A male GIFT strain (*Oreochromis niloticus*) used for breeding at the Highland Aquaculture Development Centre (HAQDEC) in the Aiyura Valley. In spite of the loss of the original breeding families, the broodstock at HAQDEC and in other regions of PNG have good formation and are currently adequate for fingerling production.

Chapter 4

Fingerling production and distribution in Papua New Guinea

Kine Mufuape, Johnney Soranzie, Hopa Simon, Tensa Yasang and Paul T. Smith

Introduction

The three main fish species cultured in inland PNG are common carp (*Cyprinus carpio*), the GIFT strain (*Oreochromis niloticus*) and the rainbow trout (*Oncorhynchus mykiss*). HAQDEC is the major hatchery in PNG, breeding common carp, GIFT fish and, to a lesser extent, Java carp (*Puntius gonionotus*) and distributing them throughout the country. It is located in the Aiyura Valley near Kainantu in EHP and operated by officers from the Eastern Highlands provincial government. The other major source of GIFT fingerlings is the Erap Aquaculture Centre, which is located in the lowlands near Lae and operated by the Food Security Branch of NDAL. The GIFT fingerlings it produces are mainly distributed to farmers in Morobe province. The Lake Pindi Yaundo Trout

Trout eggs in the hatchery at the Lake Pindi Yaundo Trout Farm and Hatchery

Farm and Hatchery in Simbu province, owned and managed by Mrs Betty Higgins, has been the major source of trout fingerlings and eyed eggs. However, trout farmers also obtain fry from smallholder hatcheries or wild caught trout. As for coastal aquaculture, Bismark Barramundi Farm in Madang is run by Mr Ian Middleton and produces barramundi and marine fish. There are also large crocodile farms in PNG that are successfully exporting product.

Juvenile crocodile at Mainland crocodile farm near Lae, Morobe province

Data was gathered on production and distribution patterns from the two major fingerling producers (i.e. HAQDEC in EHP and Erap Aquaculture Centre in Morobe province). In addition, a total of 19 small-scale hatcheries were surveyed. The survey was an opportunity to identify the needs, problems and future plans of hatchery operators.

Fingerling distribution by the main hatcheries

The most significant hatchery in PNG is HAQDEC, which has the capacity to produce more than 1 million fingerlings per year (HAQDEC 1999). However, fingerling production has been severely impacted by factors such as ageing infrastructure, lack of funding, loss of technical expertise, lack of hormones for maturation of carp broodstock (such as Ovaprin and LHS), intermittent electrical supply, no aeration in ponds, water shortages, theft of broodstock, lack of fish feed and a steady decline in the quality of broodstock. Consequently, the frequency of spawning has been curtailed and fingerling production has regularly suffered from high rates of mortality.

Quarantine facilities at HAQDEC include ponds, shed and tanks. GIFT fish came to quarantine in 1998 and were held there until released in late 2002.

Dead carp fingerlings in a pond at HAQDEC. High rates of mortality of common carp and GIFT fingerlings have occurred at HAQDEC because of problems such as lack of electricity for aerators, low water supplies, loss of technical expertise, lack of food for spawners, poor handling of fry and lack of hormones to induce spawning.

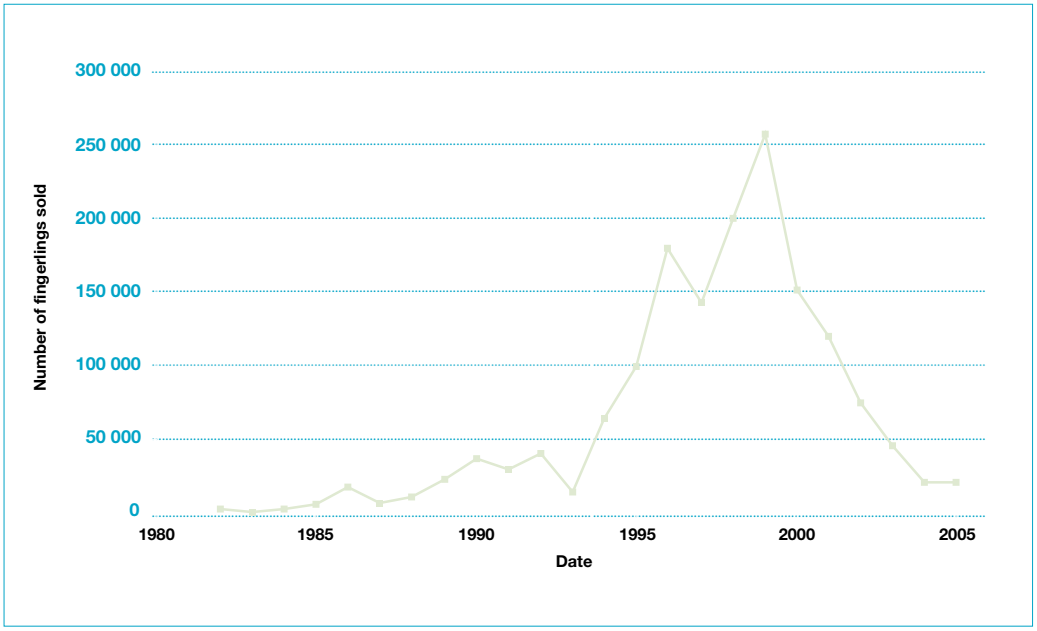
The following is an example of the results of natural spawning methods and the difficulties faced at HAQDEC. On 4 April 2005, 27 female and 54 male carp broodstock, which had been pre-conditioned, were placed in spawning tanks. The total weight of females before spawning was 14.28 kg, compared with 9.84 kg after spawning, so the resulting egg mass was 4.39 kg. The average weight of the female spawners was quite low. On 7 April 2005 the kakabans with eggs attached were removed from the spawning tanks and put into hatchery tanks. On the 29 April 2005 the number of surviving fries was only 63,840 and they were released into two nursery ponds. During this period HAQDEC was without electricity so the tanks could not be aerated. Also, the water supply was poor because of very high levels of suspended mud. The hatchery runs about six spawning runs per year of common carp.

The measure of success of the hatchery is fingerling distribution rather than fingerling production. Trends in distribution as determined by sales receipts are illustrated in Table 4.1 and

An example of broodstock of common carp at HAQDEC

Figure 4.1, revealing that a peak was reached in 1999 when 258,731 fingerlings of carp were distributed. Since then distribution figures decreased to 20,768 carp fingerlings in 2004 and remained steady in 2005. Distribution of GIFT fingerlings commenced in 2002–03, and the demand has been steadily increasing (Table 4.1; Figure 4.2) and is now greater than the demand for common carp.

Figure 4.1

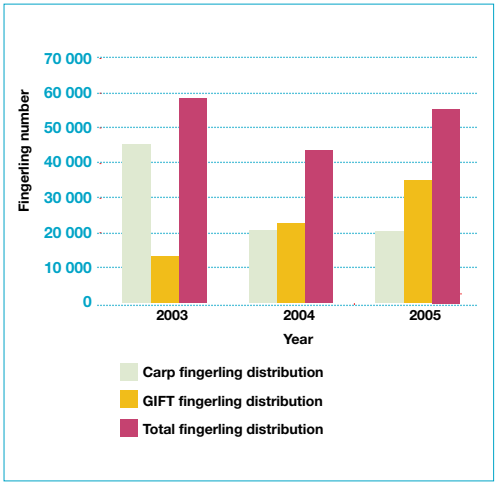


Trends in annual distribution of common carp fingerlings by HAQDEC

Table 4.1
Data on the annual distribution of carp and GIFT fingerlings from HAQDEC, as well as funding by EHPG to HAQDEC

Year	Carp fingerling distribution	GIFT fingerling distribution	Total fingerling distribution	Funding by EHPG (K)
1982	2,000		2,000	
1983	0		0	
1984	2,000		2,000	
1985	5,031		5,031	
1986	17,614		17,614	
1987	6,305		6,305	
1988	10,437		10,437	
1989	22,779		22,779	
1990	36,729		36,729	
1991	29,448		29,448	
1992	40,199		40,199	
1993	13,708		13,708	
1994	64,147		64,147	
1995	100,000		100,000	
1996	180,007		180,007	
1997	143,627		143,627	
1998	201,022		201,022	50,000
1999	258,731		258,731	100,000
2000	152,296		152,296	130,000
2001	120,139		120,139	80,000
2002	75,126		75,126	90,000
2003	45,368	13,302	58,670	150,000
2004	20,768	22,791	43,559	65,700
2005	20,494	34,982	55,476	59,700
2006	10,495 (6 months)	24,071 (6 months)	34,566 (6 months)	62,700

Figure 4.2



Comparison of sales of common carp and GIFT fish by HAQDEC during 2003–05

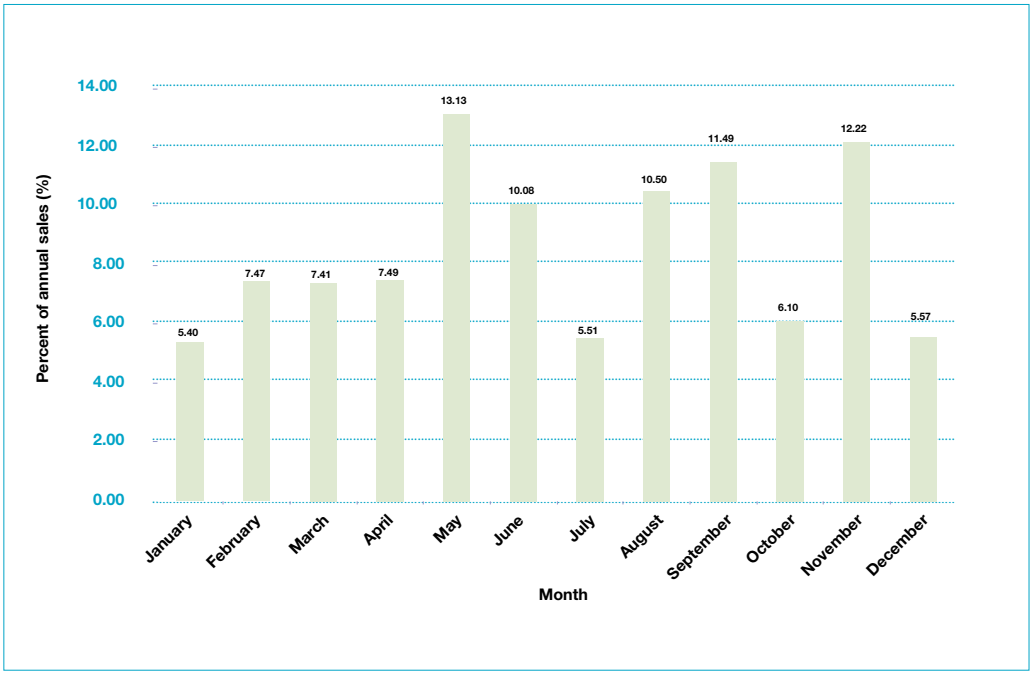
HAQDEC received technical and financial assistance from JICA from 1995 to 2002. During the expansionary phase at HAQDEC (1995–97), some K735,000 was contributed by JICA and K675,660 by National Planning (counterpart funding). This substantially increased the hatchery facilities, number of ponds and technical expertise. Since taking over management of HAQDEC, EHPG contributed an average of K90,700 per year in the 8 years from 1997 to 2005. Funding for HAQDEC from NFA ceased in 1996 and from JICA in 2002. In 1996 JICA estimated that an annual budget of K200,000 was required to produce 200,000 carp fingerlings per year (i.e. K1 per fingerling). In recent years the shortfall in funding has meant that HAQDEC has lacked the funds to pay for electricity and telephone bills, buy feed and fertiliser, repair vehicles and employ staff. The worst year was 2004. In order to supplement hatchery funds, HAQDEC started a program of growing out table-sized fish, with the result that 611 kg of table-sized GIFT fish were sold in 2005.

The original GIFT families were imported from the Philippines in 1998 and held in quarantine until they were allowed to be released to farmers in October 2002. Unfortunately, during that period the number of fish fell to approximately five. The staff at HAQDEC bred from those fish and started distributing them throughout PNG in October 2002. In 2005 the staff at HAQDEC implemented a plan to set up broodstock lines with five families of GIFT fish that they collected from various regions of PNG. The small head-to-body ratio, clean appearance and good colouring are all important features. However, deformities in GIFT fingerlings are quite common and, given the small gene pool in the original stock, it is likely that fresh families of broodstock will need to be imported if the stock is to be improved.

Example of male (upper) and female (lower) GIFT broodstock at HAQDEC (November 2005). The male fish has typical red colouration while the female fish has more pronounced stripes on the body.

Data on the monthly distribution of carp fingerlings during 1996–2005 (Figure 4.3) indicates that sales were spread throughout the year, with only 33% of sales made in the 5 months from December to April (inclusive). This period corresponds to the wet season in PNG. Mufuape (2000) determined from sales records that 70% of farmers purchase less than 50 fingerlings at a time, 7% purchase 50–100, 10% 100–500 and 6% >500. Over the 6 years from 2000 to 2005, a total of 484 shipments of fingerlings were made from HAQDEC to buyers (Table 4.2). In that period the average number of fingerlings sold by HAQDEC was 89,294 per year, with an average of 185 fingerlings per shipment. The main destination of the shipments was EHP, the home province of HAQDEC. Individual shipments to other provinces usually contained larger numbers of fingerlings than those to EHP, and these shipments were usually redistributed by NGOs, farmers or officers to farmers. The NGOs form a loose network of active Papua New Guineans who are associated with church missions and schools.

Figure 4.3



Average monthly distribution of common carp fingerlings from HAQDEC (1996–2005)

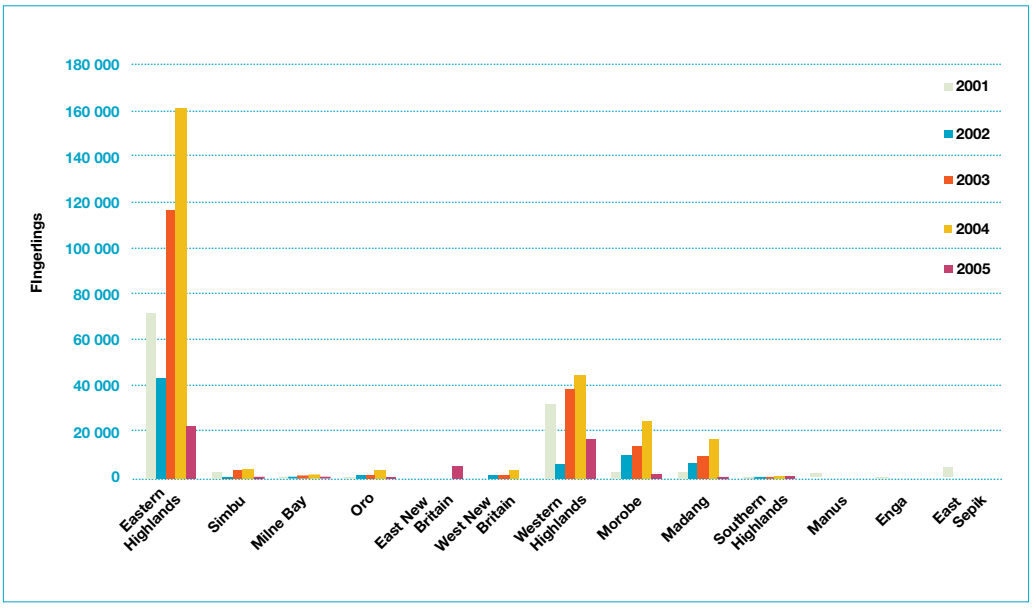
Table 4.2

Number of shipments of all fingerlings from HAQDEC (2000–05). Other provinces include Milne Bay, Oro, East New Britain, West New Britain, Manus, Enga, East Sepik, Gulf, National Capital District (NCD), Central and West Sepik.

Year	Eastern Highlands	Simbu	Western Highlands	Morobe	Madang	Southern Highlands	Other provinces	Total PNG
2000	328	24	49	35	21	3	39	**499**
2001	742	17	45	16	6	2	25	**853**
2002	265	9	18	15	5	8	7	**327**
2003	292	11	29	22	4	0	7	**365**
2004	557	18	17	3	1	1	8	**605**
2005	416	10	34	20	18	8	8	**514**

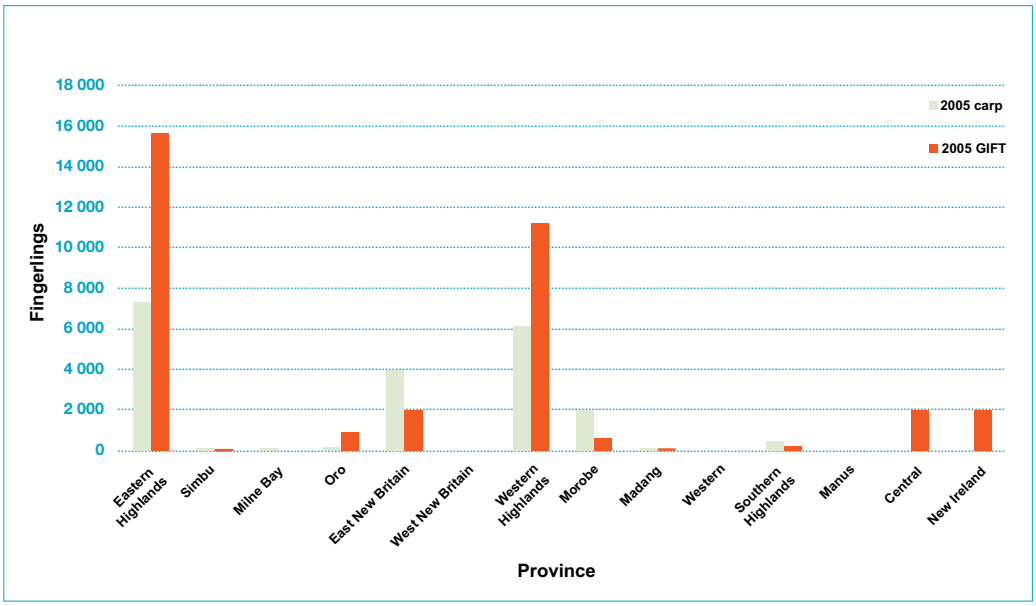
The results in Figure 4.4 agree with those in Table 4.2 and show that most of the fingerlings from HAQDEC were distributed in EHP, followed by Western Highlands, Morobe and Madang provinces. In most provinces the demand for GIFT fingerlings is stronger than for common carp (Figure 4.5). There are a few exceptions and this trend is being monitored by HAQDEC.

Figure 4.4



Numbers of fingerlings distributed to the provinces of PNG during 2001–05

Figure 4.5



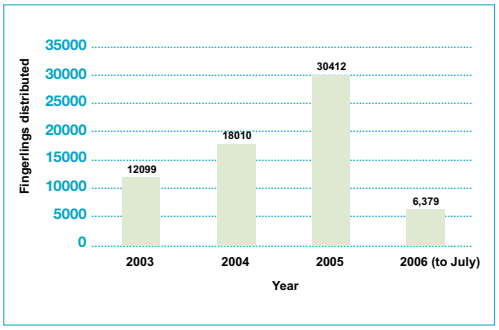
Comparison of destinations of carp and GIFT fingerlings from HAQDEC in 2005

The aquaculture facilities at NDAL at Erap include 10 fish ponds with a total area of 4,400 m^2. A small hatchery for producing GIFT fingerlings was also constructed in 2006. The water supply to the fish ponds depends on a rise in the water table to maintain levels rather than a more conventional intake system. This results in the ponds drying out during the dry months in the middle of the year.

One of the fish ponds at NDAL Aquaculture Station at Erap, Morobe province

Following the release of GIFT fish from quarantine at HAQDEC, the Aquaculture Centre at Erap has been a key source of fingerlings for farmers in Morobe province. The number of fingerlings that have been distributed from Erap has been rapidly increasing—more than doubling in the period 2003–05 (Figure 4.6).

Figure 4.6



Distribution of GIFT fingerlings from Erap to farmers

Observations of activities at smallholder hatcheries

The survey found that most of the small-scale hatcheries were ill-equipped and could not afford materials for packing and transporting fingerlings. Most fingerlings bought at small-scale hatcheries are put into buckets or containers with water and are often transported long distances to prepared ponds in this manner, the water being changed occasionally along the way. Some farmers, who had been trained at HAQDEC, had obtained fish hormones and used these at their farms for artificial breeding. However, fish hormones were absent from all inland hatcheries, including HAQDEC, from late 2002 to 2005. During this period all hatcheries used natural breeding methods to induce spawning. This usually involved conditioning males and females in separate tanks until they appeared ready to spawn. Most small-scale carp hatcheries fed broodstock with cooked sweet potato (kaukau) and, under these conditions, fingerling production was very low.

