International Council for the
Exploration of the Sea

C.M. 1962
Baltic-Belt Seas Committee
No. 103

Zoogeographical Aspects of the Southern Baltic

by

Gunnar Otterlind
Institute of Marine Research, Lysekil

Population boundaries

The results of taggings of spring-spawning herring along the south and east coasts of Sweden, from Blekinge in the south to the Åland Sea in the north, show that at Bornholm there is a rather clearly marked boundary for the Lebensraum of this important stock (cf. Otterlind 1961 a). Recoveries in the south are concentrated mainly to the waters north, east and south-east of this island. A similar restriction of distribution westwards is shown by recoveries from a number of tagging experiments on young cod made to the north and south-east of Bornholm (cf. Otterlind 1961 b). Figs.1 to 8 illustrate some of the tagging experiments made up to 1 December 1961, herring taggings in Figs.1 - 4 and cod taggings in Figs. 5 - 8.
On these maps the tagging localities are indicated by arrows. Recoveries (Figs. 1 - 6) during the tagging year are symbolized by a black dot, those from the following year by a dot in a circle, those from the third year by a dot and two rings and those from the fourth year by a ring with a cross respectively. The symbols are somewhat different in Figs. 7 and 8, but their meanings are given in the text to the figures (Fig. 8 shows only recoveries made during the tagging year). Recovery symbols inside the coast line indicate fish trade records for which the find-places are not given.

Recoveries west of Bornholm are, as the maps show, very few from the above-mentioned taggings on herring and cod (disregarding, of course, that of the experiments shown in Fig. 8, where the tagging locality was situated to the west of Bornholm). They are restricted mainly to the easternmost part of the Arkona Basin, east of a line drawn directly southwards from Ystad. Only a few isolated finds were made farther west. The difference in the frequency of recoveries east and west of Bornholm cannot at all - or only to a very limited degree - be attributed to differences in fishing intensity or distance from tagging location (cf. Fig. 8). - As far as cod is concerned, a distinct migratory tendency towards the east can be discerned in the experiments off Simrishamn (Fig. 5 and 6).

Unfortunately, we have not yet any taggings of herring spawning in the Arkona Basin. Both spring- and autumn-spawning populations, often of small size, occur off the south coast of Scania. These herring have a higher number of vertebrae than spring-spawning herring in the waters of Blekinge (VS ca. 55.45 as against 55.00 - 55.15 in Blekinge). Investigations of the mutual relationship of the populations are being made - it may possibly be a question of populations with partly changing spawning seasons in the Arkona Basin. The young herring predominate in the trawl catches in the open sea, and the stock of adult herring is generally liable to great variations.

Our taggings of cod to the west of Bornholm in 1960 and later have shown that the stock of this species seems to be strongly attached to the Arkona Basin. Recoveries from the experiment west of Rönne in January 1961 (cf. Fig. 8) show, however, that some migration eastwards took place during 1961 - possibly due to the fact that the tagged cod belonged to a mixed population.

At the ICES-meeting in 1961, Sick (1961) demonstrated that there is a distinct difference in the blood-group distribution in the cod populations to the east and west of Bornholm. The Arkona Basin is a transitional or mixing area, which towards the west has a blood-group distribution in cod which becomes more and more similar to that of the cod in the Belts, the Sound and the Kattegat.

Thus the results of the tagging of young cod and the blood-group investigations both show that there is only a relatively small exchange between the cod populations in the Arkona Basin and the waters farther east. The mixing area of the populations must be regarded as rather restricted and probably varying with the hydrographical conditions. Compared with the cod population east of Bornholm, the cod in the Arkona Basin is of relatively little commercial importance, and the stock is much smaller.

Danish taggings of mainly adult cod east and south-east of Bornholm (Jensen 1961), and also Polish taggings (Mulicki 1959, Netzel 1960) suggest that old cod migrate a little more frequently than young ones to the waters west of Bornholm. Other Danish investigations provide evidence that there is only a small immigration of cod from the Belt Sea to the Baltic. Immigration from the Sound to the Baltic is small, but perhaps somewhat larger than the former (Bagge 1961). Swedish taggings made hitherto in the Arkona Basin indicate an insignificant immigration to the Belt Sea from the east. To what degree cod eggs and larvae are transported with the water masses from one area to another is unknown at present.

The growth-rate of the cod in the southern Baltic also suggests that different populations are there more or less isolated from each other. Thus Fig. 9 demonstrates how young cod, at the same time, have grown rather more quickly in the Arkona Basin than the cod in the Gulf of Hanö, which in its turn show more difference in growth as compared with cod in the region S - SE of Bornholm, particularly with reference to age-group 0. According to our investigations, about the same size-differences have been observed in different seasons during the last eight years. Sometimes the differences may be obscured, possibly due to migrations caused by extreme changes in the hydrography. The difference in growth may be an expression of differences in spawning season, supply of food or other environmental factors, but also of genetical differences.

According to Elwertowski (1958), the south Baltic sprat, too, seems to be divided into "sub-populations", one in the Bornholm Basin, and one in the Gulf of Gdansk, with different population dynamics and rate of growth.

The salmon, like the great spring-spawning herring population in the western parts of the Baltic, show a low recovery frequency west of Bornholm from tagging experiments made in the Swedish rivers running into the Gulf of Bothnia. An extensive investigation which Carlin (1959) has reported on, gave, for example, only few recoveries in the Arkona Basin and westwards - the recoveries were almost exclusively of young salmon in their first or second year in the sea. The greatest number of recoveries was made, as always in the southern Baltic, east of Bornholm and particularly in the Gulf of Gdansk and adjacent waters. For this species, too, there is a marked boundary at Bornholm, but the centre of the occurrence of salmon is farther east than that of the herring population mentioned.

