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THE FORMATION AND THE DISAPPEARANCE
OF A STOCK UNIT OF NORWEGIAN HERRING

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With a section on herring migrations east of Iceland by

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INTRODUCTION

About 100 years ago great schools of so-called «large herring» migrated to northern Norway. Very good descriptions of this migration are published in «Norges Fiskerier» from 1868—1874. The herring were mature herring coming from the north, migrating southwards along the coast. The schools were discovered because they were followed by flocks of whales and thousands of birds. In many cases the schools went into shallow areas where thousands of barrels could be filled with herring caught even by means of dip nets. The main gears used during the fisheries were however, beach seines and tangle nets.

In 1868 the herring arrived in the coastal area of Vesterålen in the middle of October, and in 1874, the last year it showed up, as early as September 17th. Since 1875 only young immature herring have formed the basis of the herring fisheries in northern Norway.

SVEN RUNNSTRØM (1936) reported that mature herring were caught in the Andenes area in 1935, and Russian investigators found herring larvae between Røst and Sørøya in 1938. These herring were regarded as belonging to a special unit of herring which they called «Murman herring» (MANTEIFEL and MARTY 1939).

In the present century no commercial fisheries of economic importance were carried out by Norwegian ships on mature herring off northern Norway before late March 1958, when R/V «G. O. Sars» discovered schools of herring spawning in the Røst area (G. SÆTERS DAL, verbal inf.). Several Norwegian purse seiners, which were on their way home after the winter herring fishery in the Møre area, went to the Røst Bank and caught about 70 000 hl of herring before the schools disappeared in the middle of April. The herring constituted of the extremely strong 1950 year-class.

Since the winter 1950-51 a Norwegian research ship has followed the herring schools on their spawning migration from the wintering area east of Iceland to the spawning grounds along the Norwegian coast. In 1959 also the northern area was investigated with regard to spaw-

ning migration of herring to the Lofoten area, but with negative results. During the years 1960—62 the northern area was carefully investigated before and during the Lofoten cod season, but mature herring were not located.

From these previous investigations it can be concluded that mature herring occasionally have appeared off northern Norway also in this century. The years of appearance were when very strong year-classes of the Norwegian winter herring recruited the mature stock. In the years 1935—38 the 1930 year-class and in 1958 the 1950 year-class were dominating the northern unit.

According to the author's explanation of the periodicity of the appearance of the Atlanto-Scandian herring in Scandinavian coastal waters (DEVOLD 1963 a), the wintering and spawning of the main part of the Norwegian winter herring is sooner or later to be expected off northern Norway. When therefore many schools of mature herring on February 2nd, were discovered by R/V « G. O. Sars» off Finnmark at the same time as the main part of the winter herring were following its wellknown route from the wintering area east of Iceland to the spawning grounds off Møre, it was considered important to follow the further migrations of the northern unit.

MATERIAL AND METHODS

The concentrations of the northern unit of the mature herring have been located with sonar and echo-sounders by the Norwegian research vessels and by hired ships through the years 1963—66. The size of the stocks has been estimated from echo-recordings and from commercial catches.

Samples secured from the herring schools were as usual analysed with regard to sex, length, weight, age, stage of gonades etc.

RESULTS

THE 1963—SITUATION

On February 2nd 1963, R/V «G. O. Sars» located many schools of herring in the area from North Cape to Sørøya (S. OLSEN, verbal inf.). Samples taken with trawl, showed a mixture of mature and immature herring. The sampled herring belonged mainly to the 1959 year-class which seemed to be very abundant. 20% were in maturity stage IV.

On March 20th the herring were discovered off Røst and disappeared in early April. These herring were a mixture of spawning and immature herring belonging to the 1959 and 1960 year-class.

On July 11th 1963 the R/V «Johan Hjort» located herring schools in position N 68°05' E 10°08'. From this position on a direct course of 72 degrees schools of herring were located over a distance of about 50 miles. The findings were broadcasted and a few Norwegian purse seiners gathered in the area and made good catches until the middle of August, when the fishermen lost contact with the herring schools. Samples were not secured from these schools, but according to information from fishermen and from reduction plants, the herring had about the same length distribution as the herring which had been caught in late March and early April on the Røst Bank (DEVOLD 1963 b).

On September 25th 1963 schools of herring were discovered about 50 miles north of Torsvåg by the R/V «G. O. Sars». Samples showed a mixture of mature herring and immature fat herring from the year-classes 1959 and 1960. The schools stayed near the bottom during day and approached the surface in the evening (DRAGESUND 1964).

The herring schools moved eastward during October and gathered in the Ingøy Deep to the north of Hammerfest in late October and stayed on there in November—December. The vertical migration of the herring schools to the surface layer in the evening ceased during November, and the herring kept later to the cold bottom water day and night.

From October 20th to November 3rd the coastal area between Lofoten and North Cape were investigated by R/V «Johan Hjort» (DEVOLD 1964 a). Great concentrations of mature herring were located in the Ingøy Deep during this cruise, but no herring of the year-classes 1959—61 were located outside this area.

R/V «Asterias» located the herring in the Ingøy Deep several times during the autumn of 1963 (HOGNESTAD 1964). The Norwegian R/V «Thor Iversen» followed the movements of the herring schools in the Ingey Deep and secured samples with a pelagic trawl. The herring were in this way under constant observation. Fig. 1 shows the most likely movement of this herring through the year 1963.

