DAILY CATCH OF DANISH SEINERS BY THE SAME NUMBER OF DAILY HAULS AT THE SAME DEPTH ZONE IN THE BERING SEA*

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The following tendencies were found in the daily reports during the entire season in 1963 by 22 of the Danish seiners of one of the fish-meal fleets which fished in the Bering Sea: The daily catch per boat increased with depth1), in contrast with the fact that the daily haul per boat decreased with depth2); and in the same depth zones, the daily haul per boat decreased with increase in the daily catch yielded by it3). These suggested the necessity of clarifying the variability of the daily catch per boat at respective depth zones caused by the diversity in the number of daily hauls expended for yielding it. And the factor responsible for this inaccuracy should be eliminated from the analysis on the bathymetric difference in the daily catch per boat. The necessity of stratification of the records of daily catch according to the grade of daily hauls was also due to the possibility of this procedure providing an effective suggestion of the factor causing the difference of the areas in the type of frequency distribution of daily catch.

In this respect, the records of daily catch were stratified into some grades of daily hauls and were analyzed by similar methods to those used in the previous reports of this series. The results obtained are shown in this report.

Stratification of the Records

The original records used here were the daily reports of 22 Danish seiners belonging to one of the fish-meal fleets which fished in the Bering Sea during the entire season in 1963. In the previous reports1-3), the following characteristics of this set of records have already been analyzed: the bathymetric changes in the daily catch, daily haul, and the latter in relation to the former.

The daily catch by respective boats was described in tons. But the accuracy of the measurement, the range and irregularity in the distribution taken into consideration, the records were aggregated into the nearest 10 tons below the recorded values. The records in each of the depth zones were classified into grades according to the number of daily hauls. The necessity of dealing with the records after stratification into the following three areas was manifested by the clear segregation of the daily positions of the fleet, which had a close relation to the season passing: Area A (north of...
58°N, east of 167°W), Area B (58° to 60°30’N, 171°30' to 175°W), and Area C (59° to 62°30’N, 176°30' to 179°W). And the rationality of this stratification was supported by the difference of these areas in the following points: range of depth of fishing ground, leading species of catch, and the type of frequency distribution of daily catch.

The depth of fishing grounds was recorded in m; but, the accuracy of measurement and distribution of the records taken into consideration, the records were aggregated into the nearest 10 m. But some of the depth zones had not sufficient records to be stratified further into some strata according to the grades of daily hauls. This brought about the necessity of aggregating some consecutive depth zones with insufficient records. In Area A, the fleet stayed long in the 110 m zone, but shifted rapidly from the 100 m to the 50 m zone. Each of the depth zones of 10 m intervals other than 110 m zone had, accordingly, records not sufficient to be stratified into some strata according to the grades of daily hauls. The 80 m zone was excluded from the analysis, because this zone differed from others of this area in the major objectives as well as the type of frequency distribution of daily catch. The records in this area were, accordingly, stratified into the following three depth zones: the 70 m (including the records from the 50 m and 60 m zones), the 90 m to 100 m, and the 110 m zones. In Area B, the boats fished at depths between 100 m to 120 m. But most of the records in the 120 m zone were concentrated in a single grade of seven hauls a day. This made the 120 m zone unsuitable for the present analysis. And the records in this zone were not used in this report. The records in Area B were, accordingly, stratified into two depth zones: the 100 m and the 110 m zones. In Area C, the records in the 110, 120, and 130 m zones were aggregated into a single depth zone, because each of them had insufficient records to be stratified into some strata according to the grades of daily hauls. Namely, the records in Area C were stratified into the following three zones: the 130 m (including the records in the 110 m and 120 m zones), the 140 m, and the 150 m zones.

The catch yielded from 110 m zone in Area B by six or seven hauls differed with the passing of the season, which caused the bimodality in the frequency distribution. The records in this stratum were, therefore, stratified into two sub-strata—June and July. In each of the depth zones, most of the records were concentrated into two to four grades of daily hauls. Moreover, these grades of rich records differed with depth, because the daily hauls decreased with depth. This made the other strata than those shown in Fig. 2 inapplicable to the present analysis.

**The Type of Distribution**

The frequency distributions of daily catch per boat in most of the depth zones before stratification according to the grades of daily hauls were agreeable to logarithmic normal series in Area A or B, whereas to normal series in Area C. But the outline
of the observed series of frequencies suggested that the stratification into the grades of daily hauls tended to normalize the distribution of the records with respect to the grades of daily catch. To confirm this, the expectant frequencies of normal distribution in each of the strata were estimated by the following method: The cumulative value of relative frequency at any grade of daily catch in the observed series was standardized by reference to the table of normal distribution function. And the expectant series was estimated from the linear regressive relation of the standardized variables on the grade of daily catch. Here, the grades out of the range of the grades with consecutively higher frequencies than five were not used in the estimation of the regressive relation because of the following reason: As cumulative frequency is used here, the effect of statistical error in the grades with low frequency may be weakened, but it is still possible that some of the grades with low frequency, particularly in the tails of the distribution, would cause a serious error.

