International Council for the Exploration of the Sea

C.M. 1963
Near Northern Seas Committee
No. 56

On the Phenomenon of Soles Swimming near the Surface of the Sea

by

J.F. de Veen

Introduction

It has been known for a long time that soles, generally living on the sea bottom, may occasionally come to higher water levels and may sometimes even swim near the surface of the sea. In most cases only a few soles are observed at the surface, but at times the number of soles may be such that fishermen made plans for fishing them with pelagic nets. It was obscure why soles came to the surface until Møller Christensen (1962) suggested that the phenomenon might be connected with the spawning migration in spring. In general this migration towards the shallow coastal spawning grounds is very fast in the month preceding the actual spawning. The international sole tagging programme (1959-1962) demonstrated that returns of tagged soles were very scarce during this period of rapid migration. A possible explanation for this paucity in returns might be that soles are then able to avoid the demersal nets e.g. by swimming beyond the head ropes. In the same period fishermen made observations of soles swimming near the surface of the sea.

To collect more detailed information on this phenomenon of surface swimming soles, an inquiry was made among Dutch fishermen landing flatfish at IJmuiden in the spring of 1963.

Methods and results of the inquiry

Since April 1st, 1963, each skipper landing flatfish was asked personally for information on surface swimming soles which he might have observed during his last trip. During the six weeks in which surface swimming was actually observed, a total of 1400 interviews were made resulting in 172 observations of surface swimming soles.

The questions submitted were:- 1) did you or anybody else on board of your ship see any soles at the surface? 2) if so where, when and at what time of day and/or night was the observation made? 3) what was roughly the amount and the size of the soles observed? 4) all other relevant informations such as tide, direction of swimming, weather conditions and so on.

Most of the skippers responded to the first three questions. As to the reliability of the answers there is no doubt that a number of predominantly personal factors may have affected the objectivity of the observations, but by using a great number of such data, the influence of these factors on the general trends in surface swimming will be greatly reduced and will only lead to a greater spread (variance) in the results. Besides, it is clear, that it is impossible to cover such a wide area during six weeks with research ships as has been done by the commercial fleet.

Below the results obtained will be dealt with according to the various factors affecting the phenomenon. The influence of the stage of maturity of the soles on their inclination to swim at the surface will not be dealt with by lack of direct data.

Soles swimming at the surface were observed all over the sea area fished, obviously without any preference for a given fishing ground.

Light intensity

Most of the observations have been made at night. In few cases only surface swimming has been observed in the day-time. In Figure 1. the total number of observations per hour is plotted for each week in the period 14. April - 25. May, 1963. Evidently the total number of observations varies considerably from week to week, although the weekly number of interviews has been constant. Another feature is that at the beginning of the period most observations per hour could be found between 21-22^{h}M.E.T., whereas the maximum had shifted to midnight towards the end of the period under consideration. In the same time the moment the minimum light intensity of the night sky was reached shifted from 21^{h}M.E.T. (beginning of astronomical darkness) in the first week, to about midnight (minimum of light intensity of the dusk) in the last week. Moreover, the phenomenon of surface swimming was observed much less frequently in the weeks of 28. April - 11. May than in the preceding and following week. In this period the moon was shining during the night (first quarter in the first week, full moon in the second week). This indicates that a given low light intensity could favour surface swimming, and that the light intensity of the moon-lit sky is sufficient to suppress the inclination to come to the surface. If this is true, the critical value of the light intensity inducing surface swimming will be lower than that of the first quarter of the moon (0,02 lux at the surface of the sea).

Tidal currents.

Only in seven cases the phase of the tide at the time of the observation had been stated. In these seven cases surface swimming was seen during flood tide. These observations came, however, from one and the same region. In order to find out which phase of the tide will have prevailed during all other observations, direction and strength of the tidal current for each case has been determined with the aid of hydrographical tables.

