Intermission of Dissection Process in Whaling Operation

By

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1. Introduction

In the mothership fleet whaling operation, whales harpooned by catchers are towed one by one, or by twos and threes, to the mothership, dissected and cut into pieces. This paper reports an analysis of the dissection process some fleets practised in three seasons.

Data for analysis were obtained from the following whaling campaigns:

A_2 : Kinjo Fleet, 1960-61 season,
B_1 : Tonan Fleet, 1959-60 season,
B_2 : ditto, 1960-61 season,
B_3 : ditto, 1961-62 season,
C_1 : Nisshin Fleet, 1959-60 season,
C_2 : ditto, 1960-61 season.

For the indication of the source of data the notations A_2, B's and C's will be used in the statement and tables that follow. For the sake of comparison records used for analysis were those for fin whale as the exclusive daily game. The sizes of six samples used for statistical anaysis are shown in Table 1.

Table 1. sample size

Campaign	The number of days of operation	The number of whales killed
B_1	16	463
C_1	15	503
A_2	17	456
B_2	20	510
C_2	12	429
B_3	19	450
Total	99	2814

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2. Working hours spent for dissection

As is reported previously[1], the distribution of arrival time, the time of killing a whale, is exponential. This fact shows that killing a whale occurs at random in time. After harpooning a whale comes towing it, which requires usually some hours of hard work, and then comes a series of processes, such as landing and dissecting the game.

As the result of such human work, it is expected, arrival of whales at the dissection deck will not be so randomly distributed as that of harpooning.

Dissection was performed continually; that is, the work of dissection was suspended once or more than one times in a day. Table 2 shows how the work of dissection went, on the average, in a day.

Table 2. Mean values of working and idle hours a day.

Campaign	The number of whales killed	Working hours		Idle hours		The number of suspension
		Average	Standard deviation	Average	Standard deviation	
B_1	28.9	10.3	6.3	7.6	3.5	3.5
C_1	33.5	11.5	4.9	7.6	3.1	5.2
A_2	26.8	10.3	2.6	8.3	3.9	4.1
B_2	25.5	9.1	5.8	8.2	4.8	3.4
C_2	35.7	12.4	3.8	7.1	4.1	4.8
B_3	23.7	7.8	2.4	8.6	3.8	5.2
Average	28.4	10.1	4.6	7.9	4.2	5.3

Unit of time : 1 hr.

It can be seen from the table that the more whales were dissected, the more were the working hours and the less the idle hours. It is because it takes about twenty minutes to dissect a whale regardless of its size and sex[1]. In Table 3 are shown average service time for dissection computed from the figures listed in Table 2.

Table 3. Average service time for dissection.

B_1	C_1	A_2	B_2	C_2	B_3
22	21	23	22	21	20

Unit of time : 1 minute

As mentioned above, the longer was the net working time the shorter was the idle time. This relation is clearly seen in Fig. 1. The reason for the relation is that a big catch brought to the mothership whales in a long succession, which scarcely gave time for pause to the crew.

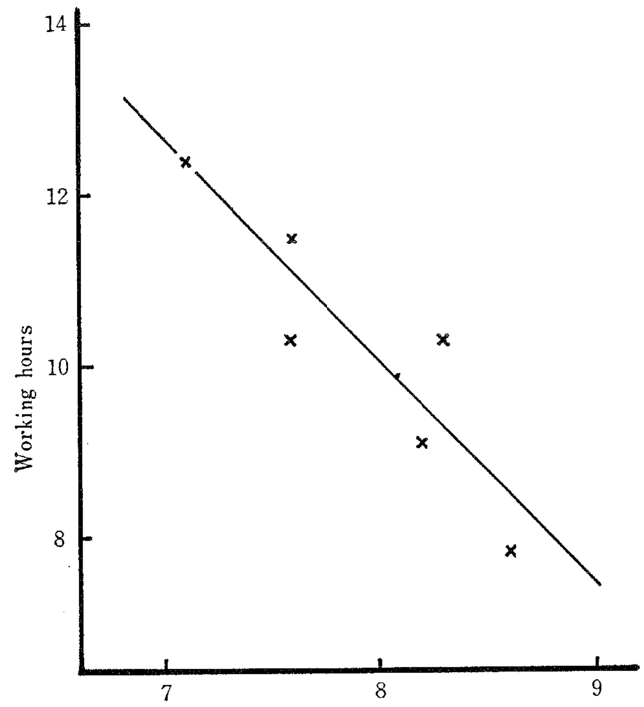

Fig. 1 Relation between Working hours and idle hours

3. Analysis of run

Dissection process went on and off; one or more than one whales were dissected in a run. Sometimes tens of whales were dealt with in succession. The number of whales dissected without intermission is called the length of a run. Between runs comes an intermission. Therefore, the number of times of intermission in a day is smaller by one than that of run. The average number of times of intermission (suspension) a day for each campaign is given in Table 2.