THE 1964—SITUATION

During late January 1964 the herring schools disappeared from the Ingøy Deep. When R/V «Johan Hjort» was available, the ship went to northern Norway to look for the disappeared herring.

On February 29th many herring schools were located about 10 miles north of Røst and in a northeasterly direction from this position for about 30 miles (DEVOLD 1964 a).

The herring schools migrated to the Røst Bank and the Vestfjord. Information to the fishermen about the movements of the schools were

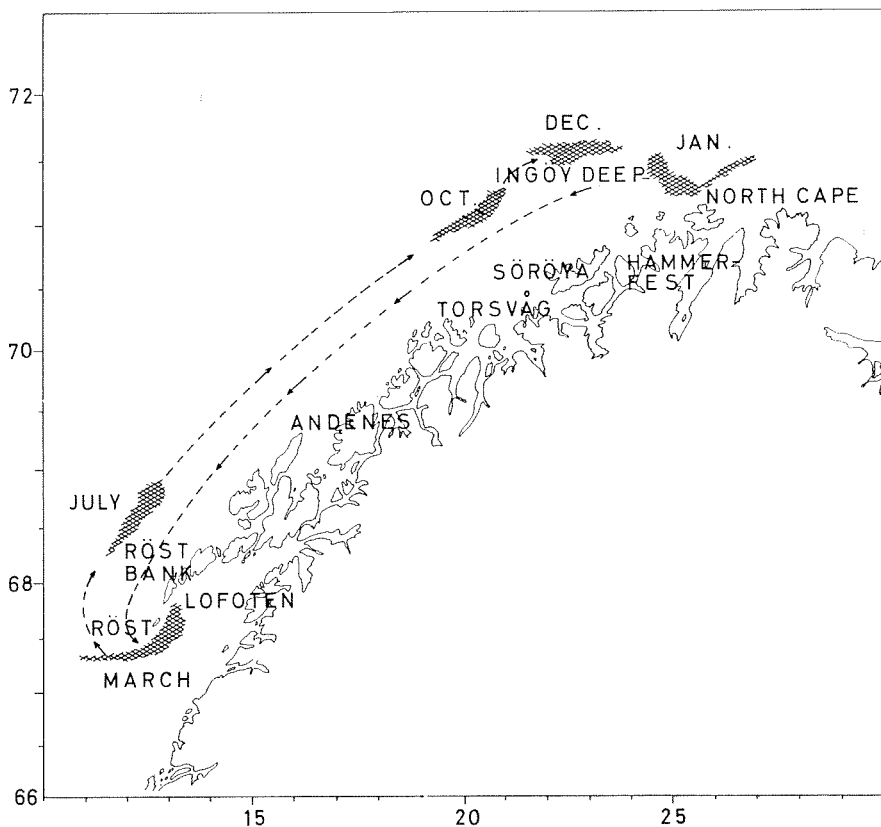


Fig. 1. The migration of the Lofoten—Røst Bank herring 1963.

broadcasted and very soon Norwegian purse seiners gathered in the area. Till March 25th about 1,5 million hl of herring were caught in the Vestfjord area, i.e. about 50 per cent of the total Norwegian winter herring catch during the season 1964.

The spent herring left the Lofoten—Røst Bank area in April. The Norwegian fishing fleet got contact with the northern component again in late August. A Soviet fleet, however, were catching herring about 200 miles northwest of Andenes during July and August. In late October the wintering area of this northern component of mature herring were located by R/V «Johan Hjort» (DEVOLD 1964 b).

Fig. 2 shows the most likely route of the herring schools through the year 1964.

THE 1965—SITUATION

On January 17th the Norwegian research ship «G. O. Sars» located herring schools about 100 miles northwest of Torsvåg (DRAGESUND 1965).

