In memoriam

Dr. Mira Zore-Armanda
(Zagreb, 6 January 1930 – Opatija, 8 April 2012)

Dr. Mira Zore-Armanda, retired senior scientist at the Institute of Oceanography and Fisheries in Split and a longtime member of the Editorial Board of the journal *Geofizika*, departed us this year. By researching physical processes in the Adriatic Sea she achieved an exceptional international reputation. Her wholehearted involvement in many activities, including field work, data processing, writing articles, leading projects, managing the institute, publishing books and teaching, raised the bar for future generations. And she will also be remembered for an ability to combine efficiency and resolution in her professional relations with humanity and tolerance in her personal contacts.

Mira Zore’s parents were Miro (a clerk) and Marija (nee Nabergoj, housewife). She was born in Zagreb, as her family was forced to flee Opatija, where they had a home, after the First World War. On many occasions she spoke to the author of this text about how she grew up with stories of the coastal roots of her family, to which her later interest in oceanography can partly be attributed.

After graduating from the Ninth Gymnasium in Zagreb, she enrolled in the study of geophysics at the Faculty of Science, University of Zagreb. She graduated from the program in 1952 with a thesis entitled “Oscillation of bays with an application to the Kaštela Bay”. Her supervisor was Academician Josip Goldberg, a well-known geophysicist and the founder of the study of geophysics, who conducted empirical and theoretical research on standing waves in the Bakar Bay in 1930s. Mira Zore’s graduate thesis was also based on a combination of empirical and theoretical approaches, as seen in the published paper that was based on the thesis (reference number 1 in the attached list of publications).
Immediately after graduating, Mira Zore took employment at the Institute of Oceanography and Fisheries in Split, and remained there until her retirement in 1989. In Split she met Dr. Miljenko Buljan, a biologist who at the time of her arrival was intensively studying hydrographic properties of the Adriatic Sea on the basis of data collected during the cruises of research vessels *Najade* and *Ciclope* in 1910s. At the urging of her colleague Buljan (reference number 2) and with the wholehearted support of Professor Goldberg (reference number 154), Mira Zore began an extensive project of analysing residual currents and water masses of the Adriatic Sea, also primarily using the data from the *Najade* and *Ciclope* expeditions. This ultimately led to her doctoral dissertation, which she defended at the University of Paris in 1963. Her supervisor there was Professor Henri Lacombe, a well-known French oceanographer who distinguished himself by a research of physical properties and dynamics of the Mediterranean Sea. Her thesis was entitled “Les masses d’eau de la Mer Adriatique” and it resulted in a paper published under the same title (reference number 6).

This education was the foundation for an exceptionally successful scientific career, which included 64 scientific papers, 38 conference communications, 81 professional and popular articles, and 5 books and lecture notes. After her marriage to Igor Armanda, a chemist from Split, she published her work under both surnames. Considering that for the first twenty years of her career she was the only person studying physics of the sea at the Split institute, she was intensively involved in all aspects of research – from field work, via data processing, to the writing and publication of scientific papers. It is especially worthy to note her participation in numerous expeditions on the research vessel *Bios*, at a time when women around the world had access to research vessels only very exceptionally. In her memoirs (reference number 188) she mentioned an episode from 1962, when the Americans did not permit her to join an Adriatic expedition on the research vessel *Atlantis*.

In this text it is not possible to analyse all the scientific contributions of Mira Zore-Armanda, and, therefore, only a short overview of her most important findings follows. In the early years of her work, she determined surface geostrophic currents in the Adriatic, and detected the presence of seasonal variability in the current field (reference number 2). She later studied relationship between the variations in current field and the seasonal oscillations of sea level (reference number 4). In her doctoral dissertation (reference number 6), she used T-S diagrams to detect four water masses in the Adriatic Sea, which enabled her to investigate currents not only at the surface but also in the deeper layers. A significant result of this pioneering research effort was the discovery that the surface of the Adriatic is characterised by cyclonic currents that are modulated seasonally, with an inflow along the Croatian coast dominating in winter and an outflow along the Italian coast dominating in summer, and that overall transport of the surface currents is compensated by deep-layer transports. This schematic representation of the Adriatic circulation has been widely accepted over the
years, and has served on many occasions as the basis for the interpretation of chemical and biological processes in the sea.

This kinematics-related research was furthered with analysis of dynamical relationships (reference number 16), which allowed not only for buoyancy forcing but also for the influence of atmospheric factors – air pressure and wind – on the sea. Following the development of instrumentation, Mira Zore-Armanda began to increasingly use direct current measurements in her work (reference numbers 9, 11, 14, 31, and 34), thereby supplementing the results achieved by using indirect methods. Her early work was rounded out with a review paper (reference number 32) in which she, together with Miljenko Buljan, gave a detailed overview of the important studies of abiotic conditions in the Adriatic Sea, along with a comprehensive bibliography.

From the early 1970s, Mira Zore-Armanda concentrated more on investigation of the coastal sea. This was stimulated by the need to protect the coastal area from pollution, and resulted in numerous professional studies, which, as she often said, enabled modern instruments to be used in the Adriatic Sea, but also required a great deal of effort and thus left the researchers with little time for scientific work. Even under these circumstances, however, she found the time and energy for new scientific challenges, and the crown of this part of her career was certainly the MEDALPEX project, which she led in the Adriatic in 1982. This project resulted in the discovery of a front in the Istrian coastal region (reference number 43) and a detailed study of the movements of that front under the influence of changing winds, especially the north-easterly bora wind (reference number 48).