The hydrographical background

Topographically it has for a long time been suitable to speak of three principal regions of the southern Baltic: the Arkona Basin (max. depth ca. 50 m), the Bornholm Basin (ca. 100 m), east of Bornholm, and the Gulf of Gdansk (ca. 110 m) in the extreme south-east. The last mentioned deep is through the Stolpe Channel (ca. 65 m deep) connected with the Bornholm deep. It is natural that these areas and their boundaries act as isolating mechanisms to some extent. It was in conjunction with the tagging experiments on herring, cod and salmon, however, that the sharp demarcation of the Arkona Basin from the waters to the east, from the aspect of fishery biology, became known.

The hydrographical conditions in the Arkona Basin are characterized primarily by the connection of the area with the Belts and the Sound, and its moderate depth in relation to the rest of the Baltic. The basin is bounded to the west by the thresholds at Darsserort-Falster and at Drogden (18 and 9 m deep respectively). In the south-east the Arkona Basin is connected by a shallow-water area and the Adlergrund trench (28 m deep) with the Bornholm Basin. The most important connection with the Bornholm Basin is the Bornholm Channel between Scania and Bornholm (ca. 47 m deep). There the Arkona Basin merges almost without a threshold in the deeper Bornholm Basin, whereby a relatively free exchange can occur between the different water masses.

The Arkona Basin has been described as a Mischpfanne (Wüst 1957) for waters of different origin. Fig. 10 A gives some idea of the temperature, salinity and oxygen content in the central part of this region in 1960. The observations were made at station S 12 (55°00'N, 14°05'E, depth 48 m) by the hydrographical department of the Swedish Inst. of Marine Research. The surface layer always consists of water with a rather constant salinity of 7 - 8 ‰, but at the bottom, and often up to a depth of 30 m at least, the salinity is higher owing to deep-water flowing in from the west. During February - April and in late autumn, more or less homothermal conditions are prevailing, with cold and moderately warm water respectively from the surface to the bottom. During late spring and summer the cold water is warmed, partly by insolation and partly by warm water (mainly from the upper layers of the Belt Sea), which because of its higher salinity, streams along the bottom through the Arkona Basin from the west. The latter water often comprises two or more layers representing different inflows. The highest salinity values usually occur during the winter, however. Fig. 10 A gives examples of the complicated stratification that may appear, particularly in late summer, with several thin temperature strata on the top of each other (cf. 25.8.1960). This summer stratification and its striking diurnal variations have been studied by Hela & Krauss (1959) and others.

Fig. 10 B shows the corresponding conditions in 1960 at the hydrographic station north-east of Christiansö in the Bornholm Basin (55°23'N, 15°17'E, deep ca. 100 m). Comparison with those in the Arkona Basin shows clearly several significant differences that must be very important for the fish fauna and fauna in general. All the year round there is in this area a layer of warm water with a relatively high salinity at the bottom, and completely homothermal conditions are thus never achieved, although the curve for 18 March shows ca. 1°C water from the surface down to a depth of 70 m. The summer temperature stratification is characterized by less dispersion, and, owing to the more uniform salinity here, the various layers are also thicker, especially from 40 - 50 m and upwards. The contrast between the different masses of water has been partly equilibrated.

The variations in salinity are not so great as they may often be in the Arkona Basin, with its much shallower water; the salt water from the west is partly mixed with water of lower salinity during its passage through the last-named region, and it may during the transport from the Bornholm Channel and down the slope towards the Bornholm Basin mix more easily with meeting water of suitable density, than during the often short-term influx over the high thresholds to the west. It is only seldom that the deep water through the Bornholm Channel seems to have such a high salinity that it can run straight down to the bottom there. An intermediate layer of warm water is in summer-autumn therefore formed between the somewhat colder and salter bottom water from previous year and the remaining cold winter water (cf. 26.8.1960). The irregularities in the temperature curve for the upper of these two warm layers show that total equilibrium has not occurred after different masses of water have met there.

The upper part of the salinity discontinuity layer in the Arkona Basin is usually situated at a depth of about 30 m, north-east of Christiansö at ca. 50 m. As will be seen from Fig. 10, the water regions dealt with here showed, in 1960, partly a greater proportion of salt water than normally. It was probably this water with moderately high salinity that, combined with a similar inflow from the west in the beginning of 1961, made possible the large exchange of deep water in the Gotland Basin during the spring and summer 1961 described by Fonselius(1962). The bottom water in the Bornholm deep, with a salinity of more than 14 ‰ need not have taken part directly in the influx northwards.

A comparison between the two basins makes it likely that the instable hydrographical conditions of the bottom water in the Arkona Basin and the differences in depth and stratification in general, are primarily decisive for the western boundary of the commercially most important fish populations of the southern Baltic.

Generally speaking, the cod and herring populations in the Arkona Basin have to be more euryhaline and eurythermal than the larger populations to the east and north - in any case they are subjected to more frequent and rapid changes in the hydrography than in the rest of the Baltic. The extreme environmental conditions are to some extent compensated by a rich production of food, which is encouraged by the shallow stratification and blending of water masses of different origin. During summer and early autumn it is well known that cod are extremely fat in the Arkona Basin - mainly young cod. Length of life is probably shorter there than to the east and north, however. This is also true of the herring. Studies of these problems are proceeding. It is also obvious that the Bornholm Basin, particularly the north and west slopes, have a high production of food during summer and autumn, not least with reference to the fundamental importance of the area for the great population of spring-spawning herring, which spawns along the east coast of Sweden (cf. Otterlind 1961 a). - That flat-fish such as plaice and flounder do not seem to respect the boundary at Bornholm must be attributed to, among other things, the great general tolerance of these species to different degrees of salinity.

Thus it may be said of the Arkona Basin that it occupies a unique position in the Baltic - it is a transitional zone with the character of a broad lock basin. Its relation to the easterly water areas is reminiscent of that of the Belts and the Sound to the Kattegat, but the two-directional currents have both inverted direction and volume. Other factors, too, e.g. the bottom fauna, show that the Baltic, with regard to its typical features, begins at Bornholm.

