Demonstrations and laboratory exercises in aquaculture

VI. Fish pond inventory and feed budgets

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Introduction to Animal Inventory

One of the recurring problems in pond aquaculture is estimating the number of fish in a pond. You can't rely on stocking data, since fish populations decrease over time because of predation, cannibalism and disease. The reasons a farmer would want to determine the number of fish in a pond (i.e., the inventory) are obvious. If the farmer underestimates the number of fish, and puts too little feed in the pond, growth will be suboptimal. However, if the farmer thinks that there are more fish in the pond than there really are, and overfeeds, this not only means that money is wasted on uneaten feed, but water quality will also likely be reduced.

So how do you know how many fish are in the pond? Some techniques that have been suggested by researchers involve acoustical measurements or optical fish counters. Other techniques, much more commonly used, require an historical knowledge of how the fish populations change over time in the ponds that are used. That is, if you know what's happened in the past, that's a good place to start when trying to figure out what's going on at the moment. This is certainly important to know, but we'll take a different approach.

In this exercise, we'll be using tagging/marking. Currently, these are used more in fisheries management than aquaculture, but still can be useful for farmers. Tagging is the term used when an internal or external tag (Figure 1) is applied that can identify a particular individual fish. Tagging is useful for fisheries biologists, but it requires a lot of manpower to tag fish, as well as for record keeping. Marking refers to fin clipping, branding or the use of dyes and stains. Marking is easier to do when you have a large number of animals, or the animals are too small to be easily tagged. Marking allows you to identify a fish as part of the batch that was manipulated, but not the individual fish. Regardless of which method is used, it should not significantly affect the fish in terms of its behavior, growth or survival. The tags/marks that work well for one type of fish will not necessarily work well for another.

Ecologists have developed a number of ways to estimate population size using marks and tags. The methods depend on knowing if the ecosystem is open" or closed (a pond would certainly be closed) and if there is replacement after sampling and future samplings. We will use a relatively straight forward procedure called a Petersen-Lincoln estimator:

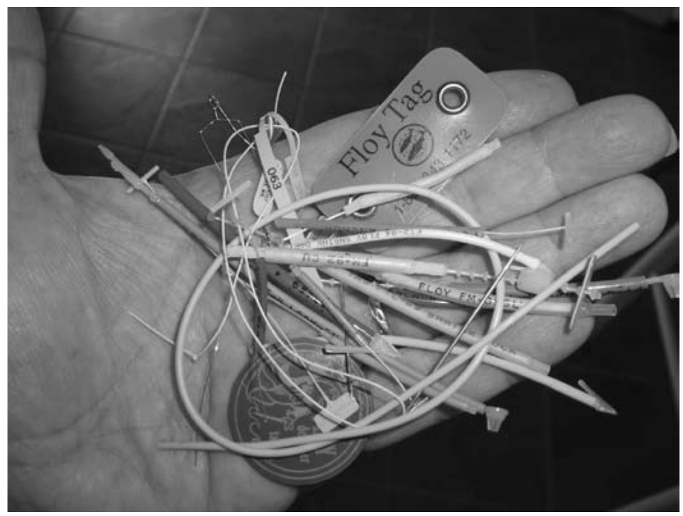

Fig. 1. Examples of tags that are used to identify fish. Photo by M. Landau.

$$\boxed{N = \left[\frac{(a+1)(n+1)}{r+1}\right] - 1}$$

In practice, some fish (a) are collected and marked, then released back into the pond to mix with the unmarked fish. After a day or two, a small seine net is dragged through the pond and a sample of fish (n) is collected and counted. While examining the fish in the sample, the farmer counts how many of those are marked (r). Finally (N), the estimate of the number of the fish in the pond is computed.

