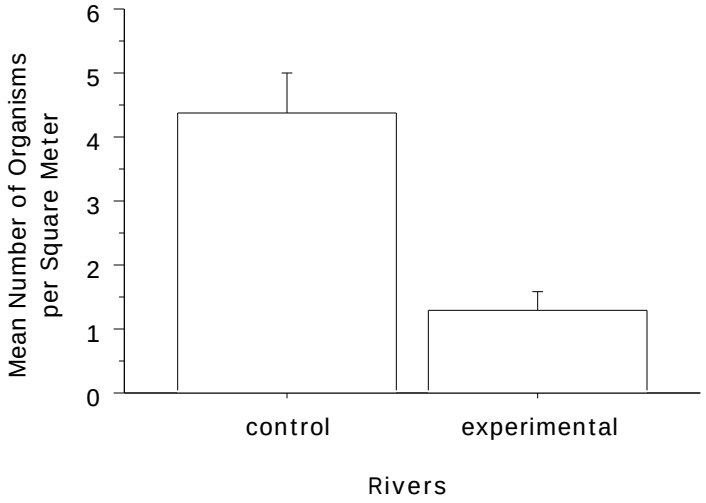

Figure 1. Mean number of organisms per square meter grouped by rivers. Densities are based on visual surveys. Experimental rivers are located above Fena Reservoir. Error bars represent standard error of the means.

DISCUSSION

Mean species density was significantly lower for all rivers combined in FY99 than in FY97, but a greater number of species were seen in FY99 than in FY97 (Table 1). Total density did not differ significantly between years. Although three years of data collection is not enough time to see broad trends, total densities and species composition appear quite consistent. Species density was significantly higher in FY97, but it has remained consistent for the past 2 years.

Densities for several species did not differ significantly between experimental and control streams. However, densities of *Stiphodon* sp. were significantly higher in control streams than in experimental streams. This also occurred in FY97 but there was no significant difference between *Stiphodon* densities in control and experimental streams in FY98. 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.

Six species and one family of snails 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. Eels have been seen above the reservoir but not in surveyed sites. Eels and sleeper gobies were certainly under-represented in our daytime, visual surveys due to the nocturnal activity of eels and the cryptic nature of sleeper gobies. *Stenogobius* sp. is normally found in the lower reaches of streams and would not be expected to exist in the experimental streams. The two primarily marine species, the jack *Caranx sexfasciatus* and the snapper *Lutjanus argentimaculatus*, are more often encountered in the lower reaches of streams, but they have also been seen much further upstream in rivers without major barriers (i.e. large waterfalls, dams, etc.).

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 FY/00, a brief survey of the spillway will be conducted. The presence of adult snails or egg sacs at the upper edge of the spillway will suggest that the lack of current due to the lake may be limiting the migration of the snails further upstream. Alternatively, the presence of shell fragments on the spillway will suggest that predation may be more important.

Tilapia zillii was seen only in experimental rivers. However, it has not been restricted to areas above the dam. It was seen in control rivers in FY98.

RECOMMENDATIONS

A new 5-year plan for this project will commence in FY00. Most of the objectives remain the same, but new emphasis will be 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.

A stock assessment will be conducted in FY00. The assessment should include the search for unknown species as well as the determination of densities of known species.

Discussion with the U.S. Navy will be required in FY00, in order to reestablish public access to fishing at Fena Reservoir.

Literature compiled for the freshwater field guide should be condensed into a practical form. Digital technology should be explored for production of the guide.

A poster showcasing the native freshwater fauna and habitats of Guam should be produced in FY00. Plans for a follow-up poster showcasing freshwater fishing on Guam should also be developed.

This project should move towards 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.

PROJECT COST

The estimated cost for this project is $72,000.

LITERATURE CITED

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