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DIFFERENTIATION OF INDEPENDENT POPULATIONS OF ANTARCTIC KRILL

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Abstract

Several countries have recently shown an interest in commercial krill fishing. An understanding of krill population structure is needed to establish sound management of krill fisheries. A short review is undertaken of recent studies in genetic and morphophysiological variability of krill and Antarctic water circulation. On the basis of the review, it is suggested that there is probably one composite population of E. superba in the Southern Ocean subdivided into several independent sub-populations. The number of these sub-populations is expected to correspond with the number of quasi-stationary cyclonic water circulations. At present, at least six stable cyclonic water circulations can be found and at least two or three of them may be habitats of independent krill sub-populations. A proposal is given for future studies into krill population structure.

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DIFFERENCIATION ENTRE LES POPULATIONS INDEPENDANTES DE KRILL ANTARCTIQUE

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Résumé

Les opérations commerciales de pêche de krill ont récemment suscité un certain intérêt parmi plusieurs pays. Pour mettre en place un système de gestion efficace de la pêche de krill, il est nécessaire d'acquérir des connaissances sur la structure démographique du krill. Un bref examen des études récentes sur la variabilité morphophysiologique et génétique du krill et la circulation des eaux antarctiques est entrepris. En se basant sur cet examen, on suggère qu'il existe probablement une seule population de E. superba dans l'océan Austral, sous-divisée en plusieurs sous-populations indépendantes. Le nombre de ces sous-populations devrait correspondre au nombre de circulations d'eau cycloniques quasi-stationnaires. A présent, un minimum de six circulations d'eau cycloniques stables peuvent être détectées et au moins deux ou trois d'entre elles pourraient constituer l'habitat de sous-populations indépendantes de krill. Une proposition relative à de prochaines études sur la structure démographique du krill est présentée.

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DIFERENCIACION DE POBLACIONES INDEPENDIENTES DE KRILL ANTARTICO

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Resumen

Recientemente varios paises han mostrado interés en la pesca comercial de krill. Se necesita una comprensión de la estructura de la población de krill para establecer una administración efectiva de las pesquerias de krill. Se da un breve resumen de estudios recientes sobre variabilidad genética y morfo-fisiológica de krill y sobre la circulación de aguas la región Antártica. Sobre la base de esta revisión se presume la existencia de una población mixta de E. superba en el Océano Austral, subdividida en varias sub-poblaciones independientes. Se parte de la suposición que la cantidad de dichas sub-poblaciones corresponda al número de circulaciones ciclónicas cuasi-estacionarias de las aguas. Actualmente, pueden encontrarse por lo menos seis circulaciones ciclónicas estables y por lo menos dos o tres de ellas podrían ser habitat de sub-poblaciones independientes de krill. Se expondrá una propuesta para estudios futuros acerca de la estructura de poblaciones de krill.

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ДИФФЕРЕНЦИАЦИЯ НЕЗАВИСИМЫХ ПОПУЛЯЦИЙ АНТАРКТИЧЕСКОГО КРИЛЯ

СССР

Резюме

В последнее время несколько стран проявило заинтересованность в коммерческом промысле криля. Для установления правильного управления промыслом криля требуется понимание структуры популяции криля. Сделан краткий обзор новейших работ по генетической и морфо-физиологической изменчивости криля и циркуляции антарктических вод. На основе этого обзора делается предположение о том, что, возможно, в Южном океане имеется одна составная популяция E. superba, разделяющаяся на несколько независимых подпопуляций. Ожидается, что число этих подпопуляций соответствует числу квазистационарных циклонических водных циркуляций. На данный момент можно выделить как минимум шесть стабильных циклонических водных циркуляций, и по крайней мере две или три из них могут быть хабитатами независимых подпопуляций криля. Высказывается предложение о будущих исследованиях по вопросу структуры популяций криля.

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DIFFERENTIATION OF INDEPENDENT POPULATIONS OF THE ANTARCTIC KRILL

In recent years, several countries (Poland, Federal Republic of Germany, Japan, Chile and some others) have shown their interest in the problem of utilization of the resources of the Antarctic krill mainly represented by Euphausia superba.