Exercise 1 — Pond Inventory Using Marked Simulated Fish

This involves counting marked individuals and estimating the size of the population after releasing the marked simulated, in this case, fish back into the pond. To start, we'll use a 0.45 kg bag of large dry lima beans; these beans will be our fish. Count out 80 beans and mark each of them with an X on both sides (Figure 2). Then, mix them with the unmarked beans in a small bucket (our pond). Use you hand to mix the marked and unmarked beans completely. After the beans are mixed up, reach in and get a handful. Count the number of marked and unmarked beans, and then return all the beans to the bucket. Repeat this procedure three times. Show your answers on Table 1.

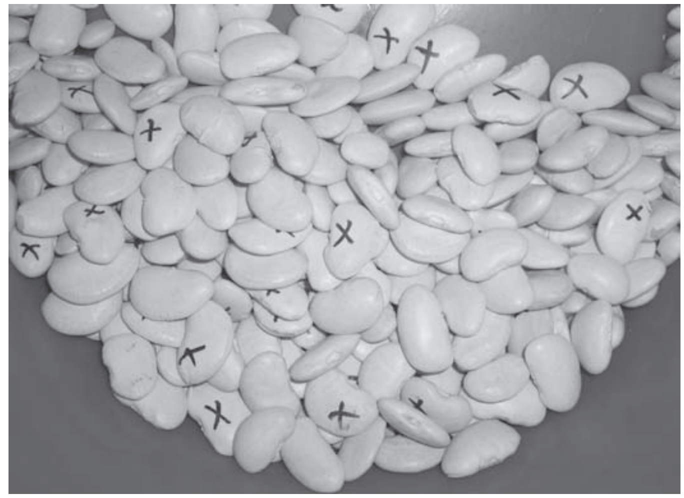

Fig. 2. Lima beans in a bucket. Some are marked with X. Photo by M. Landau.

Table 1. Estimated beans in the bucket using one handful samples.

Sample number	Total number of marked beans (a)	Total number of beans in sample (n)	Total number of marked beans in sample (r)	Estimate of total number of beans in bucket (N)
1	80			
2	80			
3	80			

Solve for N using the equation above; do this for all three samples. The value of a will be the original number of marked beans (80). Finally, count all the beans in the bucket to find out how good the estimate (N) was of the true total.

Student Question – You now know how many beans were really in the bucket. Why did you get different values for N each time you sampled?

Answer – Even though the beans were mixed in the bucket, this doesn't mean that they had a perfectly uniform distribution. That is the reason that one handful is not exactly the same as another. Therefore, since each (n) and (r) were different, each (N) was different.

To increase the accuracy of (N) you can either increase the number of marked beans, increase the sample size or both. This results in more marked beans being counted, which should result in less sample variation. To test this, mark 20 more beans and mix them in with the rest of the beans, so now (a) is 100. Now, rather than taking one handful of beans, take two handsful for each sample. Repeat the experiment above to see if (N) is now a better estimator of the true number of beans in the bucket. Put your answers in Table 2.

Table 2. Estimated beans in the bucket using two handful samples.

Sample number	Total number of marked beans (a)	Total number of beans in sample (n)	Total number of marked beans in sample (r)	Estimate of total number of beans in bucket (N)
1	100			
2	100			
3	100			

Introduction to Feed Budget

As we said, too little or too much feed going into ponds results in both biological and economic problems. When a farmer buys feed from a commercial source, the manufacturer will often include information about feeding rates and schedules. This will include what feed sizes should be for fish of different sizes (small fish are fed small granules, while big fish get large pellets) and the frequency that the fish should be fed (young fish are fed more often than older, larger fish); feed size and frequency are critical, but will not be considered in this exercise.

The other information that you need, which again will typically be supplied by the feed manufacturer, is how much feed should be used per day. This is dependent on fish species, size/age and water temperature, all of which are factors determining the food conversion ratio (how much feed is needed to increase the weight of the fish by a given amount). In Table 3, a feeding chart for a hypothetical fish is shown. For any species, there is an ideal temperature for growth, and if growth is optimized, feed intake will be at its maximum to support that growth. Like many animals, commercially cultured fish need proportionately more feed when they are small, and less as they grow. Note, for example, that at 4.4-5.6˚C, fish weighing 0.9 g should get 3.6% of their body weight in feed each day, but large fish of 0.45 kg only need 0.7% of their body weight in food daily.