Fingerlings and eyed eggs of rainbow trout were not available from the Lake Pindi Yaundo Trout Hatchery during 2003–05. Distribution had ceased because of problems with trout feed and loss of broodstock. Imported feed was uneconomical and efforts by the hatchery to produce their own feed had resulted in high rates of mortality. So this approach had been abandoned. A few small trout hatcheries attempted to produce fingerlings and Koyuni trout hatchery in EHP was reopened in 2005 through a grant from NFA. Nevertheless, throughout the period of the study, trout farmers were unable to obtain consistent hatchery supply of trout fingerlings to stock ponds.

The cost of fish fingerlings varied according to the size and species of fish. Carp fingerlings could vary from as low as 20 toea (K0.20) to as much as K2.00 per fingerling. When GIFT fingerlings were first released they cost K0.50 and were in very high demand due to the fast growth and improved biology of the fish when compared to the other types of tilapia that had been previously introduced (*Oreochromis mossambica* and *Tilapia rendalli*). The average price of fingerlings from HAQDEC in 2005 was 20 toea for common carp and 30 toea for GIFT.

The survey showed that in 2002–03, 68.4% of the hatcheries cultured common carp, while 21.0% farmed rainbow trout and the remaining 10.6% farmed both common carp and rainbow trout or tilapia (Table 4.3). The facilities at most hatcheries included hatchery tanks, nursery ponds, grow-out ponds, broodstock ponds and marketing facilities. HAQDEC, Lake Pindi Yaundo Trout Hatchery and Bismark Barramundi in Madang were the only hatcheries that carried out research as part of their fish farming activities.

Table 4.3

The types of hatcheries and their date of establishment (supply of trout fingerlings from hatcheries was intermittent or not available in 2003–05)

Hatchery name	Province	Date established	Fish species cultured
Johnson's Trout Hatchery	Simbu	1988	Rainbow trout
Ku Carp Hatchery	Simbu	1996	Common carp
Lake Pindi Yaundo Trout Hatchery	Simbu	1993	Rainbow trout
Kipere Carp Hatchery	Simbu	1998	Common carp
Mutue Carp Hatchery	Western	1999	Common carp
Keko School Leaver's Carp Hatchery	EHP	1994	Common carp
Kaveve Trout Hatchery	EHP	Unknown	Rainbow trout
Kotuni Trout Hatchery	EHP	1997	Rainbow trout
Samazi Carp Hatchery	Morobe	2001	Common carp
Kimesave Carp Hatchery	EHP	1990	Common carp
Wara Benz Carp Hatchery	EHP	1999	Common carp
Imakul Carp and Tilapia Hatchery	Madang	1998	Common carp and GIFT
Kemeyufa Trout and Carp Hatchery	EHP	1999	Rainbow trout and common carp
Tiasen Carp Hatchery	Morobe	1996	Common carp
Zuruka Carp Hatchery	Morobe	1997	Common carp
Idisa Carp Hatchery	Morobe	1997	Common carp
Toset Carp Hatchery	Morobe	2001	Common carp
Boman Carp Hatchery	Simbu	2000	Common carp
Sulma Carp Hatchery	Simbu	1999	Common carp

Table 4.4
Staff numbers involved in hatchery activities at the 19 hatcheries that were surveyed

Fish farming activity	Average number of full-time staff involved	Average number of casual staff involved	Average time allocated by full-time staff (% of week)	Average time allocated by casual staff (% of week)
Hatchery	2.1	2.4	19.0	2.6
Nursery	2.1	1.1	9.1	1.6
Grow-out	2.1	1.1	14.8	1.8
Marketing	2.1	1.1	6.9	0.3

The number of staff at each hatchery varied according to its size and productivity. In most cases the personnel at small-scale hatcheries were the farmer and/or family members. The time allocated to the hatchery by staff at the small-scale operations was low (Table 4.4), the rest of their time being spent on other activities. Subsistence agriculture, such as gardening and raising pigs, is the main activity of Papua New Guineans so aquaculture was accommodated in 'spare' time for small-scale hatcheries. Only 32% of hatchery owners kept daily records on farm activities such as feeding and spawning.

GIFT fingerlings were distributed to farmers for the first time in late 2002 after a workshop at HAQDEC, attended by farmers and representatives of various institutions. Because GIFT reproduce in ponds without the need of hatchery facilities, many farmers were suppliers of GIFT fingerlings by 2006. As an example, a smallholder farmer in Kabwun in the highlands of Morobe province received 20 GIFT fingerlings from HAQDEC during an ACIAR workshop in September 2003. Two years later the farmer attended the smallholder hatchery training workshop in November 2005 at Aiyura. He reported to the workshop that he had bred and distributed 10,000 GIFT fingerlings in the Kabwun area since receiving the original fish.

Fingerling production by smallholder hatcheries

Natural breeding occurs at most hatcheries. As some of these farmers have been trained at HAQDEC, they separate the males from the female brooders and, after checking the eggs of female brooders, put them together in the same pond for natural breeding.

Stone Hill integrated farm at Kabiufa Village in Goroka is used as a demonstration farm for smallholder carp farmers. Nephion Tarapi (technical adviser for EHPG) and a training officer look at the kakabans for collecting carp eggs from the pond.

The survival rate of the three main fish species cultured at these hatcheries varies according to the species cultured and the water quality of the farm. Tilapia and common carp, being hardy fish species with a very wide tolerance range, tend to have a higher survival rate than rainbow trout.

As many of these smallholder farmers do not have modern technology or proper breeding facilities, fingerling production is very low and there is a high mortality rate from hatch-out to fingerlings. For instance, in most cases where there is no constant supply of water, fingerlings die from very low levels of dissolved oxygen in the breeding or nursery ponds.

Predation on fingerlings is another factor which contributes to their survival rate. Birds are one of the main predators of fingerlings at the hatcheries, and other predators include dogs, cats and ducks.

The average size of fingerlings from hatcheries were as follows: common carp 37 mm, rainbow trout 30 mm, and GIFT tilapia 30 mm (Table 4.5).

Table 4.5
Fingerling sizes and their markets

Fish species	Main customer	Average size (mm)	Average age (months)	Price (kina/unit)
Trout eyed eggs	Local farmers	3	0.4	0.03
Trout fingerlings	Local farmers	30	2.5	0.3
Carp fingerlings	Local farmers and provincial DAL	37	4.0	0.2–0.45
Tilapia fingerlings	Local farmers	30	2.5	0.3–0.5

Hatchery operators' opinions on agencies and institutions

Assistance received from HAQDEC through training, extension, materials and fingerling supply was ranked high to very high by 31.58% of the hatchery owners, while 21.05% ranked it as fair. The remaining 47.37% of hatcheries ranked assistance received from HAQDEC as low to nil.

HAQDEC, under the JICA training program, conducted two to three training programs per year during 2001–05. Each program lasted 5 days, and about 40 farmers, teachers and officers took part in the training. Some training was given on hatchery operations during those programs.

The survey of the 19 hatcheries revealed that 94.7% received nil or low assistance from the government agencies. Assistance from international donors was either nil or very low, although three hatcheries ranked the assistance as fair or high.

The capital cost of starting up a hatchery was very high (52.6% of responses) and high for 26.3% of respondents. Two out of the 19 respondents (10.5%) said capital costs were fair, while another 10.5% responded that the capital cost of starting a hatchery was very low.

In response to the question about problems with land availability, 15.8% ranked this as high, another 15.8% as fair, while 36.8% and 21.1% ranked it as very low and low, respectively. The remaining 10.5% of respondents had nil or no problems with land availability.

Hatchery operators' opinions on fish farming in the local area

Most hatcheries said the degree of interest in fish farming in the local community was high to very high (79.0%). In most cases local people in the surrounding community had no constant supply of fingerlings and have no proper skills or knowledge to start farming fish. However, most of the hatchery owners thought fish farming was very important to the local community as it provides protein and an extra income for farmers and their families.

As a result of being located in remote areas and having no access to fingerling supply and extension, the amount of farmed fish available at local markets is very low or nil. Only a few fish sellers at the local market sell fish that are caught from the wild. The quality of farmed fish was regarded as very high (89.5% of respondents). Only 2 of the 19 respondents (10.5% responses) thought it was very low because of the muddy taste of carp and the large amount of bones in the meat.

Hatchery operators' suggestions

Improving development of hatcheries

Most (60%) of the hatchery operators suggested that, in order for them to expand their operation and increase fingerling production, they needed financial assistance. Although some (30%) did not mention financial assistance

directly, they needed materials such as pipes, nets, cement and other construction materials.

A good number of hatcheries felt that they needed more training to further advance their knowledge. They thought the 1-week training at HAQDEC was not sufficient and they required in-depth training. Other things regarded as necessities were: cheaper and appropriate feed (21%), infrastructure (16%) and technical support (10.2%). Licence approval and backup fingerling supply were also regarded as important.

Improving commercial success of hatcheries

In comparison to Lake Pindi Yaundo Trout Farm and Bismark Barramundi, the small-scale hatcheries were owned and operated by the fish farmers. Most of the breeding is done naturally in their ponds. However, some of them intend to expand their operations. They report that in order to succeed commercially, they need more training and development of more infrastructure, such as better road systems and markets. Of these issues, training was regarded as most important, while feed was also listed as important for their success.

References

HAQDEC (Highlands Aquaculture Development Centre). 1999. Inland fish farm development network to supply one million fish fingerlings. Proposal for inland fish farm development submitted to the Public Investment Programme, Food Security. Aiyura, EHP.

Harvest time requires teamwork, good training, planning, cool morning temperatures and rapid processing.

Chapter 5

Findings of the survey of fish farms

Paul T. Smith, Kine Mufuape, Kaupa Kia and Micha Aranka

Introduction

At the start of the study in 2001, the distribution records at HAQDEC were used to estimate that there were 5,418 active smallholder fish farms in PNG (Table 2.1). Since then, there has been a growth in the number of fish farms of approximately 10% per year, resulting in approximately 8,000 farms in 2006. However, there are possibly 10,000–15,000 fish farmers who have constructed earthen ponds but are inactive, waiting on fingerlings and training. It is very difficult to be accurate about the number of farms because many are in remote locations spread throughout PNG (including its islands) and little is known of them. Hence, the primary objective of the study was to determine the status of inland pond aquaculture in PNG through a comprehensive survey of the industry. The study aimed to provide researchers and fisheries administrators with a clear picture of the structure of the industry and indicate areas in need of resources. Also, it aimed to indicate to ACIAR and all research donors the priority issues to target for developing a sustainable industry.

This chapter summarises the findings of the survey of 313 fish farms conducted from 19 December 2001 to 1 March 2003. A significant limitation of the survey was that it was carried out immediately prior to the distribution of GIFT strain fish. So the data gathered that relates to the species of fish is not as useful as the other data in the survey. There is a plan to resurvey a cohort of the farms in a new ACIAR project (FIS/2001/083). Hence, the findings presented here provide a very useful benchmark for assessing the impact of GIFT fish in PNG.

Details of the survey methods are provided in chapter 2 (subsection 'Activities and survey methods'). Each survey usually took 2–3 hours to complete. Questions were asked on farming history, management practices, fish species, opinions on various aspects of farming, perceived problems, identifiable issues, knowledge of neighbouring fish farms, socioeconomic issues and suggestions by the farmer. During the survey, data was also collected by the research team on geophysical parameters, biophysical parameters, GPS data and farm observations. The results of the survey were entered into an Excel database and analysed with the statistical software package SPSS. The database has a total of 298 variables (i.e. columns). Wherever mean values are quoted in this report the standard deviation is also provided (i.e. mean ± S.D.)

Outline of the farms

Common carp (*Cyprinus carpio*) was the main species cultured at the farms—it was the sole species in 90.4% of farms and farmed with other species in 7.7% of farms (Table 5.1). Rainbow trout, tilapia species (*T. mossambica* and *T. rendalli*) and a few other fish species were also farmed to a limited extent. The GIFT strain was not released from HAQDEC until after the survey. The survey covered farms in 12 provinces (Table 5.2), with most being carried out in Morobe province (33.2% of surveys), WHP (26.5%), EHP (22.7%) and Simbu province (8.9%). Generally, the number of farms surveyed in each province was based on the relative number of farms that were estimated to exist in that province. However, some provinces

were not surveyed because of safety risks (e.g. SHP) or difficulties in travelling to remote regions.

Table 5.1
Species cultured at the farms in the period 2002–03. Common carp was farmed in 98.1% of farms surveyed.

Species cultured at farm	Frequency	Percentage (%)
Carp	283	90.4
Carp and tilapia	14	4.5
Carp and trout	8	2.6
Carp, puntius, tilapia, catfish	1	0.3
Carp and snow trout	1	0.3
Trout	4	1.3
Snow trout	1	0.3
Barramundi and tilapia	1	0.3
Total	**313**	**100.0**

Details of the farms that participated in the survey are found in Appendix II. They are within a perimeter bounded by Ningerum in Western province (i.e. 141° 08.534' E longitude), Kavieng in New Ireland province (i.e. 151° 03.022' E longitude), Lorengau in Manus Island province (i.e. 02° 03.156' S latitude) and Alotau in Milne Bay province (i.e. 10° 17.900' S latitude). The height of fish farms above sea level ranged from Sumkar in Madang province (i.e. 13 m altitude) to Tambul in WHP (i.e. 2,436 m altitude).

Table 5.2
The distribution of farms that participated in the survey

Province	Number of farms surveyed	Percentage of farms (%)
EHP	71	22.7
Enga	4	1.3
Madang	8	2.6
Manus	2	0.6
Milne Bay	1	0.3
Morobe	104	33.2
New Ireland	2	0.6
Oro	2	0.6
Simbu	28	8.9
Western	3	1.0
WHP	83	26.5
WNB	5	1.6

With respect to the socioeconomic aspects of the 313 respondents who participated in the survey, 81.8% were smallholder agricultural farmers, 3.2% were pastors, 2.9% were housewives and 2.2% were students. Some 286 (91.4%) of respondents were males, 27 were females, 260 (83.1%) were married and 53 were single. The average age of the respondents was 34.9 years and the average number of children of the respondents was 3.3 (Table 5.3). A large percentage (87.5%) of farms were operated by an individual (i.e. nil co-owners) and a further 7.7% were operated by a family (Table 5.4).

Table 5.3
Statistics on each respondent's age and number of children. (Most unmarried respondents replied 'not applicable' to the question of number of children.)

	Mean	Standard deviation	Minimum	Maximum	Range	Number of respondents
Respondent's age (years)	34.9	11.1	10	80	70	313
Respondent's number of children	3.3	2.2	0	12	12	266

Table 5.4
Classification of co-owners of the fish farm

Co-owners of the fish farm	Frequency	Percentage (%)
Nil co-owners	274	87.5
Family members	24	7.7
Unrelated partner	9	2.9
Community	4	1.3
Company	2	0.6

In summary, the average respondent could be described as a smallholder agricultural farmer who is a married male 35±11 years of age with 3±2 children. The average respondent grows common carp and runs the farm without co-owners. Further, the analysis suggests that there are principally three types of fish farmers in PNG—the newcomers who have not harvested yet (*nupela fama*), established farmers who have less than 1,000 fish in ponds and have harvested at least one crop (*olpela lik lik fama*), and pioneer farmers who have considerable infrastructure and are focused on selling to restaurants or export markets (*olpela fama*). Nupela represent 45–55% of farmers, olpela lik lik represent 40–45%, and olpela represent 5–10% of farmers.

On average, farms had 2.2±3.5 full-time workers and 1.05±6.53 casual staff. However, that data is skewed by olpela farms that employed as many as 35 full-time staff and 100 casual staff. Further examination of the data for full-time staff shows that for 68.4% of farms there was only one worker (the respondent), for 13.7% of farms there were two workers and for 6.4% of farms there were three workers. Large farms employed staff and used appropriate equipment in order to be efficient. As for casual staff, 90.7% of farms had no casual workers. The activities of full-time and casual workers at fish farms were strongly focused on growing fish and related activities. Some time was spent on marketing but little or no time was spent on training or research.

Feeding time at Greenarm Trout and Carp Farm in Simbu province. Trout are given a farm-based feed consisting of vegetable material and kitchen scraps. Termite nests and live worms are used to supplement the feed. A continuous inflow of river water ensures a high rate of water exchange and suitable DO levels in the small ponds.

Only 13 (4.2%) of the 313 farms kept daily records of farm activities (i.e. observations, feeding or water conditions). Records were kept by the farmer (2.6% of farms), owner (1.3% of farms) or project coordinator (0.3% of farms). Although olpela farms had been operating for many years (up to 26 years for carp, 26 years for tilapia, 12 years for trout and 22 years for other species), most farmers reported that they had only recently begun fish farming. The median number of years for farming common carp was 3.0 years (n = 305), for tilapia 1.5 years (n = 22) and for rainbow trout 1.0 years (n = 15). Some olpela farmers had stock which they had kept for many years. These fish could provide a starting point for assessing broodstock and improving breeding practices in PNG. They would be conditioned and stripped on site, and their fertilised eggs would be transferred to HAQDEC so that fingerlings could be raised and broodstock families re-established. Breeding trials could be carried out under controlled conditions to find the better performers, and fingerlings produced for distribution to farmers.

An olpela fish farmer in WHP enjoying handfeeding his common carp. Some farmers received their fish many years ago and have maintained the original fish. These fish are a vital resource of broodstock for the industry, given the problems of importing new broodstock.

Analysis of the stocking rates revealed that a majority of farms had difficulties in obtaining fingerlings during the study period. For common carp, 65.8% of farms had zero stocking of fingerlings in 2002, 63.9% had no stocking in 2001, 70.9% in 2000 and 50.2% in 1999. The carp farms with high levels of stocking (i.e. 90th to 95th percentiles) received 100–1,000 fingerlings per year in the period 1999–2002, while carp farms with

the highest level of stocking (i.e. 98th to 99th percentiles) stocked 1,003–7,060 fingerlings per year in the same period. Trout, tilapia and other fish farms in the 90th to 99th percentiles stocked at 6–272 fingerlings per year during that period. These stocking rates are consistent with the needs of integrated smallholder fish farms. The most worrying finding was that most farms were unable to obtain fingerlings during the study period.

The stocking density was calculated from the total area of the ponds and the number of fish stocked. A total of 112 farms had no stock, and more than 50% had a stocking density of less than 2 fish/m^2 (median 1.4 fish/m^2). The mean stocking density for all farms was 3.8±8.4 fish/m^2 and stocking density was as high as 100 fish/m^2 in one farm. The total number of fish stocked in all ponds at each farm at the time of the survey ranged from 0 to 120,000. The mean was 881 fish per farm; however this statistic is unrepresentative of the industry because of the high percentage of farms without stock. The median was 70 fish per farm at a median stocking density of 1.4 fish/m^2. No electrical aerators were used in any of the farms, so the results are consistent with extensive fish farming.

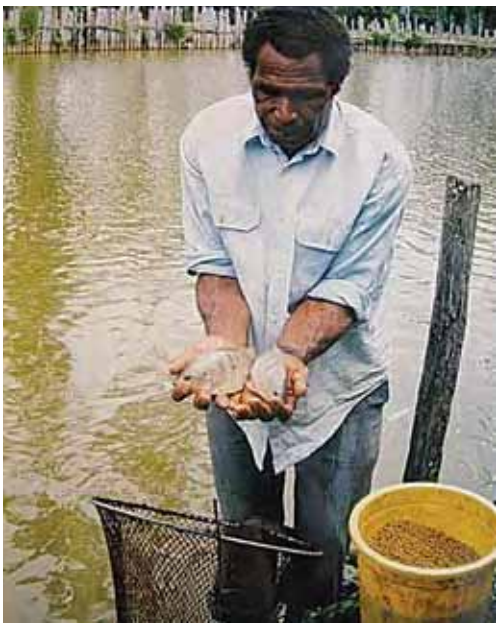
Survival rates were relatively high for all species and most farms. The mean survival rates were 85–95% for carp and tilapia and 75–85% for trout. The data on harvest size, age and price of farmed fish was limited by the number of farmers who had completed harvests. Common carp was sold at an average size of 0.81±0.64 kg (n = 58) while all other fish averaged 0.3 kg (n = 13). The average age of carp at harvest was 16.0±13.5 months (n = 59), while trout averaged 10.4±2.6 months (n = 7) and tilapia 5.4±3.9 months (n = 5). The average price of table-size carp was K7.88±3.76 (n = 47), while for trout it was K12.57±8.28 (n = 7) and for tilapia K2.54±1.50 (n = 5).

