Biography

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Mikhail Emelianov, an oceanographer of the seven seas

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Genuine collaboration, strong interdisciplinarity and a positive attitude are, now more than ever, central pillars of successful teamwork. These values have long been embraced by institutions large and small, and marine research institutions are no exception. In recent decades, driven by the magnitude of the challenges facing the oceans, marine science has emphasized the need to work together to share knowledge, skills and information. In the framework of large international and interdisciplinary programmes, democratic and inclusive principles such as open access and shared knowledge have emerged with force. At the heart of these programmes, we find generous marine researchers—ocean lovers committed to nature, science and society.

Mikhail Emelianov is an extraordinary example of a researcher who loves being at sea and working collaboratively within a team—he is truly a sea wolf, an oceanographer of the seven seas. He has sailed through troubled waters in practically every ocean basin and has addressed an enormous variety of topics. These qualities make him a fully collaborative oceanographer, a humble and empathic crew researcher, a team player, and a driving force behind progress in ocean sciences at the Institut de Ciències del Mar (ICM) of the Spanish National Research Council (CSIC).

Over nearly five decades, Emelianov has addressed an extraordinary variety of topics in the fields of marine geology, fisheries, marine ecology, physical oceanography and marine technology. In all cases, he has processed, represented and interpreted field-based physicochemical and hydrodynamic data—often in real time—to provide the environmental context of a myriad of marine processes, including the habitat of marine populations, the interaction between ocean flows and the seafloor, and the fluxes of matter and energy at very different scales.

Emelianov has been a silent but central protagonist at the heart of many projects, learning and sharing generously, and making a key contribution to their success. Over the years he has collaborated and published articles with over 30 senior investigators at the ICM, and with many more in other Spanish and international institutions. Perhaps even more noteworthy, he has always done so with empathy, trust, good humour and generosity, fostering an enjoyable working environment during his time at sea and back in the research lab. In doing so, he has gained the gratitude of many colleagues and the appreciation and recognition of technicians and researchers.

This short article offers a brief—and undoubtedly incomplete—overview of Emelianov's key contributions, as identified by some of his fellow marine researchers at the ICM. It is an admittedly subjective reflection on his career and on the technological, scientific and personal imprints he has left behind—a small token of gratitude from a few of his collaborators on behalf of many more who share his love for the ocean. At his retirement, after his 70th birthday, Emelianov leaves not only a remarkable scientific and technological legacy but also a joy for the ocean and the spirit of teamwork he showed at sea. The following sections offer a necessarily fragmented view of Emelianov's contribution to a wide range of topics. A more comprehensive compilation of his technological and scientific contributions, including the projects and cruises in which he participated, can be found in his ORCID record (https://orcid.org/0000-0002-1459-2911).

THE ORIGINS

Mikhail Viktorovich Emelianov was born in Moscow, then the capital of the Soviet Union, on 25 May 1955. Because several families of exiles from the Spanish Civil War lived in his neighbourhood, he learnt Spanish as the main foreign language in primary school. In 1977 he obtained a degree in Oceanology from Lomonosov Moscow State University and rapidly enrolled as a research-vessel oceanographer with the USSR Hydrometeorological Service in Odessa. Soon after, he started his career at the P.P. Shirshov Institute of Oceanology of the USSR Academy of Sciences in Moscow, in 1979 as an instrument engineer and in 1982 as a tenured scientist and researcher. From 1980 to 1981, he served as a lieutenant engineer in the Department of Hydrometeorology of the USSR Navy, acquiring extensive experience aboard hydrographic and meteorological vessels.