It was surprising to find that for each given region most of the observations were made at the same phase of the tide, throughout the six weeks during which surface swimming was observed. But this phase of the tide was different for each of the various regions (Figure 2.). In region A and B (from which the seven observations mentioned above came) most observations coincided with flood tide. In other regions, however, ebb tide or turning tide were apparently preferred for surface swimming. It is clear, therefore, that a given phase of the tide is related to surface swimming in a very restricted area only. For the whole sea area as such a given phase of the tide can obviously not be held responsible for surface swimming. In the same way the velocity of the current has no bearing on the phenomenon.

If the directions of the currents, prevailing at the time of surface swimming, are plotted for the various areas (as has been done schematically in Figure 3. by small arrows within the dotted circles) it becomes evident that most of these currents are roughly pointing in the same direction. Figure 4. based on all observations irrespective of the area, gives the frequency distribution of the various directions of the currents occurring during the actual observation of surface swimming soles. 68% of all observations were made with currents flowing in the directions E, SE and S.

This suggests that a kind of compass orientation may be operating during surface swimming. By selecting the current with the adequate direction, soles may be transported, even passively to the coastal waters where the spawning grounds are situated.

Size and amount of soles observed

Soles of all sizes have been reported swimming at the surface with emphasis on bigger soles. In cases where only a few soles were observed, these fishes were mostly big ones. When many soles were seen at the surface, all size categories were present but still with a preponderance of the bigger soles. There were, however, areas where only small soles were observed, this independently by the crews of at least three ships.

In the majority of the cases a small number of soles were observed, but in the week in which the highest number of observations were recorded (12.-18. May) more than 60% of the cases refer to the observation of many soles at the same time. In those cases it was as if all soles had left the bottom to swim near the surface. Quite a few fishermen stopped fishing during such nights for in contrast to normal conditions (night catch several time the day catch) the night catches had dropped to below the day catches level. In such nights the daily periodicity in the sole catches was completely reversed. This did not only happen in nights when many soles were observed at the surface, but also during nights with a few surface swimming soles only.

Discussion and summary

Observations made by Dutch flatfish fishermen in the spring of 1963 revealed that soles swimming near the surface of the sea could be encountered during the night in the whole area fished in the period 14. April up to 25. May.

In the course of this period the peak activity of surface swimming shifted from about 21-22^{h}M.E.T. to midnight. Simultaneously the moment of reaching minimum light intensity of the night sky shifted from 21^{h}M.E.T. to about midnight. In the weeks with moonlit skies the surface swimming tendency seemed to be more or less suppressed. This led to the assumption that light plays a significant part in this phenomenon: the light intensity of the night sky should drop to a given, low level in order to make it possible for the soles to swim at the surface. This is in agreement with the results of laboratory experiments by Kruuk (1963). He found that the periodicity in normal activity = moving and feeding at night, digging in and remaining inactive during day-time = mainly governed by light intensity.

Provided the light intensity of the sky is low enough for surface swimming, soles prefer to use water currents flowing in a given direction. In the sea areas covered by the inquiry this compass orientation apparently guides the soles to the coastal waters where their spawning grounds are located. This leads to the phenomenon that in certain regions soles use the flood tide, in other regions ebb tide or turning tide. Swimming in the surface layers promotes quick transportation of the soles in the adequate direction since maximum current velocities are to be expected in the surface layers. Thus the tendency to swim at the surface may be understood as a means for speeding up migration.

The mechanism by which soles migrate towards the spawning grounds, seems to be an exception to Verwey's assumption (1958) that "heading the residual current as a means to reach the spawning places may be of common occurrence in species with floating eggs, the young of which do not get an opportunity to take with them the geographical position of the spawning grounds".

Apart from the sole other marine species are periodically coming to the surface in the North Sea in the course of their migration and make use of tidal currents e.g. elvers (Deelder, 1952 and Creutzberg, 1961), swimming crabs, shrimps and some worms (Verwey, 1958). Most of these species are guided by a given phase of the tide and have means to distinguish between different phases. In the sole the phase of the tide is not important, so here the difficulty of distinguishing between tides by means of perceiving gradients in temperature, salinity, or compounds originating from fresh water, does not exist.