References:

Bagge, O. 1961. Maerkning af torsk i indre danske farvande.- Fiskeriundersøgelser 1960. Skr. fr. Danmarks Fiskeri- og Havundersøgelser, nr 21: 10-22.

Carlin, B. 1959. Results of salmon smolt tagging in the Baltic area. - ICES Rapp. et proc-verb. 147: 89-96.

Elwertowski, J. 1958. Preliminary investigations on the dynamic of the sprat living in the southern Baltic.- Paper no. 45, ICES Meeting 1958.

Fonselius, S.H. 1962. Hydrography of the Baltic deep basins.- Fishery Board of Sweden, Ser. Hydrography, Report no. 13: 1-41.

Hela, I. & Krauss, W. 1959. Zum Problem der starken Veränderlichkeit der Schichtungsverhältnisse im Arkona-Becken. - Kieler Meeresforsch. 15: 125-143.

Jensen, A.J.C. 1961. Danish investigations on cod in the Bornholm region. - ICES Ann. Biol. 16: 141-145.

Mulicki, Z. 1959. Wędrówki dorsza bałtyckiego. - Dorsz bałtycki. Gdańskie Towarzystwo Naukowe, Gdansk, pp. 60 - 68.

Netzel, J. 1960. Polish tagging experiments in the southern Baltic. - ICES Ann. Biol. 15: 108-110.

Otterlind, G. 1961 a. On the migration of the Baltic herring.- Paper no. 121, ICES Meeting 1961.

- " - 1961 b. Swedish cod taggings in the Baltic. - Paper no. 122, ICES Meeting 1961.

Sick, K. 1961. Haemoglobin polymorphism in whiting and cod. - Paper no. 128, ICES Meeting 1961.

Wüst, G. 1957. Die Verteilung von Temperatur, Salzgehalt und Dichte. Ergebnisse eines hydrographisch-produktionsbiologischen Längsschnitts durch die Ostsee im Sommer 1956. - Kieler Meeresforsch. 13: 163-185.

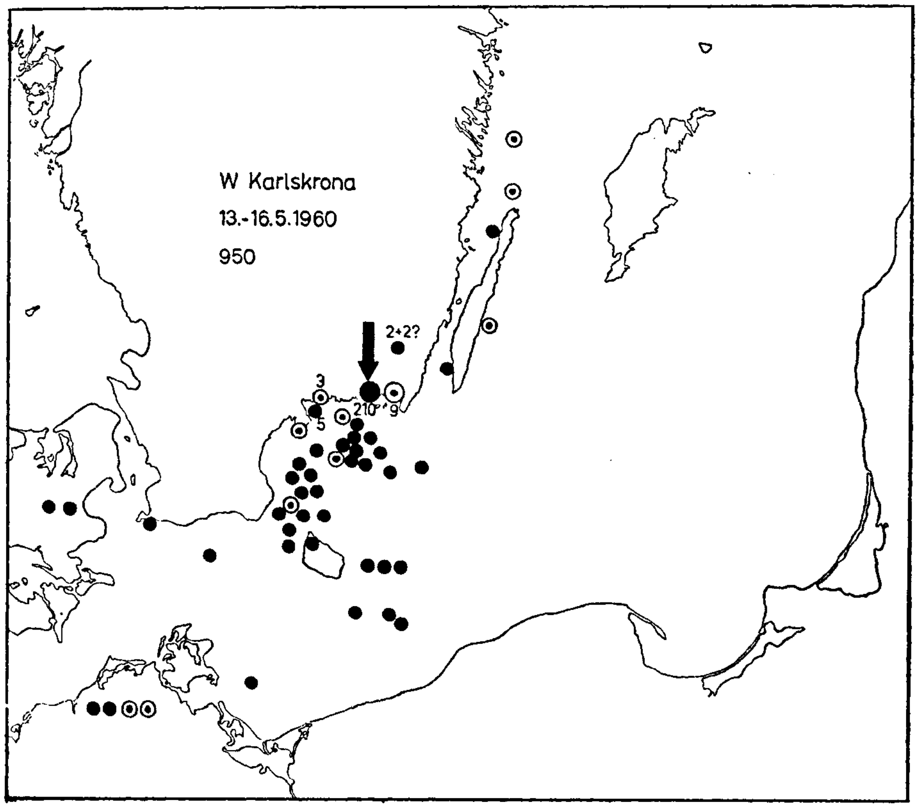

W Karlskrona
13.-16.5.1960
950
2+2?
3
210
9
5

Fig. 1.

