International Council for the Exploration of the Sea

C.M.1974/N:6
Marine Mammals Committee

FIN WHALES, BALAENOPTERA PHYSALUS (L), OFF THE WEST COAST OF ICELAND

by
Carl J. Rørvik, Jón Jónsson, Åge Jonsgård and Ole Mathisen

The Department of Marine Zoology and Marine Chemistry, University of Oslo, Postbox 1064 Blindern, Oslo 3, Norway

and

Marine Research Institute, Skúlagata 4, Reykjavik, Iceland

INTRODUCTION

Modern whaling was introduced in Icelandic waters in 1883. Because of overexploitation the whaling operations ceased in 1915. In the seasons 1929 to 1937 Norwegian floating factories were operating in the northern North Atlantic, some of which were catching fin whales in the Denmark Strait. One whaling station operated from 1935 to 1939. In 1948 an Icelandic company resumed shore station whaling off the West Coast of Iceland, and since then whaling operations have been carried out with four catcher boats. Table 1 shows the catches from 1948 to 1973.

A comprehensive research program for stock assessment was initiated by Jón Jónsson when the Icelandic whaling started up in 1948, this program also included the organization of the field work. The study of the complete material available has been carried out by The Department of Marine Zoology and Marine Chemistry, University of Oslo, in cooperation with The Institute of Marine Research in Iceland.

The present paper is an abstract of a detailed paper not yet published.

METHODS OF ANALYSIS AND RESULTS

Catch per unit effort

To standardize the catches, corrections have been made for the length of the season by using the number of fin whales caught in the period from June 1 to September 20, corrections have also been made for the seasons when the catchers were allowed to take more than 2 fin whales per trip.

The estimation of catchers efficiency is based on the fin whale catches, using multiple regression (Robson, 1966). The efficiency of the catcher Hvalur 4 is defined as the unit. The results are given in table 2.

Figure 1 shows the catch per unit effort, with an approximated 95 per cent confidence intervall. The 1948 season is excluded because all the catchers did not operate full time during this first season.

In pelagic whaling catchers efficiency is taken to be proportional to tonnage. A lineary weighted regression between efficiency, ρ, and tonnage, Btn, gives

$$\rho = 0.72 + (1.1 \cdot 10^{-3}) \cdot Btn$$

Efficiency is primarely determined by two factors,

1) The time required to catch the whales on the grounds,
2) The time needed to sail between the grounds and the factory ship, or the shore station.

In pelagic whaling the efficiency is dominated by factor 1, and an increase of the tonnage and speed no doubt influences factor 1 more than factor 2. With regard to Icelandic whaling factor 2 is the dominating one. This may explain why the catchers efficiency has not increased proportionally with the tonnage for the Icelandic catchers.

In Icelandic whaling the time which is used for finding whales is only a minor part of the operation time. Most of the time is spent enroute to and from the grounds. This indicates that the estimated catch per unit effort is not proportional to the density of whales on the grounds. This statement is further elaborated in the following model:

j = index for season j,
t_{Tj} = length of the season,
t_{fj} = the mean time on the grounds per trip used for search and hunt,
t_{sj} = the mean time per trip which is not used for search and hunt,
a_j = the mean number of whales per trip,
C_{tj} = number of whales caught per unit time used for search and hunt,
C_j = the catch of one boat.

The following equation can be set up,

$$C_j = a_j \frac{tTj}{t_{sj} + t_{fj}} = a_j \frac{t_{Tj}}{tsj + (a_j/C_{tj})}$$

$$C_j = \frac{(a_j t_{Tj}/t_{sj}) \cdot C_{tj}}{(a_j/t_{sj}) + C_{tj}} \qquad (1)$$

This equation does not give the relation between catch and density of whales, D_j. However, a model developed by Paloheimo and Dickie (1964) gives the following relation (slightly modified),

$$C_{tj} = \frac{2grv\ D_j}{1 + \frac{2rv\tau}{n} D_j} \qquad (2)$$

where,

g = the fraction of a school which is taken,

r = the distance from the boat to the whales when seen,

n = number of whales per school,

v = the cruising speed of the boat,

τ = the hunting time on 1 school,

which combined with equation (1) gives,

$$C_j = \frac{(a_j t_{Tj})\ D_j}{(\frac{a_j}{2rvg}) + (t_{sj} + \frac{a_j\tau}{gn})\ D_j} \qquad (3)$$

Equation (3) is a curvilinear relation between

catch and density. By adding nonlinear equations for several boats, the matematical relation between total catch and density is no longer as simple as equation (3). However, it is reasonable to assume that the relation between catch per unit effort, based on the catches from several boats, and density of whales, will be of the same form as equation (3), or, that changes in the size of the stock will be relatively larger than the corresponding changes in the catch per unit effort.