The only other case known of a marine species revealing a migration mechanism ressembling that of the sole, seems to be that of the adult eel travelling in the Baltic in a fixed direction in dark nights, and probably in the surface layers, towards the spawning grounds in the Sargasso Sea (Määr, 1947, Deelder, 1949).

With regard to surface swimming Verwey (1958) assumes that "there may be a priori more reason for a surface dwelling species to use the sky for orientation than that it would use other means". In the case of the soles it is difficult to take celestial orientation into account, for soles have to select a current in the adeauate direction when they are not yet at the s urface. In the open sea the depth at which soles select this current is mostly considerable, and it seems hardly possible to orientate on faint star lights at such depths. Moreover, what is observed as swimming at the surface seems to be a small proportion only of the number of soles migrating off the ground in medium water layers. Fishermen did complain repeatedly of a drop in the catches during the night as compared with day-time catches, when they observed not more than a few surface swimming soles. This means that most of the soles were then swimming beyond the head-ropes of the nets, but not necessarily in the surface layers. If orientation on celestial clues is important it should have been more profitable for the soles to come all to the surface.

It is intended to repeat the inquiry next year; in the meantime fishermen are asked to look out for surface swimming soles during the rest of the year.

References.

Creutzberg, F.	1961	"On the orientation of migration elvers (Anguilla vulgaris Turt.) in a tidal area". Netherl. Journ. of Sea Res., 1,(3) pp. 257-338
Deelder, C.L.	1949	"Addendum to: Dr. J. Verwey - Migration in birds and fishes". Bijdragen tot de Dierkunde, Vol. 28.
Deelder, C.L.	1952	"On the migration of the elver (Anguilla vulgaris Turt.) at sea". Journ. du Cons., 18, (2), pp. 187-218.
Kruuk, H.	1963	"The diurnal activity pattern of the sole". Ices C.M. 1963, Near Northern Seas Committee, No. 12.
Määr, A.	1947	"Über die Aalwanderung im Baltischen Meer auf Grund der Wanderaalmarkierungsversuche im Finnischen und Livischen Meerbusen i.d.J. 1937-1939". Medd. Statens undersökn. och försöksanst. för söttvattensfisket, Nr. 27, pp. 1-56.
Møller Christensen, J.	1962	"Chapter Migration in the Report of the Working Group on Sole". ICES C.M. 1962, Near Northern Seas Committee No. 92, p.20.
Verwey, J.	1958	"Orientation in migrating marine animals and a comparison with that of other migrants". Arch. Neerl. d. Zool.

