

*This volume is dedicated to our colleague **Dr. TOMISLAV ZVONARIĆ** who was devoted to improving of analytical methods for determining trace heavy metals in the marine environment.*



**Dr. TOMISLAV ZVONARIĆ**  
**1948 – 2008**

Dr. Tomislav ZVONARIĆ, Croatian marine chemist, was born on 5 August 1948 in Jakšić (Kotar Požega) where he attended primary school. He attended secondary school in Slavonska Požega and subsequently studied at the Technological Faculty in Sisak in 1967. In 1971 he won a University award for excellent results during his studies which he completed in 1972 with the defence of his B.S. Thesis entitled "POLAROGRAPHIC DETERMINATION OF SURFACE ACTIVE MATTER IN WATER SOLUTIONS."

Dr. Zvonarić began his scientific career as an assistant in 1972 in the Centre for Marine Research in Rovinj, where he enrolled in a newly founded postgraduate course in oceanography, and shortly thereafter went to the Hopkins Marine Station in California for advanced training with Prof. Gilmartin. Under the mentorship of Dr. M. Branica and Dr. V. Žutić of the Ruđer Bošković Institute in Zagreb he completed his Master Thesis in 1975 under the title "ELECTROCHEMICAL DETERMINATION OF SURFACE MATTER IN SEA WATER." After military service in the Hydrographic Institute, Dr. Zvonarić found employment in 1977 in the Institute of Oceanography and Fisheries, where he worked in the laboratory for chemical oceanography and sedimentology until the end of his life.

Upon his arrival in Split, Dr. Zvonarić immediately founded a new section of the laboratory in which research on the biogeochemical cycles of cadmium, lead, zinc and copper in sea water was carried out. In the following years this research was successfully extended to mercury and its organic compounds.

Dr. Zvonarić was very active in those years and spent several months in the University of East Anglia in Great Britain and established a scientific collaboration with the Jožef Stefan Institute in Slovenia. He spent more than two years working on their nuclear reactor in improving analytical methods for determining trace heavy metals in the marine environment. He also worked on the topic of the influence of mercury in exposed professional workers in Idrija (Slovenia), Tuzla (Bosnia and Herzegovina) as well as in Pančevo in Serbia. He presented the results obtained during that period of research in his doctorate "DEVELOPMENT AND OPTIMIZATION OF AN ANALYTICAL METHODOLOGY FOR TRACING

THE INFLUENCE OF ELEMENTARY MERCURY ON EXPOSED PROFESSIONAL WORKERS" which he defended at the University of Ljubljana in 1989.

In the 90's Dr. Zvonarić began to lead, and participate in, many national and international projects, among which included the projects "Ecological cycle of mercury in the Kaštel Bay marine environment," "Estimation of possible danger to the health of at-risk populations due to seafood contamination by toxic forms of mercury and methyl mercury," "National Program of the Republic of Croatia for the monitoring of pollution in the Adriatic Sea," "Level and influence of pollution in the areas of big population centres" as well as "Inspection of the quality of coastal waters, Project Vir-Konavle" which he led for 16 years.

During his scientific career Dr. Zvonarić participated in a great number of local, as well as international, scientific symposia during which he gave prominent presentations, especially in the area of mercury analysis. He presented the results of his scientific activities in more than 100 scientific and professional publications.

Apart from scientific research, Dr. Zvonarić was also active at the teaching-educational level and, as a mentor, was involved in the supervision of several degrees, 3 Masters and 3 Doctoral works which contributed to the development of new young scientists who are now working in various local and international institutes. Dr. Zvonarić taught part of the postgraduate study "Engineering Chemistry" in the Technological Faculty in Split with courses on "Sea Biology and Ecology," "Sea Fisheries" as well as on the doctoral study course "Applied Marine Sciences" at the University Centre for Marine Studies.

It should also be noted that Dr. Zvonarić was a long-time member of the chemistry committee for the research of the Mediterranean (C.I.E.S.M.), of the Croatian Chemical Society and of the scientific council of the ecological association LIJEPA NAŠA (Our Beautiful Homeland).