It should be emphasised that Mira Zore-Armanda did not limit her research to physical processes in the Adriatic Sea. In cooperation with biologists she also studied how various physical factors impact primary production in the sea, and posed the hypothesis that an increased primary production would, over several years, lead to a greater production of fish and an intensification of fisheries (reference numbers 21 and 25). Later research confirmed these assumptions and showed that the forecasts provided were useful. In a series of papers she also documented hydrographic data collected in the Adriatic Sea over a thirty-year interval (reference numbers 39, 54, and 125). In doing so she collaborated with chemists and they observed an increase in salinity as well as the eutrophication and a simultaneous decrease of transparency of the open part of the middle Adriatic (reference number 51).

The exceptional quality of the scientific legacy of Mira Zore-Armanda is also seen using scientometric indicators. According to the Web of Knowledge, her most cited papers have 130 citations (reference number 32), 68 citations (reference number 16) and 50 citations (reference number 48). It cannot be a coincidence that all three of these papers were published in foreign scientific journals. However, it should be mentioned that her papers published in the journal Acta Adriatica, to which she most often contributed, also had a significant interna-
tional impact. It is particularly impressive that several of these papers (for example, reference numbers 2 and 6) are cited in the international literature half a century after their publication, which is the best indicator of their excellence.

Despite the fact that she spent the majority of her work life in a country that carefully monitored the international activities of scientists, and especially geoscientists, Mira Zore-Armanda still succeeded in intensively cooperating with her colleagues from abroad. She made two extended study visits, the first to India (1956) and the second to France (1963). As she herself once said, those study visits enriched her with new knowledge that was not exclusively scientific: in India she was fascinated by the possibility of saying anything without anyone feeling offended, while in France she took advantage of the opportunities to learn about French culture. She also often participated at scientific conferences. Particularly useful to her were conferences organised by the Commission Internationale pour l’Exploration Scientifique de la Mer Méditerranée and the International Union of Geodesy and Geophysics. She served as vice-president of the Physical Oceanography Committee in the former organisation on two occasions.

Mira Zore-Armanda was involved in teaching in various ways. Together with Miljenko Buljan she published a secondary school textbook on oceanography and marine meteorology (reference numbers 184 and 185) and in cooperation with Miroslav Gačić a set of lecture notes on oceanography for students attending the maritime studies (reference number 186). She taught the courses *Physics of the Sea* and *Hydrographic Properties of the Adriatic and Mediterranean Seas* at the graduate study of oceanography at the University of Zagreb. She also taught at international summer schools, both at home (in Split over many years) and abroad (Venice in 1970, Trieste in 1980). Finally, she supervised several M. Sc. and Ph. D. theses, and participated as a member of the committees to assess qualification theses, not only at home but also abroad (Italy, Egypt).

Mira Zore-Armanda did not avoid professional or organisational activities. She served as director of the Institute of Oceanography and Fisheries in Split for a two-year mandate (1976–1978). However, she did not find the position personally fulfilling, and could hardly wait to return to her primary calling as a scientist. She participated in or led about twenty professional projects awarded to her institute. In her published professional and popular articles she addressed various aspects of oceanographic research, summarised international meetings, and over time became more focused on the history of oceanography. Even after the retirement she kept close ties with her institute, and at that time published a beautifully illustrated monograph to celebrate the 65th anniversary of the Institute of Oceanography and Fisheries (reference number 187). Right up until 2006 she served as the Editor-in-Chief of the journal *Acta Adriatica*, and was very successful in the role as seen from the fact that the journal was included in the Science Citation Index Expanded immediately after the end of her mandate. After the death of her husband she decided to move to Opatija, where she spent
the final years of life in the old family home, which she shared with her sister
Nina Jurak and with sister’s family.

In her memoirs, Mira Zore-Armanda touched upon how scientific papers are
becoming obsolete: “Much is written, and few people read any papers more than
ten years old... I remember various discussions among my colleagues on that
topic. It was thought that one publishes with the desire to remain immortal.
This, however, is not the case, unless you are a supreme genius. At the end of
my career, it also seems to me that all that was written does not mean that much,
barely a little more than nothing. In how many years will it be forgotten?” Even
from this short overview it is obvious that her scientific results have not been
forgotten and that they will, even if not directly cited in the future, remain an
important support of the structure that is called Adriatic oceanography. How-
ever, Mrs. Mira, as her younger colleagues usually addressed her, will be remem-
bered for so much more – for the readiness to energetically and occasionally even
emotionally defend her profession and her institute, for the concern for younger
associates, for the discussions that often surpassed the boundaries of narrow
specialization and in which she was not only critical but also showed an under-
standing for human weakness. For all these reasons we can rightfully conclude
that with her life and work Mira Zore-Armanda has taken a prominent place in
the long and honourable tradition of Croatian geophysics and oceanography.

Mirko Orlić

Mira Zore-Armanda – List of publications

Scientific papers

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M. ORLIĆ: IN MEMORIAM – DR. MIRA ZORE-ARMANDA


Conference communications


[86] Zore-Armanda M. (1979): Istraživanje mogućeg djelovanja nuklearne elektrane Vir na more, Druga konferencija o zaštiti Jadrana (Hvar 1979), Zbornik referata (Druga knjiga, Savjet RK SSRNH za zaštitu i unapređenje čovjekove okoline i prostorno uređenje, Zagreb), 489–496.


Professional and popular articles


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Books and lecture notes