Figure 1

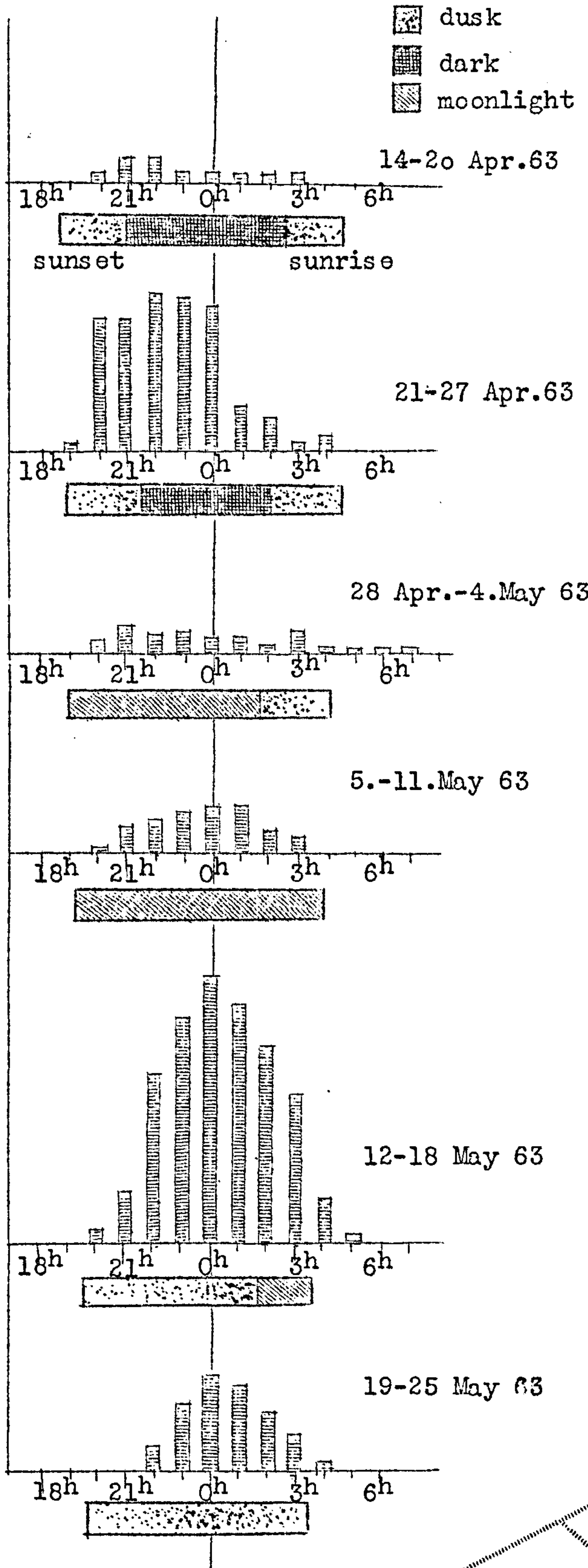
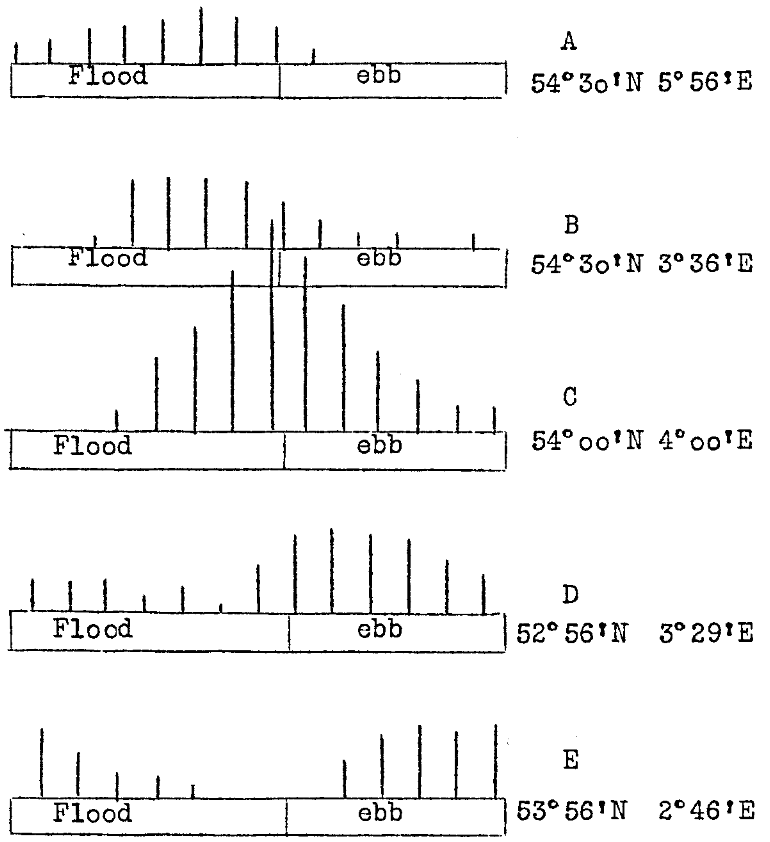