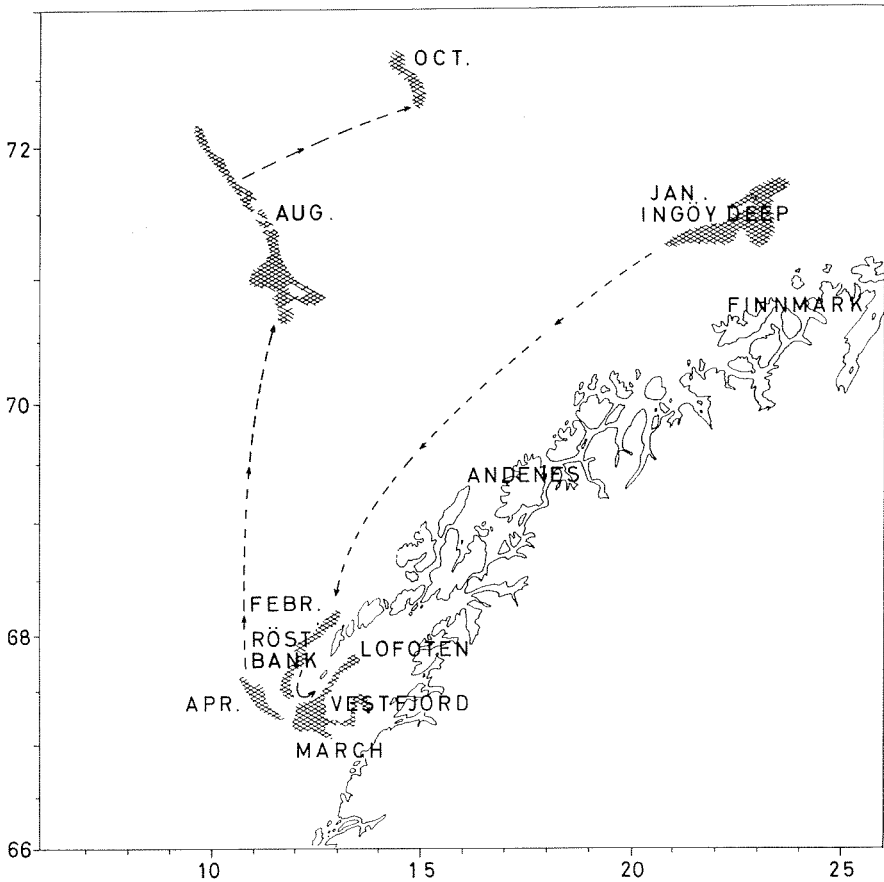


Fig. 2. The migration of the Lofoten—Røst Bank herring 1964.

The herring were found in water with temperatures between 6 and 7°C, which means that the herring had left the cold wintering area and had initiated the spawning migration.

Contact with the migrating schools was again obtained by R/V «Johan Hjort» from January 30th to February 4th along the edge of the coastal banks off Senja and Vesterålen.

Norwegian purse seiners followed the herring schools to Røst, and the spawning took place on both sides of the Vestfjord and on the Røst Bank (DEVOLD 1965 a). The Norwegian fleet caught about 450 000 hl of herring from this northern component during the winter herring season. The Soviet fleet caught about 1,2 million hl on the Røst Bank during the same season.

In April the spent herring left the northern Norwegian coastal waters and disappeared in northwesterly direction.

The herring was again located by R/V «G. O. Sars» in the first days of August about 170 miles southwest of Bear Island. The Norwegian herring fleet was informed, and a few of the larger Norwegian purse seiners headed for the R/V «G. O. Sars» position, where they had very good fishing. There were large herring schools, which in daytime kept to a depth of between 200 and 300 m. In the afternoon the herring ascended towards the surface and during the night dispersed in the surface layer.

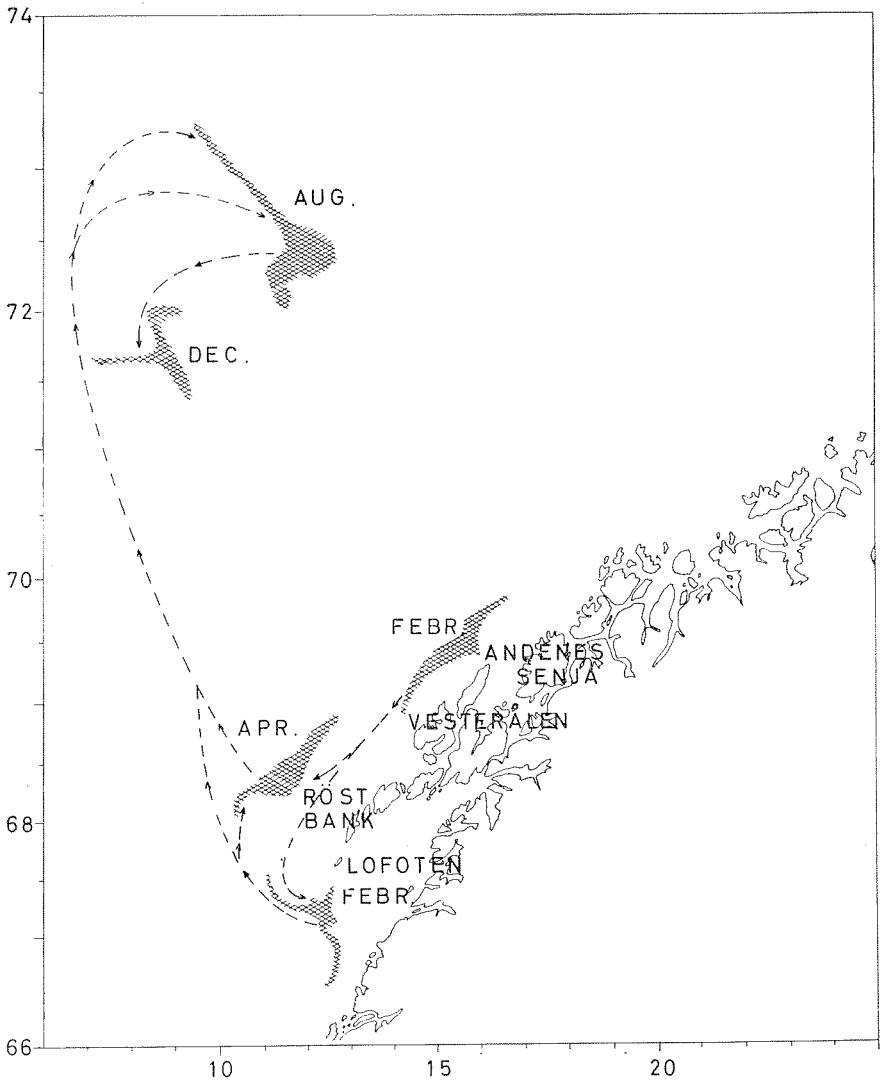


Fig. 3. The migration of the Lofoten—Røst Bank herring 1965.

The next morning schools were again formed and the herring again descended to the deeper layers (DEVOLD 1965 b).

The wintering area where this herring spent the time between October and early January was located during a cruise with R/V «Johan Hjort» from November 24th to December 10th 1965 (DEVOLD 1955).