The log-books of Hvalur 7 were examined for the seasons 1962 to 1972. C_{tj} is estimated for the period June 1 to July 31, which makes t_{Tj} constant and t_{sj} fairly constant. a_j is treated as constant although it is not strictly independent of the density of whales, because of the time limit for delivering the whales at the station. Only fin whales, which dominate the catches in the above-mentioned part of the season, are considered. In figure 2 the corresponding points between catch, C_j, and catch per hour used for search and hunt, C_{tj}, are drawn from 1962 to 1972. The best fit of equation (1) is drawn under the assumption that t_{Tj}, a_j and t_{sj} is constant. Figure 3 shows the variations of C_{tj} from 1962 to 1973.

Equation (2) shows that C_{tj} can not be regarded as proportional to the density of whales, but it is more sensitive to changes in D_j than the catches are. With regard to the trend and variations of C_{tj} from 1962 to

1973 the following should be taken into account:

a) C_{tj} is directly dependent of the hours used for search and hunt. This part of the operation time amounted to only 17 per cent of the total operation time in June and July, on the average for the years 1962 to 1972. The log-books do not include complete data to get an exact estimate of C_{tj}.

b) C_{tj} will to a large extent be determined by how the schools of whales are distributed throughout each season. This may change the availability of whales on the grounds, without changing the all over density.

C_{tj} seems to bee declining, although not signeficant.

The composition of the catches

From other areas of whaling, it is known that decreasing percentage of mature animals and decreasing mean lengths indicate declining stock of whales (see Jonsgård, 1958; Laws, 1962).

Figure 4 shows the mean length of Icelandic fin whales. The increase of the mean length may be explained by the gradual change to more intensive whaling north of 65°N since 1959. Figure 5 indicates a segregation of the whales on the grounds. This segregation can not be explained by gunners selecting the whales. To correct for the segregation, the percentage of mature animals has been estimated for catches taken between 64°N and 65°N in July and August. From figure 6 it is concluded that the number of fin whales does not seem to decrease, assuming

that only one population has been exploited and that the distribution has not changed essentially.

Whale marking

In the Denmark Strait marking of whales has been carried out by Iceland and Norway (see table 3 and 4). The efficiency of recovery of marks at the Icelandic whaling station has not been determined experimentally. We assume it is 100 % since all the meat is cut up into blocks.

Symbols,

T_j = number of marked fin whales alive at the beginning of the season j.

n_j = number of fin whales caught in season j.

t_j = number of marks recovered in season j.

m_j = number of fin whales marked at the beginning of the season j.

N = the number of fin whales.

The natural mortality is taken into account by,

$$T_{j+1} = (T_j - t_j)\, e^{-0.04} + m_{j+1}$$

The method of direct multiple sample census (Chapman, 1952) gives,

$$\hat{N} = \sum_{j=1965}^{1973} n_j T_j \Big/ \left(\sum_{j=1965}^{1973} t_j + 1\right)$$

Assuming that the stock of fin whales off the West Coast of Iceland is not exploited in other waters of the North Atlantic, and using only the results of the Icelandic marking program, we get,

$\hat{N} = 3300$

A 95% confidence intervall is given by

$N_{min} = 1400$

$N_{max} = 9000$

Assuming that the same stock of fin whales is inhabiting the waters off the West Coast of Iceland, North Norway and East Greenland, a 95% confidence intervall estimate will be as follows,

$\hat{N} = 4900$

$N_{min} = 2300$

$N_{max} = 11.200$

This estimate refers to the markings off East Greenland in the beginning of the following season. The fin whales caught off North Norway and the 19 fin whales taken by the norwegian catcher "Peder Huse" off East Greenland in 1970 are included in the calculations.

On the average the annual Icelandic catch is 242 fin whales. If the net recruitment rate, r-M, is set at 4-6% at maximum sustainably yield (see Doi, Ohsumi, Nasu and Shimadzu, 1970), the stock must be composed of at least 4033 (r-M = 0,06) or 6050 (r-M = 0,04) animals to sustain the present catches. The marking results indicate that the stock is about the size which can bear the present

exploitation. This is also indicated by the preliminary estimate of the stock of fin whale to be 8333 animals as calculated by Gambell, Jónsson and Jonsgård (1973) from the total mortality rate, which was based upon earplug readings.

