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# Diurnal, Vertical Migrations of Demersal Fish and their Possible Influence on the Estimation of Fish Stocks



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1. Fishing intensity data are widely applied for the purpose of estimating commercial fish stocks. It is assumed that increase in catch per hour trawled signifies increase of fish stock and vice versa (provided that the fishing technique remains unchangeable). Such an assumption, for instance, forms the basis of a method of assessment of fish abundance worked out by DeLury (Ivlev, 1958).

It is understandable that we have a right to consider the trawl as a fish-counting gear which enables us to judge the density of a fish population in the same way as a hydrobiologist estimates the abundance and the composition of benthos by means of a Petersen sampler. The trawling fleet perform hundreds and thousands of hauls within an extensive area operating day and night and all year round. No benthologist in the world has ever possessed so rich a series of bottom sampling stations.

However, analysing the above-mentioned index, i.e., catch per hour, one should keep in mind that fish is distributed in the ocean quite unevenly. If the density of fish concentrations had been stable and absolutely even throughout the whole area fished, a few trawlings at any spot and at any time would enable us to obtain initial material for an appraisal of the magnitude of stocks. But every day experience shows that an average catch per hour is liable to regular periodical changes, for instance, seasonal changes. The trawling operations in the Barents Sea are most efficient from March till July; towards the autumn the catch per hour decreases sharply (Table 1). It would be wrong of course to attibute the autumn decline in catches to the decrease in the stocks of bottom fish. On the contrary, the biomass of the commercial stock usually increases by early autumn due to an intensive growth increment of fish in summer. The seasonal fluctuations in catches are caused by variable distribution of fish (particularly cod - the main commercial species in the Barents Sea). In autumn, when the mid-water reaches its highest temperature throughout, cod is distributing over a rather extensive area without forming dense and stable congregations. During the winter-cooling of the sea cod is concentrating within a more limited area.

It has to be noted that not only horizontal but also vertical distribution of fish changes regularly according to seasons. In winter cod keeps at greater depths than in summer time (Trout, 1957). The same applies to wolffish (Barsukov, 1957, 1959).

The efficiency of trawling is greatly affected by the diurnal, vertical migrations of cod and other fish which are usually called "demersal" species. Redfish (genus Sebastes) for instance, at night time rises, as a rule, from the off-bottom layers to the mid-water (Konstantinov and Scherbino, 1958; Templeman, 1959). The uprise of redfish is however so bulky that night trawling is getting irrational.

Table 1 Average catch per hour trawled in fishing operations of the Soviet trawlers in the Barents Sea for 1926-1962

| Month | Average catch per hour trawled (in tons) | Month | Average catch per hour trawled (in tons) |
|---|---|---|---|
| January | 0.84 | July | 1.20 |
| February | 0.92 | August | 1.06 |
| March | 1.11 | September | 0.77 |
| April | 1.23 | October | 0.67 |
| May | 1.49 | November | 0.91 |
| June | 1.39 | December | 1.00 |

In the process of vertical migrations redfish sometimes go up to the surface layers which allows us to carry out a successful tagging of this deep-water species[x].

As seen from Figure 1 the diurnal vertical migrations of cod greatly depend on light conditions. The more conspicuous the fluctuations in light conditions are the more intensive are the vertical migrations. In December under the condition of the polar night in latitude 71°30'N the light does practically not penetrate deep into the water, whereas in March the diurnal changes in light conditions are very pronounced.

The correlation between the diurnal migrations of marine commercial fish and the variations in light conditions is well known. On the other hand, the correlation between the diurnal vertical migrations of fish and good organisms (zooplankton, for instance) is quite obvious. Therefore, two hypotheses are usually referred to, i.e., "light" and "food" hypotheses which explain the diurnal vertical migrations in different ways (Driscoll, 1953). Virtually both these factors are inseparably linked. Performing their diurnal vertical migrations the fish actually responds to changes in light owing to which it timely finds the layers with optimum feeding conditions. Thus, the light plays a role as a signalizing and orientating factor which ensures the expedient feeding migrations (Zusser, 1953). In other words, during the process of evolution the fish and other migrating organisms have gained adjusting reactions towards an external irritant which in itself is of no vital importance.