Fig. 3 shows the most likely route of the Lofoten spawning herring during the year 1965.

THE 1966—SITUATION

The wintering area of the herring was visited by R/V «Johan Hjort» in early January 1966. The herring had since late November moved about 40 miles to the south, but were still keeping to water with a temperature of 3°—4°C. The schools stayed in the depths of 200—350 m day and night. On February 24th migrating schools of mature herring were located by R/V «G. O. Sars» between Andenes and Anda light house (DEVOLD 1966).

The extremely cold winter in northern Norway in 1965—66 cooled the bankwater to a temperature lower than previously observed (DEVOLD 1966). In February the main part of the Røst Bank was covered from surface to the bottom by water with temperatures below 3°C, and the spawning of the herring took place mainly at the western and northern edge of the bank.

After spawning the herring left the Lofoten—Røst Bank area and were again located by R/V «Johan Hjort» on June 16th in the position N 70°30' to N 71°06' and E 11°13'. The schools were moving in north-westerly direction.

Fig. 4 shows the route of R/V «Johan Hjort» in June—July 1966. The temperature in 4 m depth recorded by the sea-termograph, and the registration of herring schools are also shown.

It appears a wide area with no herring between the easterly and westerly concentrations of herring in late June and early July. The main herring component, which has the more southern distribution, has not been included in the map. It was located by the Icelandic research ships south of Jan Mayen and followed through the summer by the Icelandic herring fleet.

The movements of the herring schools are described by JAKOBSSON in an appendix to this paper.

Contact with the eastern concentration of herring were kept by R/V «Johan Hjort» and by a few Norwegian purse seiners from late June to July 11th. The rest of July and August the Norwegian ship

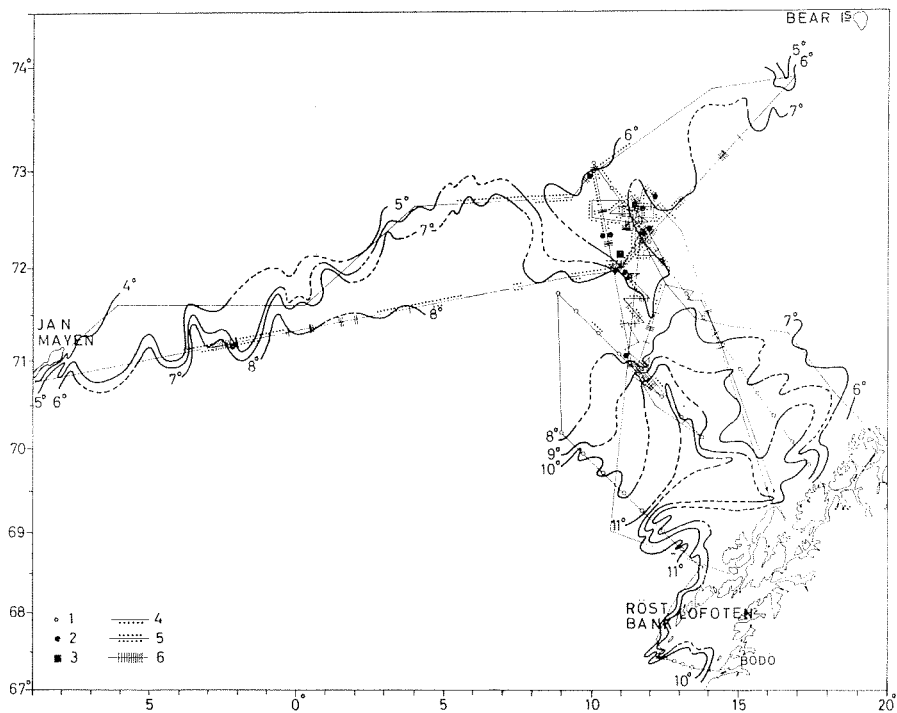


Fig. 4. Routes and stations, R/V «Johan Hjort» 1966. Temperature C^0 in 4 m. 1) hydrographical stations, 2) drift nets stations, 3) tagging locality. Herring concentrations: 4) very scattered, 5) scattered, 6) dense.

«Storeknut» kept contact with the herring schools. The most northerly concentrations of herring were located in the middle of August in a position about N $74^{\circ}30'$ with a westerly limit at about E 10° (ANON. 1966). The Norwegian purse seiners were during August joined by a fleet of Soviet drift net ships. The Norwegian ships left the area in late August after fishing 400 000 hl in this locality.

Two spawning migrations to the Norwegian coastal banks during the winter herring season 1967 were expected, one coming from the north to the Røst Bank—Lofoten area and a second one from the wintering area east of Iceland to the Møre coast. On November 18th 1966 R/V «Johan Hjort» started on a cruise for locating the wintering area of the northern component of the mature herring, but no mature herring were observed. The investigations were repeated in early January and late February 1967 with negative results. In fact, there was no spawning migrations of herring to the Røst Bank—Lofoten area during the 1967 season, nor during the 1968 season. The northern component had simply disappeared.

