ON THE FINE STRUCTURE OF OCEAN VARIABLES AND ITS CORRELATION WITH THE FIELD OF MOTION (SUMMARY AND REFERENCES).

By G. Siedler

Institut für Meereskunde
an der Universität Kiel
23 Kiel

1.-INTRODUCTION

The intention of this summary is to select some profiles showing typical features of the oceanic fine structure, to discuss some ideas concerning the generation of this structure, and to present results which indicate a weak correlation of temperature fine structure and current variability at small time scales.

2.-METHODS OF MEASUREMENTS

The state of instrumental techniques and the limitations in financial support will always imply that a sufficiently dense net of sensor packages can only be approximated, and similar restrictions apply to the resolution in time and the duration of the measurements. The most important methods allow a very high spatial resolution in either vertical or horizontal direction of a high resolution in time at selected depth levels.

The first type of measurement is achieved by lowered sensor packages like the Bathysonde (Hinkelmann, 1957, Siedler, 1963) or other salinity-temperature-depth (STD) measuring instruments, or by an underwater winch system (Siedler, Krause, 1964). The second type of measurement is obtained by instrumented moorings (Fofonoff, 1967, Siedler, 1967). In addition, there are dye techniques (Woods, 1968) and methods using towed temperature and hot film probes (Grant, et al., 1968).

3.-TYPICAL VERTICAL PROFILES OF TEMPERATURE AND SALINITY

Some typical features of the vertical profiles of temperature and salinity can be found. A few references to results obtained at Kiel University are given in the following text. There are regions like the deep Mediterranean or the deep Red Sea where there is usually no fine structure which can be detected by Bathysonde measurements. Near the surface, fine structure occurs mainly in and below the thermocline. The spatial variability is especially high in shallow areas like the Baltic (Siedler, 1961), but there is also a considerable structure in deep regions where the water is renewed by vertical convection (Holzkamm et al., 1964) or where water from adjacent seas is spreading in the open ocean (Krause, 1968, Zenk, 1970).

Detailed discussions of certain features of vertical temperature and salinity profiles obtained by STD lowerings have been given by Stommel and Fedorov, 1967.

4.-GENERATION OF FINE STRUCTURE IN THE OCEAN

There are three groups of processes which probably generate most of the temperature and salinity fine structure observed in the ocean: Air-sea interaction at the surface, shear instability and molecular diffusion in the interior of the ocean.

Air-Sea Interaction: Recent measurements obtained by an underwater winch system in the Baltic made it possible to determine the types of fine structure which are generated during certain weather conditions and the time scales of the variability of this structure (Münzer, 1969). At low wind speeds, slowly growing homogeneous surface layers with a few decimeters thickness are generated during the day-time. At most times, however, heat from the atmosphere is transferred to surface layers with varying thickness in certain time intervals. The generated irregular structures often migrate downwards. When the atmospheric conditions change rapidly, e.g.

when a front passes the position of measurement, the water is mixed down to at least 15 m within a few hours. Step-like structures are also observed from time to time.

Very thin surface layers with a vertical extension of 10 to 30 cm occur frequently, their typical duration is half an hour to a few hours. Fine structure is frequently removed by vertical convection caused by surface cooling during the night.

Possibly, most of the fine structure is generated by air-sea interaction. Stern (1968) discussed a model which assumes that all fine structure is generated at the sea surface.

<u>Shear instability in the interior of the ocean</u>:The generation of fine structure by shear instability due to internal waves was shown by Woods (1968). By using dye techniques he found that thin layers with large vertical gradients of density and current velocity existed in the seasonal thermocline. Internal waves at these layers change the current shear, and frequently shear instability is observed at the crest or the trough of the wave. The resulting transition from laminar to turbulent motion leads to the generation of temperature fine structure. A patchiness of the fine structure results from these processes. Apparently, this patchiness is a common feature of the ocean. This has been demonstrated by measurements with temperature and hot film probes which were towed or mounted on a submarine (Grant et al., 1968).

Shear instability may also be caused by the thenohaline circulation. In straits connecting the oceans and adjacent seas, very small Richardson Numbers are found which apparently explain the occurence of a strong variability in time and space of vertical temperature and salinity profiles (Siedler, 1968).

The variations of mixing processes with tidal periods in such areas lead to two peaks in the frequency distribution of water types and to a resulting structure with two main maxima in the deep ocean (Siedler, 1969).

Differences in the molecular diffusion of heat and salt in the interior of ocean: As heat is transferred much faster than salt by molecular diffusion, the temperature-salinity patterns is unstable under certain conditions (Stern, 1960, Turner, Stommel, 1964). It has been shown by tank experiments (Turner, 1967) that salt fingers can be formed at such interfaces, and step-like structures are generated if warm salty water is layered above cold, less salty water (Stern, Turner, 1969). Such step-like structures have been observed in certain areas below the "Mediterranean Water" in the Eastern North Atlantic (Tait et al., 1968, Zenk, 1970).

5.-CORRELATION OF THE TEMPERATURE AND CURRENT VARIABILITY

Recent measurements at deep-sea moorings indicate that high frequency variations of currents in the deep ocean are weakly correlated with the corresponding variation of temperature (Siedler, 1970). Probably, this is caused by the superposition of a rapidly changing temperature and salinity fine structure to a mean temperature and salinity field which controls the internal waves in the ocean.

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