The diurnal vertical migrations ensure a relative safety for small aquatic animals representing the initial links in food chains. Sinking down zooplankton enters the less sunlit layers where fishes feeding on plankton meet with more difficulties in searching for and chasing prey.

The above notions on the biological significance of the diurnal, vertical migrations were elaborated in the works by A.A. Zakhvatkin (1932), Hardy and Günther (1936), M.M. Kozhin (1947), I.I. Nikolayev (1950), B.P. Manteufel (1959), S.G. Zusser (1958) and K.G. Konstantinov (1958). However, an extremely important question which has not so far received due attention in literature, should be considered in this connection

2. Small aquatic animals are able to perform vertical movements at only relatively low speed. Meanwhile, the intensification in light at morning time takes place very quickly, particularly in the tropics. If the planktonic crustaceans started sinking only at the first sign of the dawn they would not be able to get into the safe (dark) layers in time. The submerging can ensure the planktonic crustaceans a relative safety only in the case when they start to sink before dawn. Facts of that kind are really observed (Zakhvatkin, 1932; Vinogradov, 1954; MacDonald, 1957).

Recognizing the adaptive meaning of diurnal, vertical migrations it may be naturally supposed that the zooplankton-eaters should follow their preys and sink with them before dawn. In this connection it is interesting to refer to two echograms obtained during trawling operations in the Barents Sea in latitude 76°N in the second half of October, 1957. Both echograms show rather conspicuously the rapid sinking of capelin (Figure 2) and cod (Figure 3). It has to be noted that in both cases the submerging started about 8 a.m. when no faint gleam was seen on the surface of the sea. Trout (1957) quoted data from Mosby according to which the sea lighting at 9 o'clock a.m. in latitude 73°N in October is practically nil. By 9 a.m. the light intensity reaches 2.8 lux and only blue-green rays constituting about 15% of light of all frequencies can penetrate deep down.

A question rises:- which particular factor governs the diurnal, vertical migrations when submerging of aquatic animals starts before dawn? Here we come across the widespread phenomenon in nature - internal rhythm of physiological processes.

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[x] "Fishing Gazette", August 1856; "Fiskets Gang", No. 39, 1956.

3. It is known, for instance, that a ciliary warm Convoluta being transplanted from the littoral into an aquarium with a constant water level continues to dig into the sand at the time of high tide on the sea and crawls out on the ground surface at the time of low tide.

The luminescent unicellular alga contained in a glass of water kept in a dark room shines or becomes dim in a strict diurnal rhythm. Some rodents retain nocturnal activity even after having been kept in complete darkness for seven months. In all such cases a "physiological clock" acts. It is a time factor which releases both functions. It may regulate not only rhythmical and cyclical processes but single phenomena as well. So, the domestic pigeon hatches the eggs 17 days exactly after which it leaves them, even if younglings have not hatched yet (Neinroth, 1947). Pike perch guards the eggs within a strictly limited time irrespective of the progress of their development (Konstantinov, 1957).

The great Russian physiologist I.P. Pavlov studied the higher nervous activity of human beings and animals from the materialist point of view. With an exclusive lucidity he set out the basic principles of his teaching at the International Congress in Madrid 60 years ago. I.P. Pavlov considered time as a real irritant act to form conditioned reflexes. It has to be noted, however, that time is not an external, facultative factor; it is a part and parcel of any phenomenon and object. Using the expression "time regulates physiological processes" we mean that they are proceeding according to a certain schedule.

Biological rhythms attract the most intense attention of scientists. International meetings (Kalmus, 1957) and comprising books (Lobashev and Savvateyev, 1959; Bunning, 1961) are dealing with this most interesting subject. The internal rhythm of the physiological processes should be taken into account while studying the diurnal, vertical migrations of aquatic animals.