Figure 1 shows the observed series of frequencies of daily catch in comparison with the expectant one in each of the strata of Area C, as the examples. The test of fitness of the observed series to the expectant one through chi square indicated that the frequency distribution in each of 19 strata out of 23 was agreeable to normal series (P>0.1), but that in each of four series of the rest was not to this series

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**Fig. 1.** Comparison of the observed series of frequencies of daily catch per boat with the expectant one in each of the strata of Area C. Note: The filled histogram shows the observed series, whereas the hatched one the expectant one in which it is set that the observed series is agreeable to normal distribution. Ordinate is frequency in day-and-boats.
To find whether these were kept in logarithmic normal series or modified into some other series, these were compared with the other expectant series in which it is set that the observed series plotted against \((x+1)\) on logarithmic scale is agreeable to normal series (where \(x\) is the grade of daily catch per boat in 10 tons). The chi square test of fitness revealed that the frequency distribution in each of three strata

![Catch in tons a day (x)](image)

**Fig. 2.** The difference in the type of frequency distribution, the average and the standard deviation of daily catch per boat with either the grade of daily haul or the depth of fishing ground.

Note: The true line shows the range of standard deviation of the daily catch of the stratum agreeable to normal distribution; whereas the broken one that to logarithmic normal series. The stratum of 140 m by 6 hauls was included in the former type. The triangle indicates the average of the daily catch of the stratum in Area A, the half circle in Area B, and the square in Area C. The open mark symbolizes the stratum of 9 hauls; the filled one of 8 hauls; the mark with right half filled of 7 hauls; that with left half filled of 6 hauls; and that with vertical bar of 4 or 5 hauls. For the stratum of 110 m zone in Area B by 6 and 7 hauls, two sets of values are illustrated, because the daily catch in this stratum differed with season passing and the records were stratified into two sub-strata according to the months—June (upper) and July (lower).
out of four was agreeable to the logarithmic normal series (P>0.1). But the pre-
dominance of the observed frequency in the grade of catch from 40 to 49 tons in the
other stratum (140 m zone by six hauls) made this stratum agreeable neither to normal
nor to logarithmic normal series, although the distribution of this stratum showed
close approximation to the former (0.1>P>0.05). The normal distribution was, thus,
characteristic of the frequency distribution of daily catch per boat after stratification
according to the grade of daily hauls. But there were three exceptions, the distribu-
tion of which was kept in the logarithmic normal. These had the following common
points: The strata of the highest grade of daily hauls in the zones shallower than
120 m, the average being smaller than that of the strata agreeable to normal—about
20 tons. The type of frequency distribution, average, and standard deviation of daily
catch per boat used in the estimation of the expectant series are shown in Fig. 2.

Discussion

A tendency of increase in daily catch per boat with depth was found out before
stratification1). But the grades of daily hauls with sufficient records differed according
to the depth. This resulted in the strata of the same grade of daily haul not distributed
over diverse depth zones. And this made it difficult to get a good conclusion of the
bathymetric change in the daily catch yielded by the same grade of daily hauls.

With increase in the depth of fishing ground, the daily catch per boat showed
a rough tendency of increase1), in contrast with the fact that the daily haul showed
a decrease2). These tendencies resulted in harvesting a good catch from the depth
zones where the boats did not conduct frequent hauling. But the stratification of
the records according to the grade of daily hauls afforded an evidence in support of
one of the findings in the analysis on the difference of daily hauls conducted at the
same depth zone on the days yielded the same grades of daily catch3)—the inverse
relation of daily catch to the daily hauls within the same depth zones.

It was found that the logarithmic normal was characteristic of the frequency
distribution of daily catch per boat in the same depth zones of Area A or B, whereas
the normal was of Area C before stratification according to the grade of daily hauls1). But the frequency distribution after stratification in most of the strata was agreeable
to normal series. This difference in the type of frequency distribution of daily catch
between areas or between before and after the stratification may chiefly be due to the
following reasons: The daily haul per boat conducted in the same depth zones was
distributed over wide range of grades in Area A or B whereas in narrow range in Area
C as shown in Fig. 1 of the previous report2). The daily catch differed with the grade
of daily haul even within the same depth zones in the same areas. These meant that
the frequency distribution of daily catch from the same depth zones in Area A or B
composed of many strata of the records with different average. This ended in the
distribution superficially approximate to the logarithmic normal series. But the
distribution in the same depth zones of Area C composed of few strata. This ended in the distribution kept in normal series.

In Area C, the frequency distribution in each of the strata was agreeable to normal series; but Area A and B had two and one strata agreeable to logarithmic normal. This might suggest the possibility of the presence of unknown factors, which were dishomogeneous and displayed significant influence on the daily catch in these three strata of poor catch by the highest grade of daily hauls at the shallow zones.

Summary

This report dealt with the daily reports during the entire season in 1963 by 22 of the Danish seiners belonging to one of the fish-meal fleets which fished in the Bering Sea. The stratification of the records of daily catch per boat according to the area, the depth, and to the grade of daily haul made it possible to find the following tendencies:

1. The frequency distribution of daily catch per boat yielded by the same grade of daily hauls in the same depth zones was in most of the strata agreeable to the normal series, but that yielded by the highest grade of daily haul in few of the depth zones was kept in the logarithmic normal series (cf. Figs. 1 and 2).

2. The bathymetric difference of daily hauls made it difficult to get a good result of that of daily catch yielded by the same grade of daily haul.

3. In the same depth zone of the same area, the daily catch per boat was poorer on the days when the boats conducted frequent hauling than on the days when the boats conducted less frequent hauling (cf. Fig. 2).

4. These findings and the deviation of the daily hauls in the same depth zone suggested such possibility that the frequency distribution of daily catch per boat in the same depth zones of Area A or B composed of many strata of the records with different average of daily catch, and the distribution before stratification according to the grades of daily hauls approximated superficially to the logarithmic normal series.

References