Conclusions

With regard to the status of the fin whale population off the West Coast of Iceland one can conclude:

1) Catch per unit effort has not shown a significant decrease.
2) The number of fin whales caught per hour used for search and hunt, has not decreased significantly.
3) The percentage of mature animals has increased slightly.
4) The markings indicate a population big enough to sustain the present catches.

However, the possibility that this stock is slightly overexploited can not be completely excluded. The present equilibrium should be carefully watched in the future.

ACKNOWLEDGEMENT

We are greatly indepted to the Icelandic Whaling company. The departed Director of the Company Mr. Loftur Bjarnason and his son Kristján Loftson did all their best to help us in our work, also allowing us to use the log-books and other material.

They also showed great hospitality to one of the authors (C.J. Rørvik) who stayed at the station for 7 weeks during the 1973 season.

We are much indepted to the Norwegian Government (Department of Fishery) who offered a travelling scholarship for Mr. Rørvik to visit the whaling station at Iceland.

We also want to thank Mrs. Edda Gudnadóttir at the Marine Research Institute in Reykjavik who punched the available catch data and extracted the necessary data from the log-books.

We also like to mention cand.mag. Espen Svennar and cand.mag. Dag F. Langmyr who have written the computer programs.

REFERENCES

Chapman, D.G. 1952. Inverse, Multiple and Sequential Sample Censuses. Biometrics, 8: 286-306.

Doi, T., Ohsumi, S., Nasu, K. and Shimadzu, Y. 1970. Advanced Assessment of the Fin Whale Stock in the Antarctic. Rep. int. Whal. Commn , 20: 60-87.

Gambell, R., Jónsson, J. and Jonsgård, Å. Preliminary Report on Analyses of the Fin Whales off Iceland. Report SC/25/5 to the International Whaling Commission 1973.

Jonsgård, Å. 1958. Taxation of Fin Whales (Balaenoptera physalus (L)) at Land Stations on the Norwegian West Coast. Norsk Hvalfangsttid., 47: 433-439.

Laws, R.M. 1963. Some Effects of Whaling on the Southern Stocks of Baleen Whales, p. 137-158. In The Exploitation of natural animal population. Le Cren, E.D. and Holdgate, M.W., (Ed). Oxford.

Paloheimo, J.E. and Dickie, L.M. 1964. Abundance and Fishing Success. Rapp. P.-v. Réun. Cons. perm. int. Explor. Mer, 155: 152-163.

Robson, D.S. 1966. Estimation of the Relative Fishing Power of Individual Ships. Res. Bull. int. Comm. N.W. Atl. Fish., 3: 5-14.

Table 1. The catch of whales from the Icelandic shore station in the seasons 1948-1973.

Year	Fin Whales	Sei whales	Sperm whales	Blue whales	Humpback whales	Total number of whales
1948	195	5	15	24	0	239
1949	249	12	28	33	2	324
1950	226	0	11	28	0	265
1951	312	2	13	11	1	339
1952	224	25	2	14	0	265
1953	207	70	48	5	2	332
1954	177	93	54	9	1	334
1955	236	134	20	10		400
1956	265	72	95	8		440
1957	348	78	81	10		517
1958	289	91	123	5		508
1959	178	67	120	6		371
1960	160	42	177			379
1961	142	58	150			350
1962	303	44	136			483
1963	283	20	136			439
1964	217	89	138			444
1965	288	74	70			432
1966	310	41	86			437
1967	239	48	119			406
1968	202	3	75			280
1969	251	69	103			423
1970	272	44	61			377
1971	208	240	106			554
1972	238	132	76			446
1973	267	138	47			452
Grand total	6286	1691	2090	163	6	10.236

Table 1. The catch of whales from the Icelandic shore station in the seasons 1948-1973.