At the Shirshov Institute, perhaps the principal oceanography school in the former USSR, Emelianov participated in several projects led by the institute's researchers (A. Zatsepin, A. Kolesnikov, G.I. Shapiro, A.I. Ginzburg and M. Flint), and especially with the prominent Professor Konstantin Fedorov, exploring the thermohaline fine structure of the ocean. Professor Fedorov was an outstanding Soviet oceanographer whose contribution to physical oceanography significantly expanded the understanding of mixing processes in the ocean. Under Fedorov's guidance, until his sudden death in 1988, Emelianov specialized in mesoscale and submesoscale phenomena and their influence on biological and geochemical variability in water masses (Emelianov and Fedorov 1985, Fedorov et al. 1986, Belkin et al. 1986). During this period, he participated in numerous oceanographic cruises in several ocean basins, especially in the Atlantic sector of the Southern Ocean. In the Scotia Sea, he conducted detailed studies of the thermohaline structure and submesoscale dynamics of the Weddell-Scotia Confluence and the Antarctic Polar Frontal Zone (Emelianov and Kostianoy 1989, Emelianov and Shapiro 1993, Shapiro and Emelianov 1994, Zatsepin and Emelianov 1995). As a result of this research, he obtained a PhD in Geography from the Russian Academy of Sciences in 1993 with a thesis entitled *Fine thermohaline and mesoscale structure of the Antarctic Polar Frontal zone*.

In 1991, during the Twentieth General Assembly of the International Union of Geodesy and Geophysics in Vienna, Emelianov met Jordi Font from the ICM—an encounter that unexpectedly turned out to be the start of a long and successful adventure. In early 1994, after completing his PhD in Moscow, he sent a letter to Font expressing his interest in spending a sabbatical year at the ICM in Barcelona. The research topic was rapidly agreed, but obtaining the funding for the visit took much longer. Finally, by mid-1995, a proposal was submitted to a Spanish fellowship call for "Foreign Scientist and Technologist Stays". The proposal was approved, and in February 1996 Emelianov arrived in Barcelona, marking the beginning of his Spanish venture.

In the 1990s the physical oceanography group at ICM was very small, just a handful of people, but it often received foreign colleagues for short- to medium-term collaborations. These visitors came mainly from Mediterranean countries and from North and South America. Although the group maintained scientific contacts with eastern European countries, especially through the Mediterranean Science Commission (CIESM), this was the first time that a senior physical oceanographer from eastern Europe had landed at the ICM. Emelianov brought his extensive field expertise, opening a door to the vast scientific and technological knowledge developed in Eastern Europe, which was at the time little known in Spain (Fig. 1).

Emelianov's incorporation into the physical oceanography group was almost immediate. The excellent initial impression proved to be accurate: with his open and friendly attitude, he soon built strong relationships not only within the group but also with many colleagues across the ICM. Researchers from various areas of the ICM—es-

Figure 1. A gathering with Eastern European researchers that took place at the Universitat Politècnica de Catalunya in the late 1990s. Emelianov is in the centre surrounded by several of his fellows from the Shirshov Institute, among them Anna Ginzburg who was the wife of the late Professor Konstantin Fedorov (top left inset), together with Harindra Fernando, Paul Linden and José Manuel Redondo (all three at the far right of the photograph).

pecially those who were more involved in fieldwork—soon recognized and benefited from his solid background in descriptive physical oceanography as well as his excellent oceanographic skills aboard research vessels (Emelianov et al. 2000a, Ruiz et al. 2002). His hard work, his friendly and enthusiastic personality, and the high quality of his achievements rapidly turned him into a key figure at the ICM. As a result, several principal investigators at the ICM relied on him for their projects and helped secure funding for successive temporary job contracts, until he obtained a permanent CSIC position in 2013 (Fig. 2).

Over the years at the ICM, Emelianov has been responsible for much of the field work carried out within many Spanish and EU projects encompassing a very large variety of topics under the leadership of M. Demestre, M. Es-

Figure 2. Mikhail Emelianov has always played a central role in the near-real-time gathering, processing and visualization of oceanographic data, sharing his knowledge and experience with technicians and researchers, and particularly with early-career oceanographers. The main photograph shows the group on the SPURS cruise conducted in the central North Atlantic in 2013 aboard the R/V *Sarmiento de Gamboa*. The top right inset shows Emelianov interacting with young researchers during the RETRO-ERZ cruise conducted in the western equatorial Atlantic in 2018 aboard the R/V *Hesperides*.