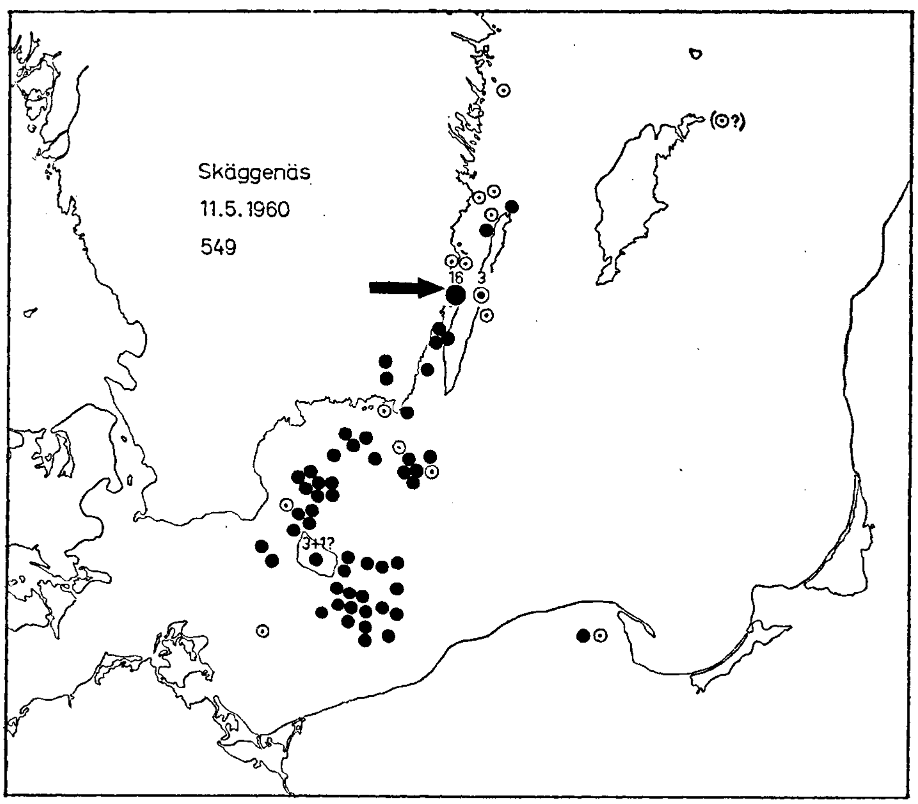

Skäggenäs
11.5.1960
549
16
3
(⊙?)
3+1?

Fig. 2.

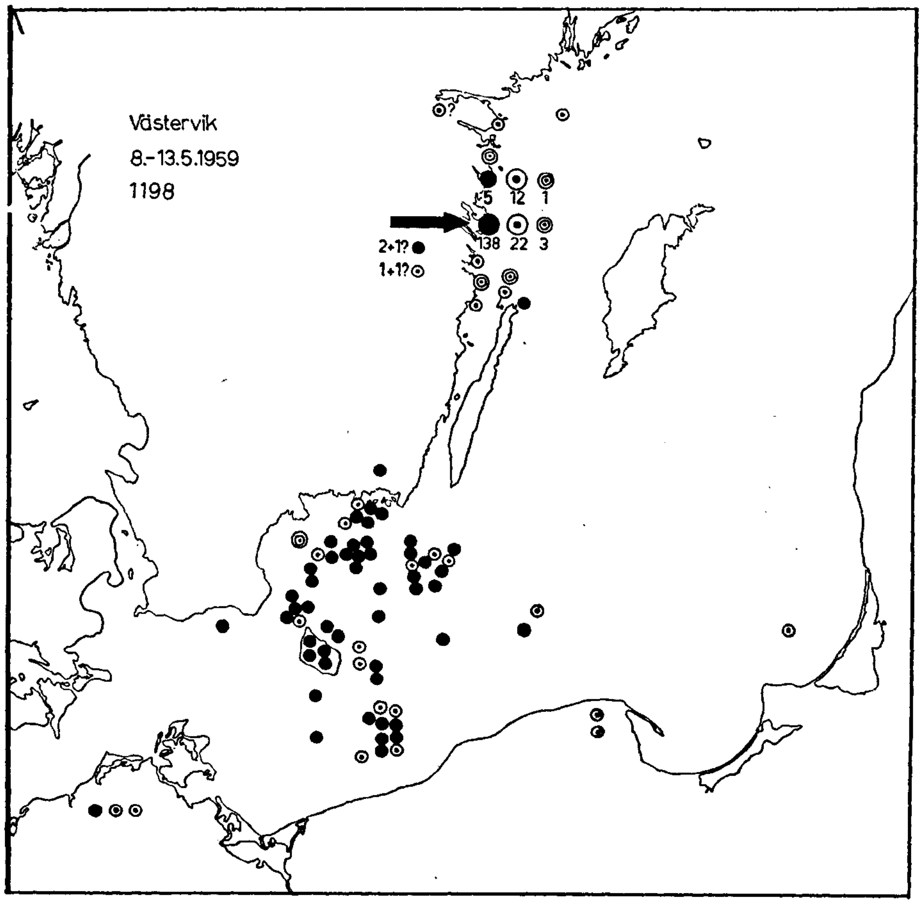

Västervik
8.-13.5.1959
1198
5 12 1
138 22 3
2+1? ●
1+1? ⊙

Fig. 3.

