EXPERIMENTAL STOCKING AND COMMUNITY MANAGEMENT OF TILAPIA IN LAKE SATOALEPAI, SAMOA

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Introduction

In Samoa, fishing has been a traditional practice, providing food, employment and economic benefits to many people. However, in recent years, it has been realised that fisheries resources, although renewable, are not infinite, and need to be properly managed if their contribution to the nutritional, economic and social well-being of the growing population is to be sustained.

The report 'Samoa Aquaculture Development Plan 2005–2010', states that,

> *…aquaculture development in Samoa has mostly been in the trial stages. Setbacks to progress include poor maintenance and management, limited manpower and facilities and insufficient funding. In addition, there have been high costs associated with the importation of organisms and feeds, limited suitable land area for construction of culture ponds, as well as unforeseen natural disasters.*

Similar scenarios in aquaculture development are present in many Pacific Island countries and territories with the exception of a few (e.g. New Caledonia, the lead shrimp farming area in the region).

In 1999, a project by AusAID and the Samoa Fisheries Division (SFD) developed a framework for the better management of fisheries resources. This framework enabled SFD to reduce fishing pressure on the overexploited nearshore fishery resources by initiating aquaculture projects, which included the stocking of natural lakes and ponds. In addition, the first SPC programme visit on aquaculture to Samoa (in late 2003), recommended that new approaches to fisheries management, embracing conservation and environmental, as well social and economic considerations, were urgently needed. SPC was asked to develop a proposal for the better utilisation and management of lakes and ponds, including Lake Satoalepai on Savaii. Subsequently, a mini project entitled, 'Experimental stocking and community management of tilapia in Lake Satoalepai, Samoa' was developed by SFD in collaboration with SPC, and conducted as part of the ACIAR-funded project, 'Sustainable aquaculture development in the Pacific Islands Region and northern Australia'. The mini project provided support for SPC's regional aquaculture initiatives in PICTs, where stocking tilapia fingerlings is a means of increasing fish production to improve food security.

Background to Lake Satoalepai

Lake Satoalepai is situated between the villages of Safai and Satoalepai in the Matautu District on the southwestern coast of Savaii Island. There are no reports regarding the formation of this lake, although according to SFD staff and others, it was formed as a result of the removal of soil and sand for road construction that was intended to link the villages to the port town of Salelologa in the late 1970s. Later, a feeder road was constructed through the centre of the lake to link the villages in the area, thus dividing the lake into two parts (Fig. 1). The lake area downstream near the sea (with an outlet that opens into the sea, thus exchanging seawater during high tide) is owned and managed by Safai village. The upstream area is owned and managed by Satoalepai village.

Upstream of the feeder road the lake is 100 m long at the roadside, 210 m on the opposite side, and about 250 m wide, giving a surface area of approximately 4 ha, with an average depth at mid low tide of 40 cm. The bottom of the lake at the road side consists of rocks and boulders and the inland side is muddy (30–40 cm deep) with remnant coral/limestone pinnacles. Three culverts, each approximately 1 m in diameter, were built into the road to allow water flow between tides and the continuous downstream flow due to spring water and also after rain-

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Figure 1: Aerial view showing the upstream and downstream sections of Lake Satoalepai, which is divided by the road. The black arrow indicates approximately where Lake Safa'i begins

fall. Freshwater springs are abundant in the lake on both sides while the seaward side (of feeder road) remains tidal and brackish.

Fresh fish is an expensive commodity and often in short supply in the area. Nearby lagoon reef resources are subject to high fishing pressure and are overexploited. Consequently, inland fisheries offer an alternative source of fish protein. Mozambique tilapia (*Oreochromis mossambicus*) was initially stocked in the lake in 1966. In 1994 and 2003, Nile tilapia (*O. niloticus*) was introduced into the lake to increase fish biomass as part of the SFD aquaculture extension programme. Subsequently, tilapias have become the most significant component of the lake's fish population and a major protein source and income earner for local people. Fishermen regularly catch tilapias using gillnets, fishing lines, cast nets, and with bare hands. Fishing activities have been banned for certain periods in the past. This occurred usually when the tilapia being caught was small and the fishing bans were imposed to allow stocks to recover. However, these bans or controls were not always strictly enforced.

According to SFD staff, some constraints to management of tilapia fishery in the lake include:

- Non-availability of information regarding past tilapia stockings (and so a difficulty in estimating stock size and also in setting management guidelines for the fishery in the lake);
- Lack of set guidelines for managing the tilapia fishery;
- Overexploitation of the lake due to its use by almost all community members with no controls or regulations or quotas;
- No consistent supply of tilapia fingerlings for restocking; and
- Lack of skilled extension staff and capital.

Collaborative work involving SFD and SPC's Aquaculture Section began as part of a small grant to purchase tilapia hatchery equipment in December 2003. This led to improvement in tilapia fingerling production. SFD staff also attended tilapia training workshops (conducted by SPC) in various aspects of tilapia and freshwater prawn culture in Apia as well as in Fiji. Tilapia fingerlings are now produced in tanks, hapas and earthen ponds in sufficient quantities for stocking ponds and lakes.