We will always treasure the memory of Dr. Zvonarić as a good scientist and teacher, and especially as a very kind colleague who would always find time to help others regarding both scientific as well as personal problems

Dr. Grozdan Kušpilić

## BIBLIOGRAPHY OF SELECTED PAPERS

### Papers published in Current Contents and SCI data basis:

1973. ZVONARIĆ, T., V. ŽUTIĆ & M. BRANICA. Determination of surfactant activity of sea water samples by polarography. *Thalassia Jugosl.*, 9(1/2): 65-73.
1976. ZVONARIĆ, T., Z. KOZARAC, V. ŽUTIĆ, B. ČOSOVIĆ & M. BRANICA. Electroanalytical estimation of seawater pollution by organic substances. Analysis of north Adriatic samples. *Rapp. Comm. Int. Mer Medit.*, 23: 55-56.
1976. ČOSOVIĆ, B., V. ŽUTIĆ, T. ZVONARIĆ & Z. KOZARAC. Electroanalytical estimation of seawater pollution by aromatic hydrocarbons. *Rapp. Comm. Int. Mer Medit.*, 23: 57-58.
1977. KOZARAC, Z., T. ZVONARIĆ, V. ŽUTIĆ & B. ČOSOVIĆ. Comparison of some methods for estimating surface active substances in sea water. *Thalassia Jugosl.*, 13(1/2): 109-117.
1979. ZVONARIĆ, T. & V. ŽUTIĆ. Cruises of RV "Vila Velebita" in the Kvarner region of the Adriatic Sea-VI, Electrochemical determination of dissolved surfactants. *Thalassia Jugosl.*, 15(1/2): 113-121.
1980. STAREŠINIĆ, N., R. CHESSELET, C. LAMBERT, N. SMODLAKA, T. ZVONARIĆ & A. BENOVIĆ. Downward flux of particulate matter in the Mediterranean Sea. V<sup>es</sup> *Journes Etud. Pollutions*, pp. 1011-1012.
1983. STAREŠINIĆ, N., T. ZVONARIĆ & BENOVIĆ, A. Particulate organic matter sedimentation in the middle Adriatic Sea. *Thalassia Jugosl.*, 19(1-4): 342-349.
1984. VUKADIN, I., P. STEGNAR, M. TUŠEK, & T. ZVONARIĆ. Heavy metal analysis in sediments and marine organisms of the Bay of Mali Ston and adjacent sea. VII<sup>es</sup> *Journes Etud. Pollutions*, pp. 327-330.
1985. ZVONARIĆ, T. & I. VUKADIN. Intercomparison of the content of some heavy metals in the sea water obtained by different analytical methods. *Rapp. Comm. Int. Mer Medit.*, 29(7): 121-124.
1986. ZVONARIĆ, T., P. STEGNAR & Z. PLANINŠEK. Total mercury and cadmium contents of sediments and mussels from the coastal region of the central Adriatic. Proc. "Environmental Contamination" 2<sup>nd</sup> Int. Conf., Amsterdam. CEP consultants, pp. 306-308.
1986. HORVAT, M., T. ZVONARIĆ, P. STEGNAR & A. PROSENC. Determination of mercury in biological samples: Evaluation and comparison of results obtained by cold-vapour atomic absorption spectrometry (CVAAS) and neutron activation analysis (NAA). Proc. "Environmental Contamination" 2<sup>nd</sup> Int. Conf., Amsterdam. CEP consultants, pp. 138-140.
1986. ZVONARIĆ, T., P. STEGNAR & Z. PLANINŠEK. Total mercury, cadmium, copper, zinc and arsenic contents in surface sediments from the coastal region of the central Adriatic. In: *Rapports et process-verbaux des reunions, Palma De Mallorca. CIESM, Monaco*, 30(2): p. 115.
1986. HORVAT, M., M. ŠKREBLIN, T. ZVONARIĆ & P. STEGNAR. Determination of mercury in sea water by cold - vapour atomic absorption spectrophotometry. In: *Rapports et proces-verbaux des reunions, Palma de Mallorca. CIESM, Monaco*, 30(2): p.116.
1986. HORVAT, M., T. ZVONARIĆ & P. STEGNAR. Optimization of a wet digestion method for the determination of mercury in blood by cold vapour atomic absorption spectrometry (CVAAS). *Vestn. Slov. Kem. Drus.* 33(4): 475-487.
1987. HORVAT M., T. ZVONARIĆ & P. STEGNAR. Determination of mercury in sea water by cold - vapour atomic absorption spectrophotometry. *Acta Adriat.*, 28(1/2): 59-64.
1987. ZVONARIĆ, T. & P. STEGNAR. Total mercury, cadmium, copper, zinc and arsenic