Considering the krill resource has been estimated for the entire area of its distribution, while it is fished only in particular areas, the question of the stock size and of permissible removal from the stock in a particular area where krill forms commercial concentrations and is represented by an independent population acquires vital importance, because in areas where the fishery is intensive, krill may be threatened by overfishing while in other areas the stocks may be underexploited.

The problem becomes important because of the necessity of setting krill catch quotas for each fishing country in the near future. These problems can only be solved satisfactorily if the population structure of the species is studied adequately. To gain more insight into the population structure of the Antarctic krill, priority should be given to two questions : the existence in the Southern Ocean of stable large-scale water circulations, and the existence of definite morphophysiological and genetic differences between individuals inhabiting different areas within the distribution range.

Until recently it has been customary to assume that in the Southern Ocean there is only one cyclonic circulation with its centre in the Weddell Sea and the coastal current is a single flow directed from the east to the west around the whole Antarctic Continent. With the increase in the amount of data on the Southern Ocean water dynamics, it has become evident that the flow of the coastal current is divided into a number of localized sections (southern components of cyclonic water circulations) which exist as a result of the action of persistent deep cyclones in the same areas, as

well as of shoreline configuration and bottom relief. A map of the total water transport system in the Southern Ocean shows six cyclonic circulations of which two are large-scale circulations. The first covers the entire southern part of the Atlantic sector, the other is in the Ross Sea area. The maps of large-scale water circulations in the World Ocean also show six cyclonic circulations in the Southern Ocean, two in each sector. Here we find three large-scale circulations - two in the Atlantic and one in the Pacific sector. According to recent data it thus appears that there are at least six cyclonic circulations in the Southern Ocean of which two or three are large-scale (Beklemishev, 1969) and, consequently, may serve as habitats for independent populations.

Papers on the subject of intraspecific variation in E. superba are not numerous. One paper (Ayala et al., 1975) reports the study of genetic variability of krill by electrophoresis. The data obtained by the investigators point to low genetic variability of the species which is associated by the authors with large variability of feeding conditions as compared to species occurring in tropical waters. The homogeneity of the physical parameters of the waters inhabited by krill is pointed out, which suggests the absence of genetic variability between the krill separated by large spaces or inhabiting different water circulations within the Southern Ocean. In this connection, morphophysiological variation in the species is also unlikely. Although the larvae have been found to have five larval forms (this will be discussed below) the differences seem to disappear during postlarval development due to homogeneity of physical environmental parameters. To the best of our knowledge, no studies on the subject of morphophysiological variability of krill postlarval stages have been reported up to now.

Another paper (Makarov, 1974) reports that new forms of krill larvae have been found and five larval forms have been recognized in the plankton from the Scotia and Weddell Seas. It is pointed out that the development of E. superba most commonly goes through form 5 (i.e. furcilia with five pairs of pleopods without setae). It is assumed that this path of development corresponds to environmental conditions optimal for the growth and development of the larvae while any change from this path is associated with deviations of environmental conditions from the optimum.

The papers on the subject of population structure of E. superba are not numerous either and the deductions reached are as yet far from conclusive. J.T. Ruud (Ruud, 1932) was the first to suggest that the existence of the population in the Weddell Sea is made possible by horizontal circulation which carries the krill from the south to the north and vice versa. J.W.S. Marr (Marr, 1962) explained the occurrence of the krill population in the Weddell Sea circulation system by the transport of adults to the north by the surface water and that of larvae to the south by warmer deep water. R.R. Makarov suggested that by performing vertical migrations and thus entering different water masses, part of the larvae hatched in the southern Scotia Sea finally drifted to the Weddell Sea. "In this way the circulation in the Weddell Sea makes possible the existence there of an independent (Beklemishev, 1969) population of E. superba" (Makarov, 1972). In a later paper (Makarov, Maslennikov, 1975) after the absence of larvae at great depths in winter was established, the dominant role of horizontal circulation in the transport of the larvae to the Weddell Sea was suggested. I. Everson (Everson, 1976) proposed a radically different migration pattern of krill in the Atlantic waters of the Antarctic. He believes that the existence of the krill population there is made possible by spawning both in the Weddell Drift waters and in the waters of the coastal current between the zero meridian and 30°E. The larvae hatched in the Weddell Drift waters are carried away by the warm deep current to the surface layers of the coastal current which carries them to the Weddell Sea. Everson rules out the possibility of the krill returning from the eastern part of the Weddel Drift to the coastal current waters at post-larval stages.

