Section II: Methodology and models

SURVIVAL TESTS OF INTERNALLY TAGGED HERRING

by

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ABSTRACT

Two separate survival tests were run in an indoor basin. Herring was tagged applying internal metal tags as used in the annual tagging experiments on the Norwegian spring-spawners. The mortality caused by tagging was severe in the first few weeks after release, declining to a normal level in about 8 weeks. The survival of tagged herring in the two tests varied substantially, and the coefficient was calculated to be 0.74 and 0.91 respectively. The difference is explained by the difficulties in handling herring in captivity.

INTRODUCTION

Tagging of fish is a frequently applied method for studying migrations, and to assess the mortality and the abundance of fish stocks. Practical difficulties have been encountered because herring is very sensitive to handling. Dahlgren (1933) tested the performance of different types of tags by comparative experiments, and found that the most successful method proved to be an internal belly tag. This method was introduced in the Norwegian-Icelandic tagging scheme (1947-1952), with the aim to verify the theory that the herring caught during summer off the northern coast of Iceland were identical to the Norwegian winter herring (Fridriksson 1944, Fridriksson and Aasen 1950). The data from this experiment were later used to assess the abundance of the stock (Dragesund and Jakobsson 1963).

In 1975, a new tagging programme for herring was started and since then a total of 30-40 000 tagged herring have been released every spring at different localities on the Norwegian west coast.

The basic assumptions underlying the use of tagging data in stock abundance studies are discussed by Aasen (1958). The survival of tagged herring is a crucial factor in this respect, and mortality experiments were carried out in 1948, 49 and 50 (Fridriksson and Aasen 1950). The conclusions drawn from these experiments were that the tagging did not affect the herring seriously when properly executed on fish in good condition, but no estimate of survival was made. Dragesund and Jakobsson (1963) concluded however, that when the total returns from each experiment where examined, there was a significant variation in returns from the various releases even within the same experiment. The same has been experienced in the recent years. This variation may be due to varying tagging mortality and shedding, but may also be due to non random mixing of the tagged herring in more than one stock unit.

MATERIAL AND METHODS

Two separate survival tests were accomplished, one in 1987, the other in 1988. The fish was caught by purse seine on the coast of western Norway and brought to Bergen in tanks on a commercial purse seiner. Arriving in Bergen, the herring was transfered to an outdoor basin at the Institute of Marine Research.

Test no. 1.

Before tagging, the herring was adapted to life in captivity for 11 weeks to be sure that only healthy fish were used in the test. After 5 weeks of the accomodation period, the fish was moved to an indoor, 185 m^3, basin as shown schematically in Figure 1. Here they dwelled for 6 weeks before the test started. During the accomodation period and in the test period, the fish was fed krill (Euphausiacea), copepods (Calanus sp.) and pellets of dry food. The fish was treated with Flumequine on two occations, to prevent the outburst of vibriosis.

A total of 962 fish were used in the test. About half of them (498) were tagged while the rest (464) remained untagged as a control group. A small seine net was used to catch the fish in the basin and the tagging was done applying the same method as used in the annual tagging programme. A metal tag was shot into the belly of the fish using a tagging pistol as described by Fridriksson and Aasen 1950.