- contents in surface sediments from the coastal region of the central Adriatic. *Acta Adriat.*, 28(1/2): 65-71.
1987. ZVONARIĆ, T., M. HORVAT & P. STEGNAR. Ecological cycle of mercury in the marine environment of Kaštela Bay. *Proc. VI Int. Conf. "Heavy Metals In The Environment"*, New Orleans, USA, 2: 461-463.
1988. HORVAT, M., T. ZVONARIĆ, P. STEGNAR & A.R. BYRNE. Comparison of different methods for total and methyl-mercury determination in marine sediments and mussels. *Proc. "Environmental Contamination" 3<sup>rd</sup> Int. Conf. Venice. CEP consultants*, pp. 393-395.
1988. ZVONARIĆ, T., M. HORVAT & P. STEGNAR. Total and methyl mercury in some fish species from wider region of middle Adriatic. *Rapp. Comm. Int. Mer Medit., Athens*, 31(2): p. 162.
1988. HORVAT, M., P. STEGNAR, Z. BRANICA, T. ZVONARIĆ, A. PROSENC, D. KONDA & M. DERMELJ. Biological monitoring of methylmercury in the Yugoslav population: Hg, MeHg, Se levels in blood, umbilical cord blood, hair and placenta at parturition. *Rapp. Comm. Int. Mer Medit., Athens*, 31(2): p. 162.
1988. VUKADIN, I., T. ZVONARIĆ, L. STOJANOSKI & G. KUŠPILIĆ. Hydrographic and chemical properties of middle and south Adriatic Sea. *Rapp. Comm. Int. Mer Medit., Athens*, 31(2): p. 46.
1989. ZVONARIĆ, T., M. HORVAT & P. STEGNAR. An analytical technique for determination of mercury in the exhaled breath of workers professionally exposed to mercury vapour. *Proc. VII Int. Conf. "Heavy Metals In The Environment" Geneva. CEP consultants Ltd. ISBN 0 905941 37 (3) (vol.1): pp. 636-638.*
1989. HORVAT, M., T. ZVONARIĆ, P. STEGNAR, A. PROSENC, D. KONDA & A. SABADIN. Relation between total mercury, methyl mercury and selenium in fish muscle from the Adriatic Sea. *Proc. VII Int. Conf. "Heavy Metals In The Environment" Geneva. CEP consultants Ltd. ISBN 0 905941 37 (3) (vol.1): pp. 370-373.*
1990. TUDOR, M. & T. ZVONARIĆ. An analysis of mercury levels in the Kaštela Bay (case study), MAP/PAP/RAC/UNEP/PPP/1988 - 89 /YU/ DOC.3C, Split, pp. 1-46.
1991. TUDOR, M., T. ZVONARIĆ, M. HORVAT & P. STEGNAR. Vertical transport of mercury by settling particles in Kaštela Bay. *Acta Adriat.*, 32(2): 753-763.
1992. ODŽAK, N. & T. ZVONARIĆ. The use of the *Mytilus galloprovincialis* foot as biological indicator of lead contamination in coastal waters. *Fresenius Environ. Bull.*, 1: 370-375.
1992. ODŽAK, N. & T. ZVONARIĆ. Effects of weight and age on cadmium and lead levels in foot, gills and the rest of soft tissue of mussel *Mytilus galloprovincialis*. *Rapp. Comm. int. Mer Medit., Trieste. CIESM*, vol. 33: p. 81.
1992. JURETIĆ, I., N. ODŽAK, T. ZVONARIĆ & A. BARIĆ. Cadmium, chromium, lead and manganese content in sediment of the Gruž Bay. *Rapp. Comm. int. Mer Medit., Trieste. CIESM vol. 33: p. 73.*
1993. ZVONARIĆ, T., J. BELAMARIĆ & E. DRAGANOVIĆ. Evaluation of Pantan, an area of particular natural and historical importance with a proposal for its protection and utilization. MAP-CAMP/1990-91/ KAST/SPA/UNEP COASTAL AREA Management Programme "The Kaštela Bay (Croatia)" PAP/RAC Split, p. 62.
1994. ČULIN, S. & T. ZVONARIĆ. Mercury and methylmercury in fish from the eastern central Adriatic. *Acta Adriat.*, 35(1/2): 3-13.
1994. ODŽAK, N., D. MARTINČIĆ, T. ZVONARIĆ & M. BRANICA. Bioaccumulation rate of Cd and Pb in *Mytilus galloprovincialis* foot and gills. *Mar. Chem.*, 46: 119-131.
1995. VUKADIN, I., T. ZVONARIĆ & N. ODŽAK. Fate and distribution of toxic heavy metals in some marine organisms from the Eastern Adriatic Coast. *Helgol. Meeresunters.*, 49: 679-688.
1995. ODŽAK, N. & T. ZVONARIĆ. Cadmium and lead uptake from food by the fish *Dicentrarchus labrax*. *Water Sci. Technol.*, vol. 32(9-10): 49-55.