Apart from the Weddell Sea krill population, J.W.S. Marr distinguishes another population inhabiting the coastal current. However, the geographical isolation of such a population is extremely doubtful since in the Weddell Sea area the coastal current comprises the southern and western components of the Weddell Circulation and in the north of the area it transforms into the well-known Weddell Drift, i.e. is a part of the circulation in the Weddell Sea. It will be recalled that there are no papers dealing with the subject of variability of krill inhabiting different areas of the Southern Ocean.

It thus appears that only one population of krill is distinguished in the Southern Ocean at present. This is either the Weddell Sea krill population, or the krill population of the Atlantic sector of the Southern Ocean. As indicated above, a number of authors recognize six stable cyclonic water circulations in the Southern Ocean. According to current views at least two or three of them may be habitats of independent krill populations. The possibility that conditions for the occurrence of independent populations may exist in other smaller-scale circulations cannot be ruled out. Undoubtedly, there is some more or less intensive water exchange between adjacent cyclonic circulations resulting in continuous exchange of gene pool between adjacent populations and eventually in the exchange between all populations. On the basis of this it is suggested that there should be one composite population of E. superba in the Southern Ocean, subdivided into a number of independent subpopulations. The number of such subpopulations should correspond to the number of quasi-stationary cyclonic water circulations. It would be reasonable to suppose that there are two independent krill populations in the Atlantic sector rather than one as believed earlier.

As independent populations of organisms are commonly considered to be unit stocks, there seem to be at least six unit stocks of krill in the Southern Ocean which should become the subjects of further studies. It is believed that the study of the stocks, the estimation of removals from the stocks, as well as of krill catch quotas in the Southern Ocean should proceed according to the following pattern :

1. determination of refinement of the boundaries of quasi-stationary water circulations ;

2. determination of the degree of interaction between adjacent circulations ;

3. study of the life cycle of krill in each of the subpopulations ;

4. determination of the routes and volume of krill transport from one subpopulation to another ;

5. assessment of krill stock in each of the subpopulations and study of its year-to-year and seasonal fluctuations ;

6. study of the causes of fluctuation ;

7. setting up of an international catch prediction service.

Considering the international character of krill fishery, the work should be carried out by scientists of the countries concerned in joint research cruises according to programs worked out by a unified centre.

REFERENCES

Ayala F.J., Valentine J.W., Zumwalt G.S. 1975. An electrophoretic study of the antarctic zooplankton Euphausia superba. Limnology and Oceanography, vol. 20, N 4, p. 635-640.

Beklemishev K.V. 1969. Ecology and biogeography of the Ocean. Moscow.

Everson I. 1976. Antarctic krill : a reappraisal of its distribution. Polar Records, vol. 18, N 112, p. 15-23.

Makarov R.R. 1972. Life cycle and distribution pattern ofEuphausia superba Dana. Trudy VNIRO, v. 77, p. 85-92.

Makarov R.R. 1974. Dominance of larval forms in euphausiid (Crustacea : Eucarida) ontogenesis. Marine Biology, vol. 27, N 2, p. 93-99.

Makarov R.R., Maslennikov V.V. 1975. A study of the distribution pattern and the drift with currents of Euphausia superba larvae in the Scotia Sea and adjacent waters. Biologiya Morya, N 3, P. 37-43.

Marr J.W.S. 1962. The natural history and geography of the Antarctic krill (Euphausia superba Dana). Discovery Reports, vol. 32, p. 33-464.

Ruud J.T. 1932. On the biology of Southern Euphausiidae. Hvalrades Skrifter, N 2, p. 1-105.