

This volume is dedicated to our colleague Dr. Mira ZORE-ARMANDA, physical oceanographer who has introduced physical oceanography to the Institute of Oceanography and Fisheries Split. One of her major contributions was identifying the main types of water in the Adriatic giving a phenomenological model of the Adriatic Sea circulation, and designated the places where these waters were formed and how they circulated in different seasons.



**Dr. MIRA ZORE-ARMANDA**

**1930-2012**

Dr. Mira ZORE-ARMANDA was born on 6<sup>th</sup> January 1930 in Zagreb, where she attended school and graduated in 1948. In 1952 she graduated at the Faculty of Science in the Department of Mathematics and Physics, under the branch of Geophysics. She obtained her Ph.D. degree in physical sciences at the Sorbonne University of Paris, France in 1963.

She started working in 1952 as an assistant in the Laboratory of Hydrography of the Institute of Oceanography and Fisheries (IOF), and ultimately where she had spent her entire lifetime. She became a scientific advisor in 1974.

Dr. Mira ZORE-ARMANDA paved the way for women in oceanography, when they were poorly represented. Also, she paved the way for oceanographers from a small country (Croatia), since she had experienced a lack of belief from foreigners that such a country had an organized system of oceanographic measurements. She was a versatile scholar and intellectual that is very rare nowadays.

As the first physicist working in IOF, she introduced physical oceanography into that institution. From 1952 to 1972 she led physical oceanography field work at the permanent stations of the Institute. In 1956 she went to India with a Norwegian government scholarship. In 1957/58 she was a member of the organizing committee of the International Geophysical Year, where she led the cruise for the Adriatic Sea. In 1962 she participated in the organization of joint research of the Adriatic Sea with the Woods Hole Institute (Atlantis and Bios expedition). However, she was not allowed to join the Atlantis ship cruise since women were not allowed on board in those times, as was also the case here in the Adriatic.

Based on the data from the NAJADE CICLOPE expedition she calculated geostrophic currents from which she demonstrated seasonal changes in flow regime, as confirmed by later measurements. She showed that the basic cause of these seasonal changes derived from the fact that the northern Adriatic, as a shallow area, is under high continental influence contrary to the deep southern Adriatic. It is heated more in summer and cools more in winter than the southern Adriatic and is exposed to the inflow of the river Po and other northern Italian rivers. She

estimated seasonal differences in the slope of sea level along our coast, which were confirmed from tide gauge data.

Analyzing TS diagrams she identified the main types of water in the Adriatic, giving a phenomenological model of the Adriatic Sea circulation, and designated the places where these waters were formed and how they circulated in different seasons. It was shown that certain types of water form in winter, when the cooled surface waters mix vertically to great depths, and the source areas of these waters are the northern Adriatic shelf, the Jabuka pit and the southern Adriatic basin. The eastern Mediterranean type of water enters the Adriatic in the intermediate layer, while the south Adriatic water extends in the bottom layer towards the eastern Mediterranean. In monitoring water types she has also schematically shown the vertical distribution of circulation in the Adriatic by season.

Her further research carried her in several directions. She applied her knowledge of currents and water masses to the biological conditions in the Adriatic in co-authorship with her biologist colleagues. It was discussed how various physical factors affect the size of primary production in the sea and the possibility of forecasting the fish catch. A link was established between climate and oceanographic parameters and the size of primary production. A hypothesis was set out that increased primary production after three years resulted in increased fish production. In more recent studies the figures are somewhat corrected, but the first estimate was among the first works of this kind.

Dr. Mira ZORE-ARMANDA also studied the effect of meteorological factors on conditions in the sea and had recognized the broader role of long range climate factors than local meteorological conditions. From this aspect she studied the influence of meteorological conditions of the wider area from the Atlantic to the Mediterranean to the Adriatic Sea. She related the intensity of water exchange between the Adriatic and the Mediterranean to amounts of nutrients and salinity, which proved to be a good indicator for the intensity of water exchange between the Adriatic and Ionian Sea. Further

she explored the conditions of water formation types on multi-annual timescales. She noted that pressure gradients affect the geostrophic flow when viewed from an area wider than the Mediterranean and influence both seasonal and inter-annual fluctuations of circulation in the Adriatic. In terms of tele-connection she looked at the impact of the Atlantic Ocean on the Adriatic and noted that the amount of ice in the North Atlantic is highly correlated with certain phenomena in the Adriatic Sea. At that time it was pioneering work, and even today such an approach is still relevant. She realized that the Adriatic is only a small part that responds to the changes of a larger system. Subsequently she studied the relationship between the sea and atmosphere and calculated evaporation levels of the Adriatic Sea. She related the inter-annual changes in meteorological parameters with the formation of dense water in the Adriatic Sea.