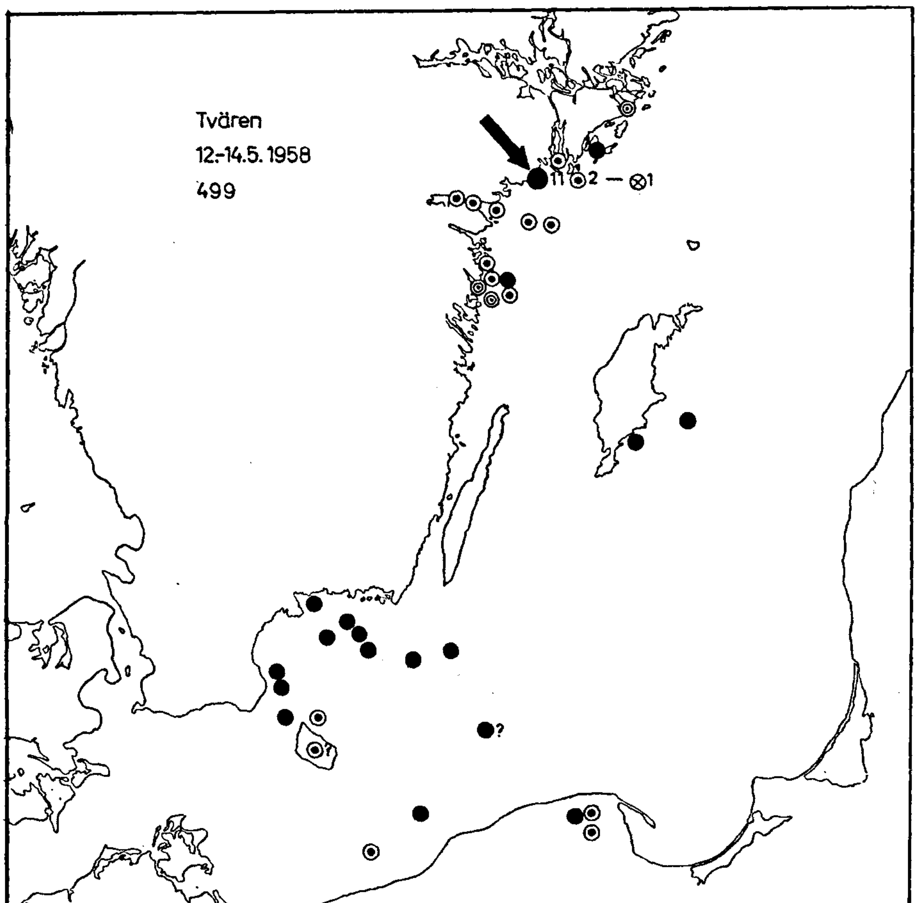

Tvären
12.-14.5.1958
499
11 2 — 1

Fig. 4.

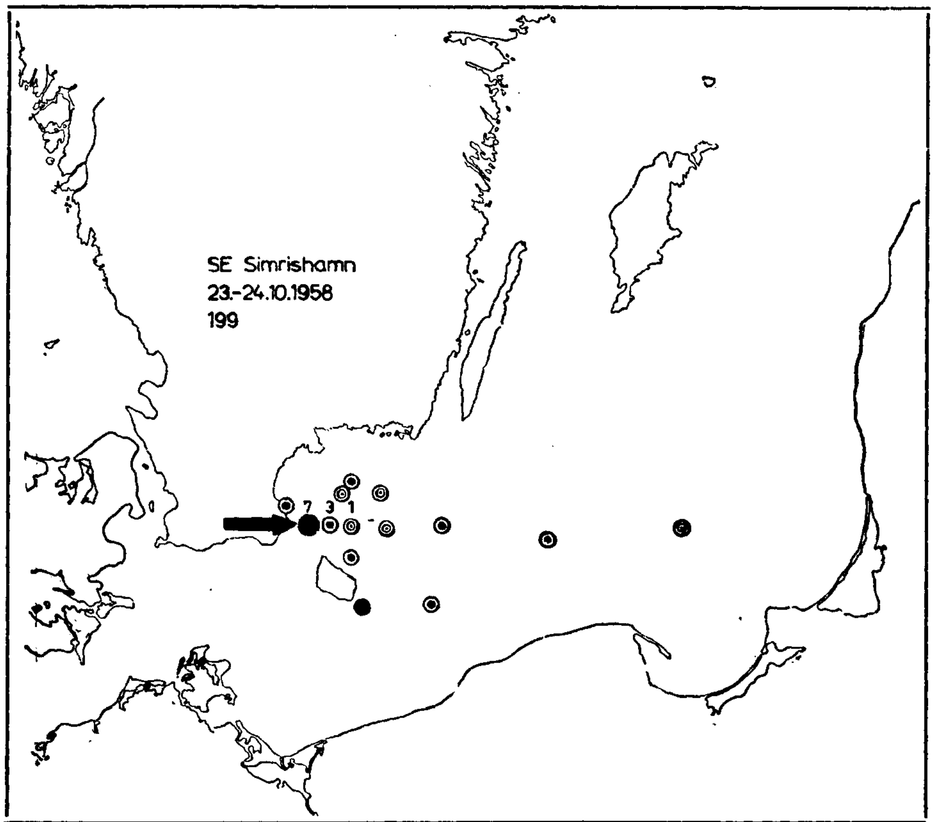

SE Simrishamn
23.-24.10.1958
199
7
3
1

Fig. 5.

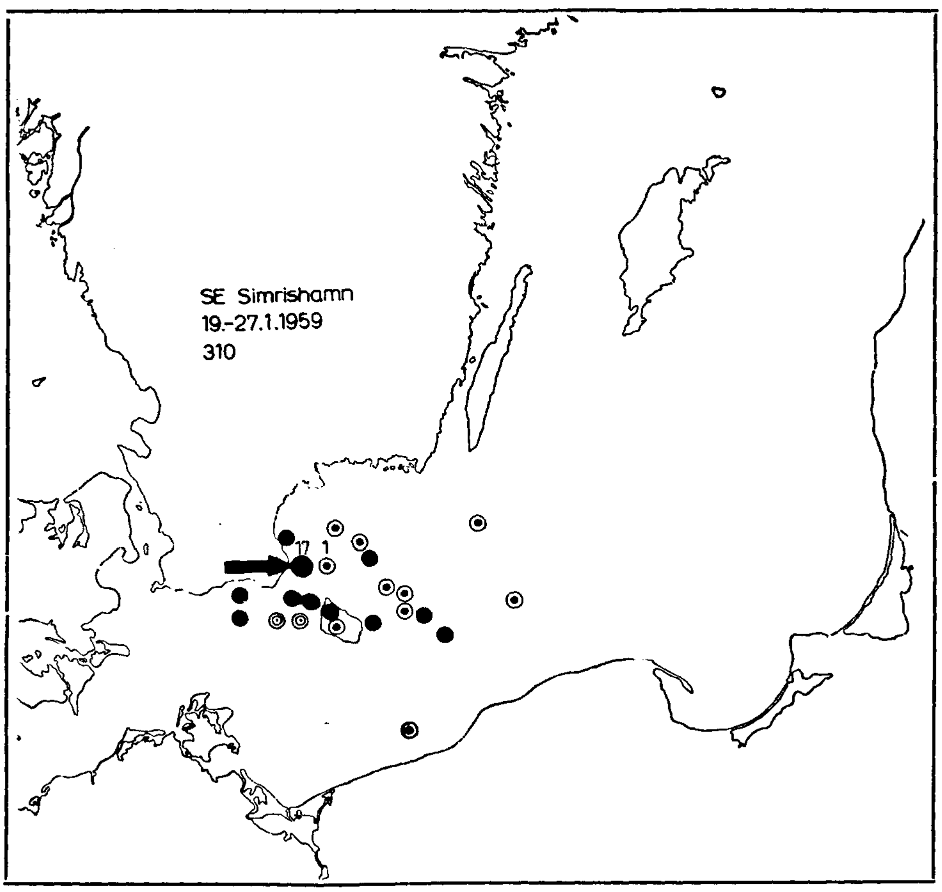

SE Simrishamn
19.-27.1.1959
310
17
1

Fig. 6.