Significantly, 80.2% of farms had not made any sales, while 43.7% of farmers had consumed some of their own fish. Home consumption of farmed fish accounted for 39±35% of the harvest. These results suggest that fish farming is an important source of protein for the farmer and family.

The analysis of data on the marketing of fish (Table 5.5) reveals that carp, trout and tilapia were sold to different customers. The main buyers of farmed carp were local villagers (11.8%) and other farmers (3.2%). Carp farmers also reported that minor sales were made at street markets and to companies. In comparison, trout was sold to restaurants, hotels, town markets, supermarkets, town workers and villagers, and as broodstock to the Lake Pindi Yaundo Trout Farm and Hatchery. Tilapia was sold to villagers, town dwellers and other farmers.

Table 5.5
Main customers of farmed carp

Buyers	Frequency	Percentage (%)
Nil sales yet	251	80.2
Market	3	1.0
Other farmers	10	3.2
Public servants	4	1.3
Restaurants	1	0.3
Supermarkets	3	1.0
Town dwellers	1	0.3
Villagers	37	11.8
Total	**313**	**100.0**



Farmers need to sample fish to check on size and health. This farmer, Osume, trains his fish by feeding them at a single location in each pond. In this way he can easily observe daily feeding behaviour and can collect fish with a scoop net when they come to feed. While this method does not provide a randomised sample, it is practical and appropriate for the technology and circumstances.

The average price of fingerlings in the local area was K0.39±0.91 (n = 306). Fingerlings were obtained from middlemen (30.4%), HAQDEC (24.8%), another farmer (22.7%), small hatcheries (12.8%), their own farm (4.5%) and the wild (1.6%).

With respect to the management of water at the farm, 36.7% of farmers responded that they did not change the water in ponds, while 43.8% used a continuous flow-through system. The remaining 20% of farmers reported using a variety of water exchange routines ranging from weekly to annually. The management of water is a key issue because it is the main method of maintaining dissolved oxygen levels and general water quality, and it determines the rate of loss of nutrients to the environment. Sampling of the fish is another important part of pond management, but this is rarely carried out. Farmers need to be alerted to the need to regularly check their fish for health, size and breeding condition.

The types of feed that farmers used on their crop are summarised in Table 5.6. Some 78.9% of farmers used garden vegetables and a further significant percentage used garden vegetables in combination with live worms and termites. The types of garden vegetables that were fed to the fish include: banana, kaukau (sweet potato), rice, pawpaw, breadfruit, cassava, potato, avocado, taro, kitchen leftovers, pumpkin, coconut and fruits. In up to 10% of farms various types of pellet feeds were used, including chicken, trout and home-made feed based on local ingredients. The cost of commercial pellet feed was beyond the means of most farmers. In the cases where pellet feed was used (32 of 313 farms), it was generally in combination with garden vegetables. The median amount of pellet used by the 32 farms was 50 kg per crop, and the expenditure on pellet feed by farms in the 75th percentile was K6 for the crop. These results confirm the finding that smallholder fish farmers are, in the main, unable to expend funds on purchasing pellet feeds for their fish.

With regard to fertilisers and chemicals, 62% of respondents said that fertilisers were not used (Table 5.7). Where fertilisers were used, 18.8% of farms used chicken manure alone and 3% used chicken manure in combination with other animal manure. Inorganic fertilisers were rarely used (two farmers reported using NPK in combination with manure).

Table 5.6

The types of feed used by fish farmers. A wide variety of vegetables grown by the farmer's family on the farm were reported, and this was dependent upon the food preferences of the family as well as environmental conditions at the farm.

Feed	Frequency	Percentage (%)
Chicken pellet	2	0.6
Fish pellet	2	0.6
Fish pellet and vegetables	3	1.0
Pellet	3	1.0
Unknown pellet and vegetables	19	6.1
Termites	2	0.6
Vegetables	247	78.9
Vegetables and termites	25	8.0
Vegetables and worms	7	2.2
Wheat	1	0.3
Total	**313**	**100.0**

Table 5.7
Types of fertilisers used by farmers

Fertiliser	Frequency	Percentage (%)
Chicken and cattle manure	1	0.3
Chicken and duck manure	1	0.3
Chicken and goat manure	2	0.6
Chicken and pig manure	1	0.3
Chicken and rabbit manure & NPK	1	0.3
Chicken and duck manure	1	0.3
Chicken manure	59	18.8
Chicken manure and compost	2	0.6
Chicken manure and NPK	1	0.3
Compost	8	2.6
Duck manure	2	0.6
Goat manure	7	2.2
Manure—type unknown	16	5.1
No fertiliser	194	62.0
Pig and goat manure	1	0.3
Pig manure	12	3.8
Rabbit manure	2	0.6
Total	**313**	**100.0**

Selling of the harvest was principally carried out by the farmer (19.8% of respondents), while the farmer and family were the sellers in 1.6% of cases. Some 77.6% of farmers responded that they had not sold their harvest yet. In a follow-up question, 51.4% of farmers responded that they had not harvested yet (i.e. they were nupela fama). Of the farmers that had harvested, 45.7% selectively harvested while 2.2% carried out a single complete harvest.

Influences of agencies and institutions

When asked about the assistance that was received from institutions and organisations, farmers generally responded that they rated the assistance as either 'nil' or very low. Assistance from HAQDEC was rated as 'nil' by 44.4% of farmers and 'very low' by 40.0% of farmers. Assistance from international donors was rated as 'nil' according to 83.1% of respondents. When

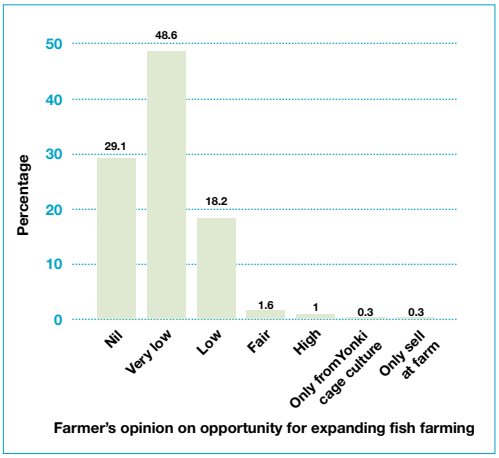
asked to identify international donors that had provided assistance, 10.2% of farmers replied that they had received assistance but did not or could not identify the body. Funding assistance from government was rated as 'nil' by 77% of farmers and 'very low' by 15.7% of farmers. Assistance from government with licences and approvals was rated as 'nil' by 94.9% of farmers and 'very low' by 3.8% of farmers. Assistance from NGOs was rated as 'nil' by 83.1% of farmers and 'very low' by 7.7% of farmers.

Respondents reported that there were a variety of means by which they first became aware of fish farming. However, more than 70% were influenced by the following four means: other farmers (26.8%), their own interest (20.8%), an NGO network (13.1%) and officers from DAL (10.5%). A range of educational and training programs accounted for more than 10% of farmers' awareness (e.g. the Lutheran Development Service accounted for 2.6% of cases).

Issues affecting fish farming in Papua New Guinea

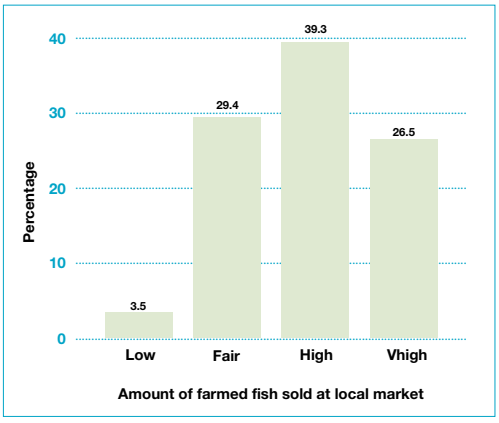
There appears to be a strong interest by local communities in fish farming, with 33.2% of farmers indicating very high interest and 38.3% high interest. In the opinion of the farmers, the quality of farmed fish was high (36.7% of responses) or very high (28.4%). However, as shown in Figure 5.1, the amount of fish sold at the local markets is very low (48.6% of responses) or nil (29.1%) according to the farmers, and the number of sellers of farmed fish at the markets is very low (50.8% of responses) or nil (31.9%). Farmers are interested in expanding their fish farming activities, with 39.3% of responses indicating a high degree of interest and 29.4% a fair interest (Figure 5.2). Among farmers the intention to construct more ponds is high (38.0% of responses) or very high (31.9%). In general, farmers consider that fish farming is highly important for the community (51.4% of responses) or fairly important (31.0%). Only 4.2% of farmers are already members of local fish farmer associations, but 25.6% have a high level of intention to join an association and 44.1% a fair/average intention to form or join an association.

Figure 5.1



The amount of farmed fish sold at markets is insignificant, indicating that there is an opportunity for fish farmers to meet the unfulfilled demand.

Figure 5.2

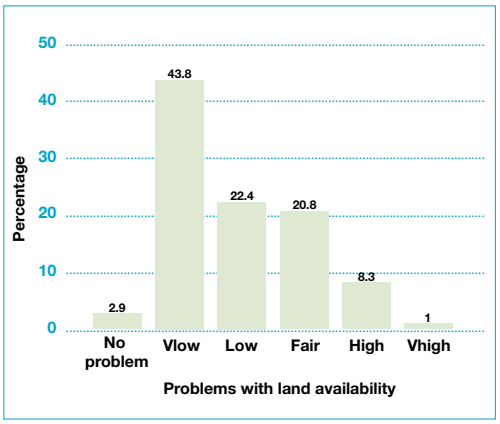


Farmers believe that there is a very good opportunity to expand fish farming.

Given those generally favourable outlooks for fish farming, farmers were asked about the main limitations (problems) to people starting up commercial or small-scale fish farming. Eight categories were questioned and the findings were as follows:

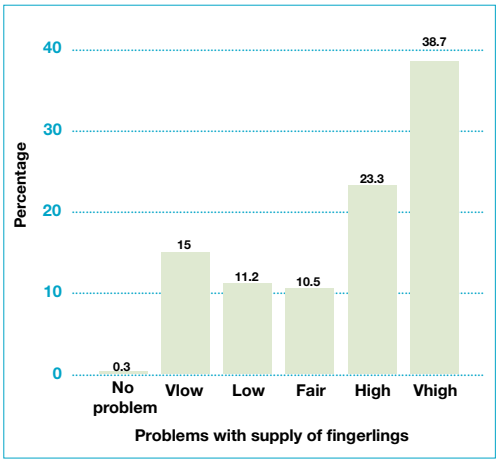
- Problems with land availability were mainly very low (43.8% of farmers) or low (22.4%), as shown in Figure 5.3.
- Problems with roads and infrastructure were mainly fair (21.7% of farmers), low (13.1%) or very low (25.2%).
- Problems with skill levels were mainly fair (41.2% of farmers) or high (31.6%).
- Problems with construction of ponds were mainly fair (45.7% of farmers) or high (27.2%).
- Problems with financial viability were mainly high (52.1% of farmers) or fair (23.0%).
- Problems with supply of fingerlings were very high (38.7% of farmers) or high (23.3%), as shown in Figure 5.4.
- Problems with finding marketable species were mainly high (49.2% of farmers) or fair (27.8%).
- Problems with market accessibility were high (21.7% of farmers), fair (29.4%) or low (19.2%).
- The capital costs for setting up a fish farm were generally regarded as very high (43.7% of farmers) or high (21.7%) but some farmers reported that the capital costs were 'nil' (11.2%). When asked for their comments on capital costs, farmers responded that materials, such as piping, were expensive. However, 14.0% of farmers commented that they used bush materials to construct their farms.

Figure 5.3



Problems with land availability for starting up fish farming were generally not substantial.

Figure 5.4

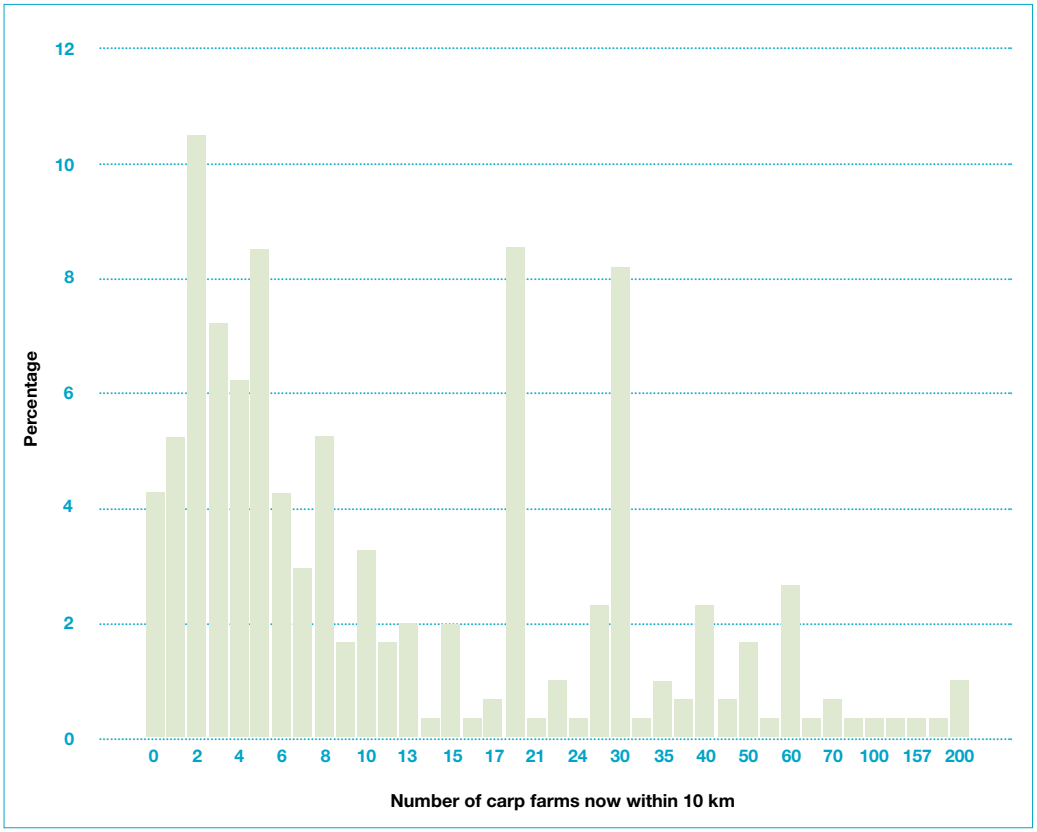


Problems with fingerling supply for starting up fish farming are rated as the most important issue.

In conclusion, the issues that were rated as the most significant for starting up fish farming were the supply of fingerlings and financial costs. Other issues such as skill levels, training and finding marketable species were also important.

Fish farms are regularly being constructed in PNG. This photograph shows one of the ponds built in March 2006 by the Kinki community farmers in EHP. These farmers are typical of the force that drives fish farming in PNG. Since the time of colonial administration in the 1960s, smallholder farmers have enthusiastically dug ponds with spades and constructed fish farms with natural materials.

Figure 5.5



The number of carp farms in the local area (within 10 km) of the farmer could be as high as 200 but there was a median of 8 farms (n = 310).

Activities carried out at the farms

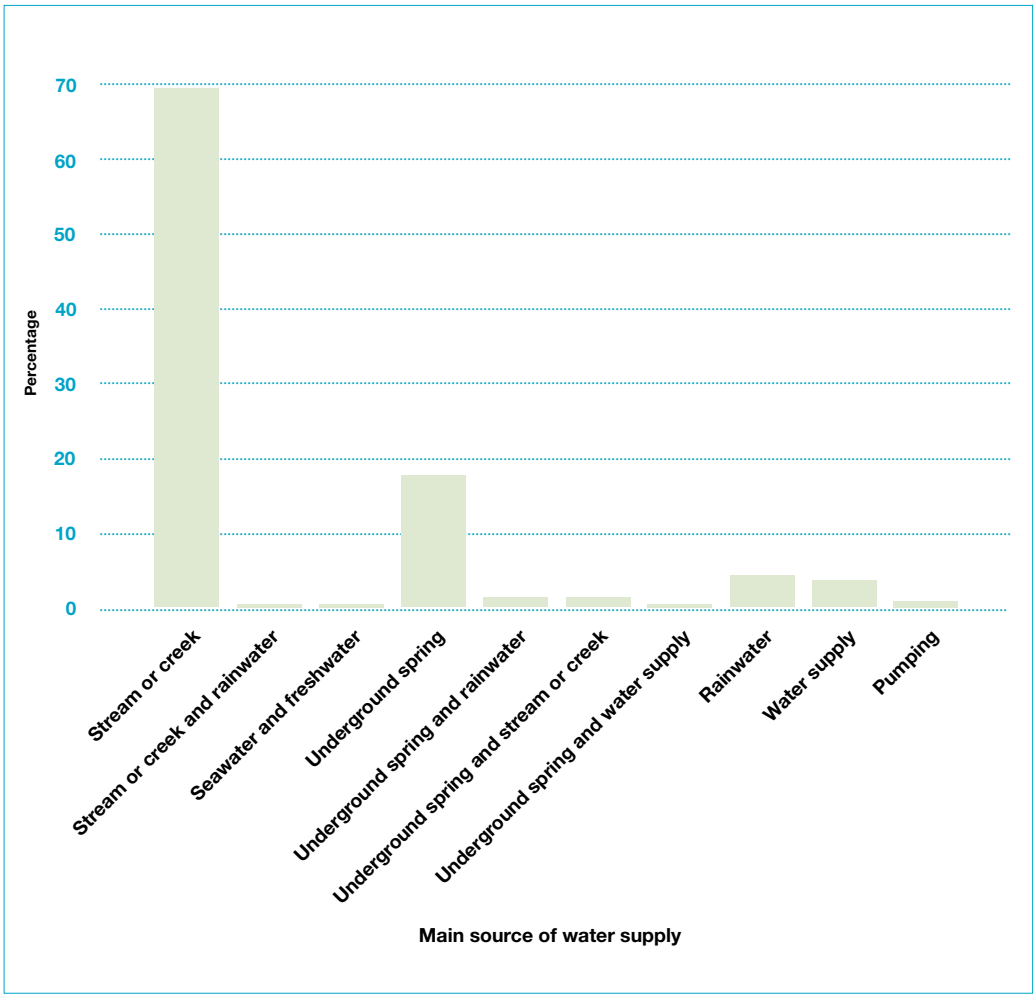
Common carp was the main species farmed in PNG at the time of the survey. According to farmers, there can be up to 200 carp farms in an area of 10 km radius (Figure 5.5), and up to 30 trout farms and 10 tilapia farms in similarly sized areas. Carp farming was introduced to some areas 35 years ago, while trout farming began 21 years ago, tilapia farming 10 years ago and other fish farming 3 years ago. Most respondents did not have carp or trout hatcheries in their locality.

Responses to questions on farm management and related activities are summarised as follows:

- The respondents strongly identified fish farming as a means of obtaining cash income and improving family nutrition in 86.9% of cases, and solely for family nutrition in 8.0% of cases.
- Fish farms were located either on the slope of a hill (33.2% of farms), in a valley (33.9%) or beside a stream or river (14.1%). Many of the other responses indicated that the farm was a combination of these three sites.
- The main source of water was from a stream or creek (69.3% of farms), underground spring (17.6%) or a combination of water sources. However, some farms relied on water sources that carry a high degree of risk or cost, for example rainwater, pumping and town water supply (Figure 5.6).
- The source of seed (fingerlings) was mainly from HAQDEC alone or in combination with other suppliers (41.9%). Also, 32.6% of respondents received fingerlings from another farm and 9.6% produced fingerlings at their own farm.
- The main type of feed used was kitchen leftovers and vegetables (64.2%) or kitchen leftovers and live feed (21.7%). These responses were consistent with those to a previous question (Table 5.6), in which 78.9% of farmers described a variety of garden vegetables and leftovers as the main feed for fish. In less than 10% of farms manufactured pellet feed was used in combination with other home-based feeds. This finding about pellet feed is consistent with data shown in Table 5.6.
- No fertiliser was used in 59.1% of farms. In cases where a fertiliser was used, organic animal manure was the most common form (33.2%). These responses were consistent with those for a previous question in which 62% of respondents said they did not use fertilisers and the other respondents gave examples of various types of animal manures that were used.
- Ponds were visually checked on a daily basis at 63.6% of farms (Table 5.8). Similarly, the feeding of fish was carried out on a daily basis at 69.3% of farms.
- Discharge of water from the ponds was mainly to a river or stream (82.7% of responses). Only 6.4% of farms discharged onto agricultural land and 1.6% of farms discharged onto fallow land.