With co-authors she described the general hydrographic conditions of the Adriatic on the basis of long-term data series for stations in the middle and southern Adriatic since 1952. In the Seventies the attention of the Institute was focused on the protection of the Adriatic Sea from pollution and for this purpose she started to work on coastal oceanography. The basic difference was in the dynamics between open and coastal waters caused by the influence of the coastal wall, which requires a compensatory flow toward and from the shore, with a very strong influence of wind on currents and the emergence of multi-day oscillations.

In 1982-1983 she led the oceanography part of the international project ALPEX, called MEDALPEX, and worked on the dynamics of the northern Adriatic, discovering the existence of the coastal front and its dependence on wind intensity. This was the first experiment of IOF with a dense network of stations in a small area.

For the purposes of modeling of the Adriatic currents, together with colleagues she explored the impact of topography on the flow through simple analytical models. She studied the influence of the Po river on the northern Adriatic circulation.

Later analysis of the long-term data has

shown the impact of pollution on the open sea as well. She also presented a hypothesis about tsunamis in the Adriatic. She led 18 ecological studies among which the biggest were a study for nuclear power plant Vir and a study for the exploration of oil and gas.

Here are some other activities of  
Dr. M. ZORE-ARMANDA:

- leading of the UNEP-MAP project on the transport of pollutants in the coastal area.
- working in the Commission for the preparation of the MEDALPEX program in Paris 1980
- a member of the Commission for the creation of an international research project for the eastern Mediterranean (POEM).

- Has participated in seminars, conferences etc. organized by CIESM, IUGG, CNRS, UNESCO, the Royal Society, NATO and International Marine and Atmosphere Panel, and attended the conferences in Monaco 1952, Bucurest 1966, Monaco 1968, Split 1976, Antalya 1978, Berlin 1980, Cannes 1982, Palma de Mallorca 1986, Athens 1988, Bern 1967, Moscow 1971, Grenoble 1975, Tokyo 1970, Paris 1972, Trieste 1971, Malta 1973, London 1981, La Spezia 1983 etc.

- a member of local organizations such as the National Committee for the Scientific Exploration of the Mediterranean, Society for the Advancement of Maritime Affairs of Yugoslavia, Council for improving Maritime Affairs at the Croatian Academy, National Committee for Geodesy and Geophysics.

- a member of international organizations like the Committee for International Exploration of the Mediterranean where she was twice a vice chairman of the Committee for Physical Oceanography.

- a member of American Meteorological Society and American Union of Geodesy and Maritime Affairs.

She participated in several courses at IOF and ICTP (Trieste), and at the Postgraduate Study of Oceanology at Zagreb University with lectures on hydrographic conditions of the Adriatic and the Mediterranean. In co-authorship she has

published a series of textbooks in six different editions, for the Maritime School, International Institute course for fisheries personnel from developing countries and Postgraduate Studies of oceanology.

She led several masters and doctoral theses and reviewed theses for the University of Alexandria and University of Bologna as well.

She motivated us to be engaged in a variety of new issues, supported our needs for new equipment and also made efforts to obtain the first data processing equipment in the Eighties, which was a basis for the future data center.

She has published over 150 scientific and technical papers some of which are still cited, and in any case are an indispensable body of work for oceanographers in the Adriatic.

As Editor-in-Chief of the Institute's publication since 1976 she pushed towards reaching higher standards in *Acta Adriatica*, which became an internationally recognized journal of Mediterranean Oceanography and in 2007 became one of the few Croatian journals cited in SCI-Expanded.

Mrs. Zore-Armanda retired in December 1989, but continued working as Editor-in-Chief of *Acta Adriatica* and subsequently published several more papers. Her tips are still very valuable and relevant.

She used to say: "One cannot be a saloon oceanographer; oceanographers must participate in the field work!" She urged for the continuation of measurements at our permanent stations. Her wish was to make measurements at the Otranto straits, and we hope to realize it with our new vessel some day.

All science re-organizations that took place during the course of her work history have not impressed her and she expressed the opinion that politics should be less involved in science.

She told us: "Stay away from lobbies, to which everything is more important than the protection of the Adriatic." She advised us that it is not worthwhile to work on economically valuable projects if these do not contribute to scientific knowledge.

Disappointed by the war situation in Croatia in the Nineties, she somewhat resignedly stated that progress of technology has not led to the advancement of humanism. However, she hoped that the independent Croatia, which governs most of the Adriatic, shall recognize and protect its great wealth – the Adriatic Sea.

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