Year	Fin Whales	Sei whales	Sperm whales	Blue whales	Humpback whales	Total number of whales
1948	195	5	15	24	0	239
1949	249	12	28	33	2	324
1950	226	0	11	28	0	265
1951	312	2	13	11	1	339
1952	224	25	2	14	0	265
1953	207	70	48	5	2	332
1954	177	93	54	9	1	334
1955	236	134	20	10		400
1956	265	72	95	8		440
1957	348	78	81	10		517
1958	289	91	123	5		508
1959	178	67	120	6		371
1960	160	42	177			379
1961	142	58	150			350
1962	303	44	136			483
1963	283	20	136			439
1964	217	89	138			444
1965	288	74	70			432
1966	310	41	86			437
1967	239	48	119			406
1968	202	3	75			280
1969	251	69	103			423
1970	272	44	61			377
1971	208	240	106			554
1972	238	132	76			446
1973	267	138	47			452
Grand total	6286	1691	2090	163	6	10.236

Table 2. Relative efficiencies of the catcher boats used in the Icelandic fin whale harvest 1948 through 1973

Catcher	Tonnage	Horsepower IHP	Time in operation	Estimated catcher's efficiency	95% confidence limits	
Hvalur 1	248	800	1948-1956, 27/6-29/7, 1961	0.935	0.831	1.056
Hvalur 2	256	1200	1948-1955, 1957-24/8, 1961	0.996	0.896	1.109
Hvalur 3	266	1200	1948-15/6, 1961	1.057	0.954	1.174
Hvalur 4	250	800	1948-1961	1.000		
Hvalur 5	387	1400	1956-1965	1.080	0.946	1.238
Hvalur 6	434	2100	30/7, 1961 -	1.285	1.049	1.592
Hvalur 7	427	2100	26/8, 1961 -	1.341	1.095	1.662
Hvalur 8	481	1800	1962-	1.120	0.914	1.388
Hvalur 9	631	1900	1966-	1.415	1.137	1.784

Table 3. Fin whales marked off the West Coast of Iceland under the Icelandic marking program, and recoveries made at the shore station in Iceland.

Number of fin whales marked	13	1	3
Date of marking	1965, May	1970, May	1972, May
Recoveries	3, 1966 1, 1972 1, 1973		1, 1972

Table 4. Fin whales marked off East Greenland under the Norwegian marking program, and recoveries made at the shore station in Iceland.

Number of fin whales marked	14	2
Date of marking	1968, August	1970, July
Recoveries	1, 1968 1, 1969	