- Pond management practices that were carried out between each crop were mainly to leave water in the pond (35.3% of farms). Drying out of ponds was carried out for varying intervals from one day to several months at some farms. However, 48.9% of farmers had not competed a full harvest cycle yet.
- Most respondents had not received any prior training (72.2% of cases). Some 7.0% of farmers received training from wokabaut skul, 6.4% at HAQDEC, Aiyura, and 5.1% from NGOs.

Figure 5.6



The main source of water for fish farms is either a stream/creek or an underground spring (i.e. water table).

Table 5.8
Frequency of checking fish ponds by farmers

Time interval between checking fish ponds	Number of farms	Percentage of farms (%)
Daily	199	63.6
Weekly	82	26.2
Fortnightly	22	7.0
Monthly	7	2.2
Total	**313**	**100.0**

The fate of the last crop of farmed fish was investigated. As mentioned previously, some 55.9% of farmers had not harvested yet (nupela fama). However, for those who had harvested, an average 34.6±34.3% of the crop was consumed by the family, while 11.16% was sold at the market, 2.8% was given as a gift and 2.9% was eaten by others.

The amount of time spent working on the fish farm was generally a family effort. The father/male carried out 50.0±25.7% of the work, the mother/female did 21.6±16.4% of the work, and the children also assisted with an average of 20.2±22.5% of the work. In a few cases the grandparents assisted, while other people provided an average of 8.0±18.9% of their time assisting.

Farmers were asked about their source of income and the results are very interesting (Table 5.9). Coffee was a substantial cash crop for respondents, providing an average 34.1±28.0% of their farm income. Cocoa, copra and cows/goats were not significant income earners for most farms in the survey. Income from vegetables, betel nuts and fruit was a substantial income source for many farmers, providing on average 20.3±22.7% of the farm income. The percentage of farm income from farmed fish was 4.0±11.5%, from poultry 5.9±10.7% and from pigs 6.1±9.9%. The percentage of income from relatives averaged 5.9±9.9% and from off-farm activities 20.1±24.2%.

Table 5.9
Percentage of farmers' incomes from various sources (n = 313)

Proportion of farm income	Mean	Standard deviation	Minimum	Maximum
Coffee (%)	34.1	28.0	0	90
Cocoa (%)	0.6	4.1	0	50
Copra (%)	1.1	6.0	0	50
Vegetables and betel nut (%)	20.3	22.7	0	100
Farmed fish (%)	4.0	11.5	0	80
Poultry (%)	5.9	10.7	0	70
Pigs (%)	6.1	9.9	0	60
Cows or goats (%)	0.8	3.4	0	30
Relatives (%)	5.9	9.9	0	65
Off-farm (%)	20.1	10.0	0	100

Farmers were questioned about the frequency that protein was eaten. Most respondents and their families appear to rarely eat meat protein. When questioned as to the source of protein for the respondent's family, the responses were quite varied (Table 5.10). The most significant forms of protein identified by the respondents were poultry, pig, lamb flaps and tinned meat, each providing an average 11.5–14.5% of protein to families. There was also a significant percentage of respondents (28.0%) who did not identify the main source of protein. Many of these apparently did not eat meat. Farmed fish provided an average 4.9±9.4%, and in some cases as much as 50%, of the family's protein.

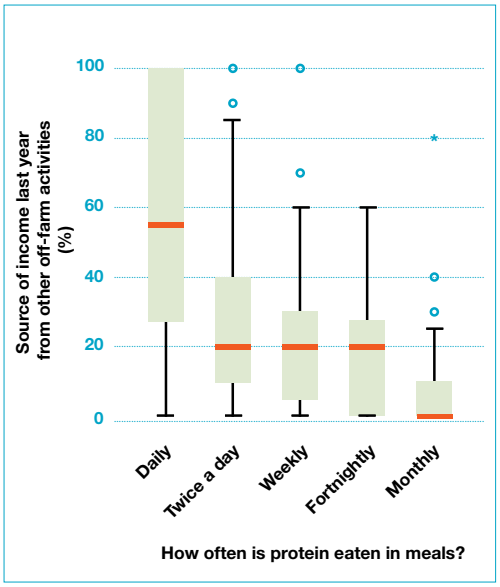
Table 5.10
Sources of protein for farmers and their families

Family's source of protein taken from:	N	Minimum	Maximum	Mean	Standard deviation
Eggs (%)	310	0	40	3.9	6.4
Any fish (%)	310	0	60	6.7	10.1
Farmed fish (%)	310	0	50	4.9	9.4
Chicken (%)	310	0	60	14.5	10.4
Pig (%)	310	0	70	11.5	12.1
Lamb flaps (%)	310	0	70	14.3	14.6
Goat (%)	310	0	30	0.9	3.1
Tinned meat (%)	310	0	70	12.3	13.9
Frozen meat (%)	308	0	35	3.1	4.7
Unknown source (%)	310	0	100	28.0	20.8

When considering the association between source of income and frequency of consuming meat protein by the farmer's family, there appears to be a linear association between off-farm income and higher rates of consumption of protein in meals (Figure 5.7). For these variables the Pearsons Correlation Coefficient was –0.442 (n = 309), which is significant at the 0.01 level. The coefficient is negative, indicating that when off-farm income was a high percentage of farm income (mean of 60%), the time interval between consumption of protein in meals was small (i.e. daily).

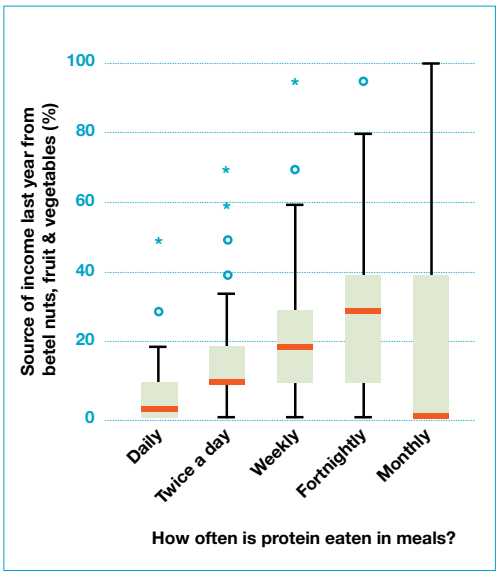
In comparison, the frequency of consumption of protein decreased with an increased reliance of income on betel nut and vegetables (Figure 5.8). Similarly, an increasing dependence of income on coffee resulted in a decreasing frequency in consumption of protein in meals. The decrease is significant at the 0.01 level and the Pearsons Correlation Coefficient is +0.343 (n = 309) (Figure 5.9).
The income from poultry and pigs was generally low, at 5–6% of income (Table 5.9), and the consumption of protein was evenly spread from daily to monthly (Figure 5.10).

Figure 5.7



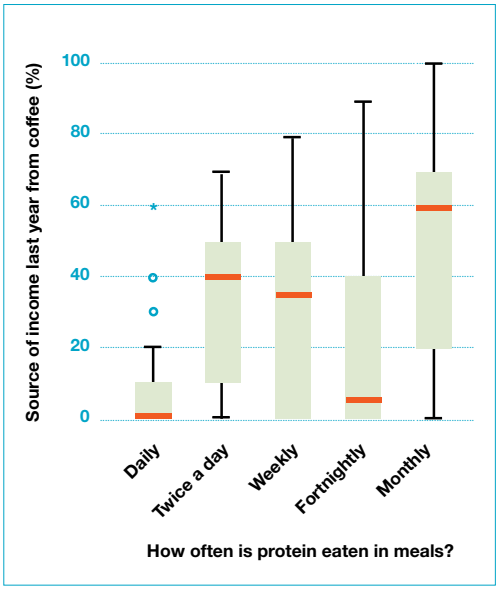
The frequency of eating meat protein is high when the source of off-farm income is highest.

Figure 5.8



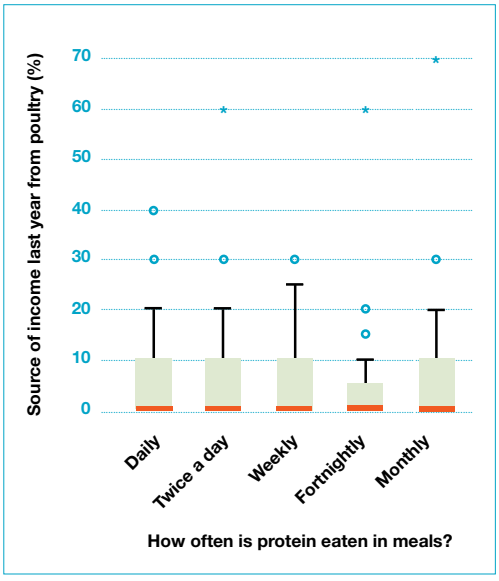
The frequency of consumption of meat protein decreases as the proportion of income from betel nut, fruit and vegetables increases.

Figure 5.9



The frequency of consumption of meat protein in meals decreases with increasing income from coffee.

Figure 5.10



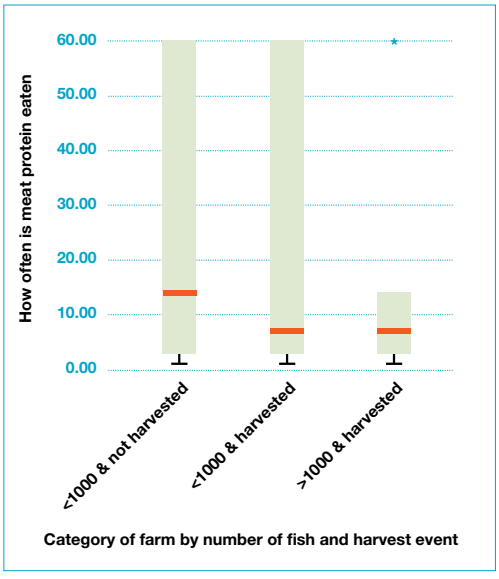
Poultry usually does not represent more than about 10% of farm income and the frequency of meat protein consumed is evenly spread from daily to monthly.

Boxplots show median, interquartile range, outliers (o) and extreme cases (*) of individual variables.

The low rate of protein intake is clearly illustrated by the finding that for all farmers, the average time between eating meals with meat was 24±26 days (n = 309). Interestingly, the farming of fish had a positive impact on the consumption of meat protein. For farmers who had already harvested, the time between eating meals containing meat averaged 20±24 days (n = 134), while for farmers who had not harvested, the time between meals containing meat averaged 27±26 days (n = 175). The difference was significant (F = 6.36, P = 0.012).

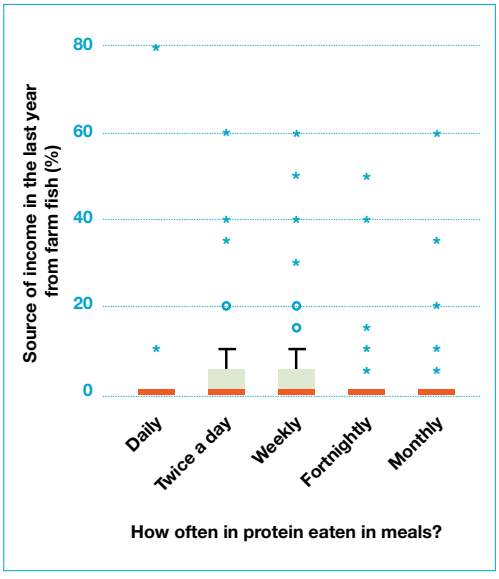
The data was further analysed to compare the frequency of consuming meat for three categories of farmers: nupela (less than 1,000 fish and not harvested), olpela lik lik (less than 1,000 fish and had harvested) and olpela (more than 1,000 fish and had harvested). The frequency of consuming protein averaged once in 28±27 days (median 14 days, n = 156) for nupela farmers (Figure 5.11). However, the frequency was once in 21±24 days (median 7 days, n = 97) for olpela lik lik farmers and once in 15±21 days (median 7 days, n = 29) for olpela farmers. These findings provide a very significant argument for the benefits of fish farming to inland smallholder farmers in PNG.

Figure 5.11



The frequency of consuming protein was highest for farmers who had more than 1,000 fish and had already harvested (olpela fama).

Figure 5.12



The frequency of consuming meat in meals increased slightly with increasing income from farmed fish.

Boxplots show median, interquartile range, outliers (o) and extreme cases (*) of individual variables.

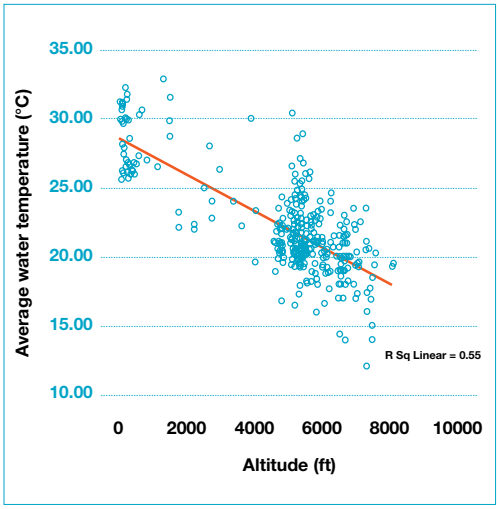
Further analysis of the data reveals that the frequency of consuming meat increased with a greater proportion of farm income from farmed fish (Figure 5.12). The association between these two variables was weakly significant (P = 0.074) and the Pearsons Correlation Coefficient was –0.102 (n = 308).

In conclusion, the three most significant sources of cash income of the respondents were coffee; vegetables, fruits and betel nuts; and off-farm income. Fish farming provided a percentage of income for respondents similar to that from poultry, pigs and support from relatives. The least significant sources of income for the respondents were copra, cocoa and cows/goats. The frequency of protein consumption significantly increased when income from off-farm activities increased. Protein consumption significantly decreased when there was a higher percentage of income from either coffee or relatives. Importantly, fish farming significantly increased the frequency of protein in meals.

Site information from fish farms

Environmental parameters were measured at the farm by the technical officers and this data is summarised in Table 5.1. The number of ponds at the farms averaged 3.25±3.43 (median 2 ponds) and the total area of ponds was 141±199 m^2 (median 60 m^2). The average water temperature was 22.0±3.5 °C (median 21.1 °C) and statistical analysis revealed a high correlation between altitude and water temperature (Figure 5.13). There were no significant correlations among the other pond parameters in Table 5.11. Importantly, from the perspective of pond management and productivity, the blooms in the ponds were often very weak and the Secchi visibility depth was highly variable, averaging 63±76 cm (median 25 cm).

Figure 5.13



There is a good correlation between water temperature in ponds and altitude (correlation coefficient = –0.741, P<0.01).

Table 5.11
Summary of pond parameters at the fish farms

Parameter	N	Minimum	Maximum	Mean	Standard Deviation
Number of ponds	310	0	24.0	3.25	3.43
Total area of all ponds (m^2)	308	2.5	1,500.0	141.7	199.0
Average water temperature (°C)	306	12.0	32.9	22.0	3.5
Average DO in ponds (mg/L)	306	0.48	12.75	6.75	2.67
Average pH of pond water	304	3.4	12.9	8.2	1.3
Average depth of ponds (cm)	308	10.0	500.0	51.0	38.0
Average Secchi depth of ponds (cm)	308	2.0	200.0	63.0	76.0
Distance of ponds from the house (m)	310	0.5	6,000	288.0	683.0
Distance of farm to nearest market (km)	309	0	180.0	2.34	10.5
Distance of farm to nearest public road (m)	310	1.0	20,000	945.0	2,521
Family members living with farmer	309	0	18.0	6.0	2.9
Percentage of clay at the farm	308	0	100.0	34.0	32.0

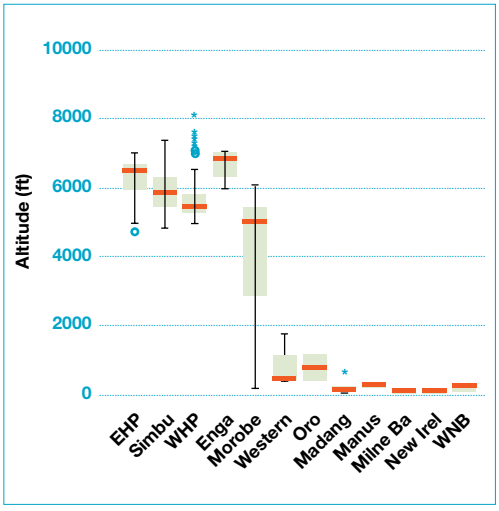
Water temperature is critical to the growth rate of fish. In general, tilapia is more suited to farming in tropical areas, carp in moderate temperatures and trout in cool waters. However, the survey showed that there are many carp farms in tropical waters. A comparison between the altitude of the farms in the 12 provinces (Figure 5.14) shows that four of the provinces had farms in high altitudes (EHP, Enga, WHP and Simbu), while Morobe had farms in coastal lowlands as well as highlands, and the farms in the remaining seven provinces were in coastal lowlands (Western, Oro, Madang, Manus, Milne Bay, New Ireland, West New Britain (WNB)).

The average distance from the farm to the nearest market was 2.35 km and from the public road 944 m (Table 5.11). The average number of family members living with the farmer was 5–6, although up to

18 people were recorded. The average distance of the ponds from the farm house was 287±683 m (median 70 m).

The proportion of clay in the soil at the farms averaged 34% (Table 5.8) and the main soil types at respondents' farms were loamy clay (37.4% of farms), a range of clayey soils (ca. 20%), loamy soils (ca. 15%), sandy soils (ca. 8%), and stony soils (ca. 10%). Most farms (93.6%) did not use concrete to construct pond walls; however, some farms (5.4%) used concrete to partially construct walls and drains. With respect to the water flow, 19.2% of farms had stationary water at the time of the survey and 79.2% had flow-through of water.

Figure 5.14



Measurement of the altitude of farms in the survey illustrates the division of PNG into highlands provinces and lowlands provinces. Some provinces, such as Morobe, have both highlands and lowlands.

Boxplots show median, interquartile range, outliers (o) and extreme cases (*) of individual variables.

Key issues confronting fish farmers in Papua New Guinea

When respondents were asked whether they knew of any cases of local fish farms that had failed, 40.9% of respondents did not know of failures. The most common reasons provided by those respondents who knew of failures are summarised in Table 5.12. Significant reasons were:

- vandalism and theft
- lack of help or extension
- shortage of fingerlings
- water supply problems.

Table 5.12
Reasons for failure of local fish farms

Cause of failure	Percentage of cases (%)
Vandalism or theft	30.0
Problem with fish feed	1.9
Financial problems	1.0
Shortage of fingerlings	14.4
Lack of skills in pond management	7.0
Laziness or lost interest	4.2
Water supply—shortage or flood	10.2
Lack of help or extension	18.8
Fish mortality	0.3
Poor farm construction	1.0
Other priorities	1.3
Land and social issues	1.6

Table 5.13
Suggestions for improving the development of fish farming in local communities

Suggestions to increase development of fish farming	Percentage of respondents (%)
Improve fish species and fingerling supply	49.8
Training and advice	89.1
Equipment and materials	22.4
Land, water and infrastructure	15.3
Improved feed	24.6
Financial support	34.5
Better planning decisions	2.9
Post-harvest and markets	4.2

Table 5.14
Suggestions on how to improve commercial success of fish farming

Suggestions for increasing commercial success of fish farming	Percentage of cases (%)
Better fingerling supply	42.5
Technical advice and training for farmers	54.0
Supply of materials and equipment	10.5
Financial support	31.9
Better land, water and infrastructure	27.5
Improved feed	14.1
Fish farmer associations	1.3
Planning decisions	6.7
Post-harvest and markets	24.0
Awareness and advertising	1.0

The respondents were asked to offer suggestions to improve development of fish farming in the local area. The responses are summarised in Table 5.13. Some of the relevant specific comments were:

- develop hatchery and breeding facilities in nearby areas
- set up fingerling supply centres
- increase the number of visits by DAL officers to farms
- provide backhoe or pond-building equipment
- provide piping, fencing and cement
- give funding support
- improve infrastructure (i.e. water supply and roads)
- develop better fish feed or improved feed
- educate people on the importance of fish as a protein source
- establish markets for farmed fish.

Some of the comments by respondents for improving commercial success (Table 5.14) coincide with those identified for improving development of fish farming (Table 5.13). Some specific comments by respondents were:

- provide new marketable species of fish
- develop local hatcheries
- provide more visits to farms by DAL officers
- supply equipment (pipes, fencing and cement)
- give funding support to set up a hatchery at the farm
- survey areas for suitable fish farming sites
- cut out government red tape
- encourage foreign investment

- give training in post-harvest preparation of fish
- set up fingerling markets
- promote eating of fish
- encourage community involvement in fish farming.

In summary, the most significant issues for development and commercial success were improved fingerling supply, improved training and advice, better financial support, improved feed and better supply of equipment and materials. Respondents also suggested that better infrastructure and development of markets were issues that were important for commercial success. These key issues were repeatedly identified by respondents in comments and other questions in the survey.