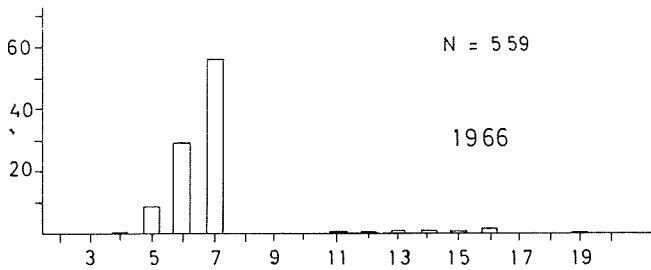
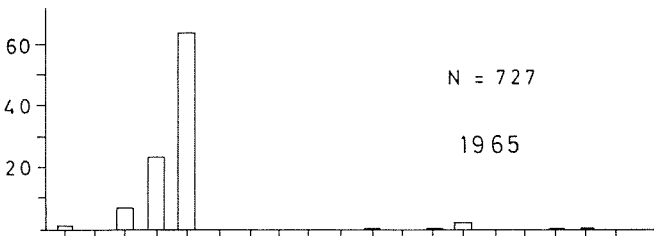
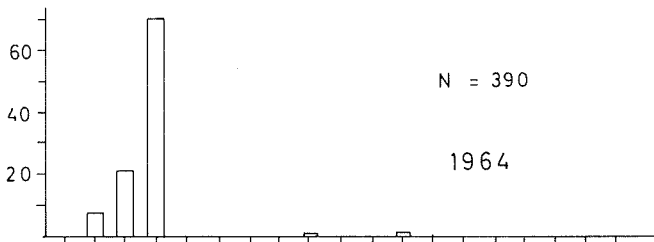
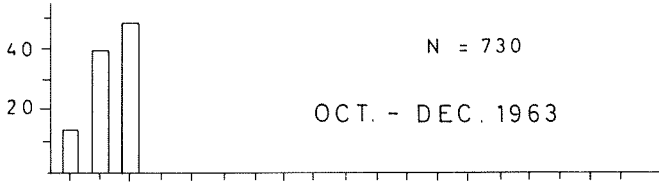
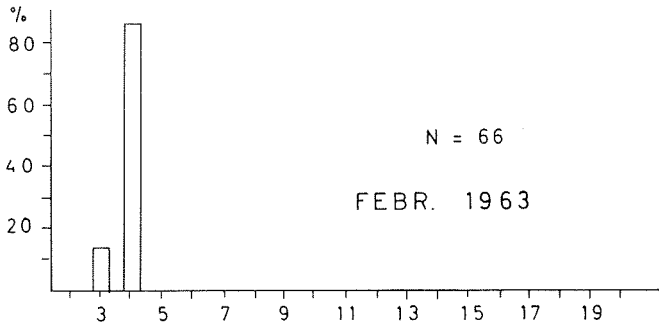


Fig. 5. Age composition off Finnmark.

THE AGE COMPOSITION OF THE LOFOTEN SPAWNING HERRING

In Fig. 5 is demonstrated the age composition in samples of herring taken in the open sea areas shown on Figs. 1—3. The samples show that the stock consists of only young herring. In February 1963 it consisted mainly of the 1959 year-class. In October—December 1963, when the herring were gathered in the Ingøy Deep, the component had received a substantial recruitment from the 1960 and the 1961 year-classes. The samples from 1964 and 1965 show the same picture, but the herring are one and two years older respectively.

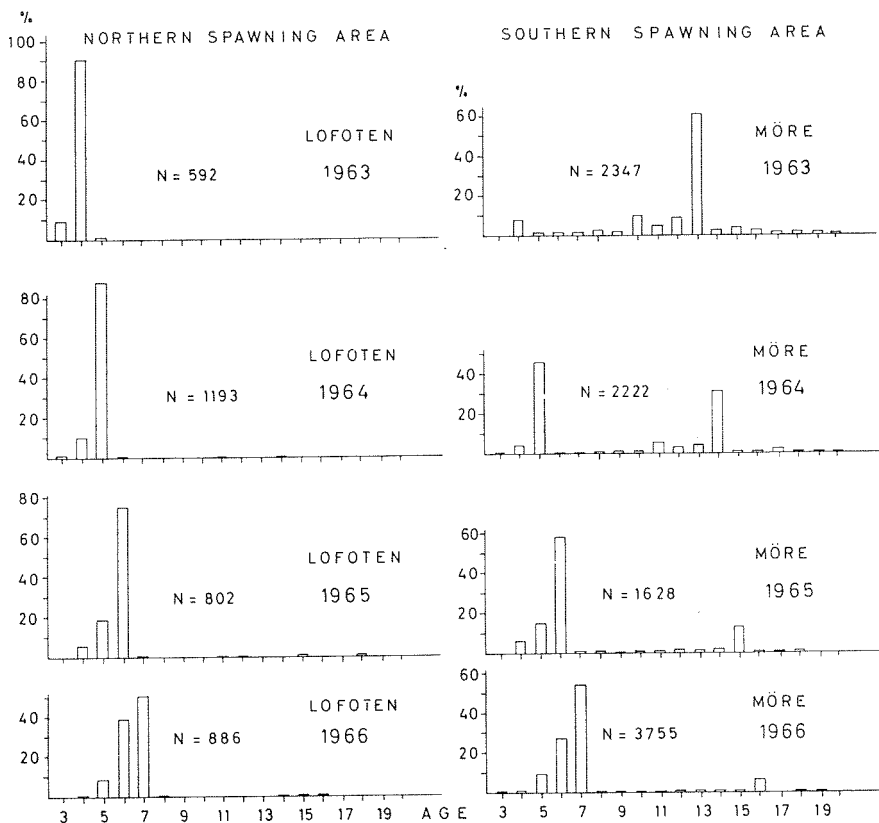


Fig. 6. Age composition Lofoten—Møre.