To use Table 3, let's say that you do a population inventory using marked fish and estimate that a pond has 5,000 fish. Based on the fish sampled you determine that the fish have an average weight of 13.6 kg; you also know that the average water temperature is 6.1˚C. Looking at Table 3, you see that the fish should be fed 3.5% of their body weight each day. Since there are 5,000 fish, with an average weight of 13.6 kg, you calculate that there are 68 kg of fish in the pond, and, therefore, 2.38 kg of feed per day are needed.

In practice you can't do daily inventories, and average fish weights will rarely match the table values exactly. While it is possible to use interpolation to calculate feeding rates, in many instances it is safer and easier to simply use a little less feed, since this will probably increase the digestive efficiency. It's also worthwhile mentioning that slavish adherence to manufacturer feed charts is probably not in the best interests of the farmer, who should experiment a little and fine tune the feeding regimen for the particular situation.

Table 3. Feeding chart for hypothetical fish. Values are in percent of body weight fed per day.

Mean fish weight (g)	4.4-5.6˚C	6.1-7.2˚C	7.8-8.9˚C
0.9	3.6	4.8	6.9
1.4	3.5	4.7	6.5
2.3	3.4	4.6	6.1
4.5	3.2	4.5	5.7
5.6	2.9	4.3	5.4
8.2	2.7	4	5
11.3	2.5	3.8	4.6
13.6	2.2	3.5	4.3
22.7	1.9	3.1	4
31.8	1.6	2.7	3.7
38.6	1.4	2.4	3.2
45.4	1.3	2	2.9
68.0	1.2	1.8	2.5
79.4	1.1	1.6	2.3
90.7	1	1.5	2.1
181.4	0.9	1.3	2
317.5	0.8	1.2	1.8
454.0	0.7	1.1	1.7

Exercise 2 — Pond Feeding Budget

Suppose we are growing a fish species that can grow from 4.54 g at stocking to 454 g (harvest weight) in 32 weeks. The feed costs $0.55/kg. Use Table 3 above to complete Table 4 (weeks 1-2 are filled in as a guide; remember to convert percent numbers to decimals).

Student Question – What is the total feed budget for they year?

Answer – Adding up the last column, you should get a total of $3,377.02.

Student Question – Assuming that feed makes up 50% of the total budget each year, what would the farmer have to sell the fish for just to break even? Assume that the inventory estimates in Table 4 are the actual numbers of fish.

Answer – If $3,377.02 is the feed budget, the total cost of operating the farmer is twice that, or $6,754.04. We know from Table 4 that 8,400 fish averaging 0.5 kg are harvested. To break even, the farmer must sell the fish for $6,754.04/3,818 kg (8,400 x 0.4545 kg) = $0.884/kg.

Notes

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Table 4.

weeks	water temperature	mean weight	inventory estimate	feed percent body weight	kg. feed used/day	kg feed used/2 weeks	cost
1-2	4.4	0.01	10,000	3.2	1.45	44.8	$22.40
3-4	4.4	0.0125	9,500				
5-6	5.0	0.018	9,400				
7-8	5.6	0.025	9,400				
9-10	5.6	0.025	9,350				
11-12	6.1	0.03	9,200				
13-14	6.7	0.05	9,150				
15-16	6.7	0.07	9,100				
17-18	7.2	0.1	9,050				
19-20	7.2	0.15	9,000				
21-22	7.8	0.15	8,800				
23-24	8.3	0.2	8,800				
25-26	8.9	0.2	8,700				
27-28	8.9	0.4	8,600				
29-30	8.3	0.7	8,600				
31-32	45	1.0	8,400				