Fried tilapia caught by fishers and selling for 20 toea and 30 toea at the roadside market on the Highlands Highway near Yonki Reservoir, EHP. The Yonki fish market is the largest in the highlands.

Chapter 6

Markets for fish in inland Papua New Guinea

Kaupa Kia, Kine Mufuape and Paul T. Smith

Introduction

Farmers have taken up fish farming for different reasons—for some it provides their family with a new source of protein, while for others part or all of the harvest is sold for cash income. A survey was carried out in 2002–03 to investigate the marketing of farmed and other fish. Roadside markets are the most common ways for farmers to sell their produce in PNG. Importantly, no farmed fish were observed at any roadside markets throughout the survey period. Roadside markets were also visited afterwards in the period 2003–06 and the result was the same—no farmed fish could be found. At the Goroka Show (Goroka Sing Sing) in September of each year, HAQDEC sells cooked farmed fish and sales are always very impressive. The HAQDEC exhibition won the award for the best stall in 2003. It would seem that there is a very high demand for farmed fish but production is not sufficient to meet demand. This study attempts to provide useful information on the marketing of fish in PNG.

A view of part of the roadside market at Umi on the Highlands Highway, Morobe province. The main items for sale are buai (betel nut), fruit, vegetables, fried foods and soft drinks. Commonly, the fruits are coconut, pawpaw, banana, cucumber, passionfruit and peanuts. Farmed fish are not present at the market.

Scope and findings of the survey

Sixteen market surveys were conducted in four provinces (WHP, EHP, Simbu and Morobe). The surveys covered one farm site, one roadside market at Yonki, four hotels/lodges and 10 supermarkets, including a freezer operator. Most of the interviewees were managers and market operators aged in their 30s and 40s with an average of three children. The supermarkets, hotels and lodges were owned and operated by large companies or chains of companies. The farm and roadside markets were single-handed operations.

Supermarkets

The supermarkets were all located in urban areas. The main customers were Asians, expatriates, workers and the general public (including low-income earners and other customers whose status was not known). Supermarkets sell many food items, soft drinks and general merchandise, so farmed fish would compete with various meats and fish.

Supermarkets prefer to market marine fish rather than freshwater and farmed fish because the supply is said to be consistent. Some interviewees said that this situation would possibly change once the companies saw that farmed fish were readily available. Although one interviewee said that farmed fish is expensive, he was only referring to rainbow trout. Marine species, which cost on average K7.00/kg wholesale, sold to consumers at approximately K12.00/kg. In comparison, fresh farmed fish from Yonki and HAQDEC sell for K5.00/kg, which is less expensive than reef fish.

Mackerel (Besta) and tuna (Diana) are the most preferred tinned fish in supermarkets. The prices of these two brands of tinned fish are fairly reasonable, compared to other imported varieties, because they are canned in the country. An average 425 g tin of mackerel sells for K3.15 and a 420 g tin of tuna sells fairly well at K3.50. Anchovies and salmon are fairly expensive and can only be afforded by high-income earners and the expatriate population.

Hotels and lodges

The main patrons of the hotels and lodges were travellers, expatriates and workers. Hotels and lodges serve food and alcoholic beverages as well as soft drinks and souvenir items. The restaurants in hotels and lodges prefer high-quality fish such as rainbow trout, barramundi and other marine species on their menus. They also demand a constant supply. Some of the market interviewees said they preferred farmed fish such as rainbow trout but they were not available. This indicates that markets exist for certain farm species that satisfy standards of high quality.

Yonki roadside market

The patrons at the Yonki roadside market were travellers on the Highlands Highway. Roadside markets generally have many people selling various garden foods as well as a mixture of cooked food and other miscellaneous items. At the Yonki roadside market, fishers and merchants mainly sell fried and fresh tilapia but there are other fish species. The other fish species generally make up 10–20% of the total fish sale, and include common carp (*Cyprinus carpio*), tor (*Tor putitora*) and other introduced species caught by fishers

in Yonki Reservoir. On the main market days 25% of stallholders are selling fish.

A few roadside markets may sell farmed fish but the survey did not identify any. The only 'roadside' market in the highlands with fresh fish, out of the many markets visited, was the Yonki Market. On the coast there were some markets with marine fish and freshwater crustaceans but none of the fish were farmed.

Farm-side markets

The farms usually sell their fish to surrounding villages and workers in their local communities. However, some farmed fish are sold to a wide range of patrons, including hotels, restaurants, expatriates, lodges and tourists who visit the farm. Fish farmers often transport fresh fish to the hotels and supermarkets to sell, and buyers also travel to farms to purchase fish. Roadside markets are usually unreliable so farmers hardly ever sell their fish there.

The demand for farmed fish in many villages in Papua New Guinea, especially in the highlands, is quite high and farmers decide the price of their fish. A common carp weighing 1 kg would fetch a price of K10.00 at the farm site.

The Yonki Cage Culture Project, which is run by EHPG as a demonstration to encourage local cage farmers, is capable of producing about 800 kg of tilapia per week. Of this, 70% could be sold at the site while the remainder could be taken to Goroka for open market sale (street sale) (Vira pers. comm. 2003).

The OISCA Training Centre in East New Britain sold its fish to Anderson's Foodland at Kokopo, which then sold them to its customers. The market proved successful, with a very high demand for farmed fish (Kembu 1998).

The Lake Pindi Yaundo Trout Farm in Simbu sells its fish to a wide range of consumers, from Asians to large hotels like the Lae International Hotel, Crown Plaza and Highlander Hotel (Higgins pers. comm. 2001).

Small-scale trout fish farmers, on the other hand, do not have established markets because they cannot maintain a consistent supply. They cannot sell their fish at the local village market because the local people cannot afford to buy them. Such a situation has forced many small-scale trout farmers to cease operating.

A coastal fish market at Wewak, East Sepik province

A coastal fish market at Wewak, East Sepik province. Java carp, tilapias and common carp are sold after being caught from the wild. No farmed fish are present at the market.

Processing of fish

Small-scale fish farmers do not have iced facilities or refrigeration. So post-harvest preparation and quality control are areas that fish farmers need to learn about in order to store and sell their fish without loss of quality. Fish is generally sold either fried or raw (not gilled or gutted). No ice is available at the roadside markets to preserve the fish.

Rainbow trout is sold at many stages of processing. Lake Pindi Yaundo Trout Farm sells its trout either raw, chilled, smoked or deep fried (gilled and gutted). The Bismark Barramundi Farm sells its fish both raw and as fillets (gilled and gutted). Tilapia caught in the Yonki Reservoir is sold either deep fried or whole raw (gilled and gutted). The Yonki Cage Culture Project has sold fish gilled and gutted or whole raw to its customers. Most of the marine fish are sold frozen (gilled and gutted). Barracuda is sold as fillets, while tuna and other species are either sold frozen whole (gilled and gutted) or as cutlets.

Market preferences and opinions about farmed fish

According to hotels and supermarkets, the availability of farmed fish is very low. Some of these places indicated that they were willing to buy farmed fish and sell it to their customers but that no fish farmers had approached them. Some of the interviewees, although they did not stock farmed or wild freshwater fish, said that they would like to stock farmed fish.

Twelve (75%) of the 16 markets expressed their views about the price of farmed fish, while the other four (25%) had no comment. Seven (44%) of the contacts felt that the sale price of farmed fish was very high while three (19%) thought it was appropriate. One person suggested that the best way to reduce the price was to increase production.

Fourteen (87.5%) of the interviewees thought that the quality and taste of farmed fish was very good. Almost half the markets felt that the fraction of edible content of farmed fish was adequate or more than adequate.

Some 30.2% of market contacts suggested that more awareness was needed in terms of training and extension. Some expressed the view that in order for farmers to advance and participate more actively, financial assistance and infrastructure were needed. A few marketers suggested that a better mechanism should be established to link farmers with markets. Another 30.2% of contacts made either no suggestion or were reluctant to comment.

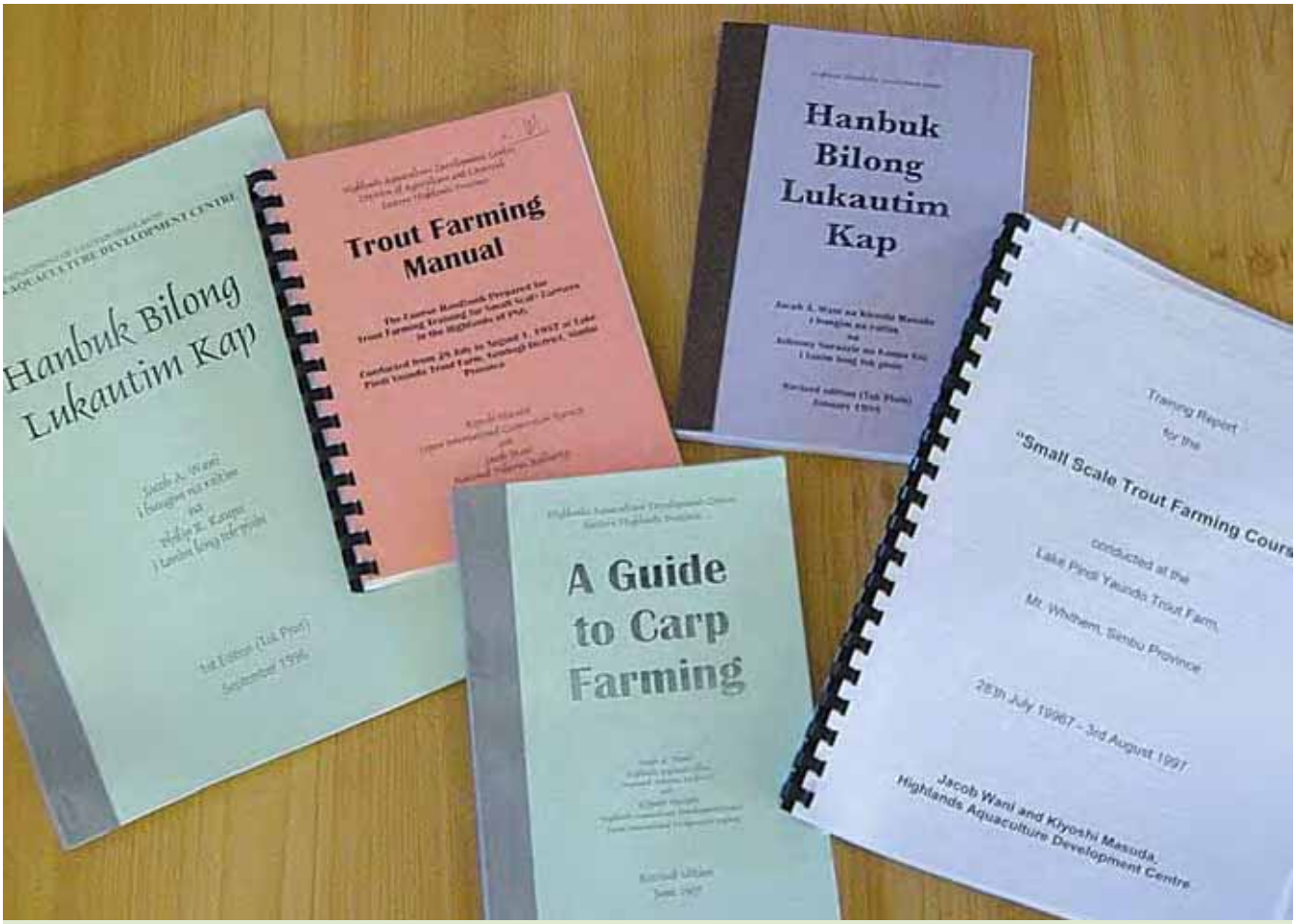
Summary of recommendations

The main recommendations of the merchants and contacts at markets were:

- Fish farmers should be encouraged with some assistance in terms of materials and technical advice to increase their production to meet high market demand. As a result of increases in production, the cost of production and the sale price of farmed fish may also decrease.
- The method of distributing fingerlings to farmers should be improved so that active fish farmers can improve their consistency of production and thus increase the quality and quantity of farmed fish.
- Improved infrastructure (i.e. roads, transport, ice supply) is needed to facilitate access of farmers to markets.
- Post-harvest preparation and quality control measures should be emphasised during fish farmers' training and 'wokabaut skul' programs.
- New marketable fish species should be identified or introduced for farmers to farm—the release of the GIFT strain after this survey answered this concern in part.

References

Kembu C. 1998. Inland Aquaculture Status Report, East New Britain, Papua New Guinea.



Manuals for learning about carp and trout farming in PNG. These resources were written by Jacob Wani and colleagues during the mid 1990s and are available from HAQDEC.

Chapter 7

Survey of attitudes of institutions to fish farming

Micha Aranka, Kine Mufuape and Paul T. Smith

Introduction

In PNG fish farming is taught in community schools, high schools and many correctional institution services (CIS). Some churches and missions also run training as a core topic in the teaching of agriculture. Institutions are introducing fish farming mostly to equip students and inmates with basic skills and knowledge so that they become useful citizens when they return to their native villages. It is hoped that this will lead to meaningful development as a means of self-employment and cash income.

The institutional survey was conducted because of the interest and involvement of institutions in fish farming over the past few years, and the importance of training and education in increasing the profitability/success of ventures into fish farming.

Under this program 17 institutions from six provinces in PNG were surveyed. They included:

- government schools (community schools, high schools, vocational centres)
- missions
- Correctional Institution Services (CIS)
- colleges and universities.

Survey methods

The survey program interviewed headmasters, agriculture teachers, instructors, farm managers and those people in charge of the agriculture section in each institution. The data covered background about the institution and their activities, the institution's opinion about the impact of their training, and their observations and opinions about fish farming in the surrounding area. Respondents were able to make suggestions to improve the development of fish farming and the training of fish farmers in the institution and the local area.

At each survey site the name and contact details of the institution were recorded, together with water quality parameters (DO, pH, water temperature, Secchi visibility and depth of water), the location of the farm (using GPS) and the farm area (using a tape measure).

Activities carried out at the institutions

The aquaculture activities carried out at the institutions include basic training and growing of fish. Fish farming is included with other agricultural activities such as a vegetable plot, a piggery, poultry production and an orchid garden. One institution taught integrated duck and fish farming.

A Catholic mission school run by Father Joseph Katika in Simbu province where training in fish farming is carried out

Table 7.1
Responses from institutions to the survey questionnaire

Institution	Type of institution	Number of staff involved	Number of students involved each year	Time allocated to staff for fish farming activity (% of week)	Time allocated to students for fish farming activity (% of week)
Bundaira CIS	Government prison	2	20 inmates	90	90
Kerevat CIS	Government prison	3	15 inmates	20	20
Bihute CIS	Government prison	1	16 inmates	5	Nil
Baisu CIS	Government prison	1	6 inmates	20	5
University of Papua New Guinea	Tertiary education	Nil	Nil	Nil	Nil
University of Goroka	Tertiary education	1	40	2	2
Muaina High School	Government school	1	124	50	37
Hagen Secondary High School	Government school	1	400	15	5
Kerowagi Secondary High School	Government school	1	700	2	2
Goroka Secondary High School	Government school	4	1,120	2	2
Lufa Primary School	Government school	14	554	5	5
Boana Community School	Government school	1	40	5	5
St Joseph Training Centre	Mission	2	15	5	5
St Michaels High School	Mission	4	558	Nil	5

Table 7.1 continued

Institution	Type of institution	Number of staff involved	Number of students involved each year	Time allocated to staff for fish farming activity (% of week)	Time allocated to students for fish farming activity (% of week)
Fatima Agriculture Vocational Centre	Mission	2	150	10	10
Kama SDA Primary School	Mission	1	80	10	10
EBC Technical School	Mission	1	70	15	15

From the data it appears that fish farming was introduced to the institutions mostly for the purposes of training and growing food. The proportion of time spent by staff and students on fish farming and the amount of time allocated by the respective institutions are shown in Table 7.1. Interestingly, the results for CIS (prisons) show the highest level of involvement in fish farming, while tertiary institutions have the least involvement. The main results from the survey are as follows.

- Each type of institution had an average of two staff involved in fish farming activities, with a range of zero at one tertiary institution to 14 at one government primary school.
- An overall average of 230 students per institution were involved in aquaculture training each year. Government schools ranged from 40 to 1,120, missions had a range of 15 to 558, and prisons had a range of 6 to 20.
- Time allocated to staff for fish farming activities per week averaged 15% across all institutions, with the highest allocation being 90% at one prison.
- Time allocated to students for fish farming activities per week averaged 13%, with a range of 0–90% for prisons, 0–2% at tertiary institutions, 2–37% at government schools and 5–15% at missions.

Common carp (*Cyprinus carpio*) was the species that was cultured at all the surveyed institutions, and had been cultured for at least 3 years prior to the survey (Table 7.2). Carp was introduced before any of the other species and it was easy to obtain from HAQDEC. Most of the institutions reported that tilapias were the dominant species in many of the rivers and streams. However, at the time of the survey, the GIFT strain was not available despite some institutions wanting to stock their ponds with it. After the survey period, the GIFT strain was distributed by HAQDEC to these institutions. However, staff are in need of training on the important differences between GIFT and common carp with respect to breeding, feeding, husbandry and management. As for trout, no institution preferred to culture this species because the culture requirements were too delicate and demanding. Also, it was restricted to high altitude areas.

Table 7.2
Summary of fish species at the institutions in 2003

Species	No. of years fish farming taught at the institution	No. of students taught at the institution last year	Comment
Carp	3 (average)	229	Fish easily obtained from HAQDEC and staff trained at HAQDEC
Tilapia species	Nil	Nil	Common in rivers
Trout	Nil	Nil	Too difficult, too demanding
Other species	Nil	Nil	Nil

Institutions' opinions about the influence of their activity

Opinions about fish-farming activities were rated according to the respondent's assessment of the degree of interest and ability of their students to apply fish farming in the near future after they leave the institution. As shown in Table 7.3, two institutions indicated that their students have a very high interest (11.8%), 11 reported a high degree of interest (64.7%), and four indicated a fair to medium interest in fish farming (23.6%). Thus, there is obviously a significant interest in fish faming by students in many PNG institutions. This suggests that government bodies should support these schools to introduce fish culturing as a major activity.

Table 7.3
Interest and participation of students in fish farming and training

	Very high (%)	High (%)	Fair/medium/ average (%)
Degree of interest	11.8	64.7	23.6
Degree of participation	5.9	70.6	23.5
Ability to apply training	17.6	23.5	58.8

The degree of participation by students in fish-farming training is significant, and many of the respondents said students participated weekly or on a regular basis as part of their training requirement. Most were attracted to fish farming because it was an easy activity, it looked attractive and it required simple culturing skills. Also, fish culturing has had good socioeconomic impacts on the livelihoods of many simple rural communities. One institution (5.9% of respondents) reported a very high level of participation, 12 (70.6%) a high level, and four (23.5%) a fair level of participation.

Respondents were also asked to consider whether the students were able to continue in fish farming and put into practice what they had learnt at the institution. However, because the institutions do not follow up with their students, the respondents said there was no clear information. Instead, the respondents gave conservative estimates (Table 7.3). It is likely that at least a fair percentage of students would end up establishing a farm because of the difficult general employment situation.

The institutions considered the limitations on students starting up commercial or small-scale fishery activities after leaving the school. The main limitations identified were capital cost, financial viability and supply of fingerlings, while some respondents included market accessibility (Table 7.4). Nevertheless, most respondents reported that students would like to develop their own aquaculture enterprise. They suggested that assistance could be provided at the initial stage, or small loans for essential materials could be sought from a commercial bank. Many students come from poor families or have parents who are unemployed and thus have very limited resources to assist in establishing a farm.

Table 7.4
Limitations on students starting up fish farming

Limitation/problem	Rank	No. of respondents
Capital cost	Very high to high	10
Financial viability	High	8
Supply of fingerlings	High	8
Land availability	Fair	8
Skill levels	Fair	11
Construction of ponds	Fair	12
Marketable species	Fair	12
Infrastructure	Fair	8
Market accessibility	Ranged from high to low	10

Table 7.5
Responses of the institutions' respondents to questions on their knowledge of the level of fish farming activity within the local area. The numbers of respondents with an awareness is shown (n = 17).

Species	Aware of farms within 10 km	Awareness of the number of years of fish farming in the local area	Location of carp and tilapia farms in the local area
Carp	3 respondents	Nil	3 respondents
Tilapia	Nil	Nil	Nil
Trout	Nil	Nil	Nil
Others	Nil	Nil	Nil

Institutions' observations about fish farms in the surrounding area

Of the 17 institutions visited, most were unsure or did not know about the existence of any fish-farming activities in their local area. This was the case even when farms were operating within 10 km of an institution. This lack of awareness is shown in the responses in Table 7.5. It is possibly because the institutions are isolated, they do not provide extension services to the community and because people at the institution do not socialise much with the surrounding farm community.