Fig. 6 shows the age composition of the Lofoten—Røst Bank spawning herring and the age composition of the herring which have followed the southern spawning migration route from the wintering area east of Iceland. In 1963 the southern component mainly consisted of old herring with the 1950 year-class dominating. The herring spawning in Lofoten

showed the same age composition as the herring caught off Finnmark in late February. The herring which arrived in Lofoten on March 20th 1963 is therefore supposed to have migrated from North Cape to the Lofoten spawning area.

In 1964 a fairly great proportion of the 1959 year-class had joined the herring in the wintering area east of Iceland. They followed the southern spawning migration route and spawned together with the older herring in the Møre area.

In the Lofoten—Røst Bank area the spawning herring consisted only of young herring belonging to the 1959 and 1960 year-classes and a few to the 1961 year-class. The spawning herring showed the same age distribution as did the herring wintering in the Ingøy Deep.

During the winter herring seasons of 1965 and 1966 the age composition of the herring spawning off Møre, shows that the old herring were still important, and that the spawning stock in the Lofoten area contained only younger year-classes with the same age distribution as the samples collected in the Bear Island area during the corresponding summers.

THE SPAWNING—CLASSES

The individuals within a stock which have attained maturity in the same calendar year constitute a spawning-class (ROLLEFSEN 1933).

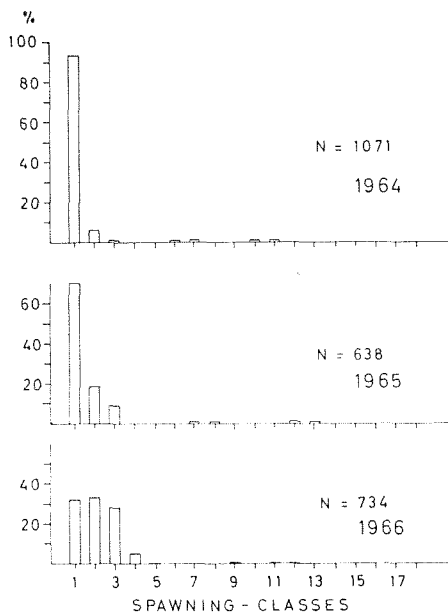


Fig. 7. Spawning-classes of the Lofoten—Røst Bank herring.

The herring which were found in the Røst area in March 1963 were first time spawners mixed with about 20 % of immature herring. Fig. 7 shows the spawning-classes of the herring during the spawning season in the Lofoten area during 1964—66. In 1964 the spawning stock of herring was composed of first time spawners and second time spawners. When the herring were spawning in the Lofoten—Røst Bank area in 1965, the third year in succession, the stock consisted of first, second and third time spawners. The following year, in 1966, there were first, second, third and fourth time spawners.

CONCLUSIONS

The conclusions we can draw so far are:

1. During the years 1963—66 a separate stock unit of the Atlanto—Scandian Herring occurred off northern Norway. It consisted of herring belonging to the year-classes 1959, 1960 and 1961.
2. The stock had a spawning, feeding and wintering area, separated far from the main stock of mature Norwegian herring.
3. In the autumn 1966 the whole stock disappeared from the area.
4. During the winter herring season in 1967 and 1968 there were no spawning migration of herring to the areas off northern Norway.
5. The vertical movements of the herring schools in the wintering area are connected with the light. There are no vertical migrations of the schools in areas where it is dark day and night.

SUMMARY

1. On February 2nd 1963 mature herring belonging to the Atlanto—Scandian herring were located off Finnmark between North Cape and Sørøy.
2. The herring arrived in the Røst Bank—Lofoten area, where it was recorded spawning late March 1963.
3. The migrations of the herring were seasonally followed by Norwegian research ships and hired ships through the years 1963—1966. The most likely migrations are demonstrated in Figs. 1—3.
4. The herring were recruited from the main stock of immature herring and consisted of the year-classes 1959, 1960 and 1961.
5. In 1963 only first time spawning herring occurred. In 1964 there were first and second time spawners. In 1965 there were also third time spawners and during the spawning season in 1966 there were first, second, third and fourth time spawners.

6. The herring had their own spawning, feeding and wintering areas separated far from the main stock of Norwegian winter herring.
7. In the autumn 1966 the stock unit disappeared. During the winter season 1967 and 1968 there was no spawning migration to the Lofoten—Røst Bank area.

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APPENDIX

HERRING MIGRATIONS EAST OF ICELAND
DURING THE SUMMER AND AUTUMN
1966 AND 1967

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SURVEY RESULTS

The first contact with the feeding summer migration of the Norwegian herring was in 1966 made on May 8th when herring was located in a large area between N 64° and N 65° and from W 6° and W 8°. The herring were concentrated in large migrating shoals and obviously well suited for purse seining. The Icelandic herring fleet was informed, and the first catches were taken on May 12th. The major part of this migration quickly moved north of N 66°, and by the end of June and the beginning of July the migration had assembled in the region south and southeast of Jan Mayen. It is quite certain that the major part of this herring migration remained in the Jan Mayen area throughout July although some part may have migrated further NE, all the way to the Bear Island area. At the beginning of August there was a distinct tendency for a westward movement of the herring in the Jan Mayen area, and by August 10th the westernmost part of the herring shoals had migrated as far west as W 14° between N 69°30' and N 70° where they met the eastern boundaries of the cold waters west and southwest of Jan Mayen. Thus the temperature in the surface layers where the shoals assembled, was about 4,5°—5,5°C, but a few miles further west the sea temperature was about two degrees lower.