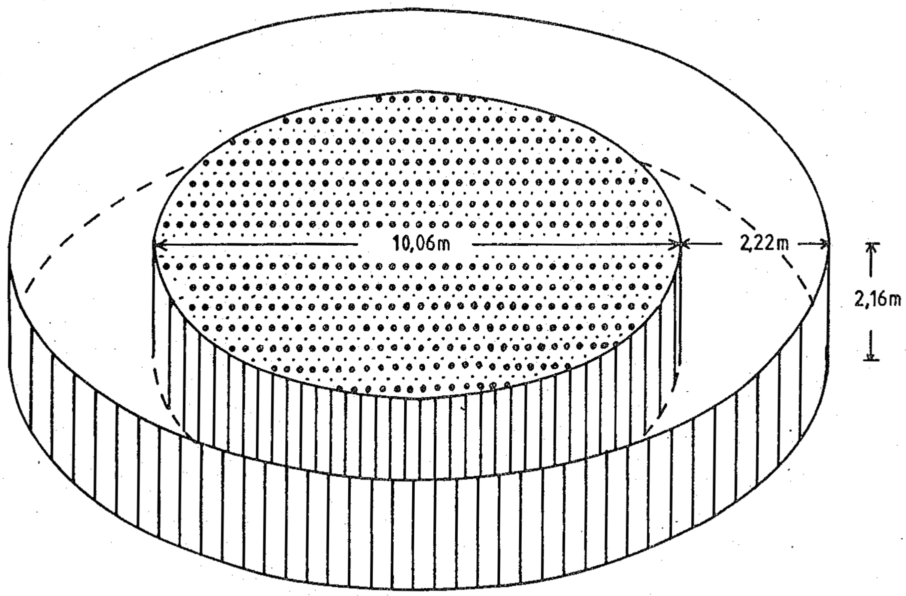

Figure 1. Shape and dimensions of the experimental tank

The number of dead herring was recorded currently and those fishes were examined for tags using a tag detector. Other characteristics such as length, weight, sex, maturation and stomach content were also recorded in 3 samples of approx. 100 fish each, after 9, 14 and 24 weeks respectively. The test was ended after 30 weeks. When ended, 3 tagged herring were found in the gutter and 45 tags were found on the floor of the basin. Of the total of 962 fish used in the test, 922 were recovered. 40 herring were missing, which were probably lost through the gutter.

Test no. 2.
The fish was kept for accomodation in the outdoor basin for 4 weeks and moved to the indoor basin where they were kept for another 4 weeks before the test started. During the accomodation period, and in the test period as well, the fish was fed copepods only. No treatment with Flumequine was necessary because there was no sign of vibriosis in the stock.

400 fish were tagged applying the same method as previously used and no control group of untagged herring was applied.

Records of dead herring were collected currently as in the previous experiment and 1 sample of 100 fish was taken after 8 weeks. The experiment was ended after 17 weeks. When ended, 6 fish were missing and probably lost through the gutter.

RESULTS

Length distributions of the herring used in the tests are shown in Table 1. There is no significant difference in length between the tagged and untagged fish.

The data of the first test grouped by week are given in the text table below:

	Survivals			Deaths			Samples	
Week	S_1	S_2	S	m_1	m_2	m_3	M_1	M_2
1	498	464	962	1	1			
2				35	3			
3				10	4			
4				3	0			
5				5	0			
6				1	1			
7				0	0	31		
8	366	501	867	2	2			
9				1	1			
10-14				4	1		48	65
15-19				3	3		50	74
20-24				2	2			
25-29				1	2		57	59
30	192	286	478	0	0	12	192	286
Σ 8-30				13	11	43	347	484
Σ 1-7				55	9	31		

S_1 and S_2 denote numbers of tagged and untagged herring at the beginning of the week, and m_1 and m_2 the corresponding numbers of dead herring recorded during the week. m_3 is a calculated figure refering to the herring lost through the gutter. M_1 and M_2 are number of fish sampled during the experiment.

In calculating the survival, one has assumed that the lost herring belongs to the group which for some reason has died during the experiment. Judging from the trend in the death rate, the table shows that the mortality due to tagging is ended, after 6 weeks. The 43 unrecorded dead herring have been allocated to the periods before and after the 7. week in the same proportion as the recorded ones (64 to 24). This gives 31 dead herring allocated to the first period and 12 herring to the last one. Assuming that the latter group is equally distributed on tagged and untagged herring, the number of surviving tagged herring at the beginning of the 7. week is found by summation of the samples and those which have died, i.e. 347 + 13 + 6 = 366 individuals. This gives a total instantaneous mortality coefficient (Z) of:

$$Z = - \ln \frac{366}{498} = 0.308$$

During the next 7 weeks 11 dead individuals were recorded. If we assume that 1/3 of the 12 lost herring died during this period, the total mortality amounts to 15 individuals. This gives a Z value of 0.017.

Considering this as the natural mortality in the stock, the mortality due to tagging is estimated to; Z = 0.291, which corresponds to a coefficient of survival S = 0.74. This coefficient includes the shedding which is estimated to 46 individuals (498 - (366 + 55 + 31)), pluss some 5-6 of the specimens recorded as dead unmarked herring which have lost their tags during the three first weeks. This means that some 10 - 11 % of the tagged herring have lost their tags.

The data from the second test are summarized in the text table below:

	Survivals	Deaths			Samples	
Week	S_1	m_1	m_2	m_3	M_1	M_2
1	400	6	1			
2		3	0			
3		4	1			
4		3	0			
5		0	1			
6		1	0			
7		2	0	6		
8	372	0	0		98	2
9		0	0			
10-16		2	0			
17	270	0	0		262	8
Σ 1-17		21	3	6	360	10

Also in this experiment the increased mortality due to tagging is over after 7 weeks. 6 specimens were lost in this test, and it is assumed that these died during the first 7 weeks. Two specimens died from the 8 to the 16 week, which shows that the natural mortality in the test period can be regarded as insignificant (less than 1 %). Altogether, 13 specimens had lost their tags and assuming that all shedding of tags had taken place during the first 7 weeks, the coefficient of survival can be taken as the total survival after the first 7 weeks minus the 10 untagged specimens in the samples.

$$s = \frac{372 - 10}{400} = 0.91$$

Only 3 % of the tagged herring in this test had lost their tags.

