OCEANIC EDDY FORMATION IN THE SOUTHERN OCEAN: COMPARED WITH OTHER OCEANS (EXTENDED ABSTRACT)

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1. Introduction

The existence of dynamic features on a meso-scale (of the order of 100 km) in the form of disturbances or eddies in the mean flow has been known since at least the study of ISELIN (1936) and some results of a multiple ship survey in 1951 in the North Atlantic Ocean (FUGLISTER and WORTHINGTON, 1951). Recently many investigators analyzed the hydrographic data in the Southern Ocean and described the meso-scale disturbance process (LUTJEHARMS and BAKER, 1979). We have also known about Gulf Stream-generated eddies (rings) (CHENEY and RICHARDSON, 1976) and the results of the Mid-Ocean Dynamic Experiment. These surveys show that the meso-scale oceanic eddy plays an important role in maintaining the oceanic circulation. The purpose of this paper is to investigate the general features of meso-scale eddies in the Southern Ocean and other oceans and the relationship between the meso-scale eddy structure and fishing grounds.

2. Eddy Distributions in the Southern Ocean

LUTJEHARMS and BAKER (1980) gave an analysis of the oceanic eddies in the Southern Ocean. According to their work and that of DANTZLER (1976), the spatial structure functions are calculated on the basis of dynamic depth (0–1000 dbar) from the historical oceanographical data in order to determine the significant eddy scale. The spatial structure function $B_f(r_1r_2)$ is defined as follows:

$$B_f(r_1r_2)=\overline{[f(r_1)-f(r_2)]^2},$$

where $f(r_1)$ and $f(r_2)$ are dynamic depths at positions r_1 and r_2 respectively. In the actual calculation it is necessary to utilize an estimated spatial structure function (ESSF) as follows:

$$E(B_f(r))=\frac{1}{N}\Sigma\ [f(l)-f(l+r)]^2,$$

where N represents the number of station pairs, $f(l)$ the dynamic depth at position l, and r the spatial interval. The ESSFs indicate the values of the energy spectrum at various diameters in eddies. The distributions of the values of the ESSF for the spatial separation of 200 km to 300 km is shown in Fig. 1. For regions A, B

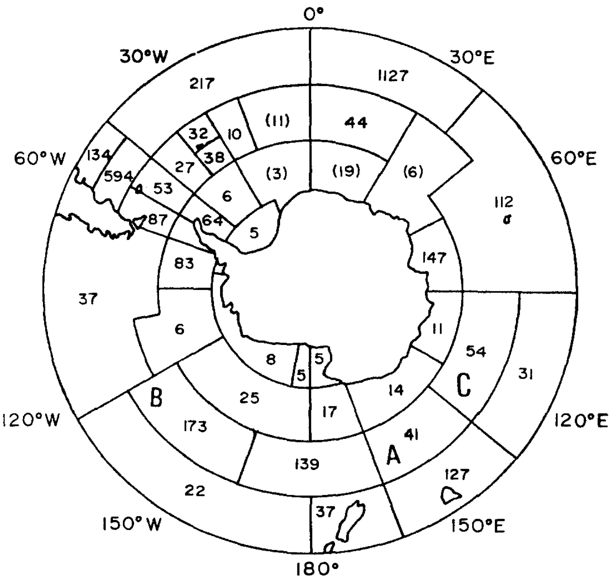

Fig. 1. *The value of ESSF of different sizes in the spatial interval 200 km to 300 km (units: $10^{-2}m^4s^{-4}$) (after* LUTJEHARMS *and* BAKER, *1980 Fig. 5).*

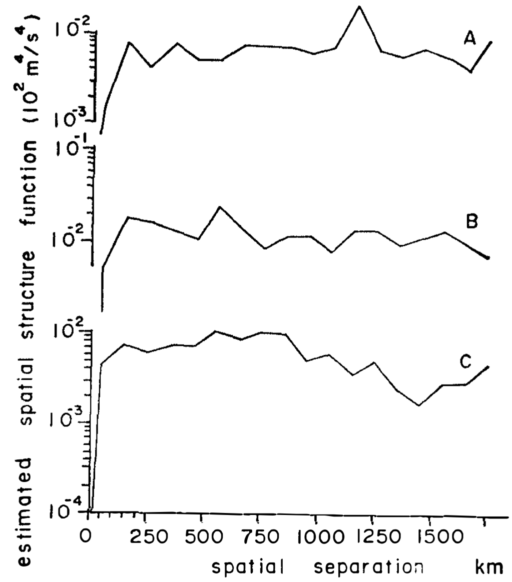

Fig. 2. *The values of ESSF for three areas (A, B and C) in Fig. 1 (after* LUTJEHARMS *and* BAKER, *1980 Fig. 6).*

and C in the figure, the values of ESSF are portrayed in Fig. 2. An examination of the ESSF in regions A, B and C shows that in almost all cases these values rise rapidly to a spatial separation between 150 km and 250 km and thereafter remain relatively flat. The fact that the functions show a significant peak at the first spatial separation indicates the validity of dominant significant scales in geophysical fields. In the Southern Ocean the meso-scale eddies occur at separations of less than 300 km.