In the past, restocking tilapias in the lake was not monitored and there were no controls or guidelines on fish harvesting practices or established protocols for managing the lake's fishery. This mini project was developed in order to:

1. evaluate growth performance and survival of stocked *O. niloticus* in Lake Satoalepai;
2. conduct village consultations to develop a co-management regime for the SFD tilapia restocking programme; and
3. increase SFD staff skills in tilapia restocking, including hatchery operations, fingerling grow-out, and fingerling transport.

Project activities

The project began in late July 2006 by a visit from SPC staff who supervised and assisted in carrying out the following activities.

- Consultations with Satoalepai village council. Council members agreed to participate and assist in the implementation of project activities, which involved banning all fishing in the lake for the duration of the trial, and providing manpower for sampling, measuring water quality parameters, and security for the fish. Following this meeting, a survey of the lake was carried out, which indicated that *O. mossambicus* was the most dominant species present followed by freshwater prawns, probably *Palaemon* species. Several indigenous species were also present, including mullet, half-beak and mud crabs.

- Preparation of equipment for seining, holding, conditioning and transport of fingerlings were carried out in Apia. A total of 10,000 fingerlings were seined, graded, and conditioned in hapas (for 36 hours) in cement tanks at SFD's hatchery. The fingerlings were transferred to a 2000-L fibreglass tank, filled with 1,500 L of fresh water and fitted with air hoses connected to an air pump. The tank was loaded on a 7-t truck and transported to the lake.

- Fingerling tagging (clipping of the right pelvic fin with a pair of scissors) was carried on the lake's bank in the compound of the village mayor's residence. Members of the village council released the first set of tagged fingerlings into the lake (Fig. 2).

- Individual weights and standard lengths of a sample of 200 fingerlings were recorded, and fingerlings were afterwards released into the lake. This sampling exercise was carried out monthly for the duration of the trial by SFD staff.

- Tissues samples from 30 individuals of *O. niloticus* and *O. mossambicus* were collected and preserved in 70% ethanol. These were sent to Queensland University of Technology, in Brisbane Australia for genetic studies (i.e. to determine whether there has been any introgression of *O. mossambicus* genes into *O. niloticus* or vice versa).

Figure 2: Release of tagged *Oreochromis niloticus* fingerlings into Lake Satoalepai

The final sampling of the stocked Nile tilapia was carried out in April 2007 by two of the authors (Satya Nandlal and Cathy Hair), SFD staff and Satoalepai villagers. Prior to sampling, consultations were carried out with the village council. We were informed that the lake flooded in October 2006, and that the flood water flowed over the road (from the stocked section of the lake to the lower side of the lake) and the fencing screens from the three culverts were broken and washed away, allowing fish to move freely in both directions. After the flood, the ban on fishing was partially lifted, with handlining allowed in the lake (inland side of feeder road) and gillnets in the lower side of the lake.

Tilapia harvesting was carried out over three days using a 100-m gillnet (mesh size 3 in) on both sides of the lake. All *O. niloticus* that were caught were sampled for total length and body weight. Wild *O. mossambicus* (bycatch) were counted and their total weight recorded. All other bycatch species were identified and recorded.

Additional sampling was restricted because of spring tides, which prevented sampling in the lake during the night as scheduled. Furthermore, the lake water was too deep to allow for cast netting and too murky to be able to see fish clearly.

Results

Final sampling results are summarised below.

1. Nine netting drives were carried out resulting in a total catch of 138 Nile tilapia: 121 tagged fish with a mean weight of 141 g (see Fig. 3), 14 large fish from previous stockings (i.e. 2005 or earlier)

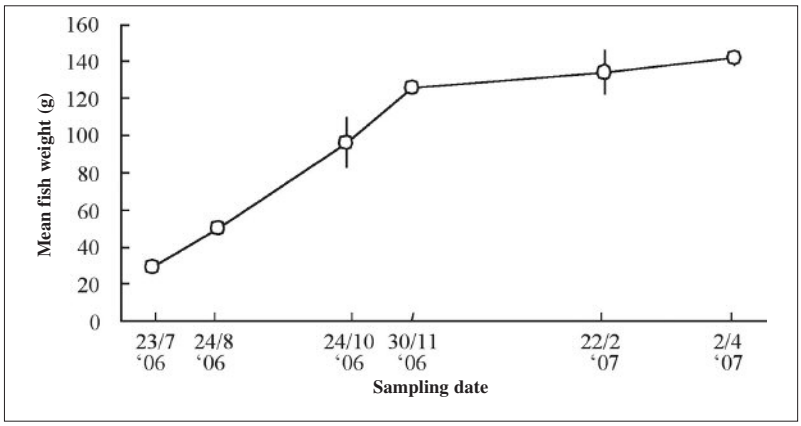
and 3 fingerlings. Netting drives involved partially seining a portion of the lake whereby the fish were driven into the nets by beating the water. Some fish hide in the mud at the base of the lead line and are caught by hands. This is the preferred method of catching tilapia in 1–1.5 meter deep water by the local fishers.