Without knowing about local farming activity, the institutions would not be aware of fish being sold at the local market or have any idea of the quality of farms. They would also not be aware of problems faced by the farm or caused by its activities, e.g. environmental problems in the water system, fish disease, flooding, farm management or feed shortages.

Opinions about fish farming

The institutions' responses to fish farming were either very positive or neutral. They showed a high level of interest in expanding the number of fish farms in the community. The institutions noted that fish farming was very important to communities and beneficial to villagers as a source of protein and self-employment opportunities. They recommended that a network of extension officers should be available to promote fish farming as it was an important activity that the government should encourage.

Problems encountered at the institutions' fish ponds

The respondents considered that the most common problem for their institution's fish farm was being able to obtain fingerlings. They reported that there are no local suppliers and it was difficult to obtain fingerlings from other suppliers or

from HAQDEC. While some institutions may be capable of carrying out natural breeding of fish in their ponds, the production of fingerlings is problematic due to lack of proper materials, equipment, vehicles for transport and other infrastructure.

The major obstacles, in descending order of priority, were:

1. shortage of fingerlings
2. lack of fish feed
3. need for skills training in pond management
4. need for training on the means of assessing and improving water quality in ponds
5. theft of farmed fish.

In many cases the respondents reported that operators of fish ponds at the institutions ignore feeding the fish with local food such as taro, sweet potato, banana and yam. Many institutions lack fish feed and, in particular, fish are not provided with an adequately balanced feed.

Suggestions by the institutions for improving training and development of fish farming.

Most institutions indicated that a number of measures were required to improve development of fish farming in the local area, including:

- more training on fish farming
- more extension services and awareness of fish farming
- a larger supply of fingerlings.

These suggestions from the institutions show that there is a need for fish farming development that could be addressed by relevant authorities. The major need was for training, since many people in PNG have no experience with fish farming or are unaware of it. Adequate skills and information are still lacking at the institution level. The resources for learning about fish farming are limited to a few books that are sold by HAQDEC. The institutions requested more teaching resources and the introduction of formal training and extension services so that they can develop fish farming in their institution or in the surrounding areas.

Conclusions

In most institutions fish farming was introduced to impart basic aquaculture skills, techniques and information to students as part of the institution's training requirements. Students developed a fairly high degree of interest in the subject. However, the teaching of fish farming is generally not supported by sufficient training resources. Consequently there is a need to equip, raise awareness and disseminate information to all institutions so they can adequately transfer basic skills and knowledge to students. This will provide them with useful skills once they graduate and return to their villages.

Aquaculture has had many false starts in PNG, especially as far as inland fish farming is concerned, resulting in a lack of trained teachers in many of these institutions. Although aquaculture now has a history of more than 50 years in inland PNG, only a few people have the required professional skills and knowledge. Additional technical people need to be encouraged to be involved in the industry and institutions are very keen to take up the opportunities.

Some of the 208 participants at the farm-based workshop held at the Potsy Community Fish Farm, Huon District, Lae. The workshop was the first in the new wokabaut skul, halpim long pis fama (help for fish farmers). The workshop ran for 3 days (8–10 August 2006) providing hands-on training and extension for farming GIFT fish. Training activities included making fish feeds, fish management, making and using Secchi poles, sexing fish, making sol pis (salted fish), making nets and transporting fingerlings.

Chapter 8

Key issues facing the development of inland pond aquaculture in Papua New Guinea

Ursula Kolkolo, Peter Minimulu, Wally Solato and Paul T. Smith

Introduction

As described in previous chapters, surveys of farms, markets, hatcheries and institutions were carried out during 2002–03 with the aim of assessing inland pond aquaculture and identifying research needs. The findings were presented to the project's major workshop in Goroka, PNG, in May 2003. The workshop was attended by more than 100 stakeholders, including key fish farmers, NGOs and representatives from national and provincial governments with responsibility for development of, and research and training in, aquaculture. The key issues for improving inland fish farming in PNG were discussed and prioritised by the stakeholders during the workshop.

At about the same time, the first batch of GIFT fingerlings were distributed to farmers by HAQDEC. In the following 3 years (2003–06) the survey team assessed the distribution and impact of GIFT on inland pond aquaculture. Farmers were interviewed, and more data was gathered. Focus workshops were conducted at Kabwun, Mount Hagen, Goroka, Erap, Rabaul, Wewak and Aiyura, which were each attended by 50–100 stakeholders. The issues and priorities of the Goroka 2003 workshop were refined during 2003–06, mainly to take into account the impact of the GIFT strain.

A summary of the discussions and priorities are presented here. It is hoped that this information can be used by departments within the PNG government as well as NGOs and international donor agencies. The key issues have been subdivided into specific activities that can be undertaken by small teams. However, there is scope for cooperative and complementary work among agencies interested in developing rural fish farming in PNG.

Process used to identify and prioritise the key issues

The process used to help participants discuss and prioritise key issues affecting fish farming began with the selection of a broad range of representative people to attend the major workshop in Goroka and the regional workshops. Participants at the workshops included smallholder farmers, community farmers, commercial large farmers, women farmers and institutional farmers. Farmers came from most of the provinces that carry out inland pond aquaculture, including EHP, WHP, Western, Simbu, East Sepik, SHP, Morobe, ENB and Madang. Also, the workshop at Aiyura in October 2004 was specifically for women in aquaculture. It was attended by women from throughout PNG including farmers who have fish cages in Yonki Reservoir.

All workshops had representatives from a range of government and non-government bodies that have functions of regulating, researching and managing the development of fisheries and aquaculture. NGOs were invited because of their involvement in training and supplying fingerlings to villages. Representatives of corrective institutions were also invited. JICA, which had trained farmers, extension officers and scientists over the previous 10 years, sent a representative to every workshop. Church organisations that run schools which train young people in fish farming participated. The participants

discussed and prioritised the key issues arising from analysis of the ACIAR survey and identified additional issues.

At each workshop participants had the opportunity to listen to a number of key speakers who described the history of aquaculture development in PNG, the status of the industry in PNG and the findings of the survey. Farmers from various provinces, including Morobe, Madang, EHP, Simbu, WHP and East Sepik, attended and spoke about their personal experiences and the issues facing village farmers at the forefront of the industry. Also, international speakers from SPC, NACA and ACIAR attended the workshops and provided relevant information on freshwater aquaculture in the Asia–Pacific region. During many of the workshops there were some training and extension activities at demonstration farms or government facilities.

Participants at the workshops were divided into three groups: experienced pioneer farmers (olpela fama), established farmers with less than 1,000 fish (olpela lik lik fama) and young farmers (nupela fama). Each group had a facilitator and recorder. The facilitator was either someone from the project team or a participant with the necessary knowledge of issues in inland fish farming. Within each group, the facilitator used the key issues to (i) discuss and record activities to address each issue; (ii) give a priority of high, medium or low to each issue; (iii) list organisations that may be able to solve that particular problem; and (iv) suggest additional issues and activities.

Workshop findings

The results of the workshops are summarised in Tables 8.1–8.3 according to the three categories of farmer (olpela fama, olpela lik lik fama and nupela fama). For each issue the tables contain the specific issue, the recommended activities, the level of priority of the issue, and the groups which can either solve the issue, facilitate the activities or have the legal responsibility to solve the issue.

Table 8.1
Summary of key issues for olpela famas (pioneer, experienced farmers)

Specific issue	Activities	Priority	Responsible organisation(s)
1. Improving fingerling supply			
High mortality rates of GIFT fingerlings during transport to farmers	Research the problem Establish fingerling distribution centres	High	NDAL, NFA, provincial governments
Lack of trout fingerlings	Provincial hatchery operators need training Re-establish wokabaut skul to train farmers in broodstock care and fingerling production	High	Provincial governments and NDAL to take initial steps and ask farmer associations to assist in organising suitable farms

Table 8.1 continued

Specific issue	Activities	Priority	Responsible organisation(s)
Carp fingerling supply is low but demand is high	Improve fingerling supply from HAQDEC Assist experienced farmers in building their own hatcheries and train them in fingerling production	High	Training by JICA and ACIAR Financial assistance through rural credit scheme or rural development bank
2. Improving nutrition and growth			
High cost of imported feeds for large farms	Formulate commercial stock feed for trout, GIFT and carp based on local ingredients Decentralise feed storage and distribution centres	High	Research institutions such as NARI, JICA, ACIAR
Poor feed quality for smallholder farms	Formulate on-farm feeds based on local ingredients Analyse the composition of local ingredients for suitability	High	Research institutions such as NARI, JICA, ACIAR
Poor nutrition of broodstock	Train farmers in care and feeding of broodstock, especially trout, so they can produce fingerlings	High	Training on broodstock nutrition by JICA and aid agencies
3. Identifying appropriate species and methods for farming at different altitudes			
Improve pond fertility for carp and GIFT	Training for integrated systems using manure Production of a training manual on fish biology for managing pond fertility	Medium	Research and training by HAQDEC Training material to be implemented in provincial DALs and through farmer associations
Selection of species for various climates	Comparative studies at different altitudes with GIFT and carp	High	Research at demonstration farms and extension by HAQDEC
Trial other local species	Breeding and growth studies of local species	Low	Not indicated
Improved farming strategies for GIFT	On-station research into feeding and animal husbandry, and extension through selected demonstration farms	High	HAQDEC and other research institutions

Table 8.1 continued

Specific issue	Activities	Priority	Responsible organisation(s)
4. Developing farming strategies for new species			
Research into indigenous species	On-station research and on selected demonstration farms using native species	Variable response—farmers were pointing to the need to resolve present problems with current species	HAQDEC and other research institutions
5. Improving marketing strategies			
Need quality, quantity and consistency of product	Establish market standards	High	NDAL, NFA to provide advice and training, and Health Department to set food quality standards for farmers
Processing and value-adding to product	Basic training on fish processing for markets Basic training of farmers on strategies for markets	High	Training by National Fisheries College
Improved infrastructure	Better roads and access to markets	High	National and provincial governments
6. Improving communication of research findings to the industry			
Improved information dissemination	Build farmer associations and networking	High	NARI, NACA, ACIAR
More information to farmers for all species	Develop extension material in tok pisin and make available at HAQDEC and fingerling distribution centres	High	HAQDEC, NGOs, provincial DAL extension services
7. Disease management			
Prevent introduction of diseases	Lack of baseline data on fish diseases in PNG Quarantine imported fish	Medium to low	NAQIA

Table 8.1 continued

Specific issue	Activities	Priority	Responsible organisation(s)
8. Minimising environmental impacts			
Wastewater management from discharges, particularly trout farms	Technical input to farmers on treating discharges	Medium to low	NACA, farmer associations, ACIAR, HAQDEC, universities
9. Political administration			
Lack of transparency at local and national levels	Determine the lead agency—NDAL or NFA Provide training to government administrators on planning and budgets	High	NARI and other bodies to run training programs

Table 8.2
Summary of key issues for olpela lik lik famas (established farmers with some experience)

Specific issue	Activities	Priority	Responsible organisation(s)
1. Improving fingerling supply			
High fingerling mortality rates during transport, especially GIFT	Devise suitable packing methods and containers to improve survival	High	HAQDEC and hatcheries to carry out research and trails
High freight costs for small orders and low accessibility to HAQDEC	Establish fingerling distribution centres	High	NFA, NDAL, JICA, ACIAR, provincial DALs
Improve fingerling supply from HAQDEC	Training on fingerling production at HAQDEC	High	ACIAR and JICA to fund workshops and training at HAQDEC
2. Improving nutrition and growth			
High feed cost	Develop suitable low-cost farm-made feed using local ingredients	High	ACIAR, NARI, NDAL, JICA, universities and HAQDEC
Need suitable feeds for carp, trout and GIFT	Feed studies on all species using local ingredients in trial feeds Extend formula and preparation methods to farmers	High	ACIAR and JICA to fund research at HAQDEC and extend results through wokabaut skul

Table 8.2 continued

Specific issue	Activities	Priority	Responsible organisation(s)
Slow growth of farmed fish	Research into improved fish nutrition under PNG conditions	High	ACIAR, NARI to fund research at HAQDEC and demonstration farms
3. Identifying appropriate species and methods for farming at different altitudes			
Farmers need technical information and skills for integrated farming	Training on integrated farming	Medium	HAQDEC, NDAL, JICA and institutions
Improve pond productivity	Training and extension on feeding and fertilising	High	Provincial DALs
Genetic improvement of currently farmed species	Improve broodstock of carp and GIFT at HAQDEC	High to medium	ACIAR, NARI, research institutions
4. Developing farming strategies for new species			
Develop farming techniques for new species	Research nutrition and breeding of new species	Medium to low	HAQDEC, ACIAR, JICA, NARI
5. Improving marketing strategies			
Better roads and infrastructure	Lobby government	High	National and provincial governments
Producing quality fish for the market	Train farmers on quality control and marketing	High	HAQDEC, NFA, NARI, NDAL
6. Improving communication of research findings to the industry			
Data collection for industry	Conduct survey and establish database	High	NDAL, HAQDEC, NFA
Improve information dissemination to farmers	Publish research data, conduct workshops and wokabaut skul	High	NDAL, NARI, ACIAR, NFA and universities
7. Disease management			
Lack of understanding about diseases	Provide training to farmers on disease management	Medium to low	NAQIA, NDAL, NFA
8. Minimising environmental impacts			
Lack of policy	Chemical controls for big farms	Low	NFA and NDAL

Table 8.3
Summary of key issues for nupela famas (inexperienced, newcomers)

Specific issue	Activities	Priority	Responsible organisation(s)
1. Improving fingerling supply			
Lack of fingerlings	Improve seed production at HAQDEC and hatcheries	High	HAQDEC and funding support from other government agencies
Poor distribution of fingerlings	Research into cause of high rates of mortality during transport of GIFT Establish fingerling distribution centres Establish farmer networks for transporting and distributing fingerlings	High	NDAL, HAQDEC, NGOs, farmer associations and provincial DALs
2. Improving nutrition and growth			
Lack of cheap suitable feed	Conduct survey to determine the availability of locally available ingredients Develop formula based on local ingredients for farm-made feed Develop a commercial feed based on local ingredients	High	NARI, ACIAR, research organisations and universities
3. Identifying appropriate species and methods for farming at different altitudes			
Limited knowledge on pond management	Research improvements in pond productivity with local fertilisers in integrated farming	Medium	HAQDEC and demonstration farms
Improve genetics of broodstock of current species	Reintroduce improved families of common carp and GIFT	Medium to low	Research institutions, NAQIA, ACIAR, NFA and JICA
4. Developing farming strategies for new species			
Lack of additional culture species, e.g. Chinese carp	Reintroduce Chinese carp species (they did not establish themselves last time)	Medium to low	NAQIA, HAQDEC, NFA, JICA and ACIAR

Table 8.3 continued

Specific issue	Activities	Priority	Responsible organisation(s)
Lack of information about culture of indigenous and other local species	Carry out growth and production trials at HAQDEC	Low	HAQDEC, JICA and ACIAR
5. Improving marketing strategies			
Need for training on strategies for marketing	Training for planning for harvest at peak times (i.e. Christmas, New Year) Training for post-harvest processing and selling Training on value-adding. e.g. sol pis (salted fish) and cooking own fish at markets	Low	Farmer associations and networks, provincial officers
6. Improving communication of research findings to the industry			
A general lack of research on aquaculture in PNG	Carry out research and publish and disseminate findings	High	All research agencies and institutions
Lack of research under local conditions	Carry out trials under local conditions using local feed ingredients and fertilisers	High	All research agencies and institutions
7. Disease management			
No disease problems but protocols are needed	Develop protocols for recognising fish diseases, particularly in imported animals	Medium to low	NAQIA and NFA
Need to educate farmers on cultured fish diseases	Improve farmers' understanding of fish diseases and stress during transport	Medium to low	HAQDEC to do awareness and farmer education
8. Minimising environmental impacts			
Lack of risk assessment for introduced species	Research the impacts of introduced species on biodiversity Develop protocols for importing species Develop risk assessment for introducing pests or diseases with exotic species (e.g. water snails introduced at Aiyura)	High	NFA, NAQIA and international donors
9. Socioeconomic impacts			
Poor understanding of the socioeconomics of smallholder fish farming	Socioeconomic study of fish farming households	High	NARI, NDAL, NFA, ACIAR, JICA and other donor agencies

1. Improving fingerling supply (item #1 in Tables 8.1–8.3)

The specific research issues for improving fingerling supply were similar for all three types of farmers—improve fingerling production from HAQDEC, reduce the mortality rate of GIFT fingerlings during transport and establish fingerling distribution centres in the provinces. Also, pioneer farmers (Table 8.1) identified the lack of trout seed since 2002 as an urgent problem that needed immediate action.

The issues relating to fingerling distribution from HAQDEC have been outlined in chapter 4 (Fingerling distribution by the main hatcheries). Problems arise from inadequate funding, low staff numbers, a need for on-going training, lack of water in dry periods, inefficiencies in supplying small orders and an ageing infrastructure of vehicles and equipment.

The mortality rate for GIFT fingerlings during transportation to farmers was around 80% for transport times of 6 hours or longer during 2003–05. In 2005 a research project funded by ACIAR began and a key objective was to reduce mortality rates of GIFT during transport. After experiments at HAQDEC and trial shipments to farms, the problem was substantially reduced. In the latter part of 2005 mortality rates were less than 5% for transport times of 6 hours or longer. The findings of the research are currently in preparation (Simon et al.).

Establishment of fingerling distribution centres was strongly recommended to help solve the problems with small orders and long travel times to regions in the various provinces. The transport time to remote areas is commonly around 24–36 hours. NFA is working with NDAL and NGOs to address this issue.

The problem with trout seed distribution is a serious issue for Simbu province and other cool regions in the highlands of PNG where the climate is suitable for rainbow trout. Although some smallholder farmers were trained in hatchery activities and trout fingerling production at the annual JICA workshops (2002–05), an alternative supplier to the Mt Pindi Yaundo Trout Hatchery has not been established as yet.

2. Improving nutrition of farmed fish (item #2 in Tables 8.1–8.3)

All three types of farmers identified the high cost of imported feeds as a serious impediment and suggested the development of farm-made feeds using local ingredients as a high priority. Pioneer and new farmers were also looking for a commercial feed made from local ingredients. Pioneer farmers rated the improvement in nutrition of broodstock as a high priority. A recurrent suggestion was for research into feed formulas and trials to be carried out at HAQDEC. The most appropriate feeds would then be tested at demonstration farms and transferred to the industry through workshops at these farms. This strategy has been successfully used by NARI to extend information and train farmers in new areas of agriculture and livestock.

3. Identifying appropriate species and methods for farming at different altitudes (item #3 in Tables 8.1–8.3)

All types of farmers identified improvements in pond productivity through integrated farming as a high priority. Pioneer farmers recommended the development of a training manual.

They also identified the use of on-station trials at HAQDEC and research at demonstration farms at different altitudes in order to determine appropriate species and husbandry for the various climates in inland PNG. Established and new farmers recommended reintroduction of improved broodstock of common carp and GIFT.

4. Developing farming strategies for new species (item #4 in Tables 8.1–8.3)

This issue was not a high priority for most farmers and variable responses were given. Pioneer farmers suggested that the priority was to first resolve present problems with current species. New farmers suggested the reintroduction of Chinese carp species such as grass carp, silver carp and big head carp. These species were brought to various fisheries stations and HAQDEC in the mid 1990s; however, they did not become established because of problems with lack of training, lack of water in a severe drought in 1997 and other factors.

5. Improving marketing strategies (item #5 in Tables 8.1–8.3)

Farmers identified the need for training in marketing strategies in order to improve quality of product and establish high standards. Marketing issues were high for pioneer and established farmers, but low for new farmers. Specific issues with high priority were improvements in infrastructure such as roads and market access. Training in value-adding and processing were also ranked highly. One of the key activities was the establishment of quality standards in the marketplace.

6. Improving communication of research findings to the industry (item #6 in Tables 8.1–8.3)

Improvements in the dissemination of information was a high priority for all types of farmers. The activities that were suggested included the production of extension material in local languages and its dissemination through farmer associations, wokabaut skul and HAQDEC. Established farmers recommended establishing a national database on the industry in order to identify trends and areas of development and need. Once fingerling distribution centres are established, they could be a suitable means for disseminating material. New farmers pointed out that there had been very little research carried out in PNG under local conditions, and they ranked this as a high priority.