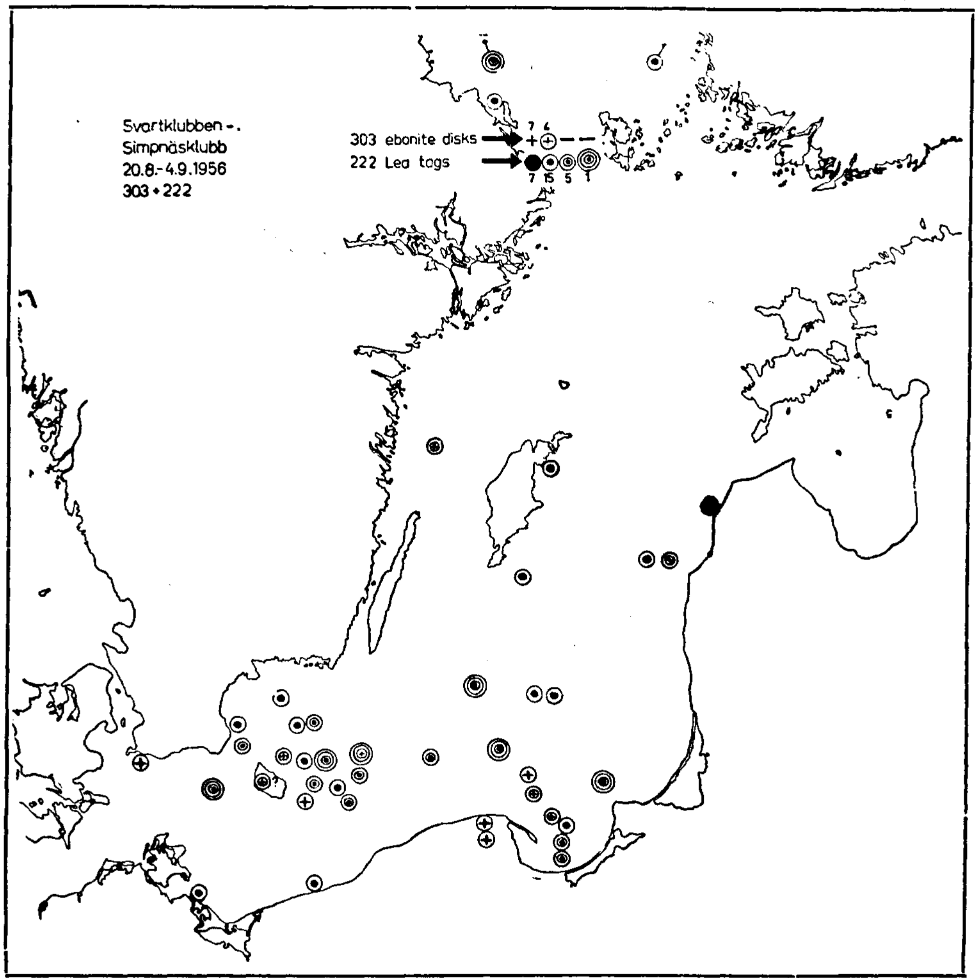

Svartklubben -.
Simpnäsklubb
20.8.-4.9.1956
303 + 222
303 ebonite disks
222 Lea tags

Fig. 7.