3. Eddy Distributions in the Other Oceans

Meso-scale eddies or disturbances are also formed in the Pacific and Atlantic Oceans. According to DANTZLER (1976) the ESSFs show a dominant length scale of 400 km to 500 km in the southern area of the North Pacific Subtropical Gyre and these lengths are consistent with those south of Hawaii reported by WYRTKI (1967) and northeast of Hawaii by BERNSTEIN and WHITE (1974). In the North Pacific Ocean, the region between the Kuroshio and Oyashio has long been known to be dominated by eddy motions about a 200 km scale (KAWAI, 1979). Recently CHENEY *et al.* (1980) has investigated the cyclonic Kuroshio ring by use of air-borne XBT and hydrographic data. From the distributions of 300 m water temperature on October 9–22, 1976, some cyclonic rings on the scales of 100–200 km are found in the Kuroshio region. Also we know that there is a significant length scale of 200 km to 400 km in the North Atlantic Ocean through the Mid-Ocean Dynamics Experiment. When we investigate a Kuroshio cold ring, we encounter the fact that the cold ring corresponds to high concentrations of nutrient (Fig. 3). From the data in the Kuroshio Extension in the North Pacific it appears that this

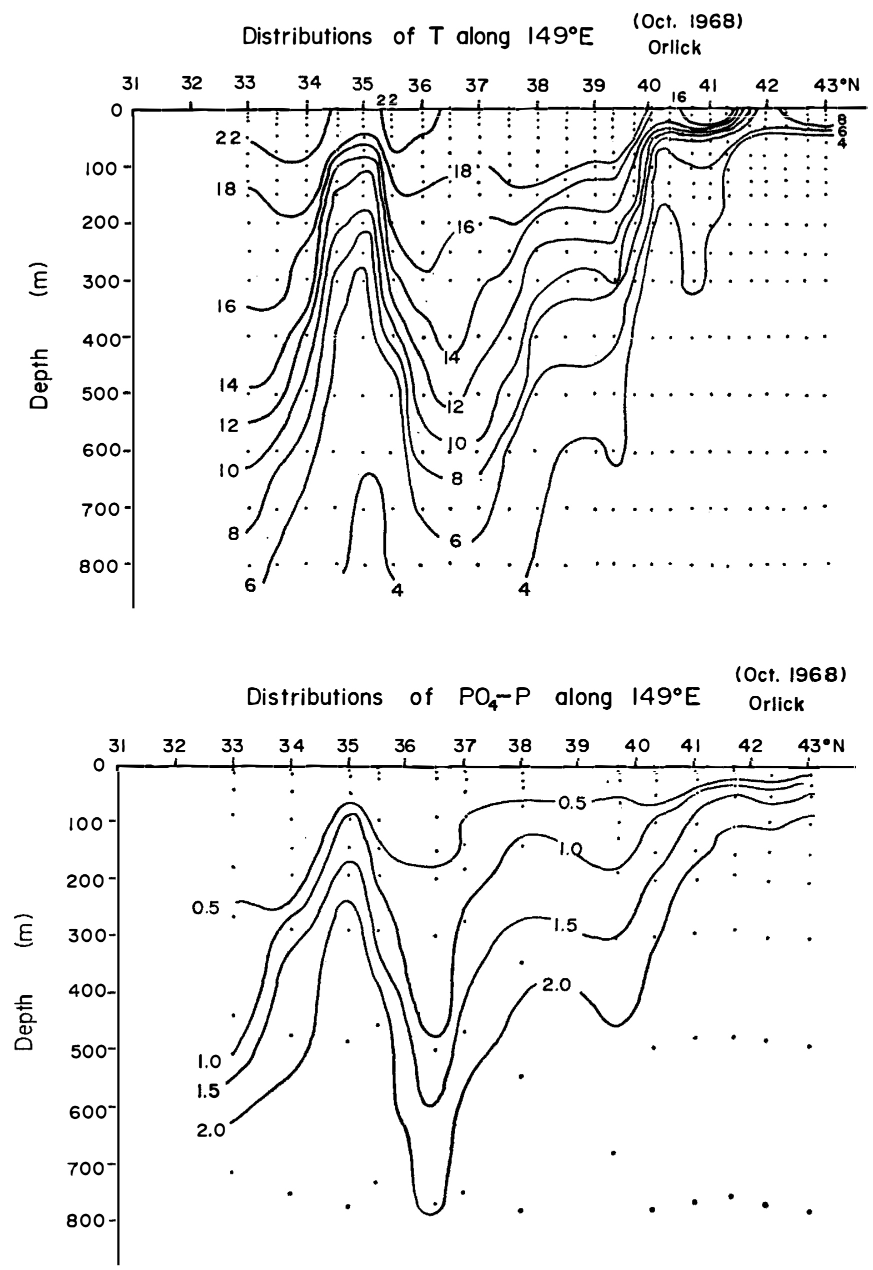

Fig. 3. Distribution of water temperature and phosphate from 33°N to 43°N along 149°E.

relation may be significant, although it is not clear whether the cyclonic meso-scale eddies are always consistent with high nutrient concentration or not.

4. The Relation between the Distributions of Nutrient and the Oceanic Meso-Scale Eddies in the Southern Ocean

This relation is not clear because we have not analyzed the nutrient distributions and meso-scale eddies there. But areas of relatively abundant nutrient are found in the intermediate layer (about 2000 m depth) (Reid, 1981) and the values in the Southern Ocean are higher than in the North and South Atlantic Oceans. The highest values are found in the North Pacific.

It is said that the values of nutrient in the Southern Ocean are generally high. If the oceanic meso-scale eddies force the ascending motion of nutrient rich water, the role of the meso-scale eddy will be important to the formation of fishing grounds in the Southern Ocean. In near future we would like to study these relations in detail.

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(Received April 3, 1982)