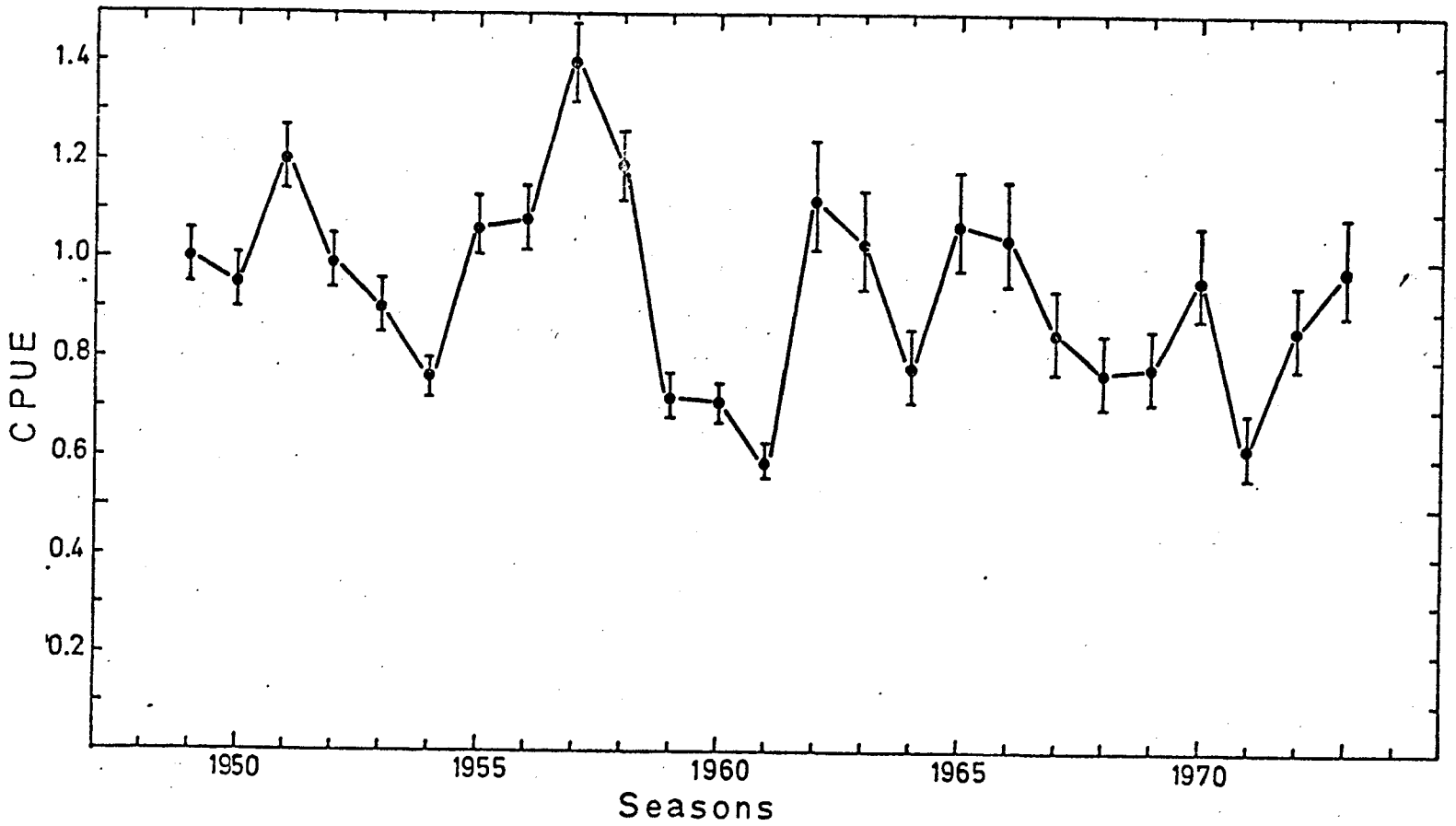

Figure 1. Catch per unit effort of fin whales off the West Coast of Iceland from 1949 through 1973. The vertical bars represent 95% confidence interval. No corrections made for variable weather conditions.