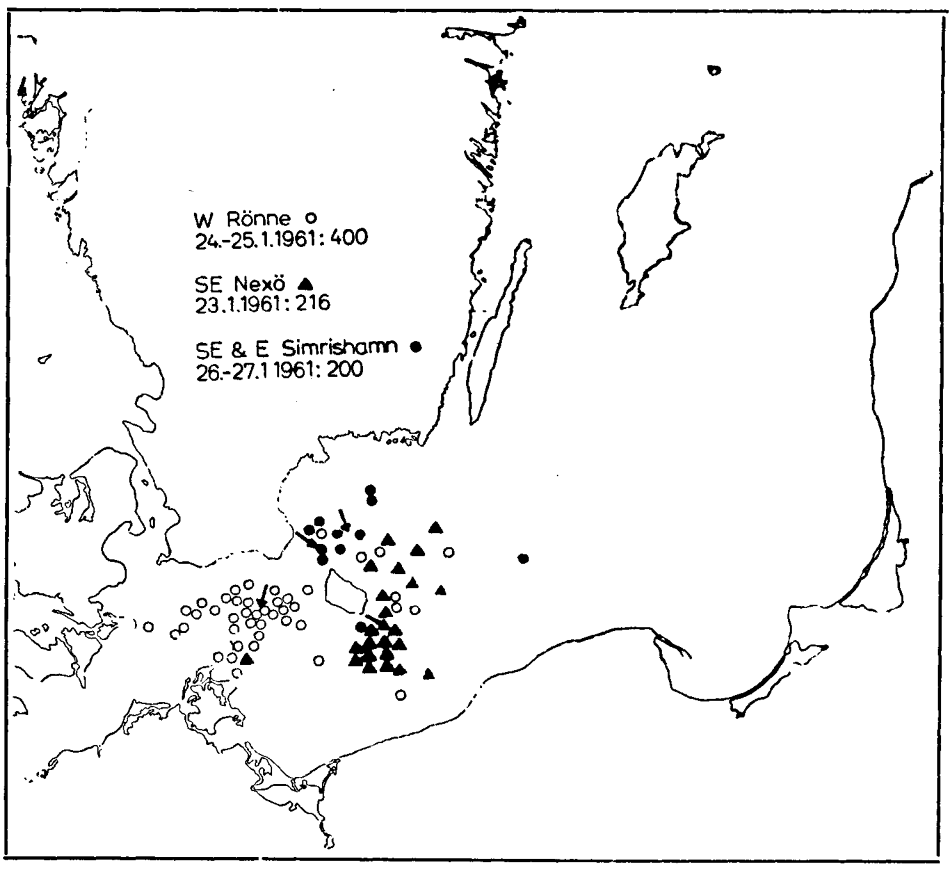
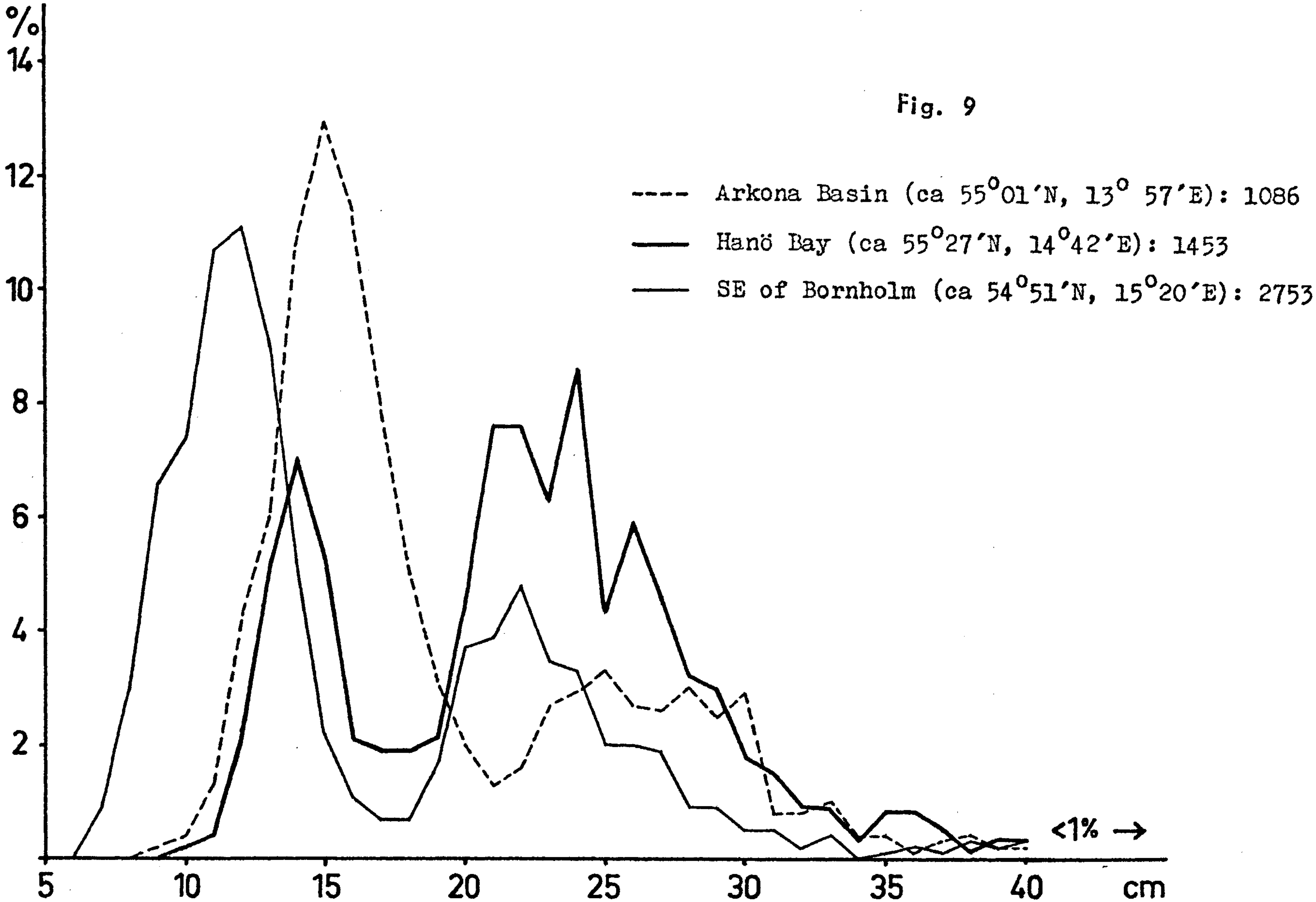

W Rönne o
24.-25.1.1961: 400
SE Nexö ▲
23.1.1961: 216
SE & E Simrishamn ●
26.-27.1 1961: 200

Fig. 8.

Fig. 9



Length-distribution of young cod in three different areas of southern Baltic 23. - 26. 1. 1961 (1 cm-groups).