2. A total of 171 wild *O. mossambicus* were caught, with a mean weight of 160 g each. Other smaller fish were caught (e.g. juvenile mullet, milkfish, trevally and half beaks).

3. From visual observations, there appeared to be an increase in the population of *O. niloticus* following the restocking.

4. The average weight of tagged *O. niloticus* (141 g) is an acceptable size considering the lake environment and more so importantly, the people consider this an edible size. Smaller *O. mossambicus* (50–80 g) are regularly caught and consumed by villagers, and residents of Satoalepai village expressed a preference for *O. mossambicus*.

5. A complete technical report is being prepared and will be available on request.



Discussion

Growth of tagged fish in the lake was 0.44 g/day. This growth rate is low but is an acceptable size given the overall condition of the lake environment (i.e., clear water indicating less primary production in the lake). The total weight at stocking was approximately 298 kg and based on average size at final sampling of 140 g, a net gain of 1,143 kg was achieved which is a significant volume of fish for the local people. There was also an increase in population of *O. niloticus* after the stocking based on our observations during the final sampling and was also obvious from the enthusiasm and happiness of the villagers of saying there is 'more fish' in the lake now. From the data collected, it was difficult to estimate survival rates of the stocked tilapia; however, the observation of large numbers of *O. niloticus* is a good indicator of high survival rates.

It should be noted that *O. mossambicus* is a pest species in many areas due to its rapid growth and reproduction; it quickly populates water bodies with large numbers of small fish. Interestingly, the *O. mossambicus* harvested during the final sampling (mean weight 160 g) were quite large. There were people seen catching *O. mossambicus* by hand, cooking and consuming these fish. The fishing ban that had been in place (although not properly enforced) may have also contributed towards allowing Mozambique tilapia to grow to larger sizes in the lake.

Figure 3: Growth of tagged tilapia in Lake Satoalepai during the study

Figure 4: *O. niloticus* (right), *O. mossambicus* (left) and a hybridized tilapia (centre) collected from Lake Satoalepai during the final sampling trip

SFD staff raised concerns that introduced *O. mossambicus* prey on native fish fry and eggs, thus reducing their populations. More data would be needed to quantify the effects of *O. mossambicus* on ecological processes occurring in the lake such as food web structure and energy flows. This needs to be ascertained scientifically, but was beyond the scope of this project.

During the final survey, we observed some *O. niloticus* showing signs of hybridisation with *O. mossambicus* (Fig. 4). This may be due to breeding between *O. niloticus* (stocked prior to this project) and *O. mossambicus*. Further investigations would need to be carried out to confirm this.

Nile tilapia was selected as a suitable species for stocking because it has a faster growth rate and matures at a larger size compared with other tilapias. Other factors contributing to the choice of *O. niloticus* include: it was already present in the lake; fingerlings were available; and this species is part of SFD's strategy to develop tilapia culture and demand for fish by villagers. In this project, 10,000 tilapia juveniles were stocked. SFD stocked a further 5000 three months after the sampling trip. There is a need to collect data (fish size and numbers caught) on the catch resulting from the restocking effort in order to monitor its success. It is not known if the tilapia stocked in the lake could become a self-sustaining population. Several *O. niloticus* fingerlings were caught after considerable effort using a seine net, which was problematic due to debris and the uneven nature of the lake bottom. More effort should be made to quantify the *O. niloticus* fingerling population in the lake. This will not only help determine if a self-sustaining population is present, but will also assist with setting management guidelines for the lake and its fish resources. The local fisheries officer should be trained to work with the villagers and be responsible for collecting the data.

One result of this project is an interest in tilapia aquaculture by villages. Several farmers are interested in developing tilapia pond culture. The study provided an opportunity for SFD staff to improve their skills in many aspects of stocking, including hatchery operations and transport of fingerlings, as well as sampling and monitoring. The impacts of the present project are not fully known and it is advisable to develop a plan and carry out activities for pond culture in stages. Before embarking on pond culture, prospective farmers need to consider local inputs (especially feed) that can be made by the villagers, since any project that involving heavy subsidies may not be sustainable in the long term.

This study provides baseline data to assist in the development of a management regime. As a result of the stocking, monitoring and sampling activities, Satoalepai villagers are in a better position to make well-considered decisions regarding the future of their tilapia fishery. Benefits could be gained from the establishment of a village committee with technical competence to oversee the lake's management and fishing practices, catch distribution and production systems suitable for the community under their local conditions. Appropriate management options include the use of larger mesh sized gillnets (> 3"), increased effort in catching all sizes of *O. mossambicus*, regular stocking of *O. niloticus*, placing moratoriums on fishing for certain periods, and enforcing a minimum size limit for *O. niloticus*. These techniques could be adapted with very little capital expenditure and may bring about an increase in fish yields from the lake. SFD and SPC can contribute to the development of a management plan by helping to develop a fishing accord into which all stakeholders should have input. It is critical that villagers benefiting from the project make the decisions and are involved from the initial stages.