7. Other issues (items #7 to #9 in Tables 8.1–8.3)

Other issues that were raised include disease management, environmental impacts, political administration and socioeconomics. These issues were either ranked medium to low or received variable levels of priority. Disease management was recognised as a potential threat but not a priority for farmers at the moment. Environmental impacts were generally considered to be low, although new farmers identified as a high priority the need for risk assessments of the impacts of introduced species on biodiversity. The introduced freshwater snail in the highlands was cited as an example. Politics, governance and administrative decisions affecting farmers were rated highly by pioneer farmers. They stated the need for greater transparency in decision-making

at the national and provincial levels of government. New farmers identified as a high priority the need to study the socioeconomic impact of fish farming. Factors which were identified as not having been previously studied were the positive and negative effects of fish farming on the family and community, possibly through improved nutrition and increased wealth. This study would need to consider the time and resources spent on fish farming versus alternative activities.

Summary of recommendations from the workshops

New farmers (nupela fama) and established farmers with less than 1,000 fish (olpela lik lik fama) make up a total of more than 90% of the inland pond aquaculture industry in PNG. They face similar developmental issues as the experienced pioneer farmers (olpela fama). In all three groups, improving fingerling supply and nutrition of farmed fish were accepted as the most important overarching priorities for research. However, the nature of the specific issues and recommended activities varied between the types of farmers (Tables 8.1–8.3). The specific research issues for improving fingerling distribution were similar for all three types of farmers—improve fingerling production from HAQDEC, reduce mortality rates of GIFT fingerlings during transport and establish fingerling distribution centres in the provinces. Pioneer farmers identified actions to overcome the lack of trout seed since 2002 as a high priority.

As for improving nutrition of farmed fish, the three types of farmers identified the high cost of imported feed as a problem and suggested that farm-made feeds based on local ingredients should be researched. Commercial fish feed based on local ingredients was also a high priority for pioneer and new farmers. Pioneer farmers considered the need for improved nutrition of broodstock as a high priority. In addition to fingerling supply and nutrition, other key issues were analysed and specific activities identified. These included identifying appropriate species and culture conditions for the various climates of PNG, trials with new species, improving marketing and better communication with the industry.

A recurrent theme from the interviews and workshops was the need for training and extension. The most popular suggestions for facilitating training at the grassroots level were the use of demonstration farms, the re-establishment of wokabaut skul and the fostering of local farmer associations. There is ample room for international donor agencies and research organisations to work cooperatively and to complement each other in addressing the key issues confronting the development of rural fish farming in PNG.

Future directions

A major legacy of this initial ACIAR project has been the development of a range of aquaculture projects in PNG. In July 2005 the team commenced a new project (FIS/2001/083) that aims to overcome the bottlenecks that were identified in this initial project

(Smith et al. 2006). The first of the farm-based workshops, called halpim long pis fama (help for fish farmers), was held in Potsy Village in August 2006. The team will extend a fish husbandry package at workshops at 20 demonstration farms throughout PNG in 2006–09.

In addition, as of mid 2006, ACIAR has funded the following suite of projects in key areas with potential to have significant impacts on aquaculture development in PNG (Menz et al. 2006).

- inland aquaculture in PNG—improving fingerling supply and fish nutrition for smallholder farms (FIS/2001/083)
- culture of promising indigenous fish species and bioremediation for barramundi aquaculture in northern Australia and PNG (FIS/2004/065)
- increasing capacity for regional fish feed manufacture in PNG (FIS/2006/001)
- evaluation of improved feed and stocking density for GIFT (*Oreochromis niloticus*) in cage culture in Yonki Reservoir (ACIAR Pacific Aquaculture Grant with SPC).

Development of aquaculture in PNG is also being assisted by ADB, JICA, FAO and the European Union (EU) in key areas of aquaculture research, training and extension. The main NGOs include the Lutheran Development Service and religious organisations.

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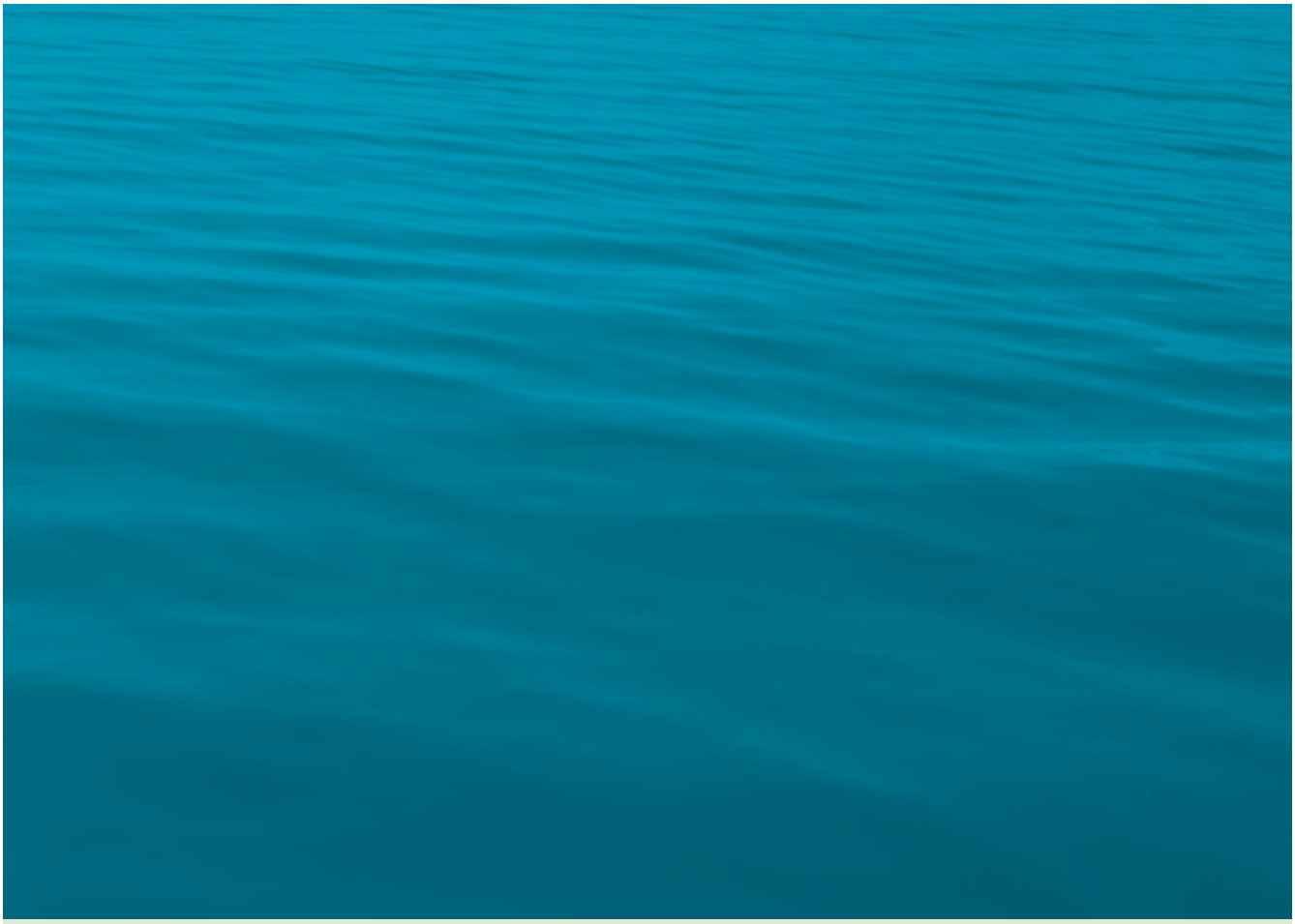
The participants at the Women in Aquaculture Workshop held at HAQDEC in Aiyura in October 2004



Appendixes

Appendix 1
Distribution of surveyed farms across the provinces of Papua New Guinea

Province	Number of farms surveyed	Percentage of farms surveyed
Eastern Highlands	71	22.7
Enga	4	1.3
Madang	8	2.6
Manus Island	2	0.6
Milne Bay	1	0.3
Morobe	104	33.2
New Ireland	2	0.6
Oro	2	0.6
Simbu	28	8.9
Western	3	1.0
Western Highlands	83	26.5
West New Britain	5	1.6
Total	**313**	**100.0**

Appendix 2
Names and locations of fish farms that participated in the study

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Jotata Baka	EHP	Kainantu	Kainantu	145°23.859’	06°00.184’	6264
Fotinain	EHP	Kainantu	Agarabi	145°54.154’	06°15.310’	6262
Baku’s	EHP	Kainantu	Kainantu	145°51.304’	06°13.929’	5460
Sairon’s	EHP	Obura Wonenara	Aiyura	145°54.703’	06°20.464’	5430
Hove	EHP	Goroka	Goroka	145°23.859’	06°00.185’	6265
Francis’s	EHP	Kainantu	Kainantu	145°46.397’	06°16.724’	5987
Kemefa	EHP	Kainantu	Kainantu	145°51.497’	06°16.506’	5210
Unanofi	EHP	Kainantu	Kainantu	145°51.307’	06°19.837’	6270
Ikana	EHP	Obura Wonenara	Aiyura	145°57.629’	06°22.105’	5161
Kaveve Trout Farm	EHP	Goroka	Gorka	145°26.514’	06°02.158’	6540
Wara Bena	EHP	Asaro	Asaro	145°19.070’	06°00.264’	5133
Keko School Leavers	EHP	Asaro	Asaro	145°17.905’	06°01.584’	5274
Kimesave	EHP	Asaro	Asaro	145°19.027’	06°01.349’	5127
Kotuni Trout Hatchery	EHP	Goroka	Goroka	145°24.222’	05°59.712’	6511
Kileku	EHP	Goroka	Kabuifa	145°22.728’	05°59.404’	6342
Riverside	EHP	Goroka	Kabuifa	145°42.082’	06°00.464’	6294
Stone Hill	EHP	Goroka	Kabuifa	145°22.413’	05°59.695’	6075
Fish Wara	EHP	Goroka	Goroka	145°23.783’	06°04.288’	4727
Aizeko	EHP	Goroka	Kabuifa	145°22.118’	06°00.397’	5798
Hoveha	EHP	Goroka	Kabuifa	145°27.179’	06°00.311’	5747
Benard’s	EHP	Lufa	Lufa	145°17.030’	06°20.689’	6749
Dani	EHP	Lufa	Lufa (Ward 17)	145°17.038’	06°20.766’	6701
Kulave # 2	EHP	Lufa	Lufa (Ward 17)	145°16.825’	06°20.873’	6777

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Kerenaga	EHP	Unggai-Bena	Bena	145°27.853’	06°06.170’	5108
Kulave # 1	EHP	Lufa	Lufa (Ward 17)	145°16.851’	06°20.869’	6771
Frog’s	EHP	Lufa	Lufa	145°18.219’	06°20.589’	6665
Famundi	EHP	Goroka	Goroka	145°24.850’	06°03.391’	5845
Verate	EHP	Lufa	Lufa (Ward 17)	145°16.988’	06°20.817’	6711
Furiri	EHP	Lufa	Lufa (Ward 17)	145°17.272’	06°20.731’	6750
Michael Azona	EHP	Bena	Bena	145°27.439’	06°06.607’	4968
Kaiyufa	EHP	Goroka	Goroka	145°26.686’	06°04.265’	6134
Yuwonie	EHP	Goroka	Kabiufa	145°22.553’	05°51.613’	6141
Keremu	EHP	Asaro	Asaro	145°16.525’	05°57.316’	5526
Homin Tree	EHP	Asaro	Kongi 2	145°15.692’	05°55.848’	5524
Kaiufa	EHP	Unggai-Bena	Bena	145°26.678’	06°04.178’	6242
Kami	EHP	Goroka	Goroka	145°24.383’	06°06.981’	4727
Gamino Peter’s	EHP	Goroka	Goroka	145°24.404’	06°07.999’	4730
Donito Development	EHP	Lufa	Hairo LLG	145°18.966’	06°20.986’	6056
Dise’s	EHP	Lufa	Hairo LLG	145°18.944’	06°21.001’	6136
Auno	EHP	Lufa	Lufa	145°17.990’	06°20.009’	5954
Beismen’s	EHP	Lufa	Hairo LLG	145°18.919’	06°21.071’	6223
Saki’s	EHP	Lufa	Lufa	145°18.029’	06°20.005’	6017
Sambu	EHP	Lufa	Lufa	145°18.118’	06°20.121’	6000
Aita’s	EHP	Kainantu	Kamano #2	145°41.463’	05°25.636’	6456
Jerry’s	EHP	Kainantu	Kamano #2	145°40.854’	06°26.365’	7013
Teet’s	EHP	Kainantu	Kamano #2	145°40.656’	06°26.468’	6950
Naru	EHP	Kainantu	Kamano #2	145°41.392’	06°25.545’	6480
Ore’s	EHP	Kainantu	Kamano #2	145°40.274’	06°26.425’	6641

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Pila's	EHP	Kainantu	Kamano #2	145°40.275'	06°26.426'	6658
Nanda's	EHP	Kainantu	Kamano #2	145°40.370'	06°26.332'	6703
Sabu's	EHP	Kainantu	Kamano #2	145°40.643'	06°25.347'	6728
Pioe's	EHP	Kainantu	Kamano #2	145°40.316'	06°26.406'	6613
Karane's	EHP	Kainantu	Kamano #2	145°40.651'	06°25.593'	6704
Ilake's	EHP	Kainantu	Kamano #2	145°40.134'	06°26.356'	6574
Semik's	EHP	Kainantu	Kamano #2	145°40.755'	06°25.846'	6687
Pitanga	EHP	Okapa	Ofafina	145°39.095'	06°26.747'	6502
Sewage's	EHP	Kainantu	Kamano #2	145°38.991'	06°25.786'	6521
Kame's	EHP	Kainantu	Kamano #2	145°40.026'	06°26.324'	6568
Riverside	EHP	Kainantu	Kamano #2	145°40.104'	06°26.348'	6557
Yoyo's	EHP	Kainantu	Kamano #2	145°40.088'	06°26.364'	6532
Kosaweompa	EHP	Kainantu	Kamano #2	145°40.271'	06°26.581'	6828
Newata's	EHP	Kainantu	Kamano #2	145°40.282'	06°26.398'	6635
Topise's	EHP	Kainantu	Kamano #2	145°40.304'	06°26.412'	6688
Wako's	EHP	Kainantu	Kamano #2	145°40.268'	06°26.545'	6671
Soren's	EHP	Kainantu	Kamano #2	145°40.307'	06°26.401'	6668
Benny's	EHP	Kainantu	Kamano #2	145°40.134'	06°26.356'	6653
Kotufa's	EHP	Kainantu	Kamano #2	145°40.295	06°26.411'	6632
Bobby'	EHP	Kainantu	Kamano #2	145°40.269'	06°26.444'	6634
Albert's	EHP	Kainantu	Kamano #2	145°40.271'	06°26.560'	6668
Tano's	EHP	Kainantu	Kamano #2	145°40.155'	06°26.375'	6585
Onkilo's	EHP	Kainantu	Kamano #2	145°40.196'	06°26.424'	6573
Pina	Enga	Wabag	Wabag	143°49.324'	05°34.275'	5962
Waiye	Enga	Wapenamanda	Wapenamanda	143°56.420'	05°44.350'	7057
Pupang	Enga	Wabag	Wabag	143°41.826'	05°28.071'	6935
Minamp Trout Farm	Enga	Wapenamanda	Minamb	143°55.879'	05°43.381'	6706
Imbrum	Madang	Upper Ramu	Bundi	145°19.673'	05°44.035'	639

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Aida Bett's	Madang	Madang	Ambenob	145°38.555'	05°15.878'	131
Imakul Bann	Madang	Madang	Ambenob	145°38.489'	05°15.836'	150
Bismark Barramundi (PNG) Ltd	Madang	Sumkar	Sumkar	145°43.661'	04°47.704'	94
Armukan	Madang	Sumkar	Sumkar	145°53.046'	04°41.754'	43
Wasabama	Madang	Sumkar	Sumgilbar	145°43.801'	04°52.036'	127
Bilbil	Madang	Madang	Madang	145°45.989'	05°16.829'	65
Lik Liksal	Madang	Sumkar	Sumkar	145°46.037'	04°50.357'	157
Salasia	Manus	Lorengau	Lorengau	147°17.348'	02°03.156'	289
Rossum	Manus	Lorengau	Lorengau	147°15.573'	02°03.237'	287
Bibiko	Milne Bay	Alotau	Alotau	150°23.883'	10°17.900'	101
Gawin	Morobe	Nawaeb	Boana	146°49.380'	06°26.039'	2990
Kukak	Morobe	Nawaeb	Boana	146°48.421'	06°25.252'	2767
Nakulan	Morobe	Nawaeb	Nek	146°50.587'	06°24.368'	3650
Gabsonkeg	Morobe	Huon	Huon	146°45.281'	06°34.858'	246
Gedisa's	Morobe	Huon	Huon	146°45.678'	06°35.165'	223
Elijah David's	Morobe	Huon	Huon	146°45.254'	06°34.830'	329
Nabiri	Morobe	Kaiapit	Kaiapit	146°07.527'	06°07.291'	1524
Pumu's	Morobe	Kaiapit	Kaiapit	146°07.469'	06°07.296	1498
Kwasalan	Morobe	Nawaeb	Boana	146°50.549'	06°23.234'	4041
Kakag	Morobe	Nawaeb	Boana	146°47.518'	06°36.724'	2691
Oli Pali's	Morobe	Kaiapit	Kaiapit	146°02.399'	06°02.252'	1515
Mitie Dangadi's	Morobe	Nawaeb	Boana	146°47.502'	06°26.634'	2764
Intoap	Morobe	Kaiapit	Kaiapit	146°14.529'	06°21.176'	839
Wawin	Morobe	Huon	Huon	146°35.848'	06°29.729'	707
Bail's	Morobe	Huon	Wawin	146°33.707'	06°31.990'	529
Maiam	Morobe	Kaiapit	Kaiapit	146°08.191'	06°11.007'	1313

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Merup	Morobe	Nawaeb	Boana	146°50.455’	06°23.699’	4051
Kawadum	Morobe	Nawaeb	Boana	146°50.725’	06°24.387’	3928
Wasin	Morobe	Nawaeb	Boana	146°47.603’	06°25.500’	3404
Mongoman	Morobe	Nawaeb	Boana	146°48.354’	06°24.860’	2529
Wasuapum	Morobe	Huon	Wampar	146°48.730’	06°33.710’	209
Guino	Morobe	Finschafen	Kote	147°45.751’	06°28.198’	2233
Masanko	Morobe	Finschafen	Kote	147°45.707’	06°28.092’	1784
Masungu	Morobe	Finschafen	Kote	147°48.897’	06°28.438’	2236
Tararan	Morobe	Huon	Huon	146°33.414’	06°31.871’	456
Buang	Morobe	Finschafen	Gagidu	147°47.105’	06°34.758’	192
Mainland Holdings	Morobe	Huon	Huon	146°56.009’	06°42.008’	163
Nasuapum	Morobe	Huon	Wampar	146°48.704’	06°33.697’	232
Yaffon	Morobe	Huon	Huon	146°45.325’	06°34.878’	251
Boga’s	Morobe	Nawaeb	Boana	146°42.841’	06°29.796’	589
4-Mile	Morobe	Lae	Lae	146°57.524’	06°42.408’	227
Ben’s	Morobe	Nawaeb	Boana	146°42.759’	06°29.512’	605
Tiasen #1	Morobe	Kabwum	Komba	147°14.980’	06°11.364’	5251
Kiptop	Morobe	Kabwum	Komba	147°15.001’	06°11.247’	5236
Engtogan	Morobe	Kabwum	Komba	147°15.160’	06°11.582’	5191
Kuyogi	Morobe	Kabwum	Komba	147°14.501’	06°10.752’	5481
Sambon	Morobe	Kabwum	Komba	147°15.237’	06°10.922’	5156
Gayondin	Morobe	Kabwum	Komba	147°14.427’	06°10.725’	5267
Qweiyasian	Morobe	Kabwum	Komba	147°14.853’	06°13.054’	5571
Tosin	Morobe	Kabwum	Komba	147°14.852’	06°13.052’	5576
Taron	Morobe	Kabwum	Komba	147°15.557’	06°13.275’	6089
Simon Mate	Morobe	Kabwum	Komba	147°15.538’	06°13.501’	6004
Ken’s	Morobe	Kabwum	Komba	147°12.825’	06°13.430’	5903
Esonga	Morobe	Kabwum	Komba	147°15.087’	06°13.980’	5854