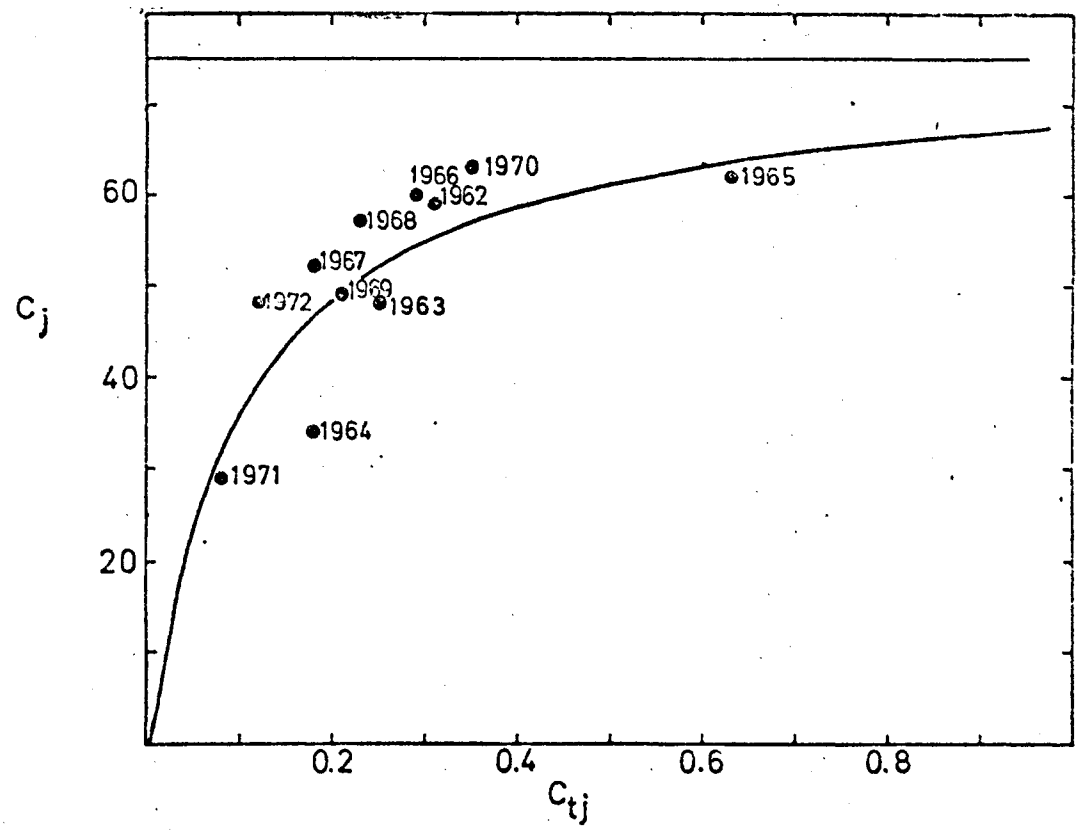

Figure 2. Relationship between catch of fin whales, C_j, at Iceland and the catch of fin whales per hour expended in searching and hunting, C_{tj}, during the same season. The values were obtained from the log-books of Hvalur 7 in June and July, 1962 through 1972. The curve is fitted from the theoretical relationship between C_j and C_{tj}.

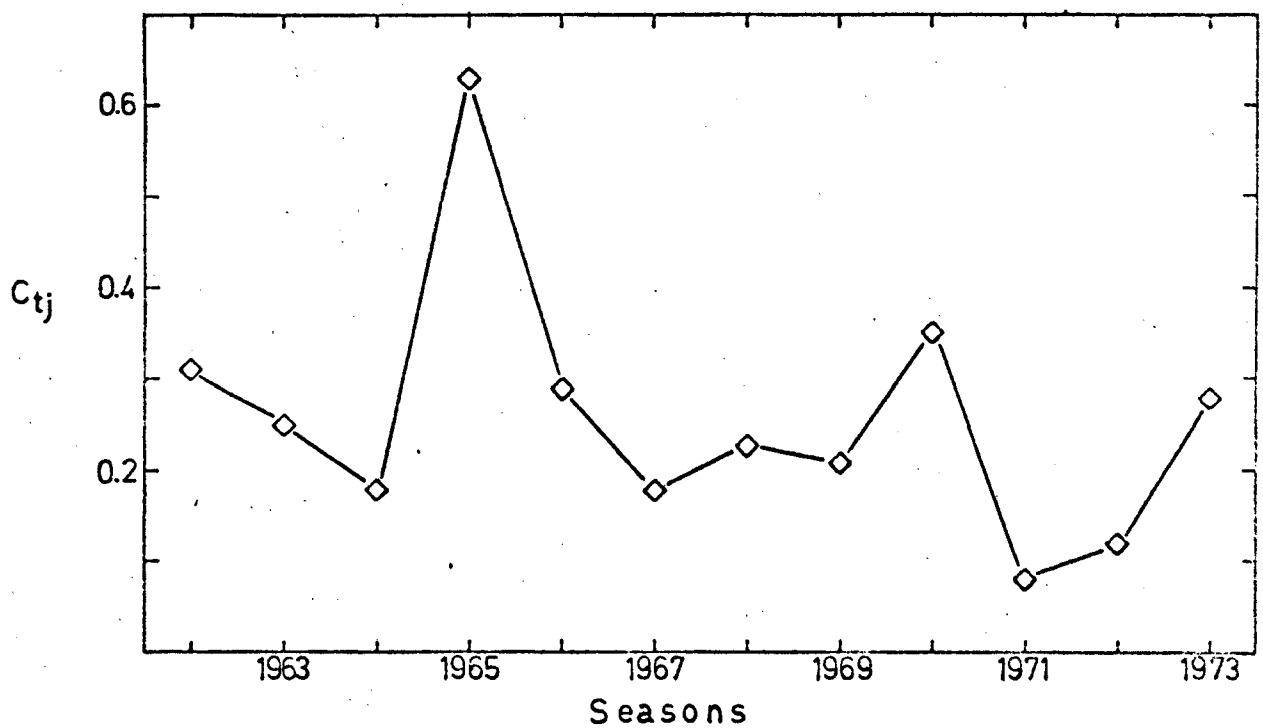

Figure 3. Number of fin whales caught by Hvalur 7 per hour used for searching and hunting in June and July, C_{tj}. The values for 1962 through 1972 are estimated from the log-books. The value for 1973 is based on the number of fin whales caught by Hvalur 7 in 1973, and the known relationship between C_j and C_{tj} in 1962 to 1972 (see figure 2).