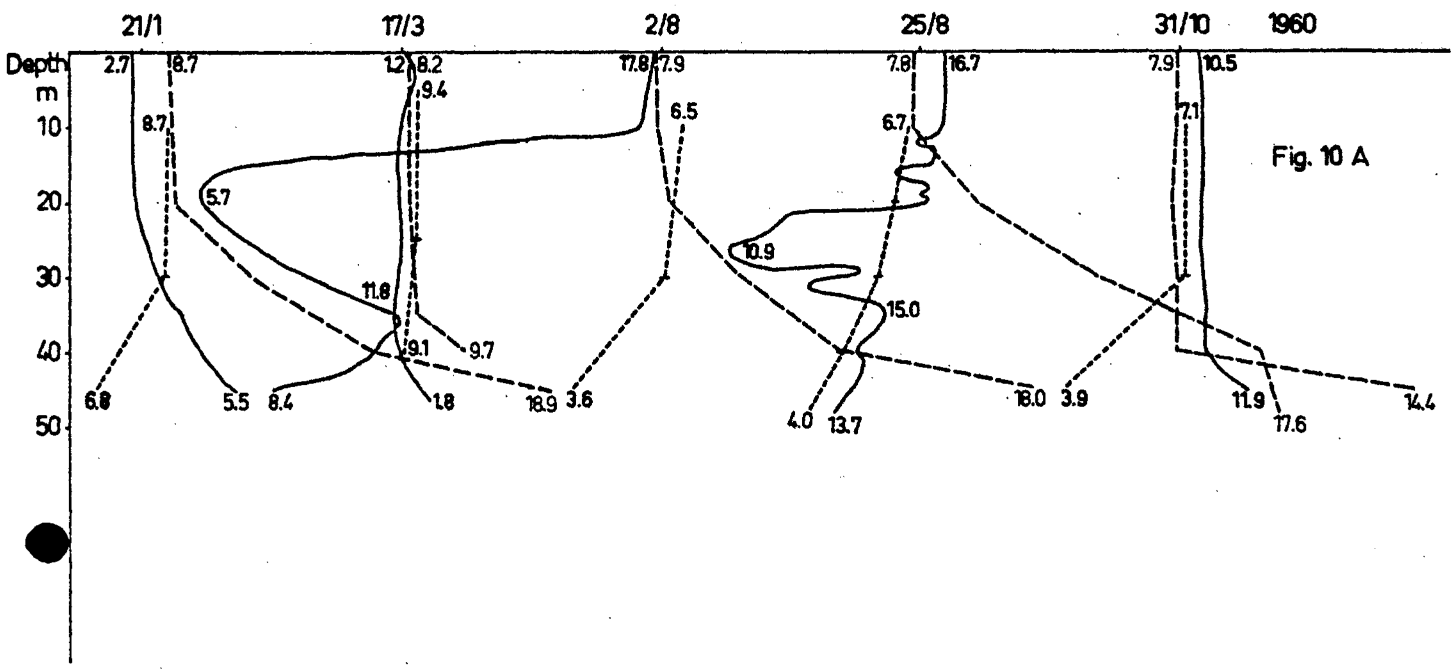


Fig. 10 A

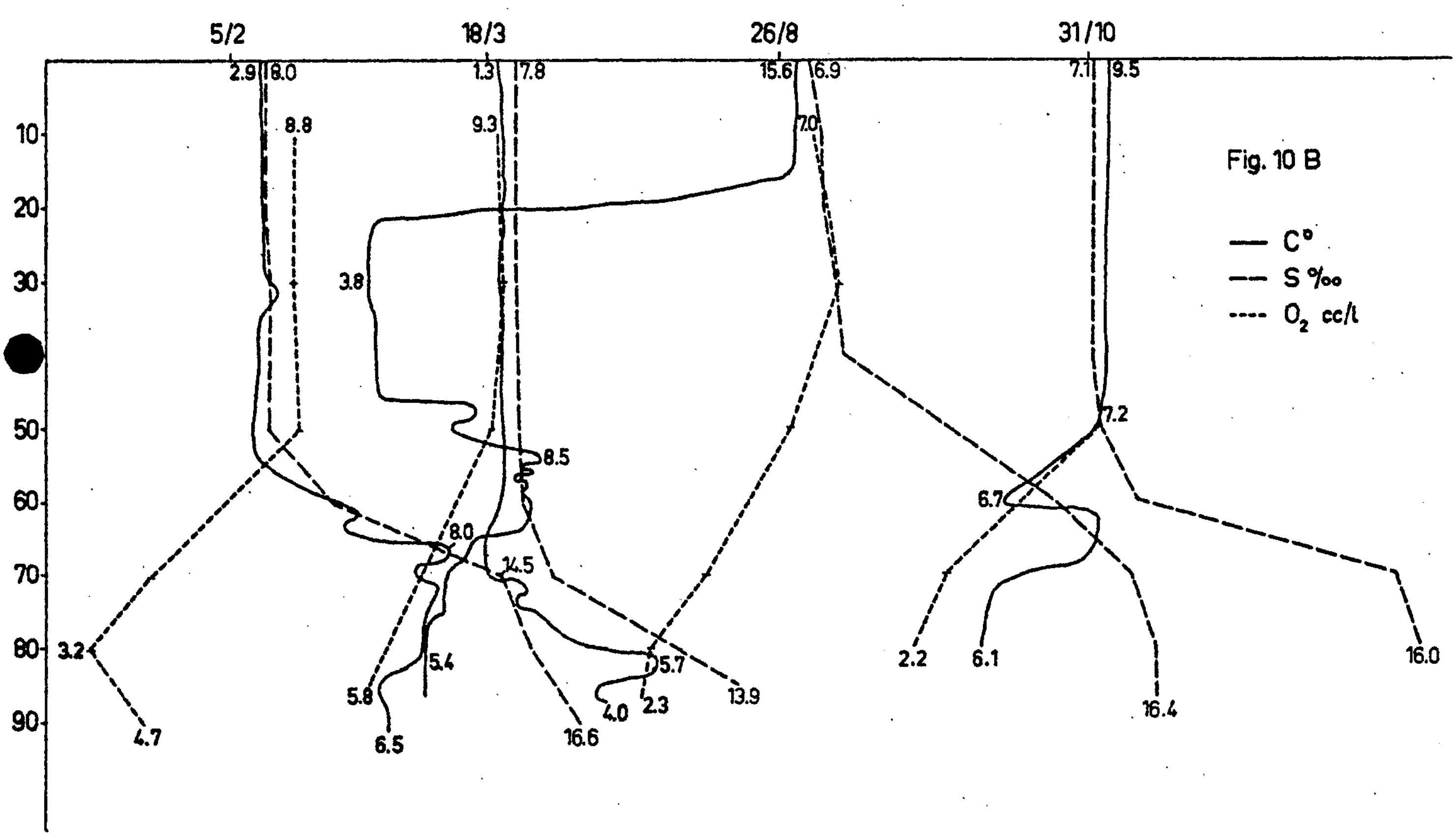


Fig. 10 B