During the latter half of August the herring migrated very fast in a south and southeasterly direction. During this phase of the migration the main concentration followed the eastern border of the cold East Icelandic current and approached the east coast of Iceland when it had reached the southern limit of the current. This appeared to be between N 64°30' and N 65°. Thus the herring covered 5° latitudes or about 300 n.m. during the last 10 days in August.

As discussed by DEVOLD (above), another part of the Norwegian herring stock had during the previous years not entered Icelandic waters, but stayed in the Bear Island region during summer and winter and spawned in the Lofoten area. Judging by the change of positions

of the Russian drifter fleet in early September 1966 there were clear indications that this stock unit had started a westerly migration towards Jan Mayen. This continued throughout September. In early October the herring concentrations were located in an area between N 60° and N 70° from W 9° to W 8°. Thus dense concentrations were observed in an area stretching some 60 n.m. from north to south and some 20—25 n.m. from east to west. Judging from the sonar surveys the concentrations were certainly of no less magnitude than the previous August—September migration. During the period from October 15th to October 25th the herring moved very quickly SSE and followed a similar route as the previous migration in August. The only difference was that in October the herring did not go as far west between N 69° and N 70° as the August migration. During November and December both migrations remained in the traditional overwintering area some 60—120 n.m. off the southern coast of East Iceland. There is therefore reason to believe that during the overwintering period shoals and individuals of both stock units had intermixed considerably prior to the spawning migration which commenced in January 1967.

The first herring concentrations were in 1967 located on May 9th in a wide area from N 65°—N 67°30' between 0° and W 3°. There was obviously a large quantity of herring in this area concentrated in dense migrating shoals. As compared with the previous year the herring were in 1967 much further east (difference of 4—7° longitudes) and north (1—2° latitudes) than at the same time in 1966.

The herring moved north and northwest during the second half of May. By June 10th the main concentrations had reached N 70° and were between W 02°30' and W 05°30'. At this stage a very curious thing took place: A considerable proportion of the herring concentrations turned west and southwest. By June 20th this part of the stock had reached N 68°45' and as far west as W 8°45'. This indicated that the summer distribution of the herring might be somewhat similar to the distribution the previous year when one «half» of the stock spent the middle of the summer south and southeast of Jan Mayen whereas the other «half» stayed some 300 n.m. northwest of northern Norway. However, the herring quickly turned after entering the very cold water in the areas south of Jan Mayen and retraced their path northeast. By the beginning of July the herring were 80 n.m. east of Jan Mayen. Later they followed the northeasterly course already taken by the other «half» of the stock and spent the summer in the Spitzbergen—Bear Island region as discussed elsewhere in this paper. Norwegian herring did not enter the western part of the Norwegian Sea, i.e. west of the 0 meridian, in any significant quantity until late September when the herring took

the traditional route towards the overwintering area off the coast of East Iceland. In 1967 the route taken by this migration was almost identical to the one taken by the 2nd herring migration in October 1966 as discussed above. However, both in 1966 and 1967 some herring did not take the northerly routes during the summer as described above, but remained off the East coast. In 1966 there was a considerable quantity in this area throughout the summer. During July 1966 the herring were scattered and difficult to distinguish because large quantities of *Gadus poutassou* were present in the area. At the beginning of August the herring assembled in good shoals suitable for purse seining and in sufficient quantity to support good fishing for 2—3 weeks.

Similarly, in 1967 Norwegian and Faroese drifters caught some herring off the east coast of Iceland in August but the catches were small and the herring never formed proper shoals for purse seining. The quantity in 1967 in this area was much less than in the previous year. It should also be noted that in 1966 the summer herring caught off the East coast consisted of many year-classes where the one from 1959 dominated. However, judging by a sample from a Faroese drifter the dominant yearclass off the East coast in 1967 was that from 1950, i.e. 17 year old herring.

TAGGING RESULTS

The joint Icelandic—Norwegian herring tagging experiments which started in 1948 have supplied a great deal of information. It is sufficient to mention the long range migrations between the spawning grounds off western Norway and the feeding grounds off Iceland. These migrations were postulated by FRIDRIKSSON (1944), and has been proved by tagging experiments. The rate of return from the experiments carried out on the feeding grounds off Iceland have been so consistent during the Norwegian winter fishery that it has proved possible to conduct stock strength studies on the basis of the rate of tagging returns.

Although the results of the Icelandic—Norwegian herring tagging experiments have thus shown for the last twenty years that the Norwegian herring migrates between the spawning grounds of western Norway and the summer feeding grounds off Iceland, the evidence that herring migrated directly from the Barents Sea to the Icelandic north coast is much more recent. The first time such a migration was shown by the results of these tagging experiments was in 1962. In late August and early September great concentrations of immature three year old herring were located some 60—80 n.m. off the North coast of Iceland between

W 16° and W 18°. During the subsequent fishing there, 4 tags were recaptured from a tagging experiment carried out in the autumn 1961 off northern Norway. Since these herring were immature, there could be no doubt that they had migrated directly from northern Norway before recruiting to the spawning stock off western Norway. Similar returns from «Feitsild» tagging experiments were also received during the period 1963—1965. Thus there can be little doubt that immature herring off northern Norway have migrated more or less regularly to the Icelandic area and have to some degree directly contributed to the overwintering herring concentrations off East Iceland.