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Qanawe	Morobe	Kabwum	Komba	147°15.440’	06°13.543’	5925
Simon Mate	Morobe	Kabwum	Komba	147°15.434	06°14.307’	5895
Karara	Morobe	Kabwum	Komba	147°13.208’	06°13.212’	5215
Iran	Morobe	Kabwum	Komba	147°14.997’	06°11.157’	5229
Katatogot	Morobe	Kabwum	Komba	147°15.421’	06°11.369’	5156
Sangat	Morobe	Kabwum	Komba	147°15.334’	06°11.676’	5366
Parotgot	Morobe	Kabwum	Komba	147°15.468’	06°11.686’	5422
Muman	Morobe	Kabwum	Komba	147°15.227’	06°11.698’	5267
Sandatin	Morobe	Kabwum	Komba	147°15.338’	06°12.169’	5331
Naisah	Morobe	Kabwum	Komba	147°15.345’	06°11.764’	5312
Ona’s	Morobe	Kabwum	Komba	147°15.410’	06°12.152’	5531
Mirabuk	Morobe	Kabwum	Komba	147°15.352’	06°11.673’	5453
Tono’ s	Morobe	Kabwum	Komba	147°13.325’	06°13.038’	4830
Johney’s	Morobe	Kabwum	Komba	147°13.601’	06°12.962’	4824
Ilamet	Morobe	Kabwum	Komba	147°15.436’	06°14.306’	5894
Zuruka #2	Morobe	Kabwum	Komba	147°14.655’	06°13.431’	5613
Siwan	Morobe	Kabwum	Komba	147°13.197’	06°13.253’	5261
Shark Farm	Morobe	Kabwum	Komba	147°11.642’	06°13.593’	5242
Kora	Morobe	Kabwum	Komba	147°11.688’	06°13.883’	5807
Tiasen # 2	Morobe	Kabwum	Komba	147°15.353’	06°11.408’	5327
Toset	Morobe	Kabwum	Komba	147°14.878’	06°11.100’	5156
Bot	Morobe	Kabwum	Komba	147°13.587’	06°12.823’	4824
Sapo	Morobe	Kabwum	Komba	147°13.074’	06°13.127’	5392
Tolembang	Morobe	Kabwum	Komba	147°13.614’	06°12.856’	4812
Patang	Morobe	Kabwum	Komba	147°13.573’	06°12.903’	4791
Gurunggurung	Morobe	Kabwum	Komba	147°13.652’	06°12.897’	4689
Botop	Morobe	Kabwum	Komba	147°13.598’	06°12.862’	4816
Botop	Morobe	Kabwum	Komba	147°13.581’	06°12.880’	4824
Idisa	Morobe	Kabwum	Komba	147°15.391’	06°11.712’	5362

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Tugole	Morobe	Kabwum	Komba	147°14.615’	06°14.003’	5772
Katik	Morobe	Kabwum	Komba	147°14.468’	06°14.206’	5439
Zuruka	Morobe	Kabwum	Komba	147°15.255’	06°13.680’	5938
Omok	Morobe	Kabwum	Komba	147°13.850’	06°12.157’	4861
Don	Morobe	Kabwum	Komba	147°13.830’	06°12.150’	4855
Nambako	Morobe	Kabwum	Komba	147°13.494’	06°12.081’	4812
Kewaug’s	Morobe	Kabwum	Komba	147°13.837’	06°12.056’	4812
Gasim	Morobe	Kabwum	Komba	147°13.388’	06°12.079’	4812
Kiaptin	Morobe	Kabwum	Komba	147°13.589’	06°12.212’	4744
Kiaptin	Morobe	Kabwum	Komba	147°13.627’	06°12.152’	4744
Karik	Morobe	Kabwum	Komba	147°13.422’	06°12’388’	4737
Kora	Morobe	Kabwum	Komba	147°13.442’	06°12.255’	4744
Kora	Morobe	Kabwum	Komba	147°13.430’	06°12.237’	4602
Kora	Morobe	Kabwum	Komba	147°13.435’	06°12.262’	4638
Kelvi’s	Morobe	Kabwum	Komba	147°13.420’	06°12.373’	4633
Sombonau	Morobe	Kabwum	Komba	147°11.487’	06°13.927’	5229
Asing’s	Morobe	Kabwum	Komba	147°11.631’	06°13.816’	5384
Samia’s	Morobe	Kabwum	Komba	147°11.678’	06°13.814’	5378
Engdawe	Morobe	Kabwum	Komba	147°11.849’	06°13.858’	5529
Omangu’s	Morobe	Kabwum	Komba	147°11.725’	06°13.744’	5370
Dawe	Morobe	Kabwum	Komba	147°11.803’	06°13.841’	5528
Bome	Morobe	Kabwum	Komba	147°11.848’	06°13.858’	5543
Kevi’s	Morobe	Kabwum	Komba	147°11.593’	06°13.713’	5244
Kembantop	Morobe	Kabwum	Komba	147°11.593’	06°13.713’	5244
Wasina	Morobe	Kabwum	Komba	147°11.564’	06°13.609’	5273
Biwan’s	Morobe	Kabwum	Komba	147°11.672’	06°13.767’	5384
Alison’s	Morobe	Kabwum	Komba	147°11.679	06°13.771’	5384
Wayaki	Morobe	Kabwum	Komba	147°11.679’	06°13.771’	5384
Gema	Morobe	Kabwum	Komba	147°11.673’	06°13.843’	5518

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Watbung	Morobe	Kabwum	Komba	147°11.903’	06°13.750’	5523
Yagi	Morobe	Kabwum	Komba	147°12.919’	06°13.969’	5423
Bol	New Ireland	Kavieng	Kavieng	151°32.022’	02°59.527’	93
Kaut	New Ireland	Kavieng	Kavieng	150°55.714’	02°42.945’	96
Garobi	Oro	Sohe	Sohe	148°03.814’	08°52.303’	1148
Alison’s	Oro	Sohe	Higaturu	148°03.096’	08°45.435’	400
Nimine	Simbu	Gumine	Gumine	144°54.820’	06°11.288’	5438
Manekewa	Simbu	Salt Nomane	Manekewa	144°59.075’	06°13.075’	7158
David & Boss	Simbu	Gumine	Boromil	144°52.411’	06°10.087’	6973
Orme	Simbu	Gumine	Gumine	144°53.027’	06°10.474’	6036
Yuribol	Simbu	Gumine	Gumine	144°51.822’	06°10.566’	7095
Diya	Simbu	Gumine	Gomgale	144°50.715’	06°09.719’	7373
Boman	Simbu	Gumine	Gumine	144°53.833’	06°10.660’	5845
Dulma	Simbu	Gumine	Gumine	144°54.527’	06°10.647’	5673
Greenarm	Simbu	Sinasina	Sinasina	145°04.146’	06°05.619’	5843
Kolibe	Simbu	Kamtai	Kamtai	145°00.527’	06°06.628’	6156
Duminiga	Simbu	Kamtai	Kamtai	145°00.484’	06°02.568’	5720
Tininil	Simbu	Kamtai	Kamtai	145°01.129’	06°05.602’	6384
Engremambuno	Simbu	Gembogl	Gembogl	145°06.142’	05°51.608’	7358
Sumbru Carp Farm	Simbu	Gembogl	Sumbru	145°03.086’	05°54.434’	6065
Gogme	Simbu	Gembogl	Gembogl	145°01.829’	05°55.857’	6035
Barengigl	Simbu	Gembogl	Gembogl	145°00.537’	05°57.985’	5500
Gogo	Simbu	Chuave	Gogo	145°08.196’	06°13.196’	6575
Chuave Forestry	Simbu	Chuave	Chuave	145°07.589’	06°07.316’	4985
Bebol	Simbu	Chuave	Chuave	145°08.172’	06°13.695’	5093
Kipere	Simbu	Chuave	Chuave	145°04.146’	06°05.619’	5843

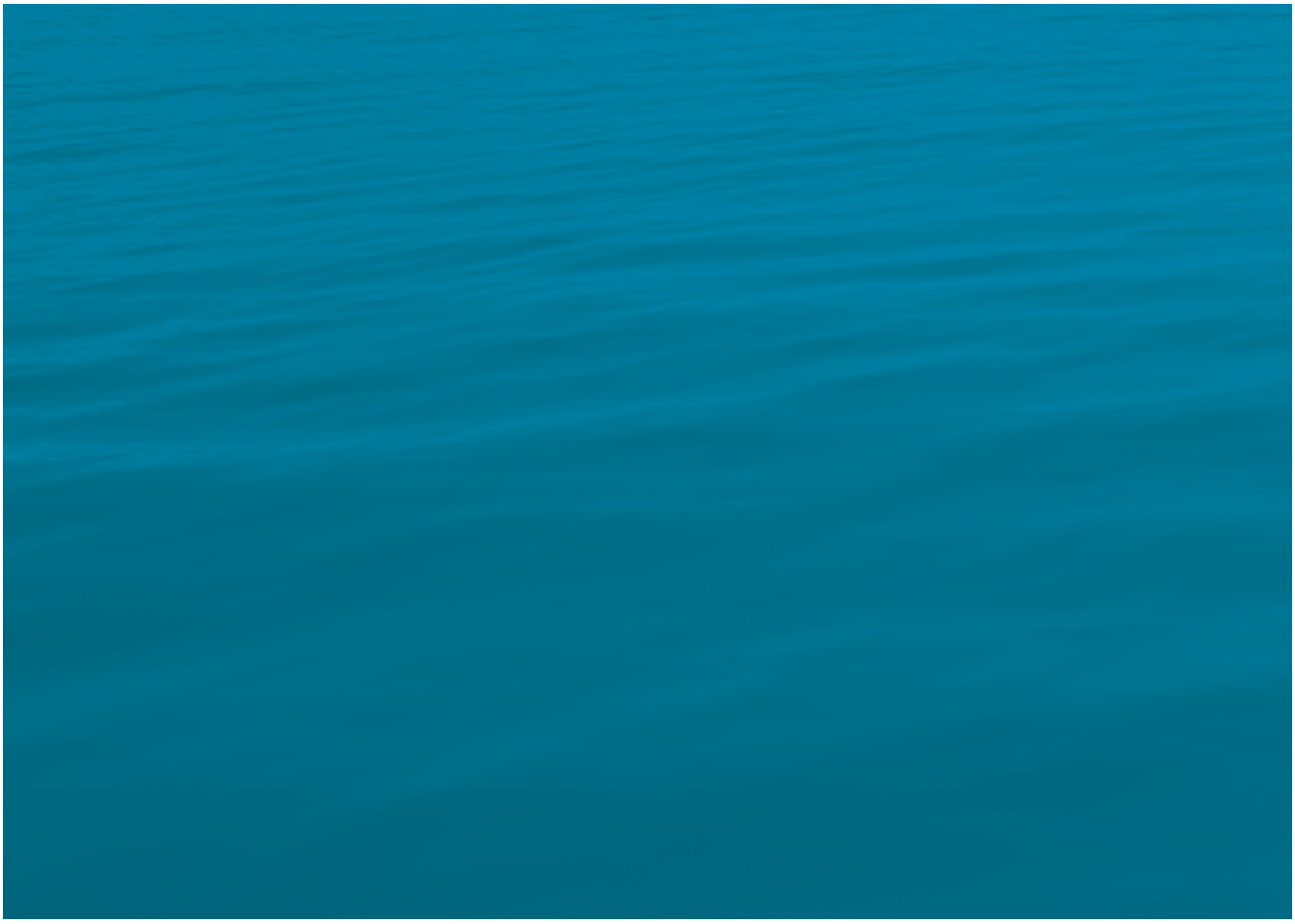
Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Viri Carp Farm	Simbu	Kerowagi	Kerowagi	144°48.102	05°55.893’	4839
Miunde	Simbu	Kerowagi	Kerowagi	144°47.642’	05°55.622’	4858
Monsui Integrated Farming	Simbu	Kerowagi	Kerowagi	144°51.308’	05°56.197’	4824
Kawage	Simbu	Kerowagi	Kerowagi	144°50.922’	05°54.605’	5422
Polko Mambuno	Simbu	Kundiawa	Kundiawa	144°57.665’	05°58.654’	5695
Peter Gandil’s	Simbu	Sinasina	Ku	145°01.336’	06°02.977’	6145
Juda’s	Simbu	Gumine	Dirima	144°53.877’	06°10.648’	5865
Sam Manu	Simbu	Gumine	Dirima	144°53.867’	06°10.656’	5832
Tabubil	Western	Middle Fly	Kiunga	141°13.930’	05°16.475’	1775
Hake	Western	Kiunga	Kiunga	141°17.965’	06°02.324’	370
Mutu	Western	Ningerum	Ningerum	141°08.534’	05°40.182’	454
Kurumul	WHP	Minj	Kurumul 2	144°37.818’	05°51.818’	5200
Kepam	WHP	South Waghi	Kepam	144°28.137’	05°50.023’	5538
Sipil	WHP	North Waghi	Banz	144°38.146’	05°48.723’	5268
Mathew Ten’s	WHP	Dei	Muglamb	144°30.781’	05°44.057’	5488
Tun	WHP	South Waghi	Anglimp	144°29.561’	05°51.795’	5707
Wara Klap	WHP	North Waghi	Banz	144°37.771’	05°49.487’	5097
Tun	WHP	South Waghi	Anglimp	144°28.985’	05°51.054’	5655
Popugl	WHP	Mul Baiyere	Mul	144°08.370’	05°45.143’	7004
Kela	WHP	Mul Baiyere	Mul	144°07.501’	05°45.274’	7329
Samuel’s	WHP	Mul Baiyere	Mul	144°08.300’	05°45.288’	7090
Lucas	WHP	Nebilyer	Nebilyer	144°06.600’	05°49.516’	7308
Tapuna	WHP	Nebilyer	Nebilyer	144°09.212’	05°54.620’	6531

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Samson's	WHP	Dei	Dei	144°08.459'	05°45.323'	7010
Samuel's	WHP	Dei	Dei	144°26.036'	05°42.657'	5418
Bongol	WHP	Dei	Dei	144°28.808'	05°42.873'	5360
MCS	WHP	North Waghi	Banz	144°32.610'	05°44.900'	5407
Sigiri	WHP	North Waghi	Banz	144°33.821'	05°46.555'	5212
Kowi	WHP	North Waghi	Banz	144°32.818'	05°42.260'	5656
Steve's	WHP	South Waghi	Kudjip	144°31.603'	05°50.849'	5193
Gulka # 2	WHP	North Waghi	Banz	144°32.301'	05°44.162'	5345
Munump	WHP	North Waghi	Banz	144°37.503'	05°43.326'	5113
Gulka # 1	WHP	North Waghi	Banz	144°32.852'	05°43.622'	5489
Malbanga	WHP	North Waghi	Banz	144°32.527'	05°44.767'	5395
Kalanga	WHP	North Waghi	Banz	144°32.385'	05°44.999'	5374
Merep Kasbal	WHP	North Waghi	Banz	144°37.760'	05°49.649'	5129
Tun	WHP	South Waghi	Tun	144°29.740'	05°51.813'	5770
Kisma	WHP	South Waghi	Banz	144°29.542'	05°51.787'	5703
Alkena	WHP	Tambul	Lower Kagul	144°00.169'	05°55.473'	7452
Paia Kona	WHP	Nebilyer	Nebilyer	144°06.579'	05°49.400'	5378
Kupal's	WHP	Nebilyer	Nebilyer	144°10.714	05°57.427'	5378
David's	WHP	Banz	Banz	144°37.480'	05°48.136'	5266
Turike	WHP	Nebilyer	Nebilyer	144°05.082'	05°48.722'	7306
Philip's	WHP	Banz	Banz	144°37.638'	05°48.033'	5354
Domel Community	WHP	Banz	Nondogul	144°44.409'	05°52.350'	8107

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Kwikalap	WHP	Banz	Nondogul	144°44.866’	05°51.983’	5461
Kamda	WHP	Nebilyer	Nebilyer	144°09.267’	04°54.835’	5381
Tabuka	WHP	Nebilyer	Nebilyer	144°07.032’	05°50.231’	5378
Kama’s	WHP	Dei	Kondopina	144°29.242’	05°44.894’	5248
Andrews’s	WHP	Dei	Dei	144°27.911’	05°43.783’	5441
Kondopina	WHP	Dei	Kondopina	144°29.833’	05°44.799’	5225
Romnom Village	WHP	Dei	Kimspi	144°29.134	05°43.393’	5448
Ben Mali’s	WHP	Banz	Banz	144°37.739’	05°47.802’	5420
Aipe Kaplt	WHP	Jiwaka	Banz	144°38.452’	05°48.222’	5264
Sigiri	WHP	Banz	Banz	144°34.086’	05°34.087’	5171
Bunu-Wo	WHP	Banz	Banz	144°32.757’	05°46.091’	5223
Kimil Lodge	WHP	Banz	Kimil	144°31.471’	05°45.331’	5214
Alkena	WHP	Tambul	Lower Tambul	144°00.283’	05°55.530’	7480
Tawal	WHP	Banz	Nondogul	144°45.309’	05°51.939’	5485
Aminagul	WHP	Banz	Nondogul	144°44.839’	05°52.240’	5442
Konjihil	WHP	Tambul	Lower Tambul	144°02.133’	05°56.266’	7494
Baula	WHP	Banz	Nondogul	144°44.657’	05°52.250’	5488
Dumakona	WHP	Tambul	Lower Kagul	143°59.536’	05°53.954’	7613
Poksy	WHP	Tambul	Lower Kagul	144°00.017’	05°54.983’	7516
Tomba	WHP	Tambul	Nebilyer	144°03.519’	05°48.997’	8121
Punduwaru	WHP	Tambul	Lower Tambul	144°00.656’	05°55.527’	7340
Wambul	WHP	Tambul	Lower Tambul	144°01.682’	05°55.331’	7394
Kobaj	WHP	Minj	Kudjip	144°35.563’	05°51.320’	5289
Lapimang	WHP	Tambul	Lower Tambul	144°00.989’	05°55.516’	7450
Dumukola	WHP	Tambul	Lower Kagul	143°59.’672	05°54.155’	7578

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Kudjip	WHP	Minj	Kudjip	144°35.046’	05°50.771’	5711
Andamun	WHP	Minj	Aviam	144°30.226’	05°49.997’	5193
Gobaj	WHP	South Waghi	Kudjip	144°35.606’	05°51.233’	5286
Soti’s	WHP	South Waghi	Kudjip	144°35.024	05°50.819’	5272
Pupigl	WHP	Mul Baiyere	Mul Baiyere	144°08.409’	05°45.306’	7032
C J’s	WHP	Minj	Kudjip	144°35.050’	05°50.773’	5772
Taban	WHP	Minj	Kurumul 2	144°37.854	05°51.272’	5075
Collin’s	WHP	Minj	Minj	144°36.998’	05°52.021’	5201
Kosge	WHP	Minj	Minj	144°41.629’	05°53.555’	4971
Palim	WHP	Hagen Central	Hagen	144°12.897’	05°51.902’	5710
Minj Road Boom	WHP	Minj	Minj	144°40’746’	05°52.805’	5383
Alta # 2	WHP	South Waghi	Anglimp	144°29.’547	05°49.478’	5307
Alta # 1	WHP	South Waghi	Anglimp	144°29.554	05°49.273’	5222
Alta # 3	WHP	South Waghi	Anglimp	144°29.521’	05°49.309’	5216
Keltepa	WHP	South Waghi	Anglimp	144°28.232’	05°50.037’	5444
Galdang	WHP	Anglimp South	Anglimp	144°28.792’	05°50.669’	5452
Tun	WHP	Anglimp South	Anglimp	144°29.211’	05°51.340’	5635
Timbilmur	WHP	Hagen Central	Koglimar	144°12.535’	05°52.585’	5679
Pepik	WHP	Minj	Minj	144°37.017’	05°50.555’	5093
Kala	WHP	Hagen Central	Mt Hagen	144°16.779’	05°51.603’	5429
Pangla	WHP	Hagen Central	Mt Hagen	144°16.’660	05°52.040’	5774

Fish farm name	Province	District	Subdistrict	Longitude (E)	Latitude (S)	Altitude (m)
Pongla	WHP	Hagen Central	Hagen	144°16.660’	05°52.040’	5774
Pumbuk	WHP	Hagen Central	Yakkondaki LLG	144°12.998’	05°22.228’	5748
George’s	WHP	Minj	Minj	144°36.611’	05°50.326’	5200
Kotou	WNB	Biala	Biala	150°51.208’	05°33.763’	249
Bubago	WNB	Talasea	Talasea	150°50.176’	05°33.161’	272
Saraklok	WNB	Talasea	Talasea	150°12.869’	05°38.190’	289
Tamba	WNB	Talasea	Talasea	150°14.424’	05°38.983’	127
Matililiu	WNB	Biala	Biala	150°00.473’	05°20.772’	106



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