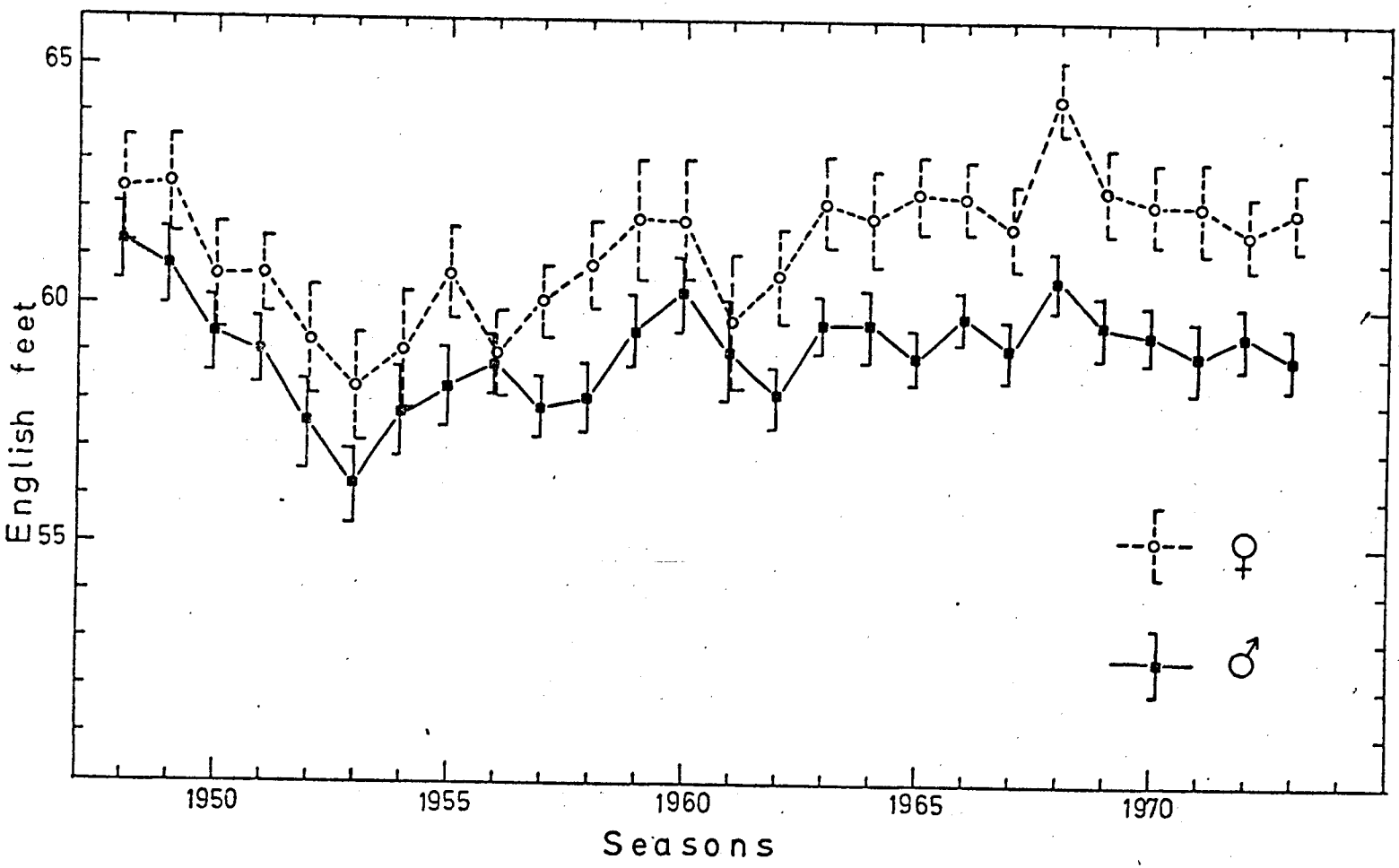

Figure 4. The mean lengths of fin whales caught at Iceland 1948 through 1973. The vertical bars indicate 95 % confidence interval.