1995. ČULIN, S. & T. ZVONARIĆ. Content of total mercury and methylmercury in some commercial fish species of the Middle Adriatic area. *Prehrambeno-tehnološka i biotehnološka revija*, 33(4): 133-137.
1996. ZVONARIĆ, T. Ecological study of gas fields in the northern Adriatic: 9. Heavy metals and macroconstituents in sea water. *Acta Adriat.*, 37(1/2): 115-120.
1998. UJEVIĆ, I., D. BOGNER, T. ZVONARIĆ & A. BARIĆ. Trace metal distribution in coastal sediment from the Adriatic Sea. *Fresenius Environ. Bull.*, 7: 701-708.
2000. ODŽAK, N., T. ZVONARIĆ, Z. KLJAKOVIĆ-GAŠPIĆ, M. HORVAT & A. BARIĆ. Biomonitoring of mercury in the Kaštela Bay using transplanted mussels. *Sci. Total Environ.*, 261/1-3: 61-68.
2001. ODŽAK, N., T. ZVONARIĆ, Z. KLJAKOVIĆ-GAŠPIĆ & A. BARIĆ. Biomonitoring of copper, cadmium, lead, zinc and chromium in the Kaštela Bay using transplanted mussels. *Fresenius Environ. Bull.*, 10(1): 37-41.
2002. KLJAKOVIĆ-GAŠPIĆ, Z., T. ZVONARIĆ, N. VRGOČ, N. ODŽAK & A. BARIĆ. Cadmium and lead in selected tissues of two commercially important fish species from the Adriatic Sea. *Water Res.*, 36(20): 5023-5028.
2003. HORVAT, M., J. KOTNIK, M. LOGAR, V. FAJON, T. ZVONARIĆ & N. PIRRONE. Speciation of mercury in surface and deep-sea waters in the Mediterranean Sea. *Atmos. Environ.*, 37(Suppl. 1): 93-108.
2003. MILUN, V., T. ZVONARIĆ & A. BARIĆ. Temporal and spatial distribution of chlorinated hydrocarbons in mussels from the Kaštela Bay (Adriatic Sea). 12<sup>th</sup> Int. Symp. on Envir. Poll. & its Impact on Life in the Medit. Region – Antalya, Turkey, 4-8 October, p. 89.
2003. BILIĆ, I., Z. KLJAKOVIĆ-GAŠPIĆ, T. ZVONARIĆ, B. ANTOLIĆ & A. BARIĆ. Distribution of cadmium and lead in *Posidonia oceanica* (L) *Delile* from the Middle Adriatic. 12<sup>th</sup> Int. Symp. on Envir. Poll. & its Impact on Life in the Medit. Region – Antalya, Turkey, 4-8 October, p. 48.
2003. BOGNER, D., I. UJEVIĆ, T. ZVONARIĆ & A. BARIĆ. Distribution of selected trace metals in coastal surface sediments from the Middle and South Adriatic. 12<sup>th</sup> Int. Symp. on Envir. Poll. & its Impact on Life in the Medit. Region – Antalya, Turkey, 4-8 October. p. 139.
2004. KLJAKOVIĆ-GAŠPIĆ, Z., N. ODŽAK, T. ZVONARIĆ, M. HORVAT & A. BARIĆ. Distribution of mercury and methyl mercury in tissues of transplanted mussels. *RMZ-Materials and Geoenvironment*, 51(2): 1129-1132.
2004. MILUN, V., T. ZVONARIĆ & A. BARIĆ. Mussels (*Mytilus galloprovincialis*) as bioindicator of chlorinated hydrocarbons pollution in the Kaštela Bay (Adriatic Sea). In: *Rapports et proces verbaux des réunions. Rapp. Comm. Int. mer Médit.*, 37: p. 226.
2004. ODŽAK, N., M. MATIĆ, Z. KLJAKOVIĆ-GAŠPIĆ, T. ZVONARIĆ & A. BARIĆ. Bioavailability of mercury in saline waters: field experiment. *RMZ-Materials and Geoenvironment*, 51(2): 1275-1278.
2006. KLJAKOVIĆ-GAŠPIĆ, Z., N. ODŽAK, I. UJEVIĆ, T. ZVONARIĆ & A. BARIĆ. Biomonitoring of trace metals (Cu, Cd, Cr, Hg, Pb, Zn) in the eastern Adriatic using the Mediterranean blue mussel (2001-2005). *Fresenius Environ. Bull.*, 15(9a): 1041-1048.
2006. KLJAKOVIĆ-GAŠPIĆ, Z., N. ODŽAK, I. UJEVIĆ, T. ZVONARIĆ, M. HORVAT & A. BARIĆ. Biomonitoring of mercury in polluted coastal area using transplanted mussels. *Sci. Total Environ.*, 368(1): 199-209.
2006. MILUN, V., D. BOGNER, A. BARIĆ & T. ZVONARIĆ. Distribution of polychlorinated biphenyls (PCBs) in surface sediments from the middle and south Adriatic coastal waters. *Fresenius Environ. Bull.*, 15(9a): 997-1002.
2007. KLJAKOVIĆ-GAŠPIĆ, Z., I. UJEVIĆ, T. ZVONARIĆ & A. BARIĆ. Biomonitoring of trace metals (Cu, Cd, Cr, Hg, Pb, Zn) in Mali Ston Bay (eastern Adriatic) using the Mediterranean blue mussel (1998-2005). *Acta Adriat.*, 48(1): 73-88.