The shortest length of a run was one, of course, and the longest 63. Generally lengths of runs were under twenty. In Table 4 are shown average lengtn of a run and average number of runs a day.

Table 4. Average length of a run and average number of runs a day.

Campaign	Average number of runs a day		Average length of a run	
	Mean value	Standard deviation	Mean value	Standard deviation
B_1	4.5	6.5	6.5	6.3
B_1	6.2	5.5	5.4	4.2
A_2	5.1	5.5	5.3	6.0
B_2	4.4	5.8	5.8	9.6
C_2	5.8	9.0	6.1	9.4
B_3	6.2	3.8	3.8	2.7
Average	5.3	5.3	5.3	6.0

It can be seen from Tables 2, 3 and 4 that dissection was carrid out, on an average, in about five runs with four intermissions, each run being five in length and one hour and a half in time. Thus, after some repetitions of work and pause about thirty whales are dealt with in about eighteen hours. The efficiency of the dissection service done in the campaigns under examination seems to have been low, though it might be the inevitable outcome of the unfavorable environment of the operation.

4. Distribution of run

As mentioned in Section 2, the randomness in time observed in the occurrence of killing whales was thought to diminish while they are towed to the mothership, and a regularity due to human work of towing was expected to some extent in the distribution of arrival time at the dissecting deck. Poor catch resulted in long intervals, sometimes more than ten hours, between arrivals of whales. Good catch of more than forty whales in a day, on the other hand, forced the crew to work for many hours without intermission. On days of good catch runs were long but few in number. Therefore, on occasions of poor catch, distribution of the length of run biassed to small figure and on occasions of very good catch to big figure. The extreme bias was characteristic of these distridutions.

When the daily catch recorded more than ten whales but did not exceed thirty, runs did not seem to be simply distributed. Statistics showed that length of run ranged from one to seventeen. The number of occurrence of each length of run was tabulated for every whaling campaign which are enumerated in Section 1. But because of calculating convenience, of which reference will be made later, the lengths one and two were coupled into one as class 1 and the lengths three and four as class 2 and so on. The distribution of runs based on this classification are shown in Table 5. It also contains expected number of occurrence to be explained just below.

Suppose we have k classes based on the length of run. Let us assume that each class has a symbol of length of run, which may be called equivalent length of run. A class, say the i-th class has its symbol t_i. Now we have m_i occurrences for the i-th class. The m_i 's are non-negative integers. We may assume, too, that the symbols t_i are integers. If m is the total number of occurrences, we have

$$m=\sum_{i}^{k} m_i.$$

Let

$$T=\sum_{i}^{k} m_i\, t_i \tag{1}$$

be the total equivalent length. Take a system in which m and T are kept constant. We define entropy H of the system (m, T) by

$$H=-\sum_{i}^{k} p_i \log p_i, \tag{2}$$

where p_i is the probability of occurrence of run of run of the i-th class. We assume

$$\sum_{i}^{k} p_i=1. \tag{3}$$

Now we want to obtain the most probable distribution, which is the same as maximizing the entropy under two conditions (1) and (3). This is done by the method of Lagrange's multipliers. We simply write the condition

$$dH-\lambda d\ (\sum_{i}^{k} p_i)\ -\mu\ dT=0$$

with the two arbitary multipliers λ and μ to be determined later. Differentiating Equations (1) and (2) with respect to p_i and substituting the expressions thus derived, we obtain

$$1+\log\ p_i+\lambda+\mu m t_i=0\ ,$$

under the assumption

$$m_i=mp_i. \qquad (4)$$

Therefore, we get

$$\log\ p_i=-\ (1+\lambda+\mu m t_i).$$

It can be written

$$p_i=e^{-(1+\lambda+\mu m t_i)}$$

We have the condition (3), hence

$$\sum_{i}^{k} e^{-(1+\lambda+\mu m t_i)}=1\ .$$

Therefore we can write

$$p_i=\frac{e^{-\mu m t_i}}{\sum_{i}^{k} e^{-\mu m t_i}} \qquad (5)$$

The condition (1) can be expressed by the relation (5) and the assumption (4) as follows.