4. Thus, vertical distribution of aquatic organisms does not remain invariable, but changes subject to complicated regularities. Consequently, when using data on bottom-trawl catches for the purpose of assessing commercial fish stocks one should be careful. The results of fishing operations with trawlers at day time cannot be compared with those obtained at night. The catches of trawlers can be analysed only after being divided into groups each of these including the hauls accomplished at one and the same phase of diurnal, vertical migration of fish. Only subject to this provision can the results of fishing operations - carried out with a commercial or research gear - be used for estimation of stocks. It is necessary to have in mind that mass sinking of aquatic animals deep down often starts before the first signs of dawn.

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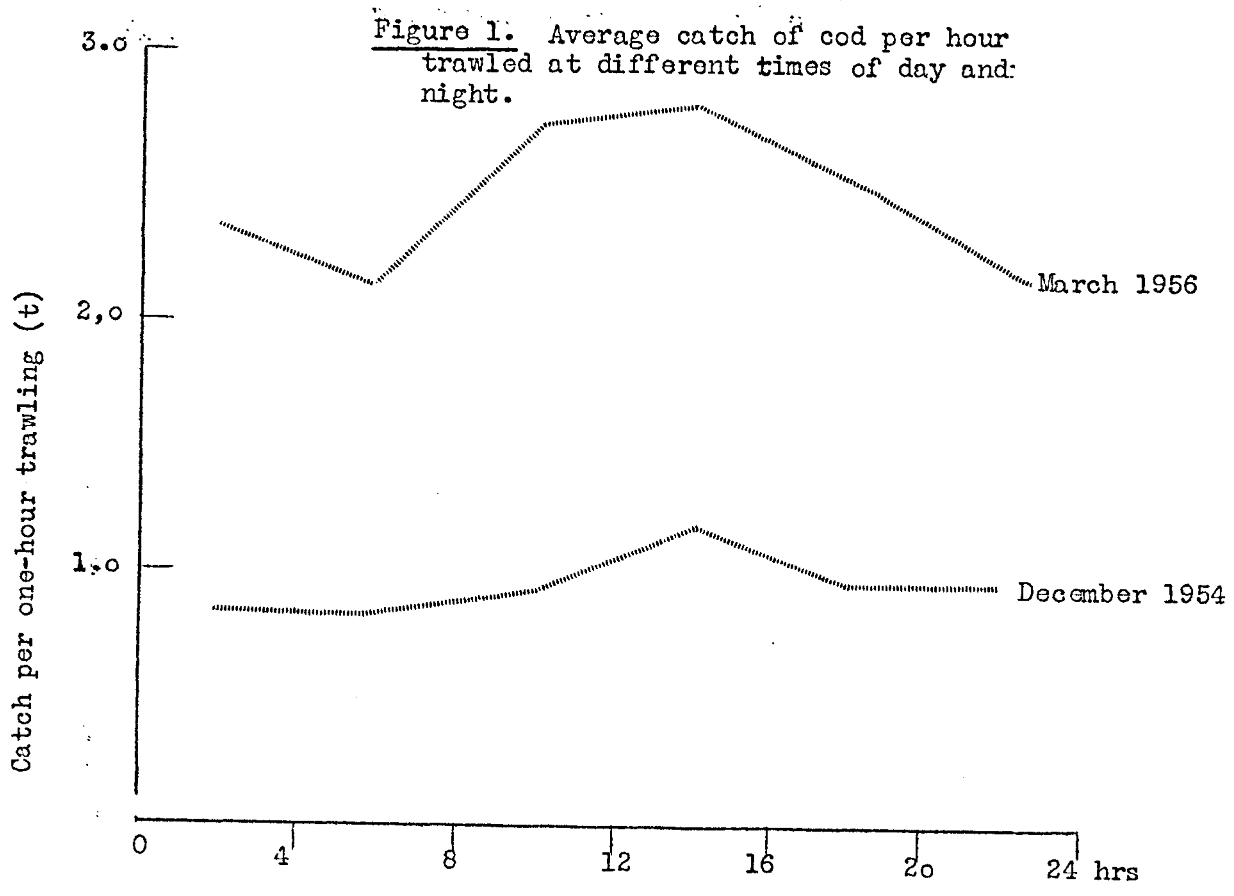


Figure 1. Average catch of cod per hour trawled at different times of day and night.