Now that this migration route has been established not only from evidence of earlier sonar surveys (DEVOLD 1952), but also from tagging of «Feitsild», let us consider the tagging returns in 1966 i.e. the year when according to the sonar surveys a whole stock unit of mature herring migrated from the Bear Island region to the overwintering grounds off East Iceland. On June 20th 1600 herring were tagged by the Icelandic herring search boat «Hafthor» in position N 69°50' and W 7°10', i.e. south of Jan Mayen. During the following months 31 tags were returned from herring caught in that area and in the area east of Iceland. Three tags were recovered from herring landed in Norway during the Norwegian herring fishery in the Bear Island region in July—August 1966. These returns suggest that part of the western component probably had migrated eastwards and joined the herring in the Bear Island region during the summer 1966.

In 1966 it was shown by means of sonar surveys that a whole stock unit of mature herring migrated from the Bear Island region to the overwintering grounds off East Iceland. As regards this westward migration it is fortunate that the Norwegian R/V «Johan Hjort» on July 5th 1966 tagged 1 500 herring in the Bear Island area. One of these was recaptured in the Bear Island area in August the same season. Two were recaptured off East Iceland in October 1966, three in November and 12 in December. A total of 17 tags were thus returned from the overwintering fishery off East Iceland. Direct migrations of mature herring between these distant areas were thereby established in 1966. For comparison it should be mentioned that during the same period 37 tags were returned from the winter herring tagging experiment carried out during the Norwegian fishery off western Norway 1966. A total of 3 300 herring were tagged. Thus the rate of returns from these two experiments were very similar. It should, however, be noted that during the summer season proper, i.e. prior to October, no tags from the Bear Island region were returned while returns were received from the winter herring tagging experiments.

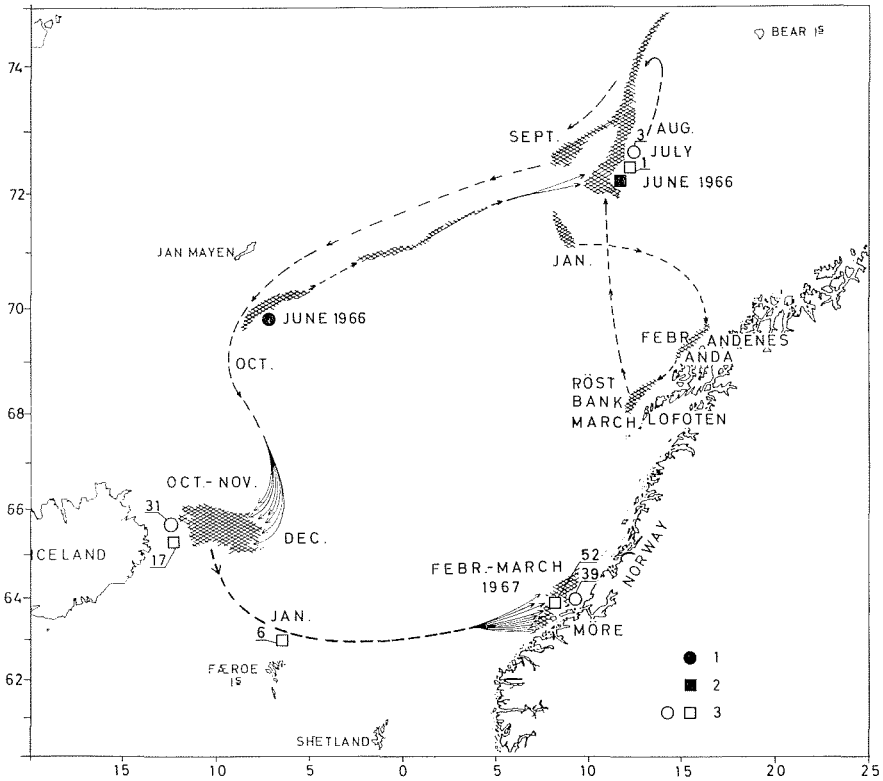


Fig. I. Tagging and recapture localities and migrations of herring till March 1967. 1) Icelandic tagging locality, 2) Norwegian tagging locality, 3) recaptures.

During January—March 1967 six tags from the Bear Island tagging were returned from the Faroe Banks spawning area and 52 from the spawning area off Møre.

In 1967 the rate of returns during the feeding and overwintering season was much higher from the Bear Island tagging experiment, i.e. 39 tags as compared with 33 tags from the winter herring tagging experiment (Fig. I).

A further evidence of the 1966 migration of the Bear Island—Lofoten stock unit to the overwintering grounds off East Iceland can be derived from a tagging experiment of 700 herring on the Lofoten spawning grounds on February 27th 1965. In spite of the great quantity reduced at the Icelandic reduction plants (approx. 0,5 mill. tons) no returns were received from this experiment during the 1965 summer and autumn season. In 1966 there were on the other hand 12 returns from this experiment.

Thus the tagging results all support the results of the sonar surveys to the effect that the stock unit which had developed in the Bear Island—Lofoten region during the period 1963—1966 undertook in the autumn of 1966 a massive 600—800 n.m. migration to the overwintering grounds east of Iceland where the herring mixed with the other part of the Norwegian stock previously assembled in this area. During the subsequent spawning as well as throughout the feeding and overwintering periods in 1967 these herring behaved as a single population unit.

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