$$T=\sum_{i}^{k} m t_i e^{-\mu m t_i}$$

Therefore we obtain a relation

$$\frac{T}{m}=\frac{\sum_{i}^{k} t_i e^{-\mu m t_i}}{\sum_{i}^{k} e^{-\mu m t_i}}$$

If T and m are given, this relation is satisfied by one specified value of μ. The solution of μ is obtained by

$$\sum_{i}^{k} e^{-\mu m t_i}=1.$$

If we put

$$e^{\mu m}=X,$$

we obtain the final conditions

$$\sum_{i}^{k} X^{-t_i}=1, \qquad (6)$$

$$C=\log_{10}X$$

and

$$p_i=10^{-C t_i}$$

When k is greater than three it is difficult to obtain the positive root of X. However, by the use of the table published by Date who had computed with FACOM 128, we could solve the Eq.(6) when k did not exceed ten. Because of this computational reason classes are made to contain the two successive lengths of run in order to reduce the degree of the algebraic equation.

Based on this theory we calculated the expected occurrences of equivalent runs. The i-th class is composed of two run lengths, one is the lengtn of $2i-1$ and the other $2i$. The i-th class has its symbol t_i. In the numerical calculation t_i is assigned the value i.

The comparison between observed and expected occurrences shows a good agreement for each whaling campagn. See Table 5. The χ^2-test was tried for every case. In the computation of χ^2 some classes were combined into one and the freedom of χ^2 was two for every case. The values of χ^2 for each case is given under each table. The χ^2-value of 1% level of significance is 9.21 for the freedom two. Therefore, good agrreement can hardly be rejected.

As it is, the actual distribution of run may well be called the most probable distribution for a given set of T and m. The most probable distribution means that the length of run is randomly distributed. Therefore, the human effort in gathering whales to the mothership may be said to have had little influence upoon the arrival of whales at the dissecting deck. To speak otherwise, the natural environment of the whaling operation was too severe to allow the work efficient.

Table 5. Distribution of equivalent length of run

B_1

Class	1	2	3	4	5	6	8	Total
Observed	17	6	6	2	1	1	1	34
Expected	17.1	8.6	4.3	2.2	1.1	0.6	0.1	

$\chi^2=1.609$, $X=1.9878$, $C=0.29837$

C_1

Class	1	2	3	5	7	Total
Observed	24	17	6	2	1	50
Expected	26.5	14.0	7.4	2.1	0.5	

$\chi^2=1.179$ $X=1.9006$, $C=0.27893$

A_2

Class	1	2	3	4	5	6	7	8	9	Total
Observed	23	18	4	3	3	1	1	2	1	56
Expected	28.0	13.9	7.0	3.6	1.8	0.9	0.5	0.2	0.1	

$\chi^2=5.483$, $X=1.9979$, $C=0.30057$

B_2

Class	1	2	3	4	5	6	7	Total
Observed	26	19	12	2	1	3	2	65
Expected	32.6	16.4	8.2	4.1	2.1	1.0	0.5	

$\chi^2=3.521$, $X=1.9919$, $C=0.29927$

C_2

Class	1	2	3	4	5	6	7	8	Total
Observed	19	12	6	1	3	1	1	1	44
Expected	22.0	11.1	5.5	2.7	1.4	0.7	0.3	0.2	

$\chi^2=1.073$, $X=1.9660$, $C=0.30161$

B_3

Class	1	2	3	4	5	6	Total
Observed	41	35	8	4	1	2	91
Expected	45.9	23.1	11.7	5.9	3.0	1.4	

$\chi^2=8.881$, $X=1.9835$, $C=0.29743$

This suggestion may be examined from another point. The two arrival rates at killing and dissection can be compared directly. This was tried for the three campaigns in the 1960-61 season. In the Table 6 are given the two arrival rates (the number of arrival per hour) with their coefficient of variation.

Table 6. Comparison between arrival rates.

		A_2	B_2	C_2
Killing	Average rate	1.58	1.36	1.65
	Coef. variation	0.87	0.94	1.16
Dissection	Average rate	1.23	1.08	1.38
	Coef. variation	0.90	1.06	1.00

It can be seen from the table that the arrival rate at dissection was smaller than that at killing for every campaign. This means that the feeding speed of whales was slowed down while they were towed. This is what was expected from the long waiting time previously reported of.[1]

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Conclusion:

1. Dissecting operation was statistically analized as to the distribution of duration of time for work and pause.
2. The distribution of the number of whales done with in a run was found to be exponentially distributed.
3. The towing process had little influence over the randomness of whale arrival at the dissection deck.

Reference

1), TESHIMA, I., 1962 : Queuing in Whaling. *This journal*, 5, 9~13.