DISCUSSION

The result of the tests is only representative for that part of the tagging mortality which is caused by the handling of the fish during the tagging operation and the injuries caused by the insertion of the tag. The mortality caused by the catching operation and the brailing of the fish on board the ship will add to the total tagging mortality in practice, and the survival coefficients derived from these experiments are therefore to be considered as maximum values. Injuries caused by the purse seine operation and brailing of the fish to the tanks may vary with weather conditions and are difficult to measure by experimental techniques. It is, however, experienced that damage of the skin and loss of scales reduce the survival of herring and the skin and loss of scales reduce the survival of herring and although no herring with apparent damage of the skin is accepted for tagging, it is reasonable to assume that such injuries contribute significantly the total tagging mortality. Another factor which obviously bias the survival estimate in these tests is the absence of predators. The tagged herring are no doubt more vulnerable to predation during the period of recovery than the untagged population.

The significant difference between the survival estimates of the two tests is assumed to be a consequence of the different condition of the tagged fish. In the first case, the herring was more densely stocked, and the fish was suffering from an outburst of vibriosis some 3 weeks before the tagging took place. Although the sample which was tagged appeared to have recovered, the natural mortality in the untagged population was relatively high when the tagging was executed. These circumstances constituted an additional strain on the tagged fish, which is not present in nature. Only the results of the second test are therefore regarded as representative for the tagging mortality of internal tagging by the present method. The test confirms the conclusion drawn by Fridriksson and Aasen (1950) that the tagging do not affect the herring seriously when the fish is in good condition. The mortality caused by the tagging operation under favourable conditions is estimated to be about 10%, but may increase considerably if the condition of the fish is poor. It may be noted that even the shedding of tags may increase when tagging herring in poor condition.

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Tab. 1. Length frequency distribution of tagged (T) and untagged (UT) herring in the 1987 experiment.

EXPERIMENT NO. 1

	18/8-87		23/9-87		3/12-87		8/1-88		SUM	
LENGTH	T	UT	T	UT	T	UT	T	UT	T	UT
23.5								2		2
24.0						2				2
24.5	1	1		1			2	1	3	3
25.0	1	2	1			1	9	4	11	7
25.5	2	5	1	3		3	10	19	13	30
26.0	6	11	6	15	3	6	22	39	37	71
26.5	3	11	8	9	9	9	23	49	43	78
27.0	12	14	10	12	8	7	31	57	61	90
27.5	9	5	9	14	17	14	33	43	68	76
28.0	4	7	3	6	9	6	19	35	35	54
28.5	3	3	6	4	8	1	18	15	35	23
29.0	2	2	2	4	1	3	8	7	13	16
29.5	3	2	1	2	1	3	6	3	11	10
30.0	1	1	1	1		1	2	3	4	6
30.5		1	1	1	1	2	3	3	5	7
31.0	1		1			1	2	2	4	3
31.5							1	2	1	2
32.0							2	1	2	1
32.5							1		1	
33.0										
33.5				1						1
34.0										
34.5								1		1
35.0										
35.5				1						1
SUM	48	65	50	74	57	59	192	286	347	484
MEAN LENGTH	27.3	27.0	27.4	27.3	27.5	26.9	27.4	26.9	27.4	27.0

Tab. 2. Length frequency distribution of tagged herring in the 1988 experiment.

EXPERIMENT NO. 2

LENGTH	30/8-88	2/11-88	5/1-89	SUM
24.5			1	1
25.0	1	2	1	4
25.5	1	3		4
26.0		3		3
26.5	1	10	2	13
27.0	2	13	2	17
27.5	5	31	4	40
28.0	16	26	3	45
28.5	16	36	3	55
29.0	15	38	4	57
29.5	10	39	1	50
30.0	13	33		46
30.5	10	13		23
31.0	3	13		16
31.5	3	5	1	9
32.0	1		1	2
32.5		2		2
33.0	2	1		3
33.5	1	2		3
34.0				
34.5				
35.0				
35.5				
36.0		1		1
SUM	100	271	23	394
MEAN LENGTH	28.6	28.9	28.2	28.6