



Fernando Fraga Rodríguez (Santiago de Compostela, 1922 – Vigo, 2020)

Fernando Fraga Rodríguez entered the world of oceanography in 1953 when he joined the Spanish National Research Council (CSIC) at the *Instituto de Investigaciones Pesqueras* (Institute of Fisheries Research, IIP). From then on, oceanography was the passion to which he applied his innate curiosity and scientific rigour, though he was also fond of medicine, entomology and even watchmaking. At the IIP's Coastal Laboratory in Vigo, Fraga began his work by studying the chemical composition of fish and molluscs using the broad experience he had acquired in the Department of Organic Chemistry of the Faculty of Science, University of Santiago de Compostela, Spain. He won the Extraordinary Prize for the Bachelor of Science, was a scholar of Organic Chemistry at the CSIC's Alonso Barba Institute and worked as an assistant of practical classes of the Organic Chemistry Chair until he defended his PhD thesis on alkaloids (1949, University of Madrid), under the direction of Professor Ignacio Ribas. In 1950 he won a public competition to

become associate professor of Organic Chemistry at the Science Faculty and also faculty secretary. Three years later, he left the University to work as a scientist at the CSIC. He then defined his main research subject in oceanography: the characterization of water masses and the interdependence between the chemical composition of sea water and marine organisms, because "as a chemical oceanographer I use the tools of chemistry to answer oceanographic questions", he said.

One year after his incorporation into the IIP, Fraga started to contribute to knowledge on dissolved and suspended organic material in sea water at the Spanish Meetings on Productivity and Fisheries (Barcelona 1945, 1957, 1960) and his published articles alternated this new scientific subject with the chemical composition of mussels (Fraga 1956a,b, 1958, 1959a, 1963, Fraga and Capont 1958). In these articles Fraga introduced essential stoichiometric considerations in the discussion of farming systems and trophic networks and highlighted the importance

of waste from marine resource processing: mussel-cooking waters.

In the early 1960s, maintaining a good friendship for more than four decades with Ramón Margalef, Fraga studied hydrography and photosynthesis in the Ria of Vigo, with particular attention to the nitrogen cycle (Fraga 1959b, 1960, 1966a, 1967). Although dissolved organic nitrogen is found in low concentrations in seawater, Fraga's technical skills with the Kjeldal method enabled him to quantify it and to detect an inert fraction in the ocean nitrogen cycle. Because of this work, he was invited in 1963 by the US National Science Foundation to take part in the international expeditions to the Indian Ocean (R/V *Anton Bruun* 1964), teaming up with David W. Menzel of the Woods Hole Oceanographic Institution (Fraga 1966b, 1969a). He later repeated this experience on other oceanographic vessels such as the Belgian R/V *Mechelen* in 1965 and the R/V *Magga Dann* in 1967 during the international expedition to the Antarctic and Indian oceans, sponsored by the *Institut Royal des Sciences Naturelles de Belgique* (Fraga 1969a).

Fraga's abilities then went beyond chemistry, into physics and also marine biology and ecology. On board the R/V *Cornide de Saavedra* (1971-1975), he studied the oceanographic conditions of the upwelling area off northwest Africa and described water mass circulation and primary production patterns (Fraga 1973, 1974, Fraga and Manriquez 1975, Manriquez et al. 1979, Manriquez and Fraga 1982, Fraga et al. 1985). He then explored the Galician upwelling by means of a series of multidisciplinary cruises (1977-1986) on board the R/V *Cornide de Saavedra* and the R/V *García del Cid*, researching the links between oceanography and productivity (Fraga 1991, Fraga et al. 1982). These included the Galicia-IV cruise on which he was the campaign leader, bringing together the top Spanish experts in marine chemistry and biology (Fraga, 1978, Manriquez et al. 1978, Fraga et al. 1978). In fact, in the scientific bulletins of the time, the Galicia-IV campaign is called "The Oceanographic Campaign". In his contribution to a book published by the American Geophysical Union (Fraga 1981), he described the front of water masses present in the Finisterre area, which was later called the "Fraga front" in international settings. This was the first conceptual model of transport and mixing between water masses and explained the remineralization of organic matter on the Galician shelf. Fraga's studies on the characterization of water masses and the regeneration of nutrients in the subsurface layer in upwelling regions are current references.

As head of the Oceanology Group of the *Instituto de Investigaciones Marinas* (IIM-CSIC) since 1979 and a skilled Fortran and MATLAB programmer, Fraga measured new sea variables in the northwestern Iberian Peninsula, such as pH and alkalinity (Manriquez et al. 1976, 1978, Fraga and Mouriño 1978, Fraga et al. 1978, Ríos et al. 2001). This provided a record of more than 40 years of data on the acidifica-

tion process and the increase of anthropogenic CO₂ on the Galician coasts (Padín et al. 2020). The object of study was always the Galician rias (Fraga and Margalef 1979, Fraga 1996), and in particular the Ria of Vigo, which Fraga considered a "nearby natural laboratory" (Fraga 1960a, 1967, 1979b, Vives and Fraga 1961a,b, Mouriño and Fraga, 1982). He was a pioneer in introducing the determination of the carbonic system in seawater to study the role played by carbon in primary production (Prego and Fraga 1988, Ríos et al. 1989, Fraga et al. 1999).

In 1987 Fraga joined the Royal Galician Academy of Sciences as a permanent member. The following year he became Emeritus Professor of the CSIC but, true to his words "a researcher never retires". He threw himself into studies that he had started earlier, bringing to fruition about 20 scientific articles between 1988 and 2005. Fraga worked on the modelling of organic matter synthesis and decomposition in coastal ecosystems and studied the elemental composition of phytoplankton to evaluate the impact of different groups of phytoplankton in the consumption and generation of nutrients, carbon and oxygen (Fraga and Pérez 1990, Ríos et al. 1998a,b, Fraga et al. 1992, 1998, 1999, Fraga 2001).

Fraga collaborated in the germination and development of the International Symposium of the Bay of Biscay and the Iberian Seminar on Marine Chemistry. He participated in numerous national and international delegations, such as the Spanish delegation to the Intergovernmental Oceanographic Commission of UNESCO, and lectured on water masses, upwelling and stoichiometry of organic matter in seawater. During this period, he received recognition for his work: he won the Medal of Galicia (1992) and the Antonio Casares Prize for Scientific-Technical Research (1999), both awarded by the Xunta de Galicia, the first Ibero-American Prize for Marine Sciences (1999) awarded by the Association of Deans of Faculties of Marine Sciences for his scientific career and for having carried it out in an Ibero-American country, a Homage at the 2000 Euroconference Water and Life awarded by the organizing committee of the Euroconference of the European Community for the excellence of his scientific career, and a Homage at the 15th Iberian Seminar on Marine Chemistry in recognition of his life in oceanography and his outstanding scientific contributions (heading photo).

Fraga, a quiet, honest and straightforward confrere with measured words and eloquent silences, created a school in the field of chemical oceanography in which he educated young scientists, among them three PhD students, Fiz F. Pérez, Ricardo Prego and Aida F. Ríos, who became research professors at the CSIC. Special witnesses of his scientific example and human quality and his legacy at the IIM-CSIC are those who are now members of the Department of Oceanography and those who have passed away (Carmen Mouriño, Fernando Saiz, Ramón Penín and Aida F. Ríos). Fernando Fraga is now sailing with them: "Eternity begins and ends with the tides of the ocean" (anonymous).

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