**Selected papers published in secondary publications and proceedings of international congresses:**

1980. ŽUTIĆ, V., T. NOVAKOVIĆ & T. ZVONARIĆ. Adsorption analysis of seawater. Method of polarographic maximum of mercury (II). "J. Heyrovsky Memorial Congress On Polarography", Prague, Czechoslovakia.
1990. KOBAL, A., P. STEGNAR, M. HORVAT, A. SABADIN, T. ZVONARIĆ, N. RUPNIK-HING, N. & E. NANUT. Biological monitoring of mercury in professionally exposed workers (Abstract). Paper present at XII<sup>th</sup> World Congress On Occupational Safety And Health, Hamburg, 6-11 May.
1991. ZVONARIĆ, T. The cycling of mercury through the marine environment of Kaštela Bay. Proceedings of the FAO/UNEP/IAEA Consultation Meeting on the Accumulation and Transformation of Chemical Contaminants by Biotic and Abiotic Processes in the Marine Environment, La Spezia, Italy, 24-28 September, MAP Techn. Rep.No. 59 UNEP, Athens, 1991: 369-381.
1991. KOBAL, A., M. HORVAT, A. SABADIN, T. ZVONARIĆ, N. RUPNIK-HIENG, E. NANUT, P. STEGNAR. Biological monitoring of mercury in professionally exposed workers. Proc. VIII Int. Conf. "Heavy Metals In The Environment", Edinburgh, 16-20 September, 1: 355-358.
1994. ZVONARIĆ, T. Distribution of copper, zinc, cadmium and lead in surface sediments from the coastal region of central Adriatic. Rep. FAO/UNEP Workshop On The Monitoring Of Chemical Contaminants In Marine Biota For Trends, Rovinj, Croatia, 12-15 October, p. 18.
2001. HORVAT, M., J. KOTNIK, V. FAJON, M. LOGAR, T. ZVONARIĆ & N. PIRRONE. Speciation Of Mercury In Waters Of The Mediterranean Sea. 6<sup>th</sup> International Conference on "Mercury as a Global Pollutant"(6<sup>th</sup> ICMGP) - Minamata, Japan, 15-19 October, p. 139.