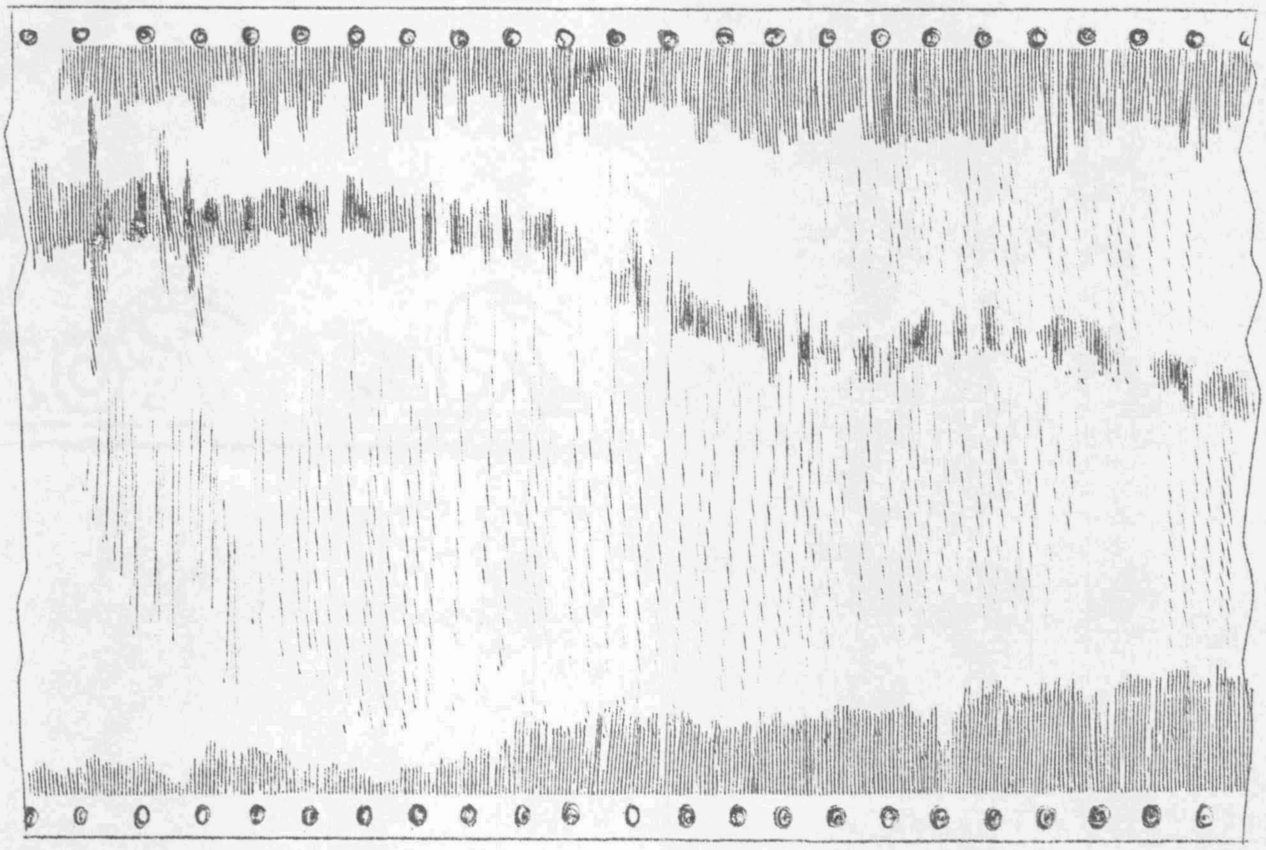

Figure 2. Sinking down of capelin in morning hours.