Figure 2



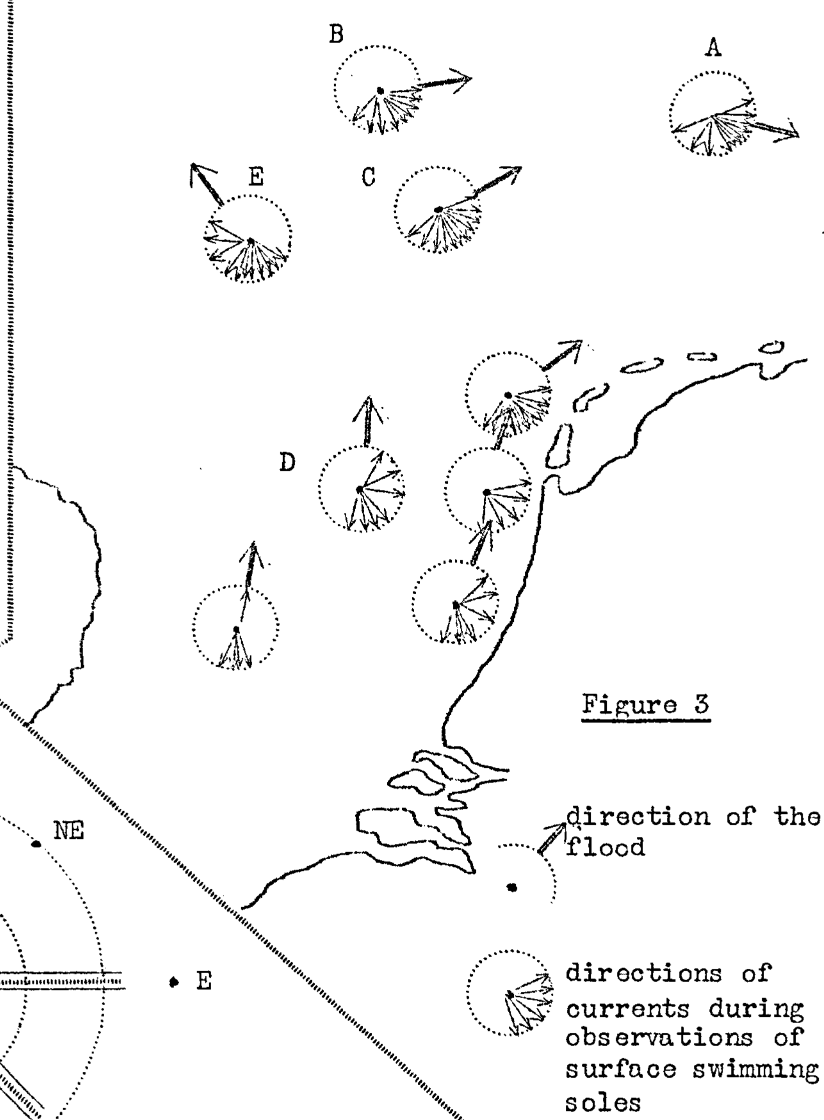


Figure 3

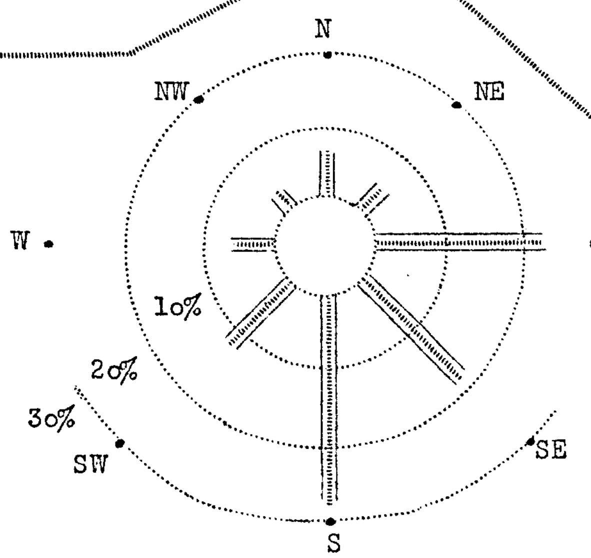


Figure 4