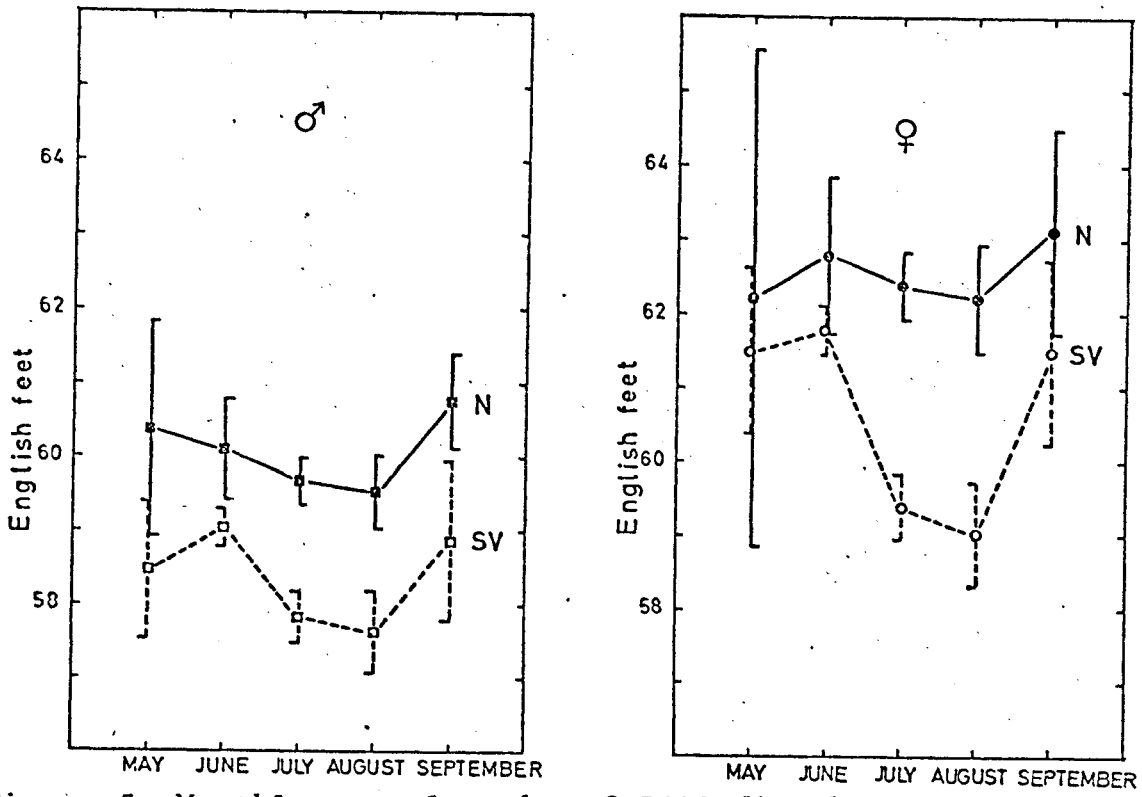

Figure 5. Monthly mean lengths of 5610 fin whales caught off the West Coast of Iceland from 1951 to 1973. N designates the area north of 65°N, SV indicates the ground south of 65°N. Vertical bars give 95% confidence interval.

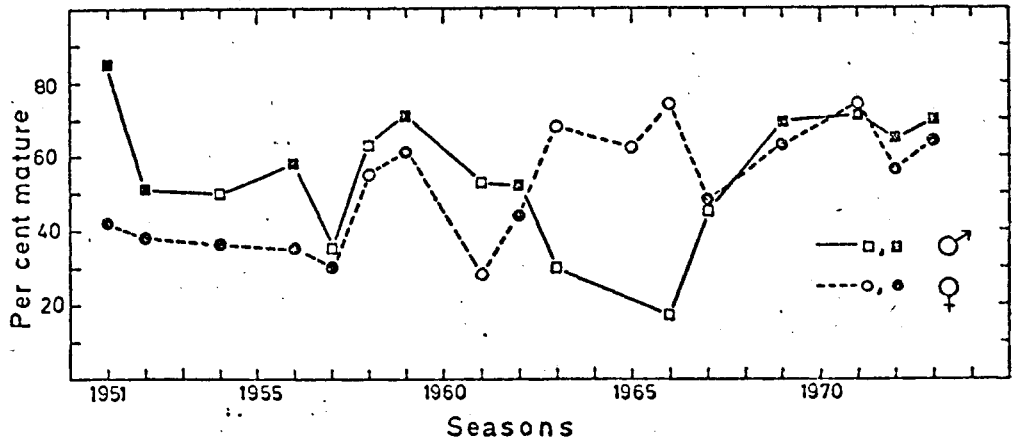

Figure 6. The percentages of mature animals in the catches of fin whales off the West Coast of Iceland between 64°N and 65°N in July and August. Males 58 feet long or larger and females 60 feet long or larger are considered mature. Years with catches yielding less than 10 animals are omitted. Catches containing 10 to 19 animals are indicated by open symbols and those with more are indicated by black symbols.