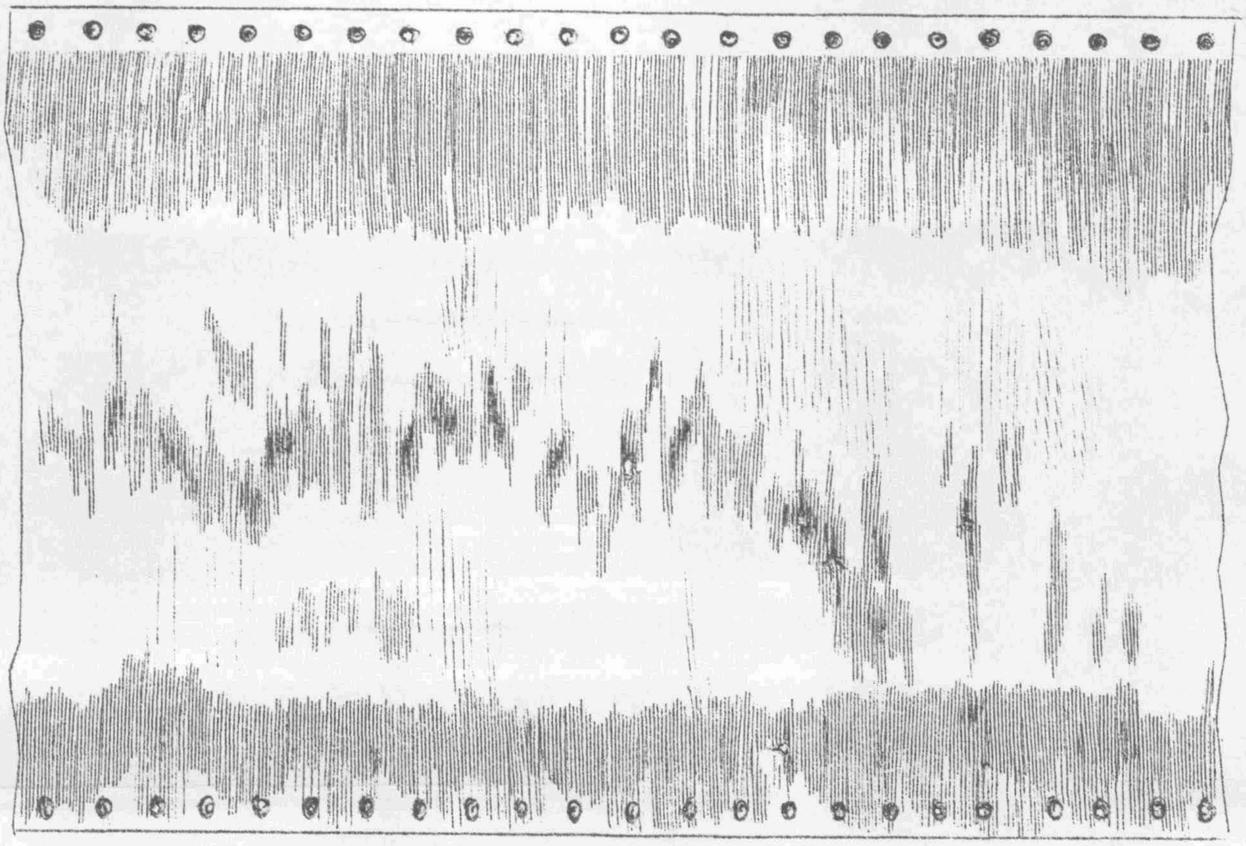

Figure 3. Sinking down of cod in morning hours.