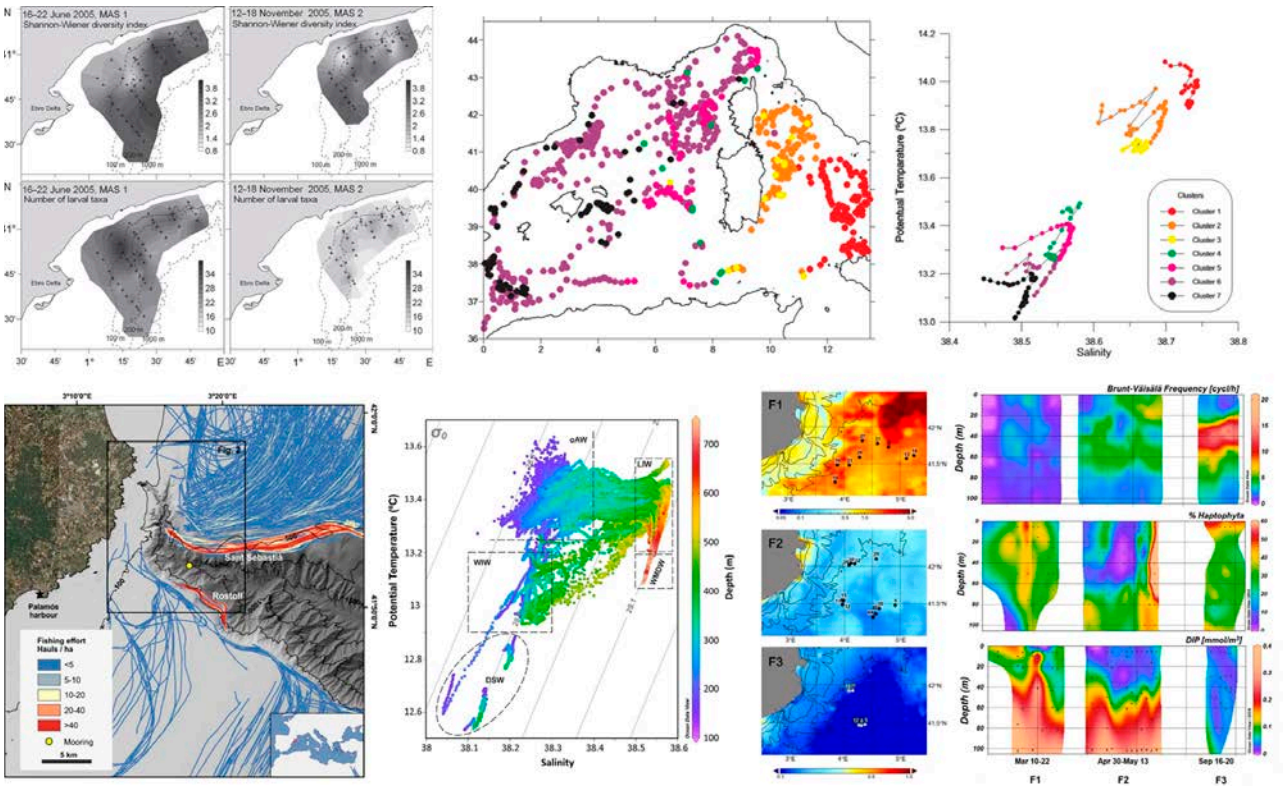

Figure 3. (Top left) Number of taxa and diversity of fish larvae in the Catalan Sea in June and November 2005, reproduced from Olivar et al. (2010). (Top right) Clustering of Levantine Intermediate Waters in the Western Mediterranean in the early 2000s, reproduced from Emelianov et al. (2006). (Bottom left) Bathymetry and fishing effort in the Palamós Canyon in 2017, together with a temperature-salinity diagram for the same period obtained with the Aqualog profiler, reproduced from Arjona-Camas et al. (2021). (Bottom right) Environmental conditions during the FAMOSO cruises, reproduced from Latasa et al. (2022).

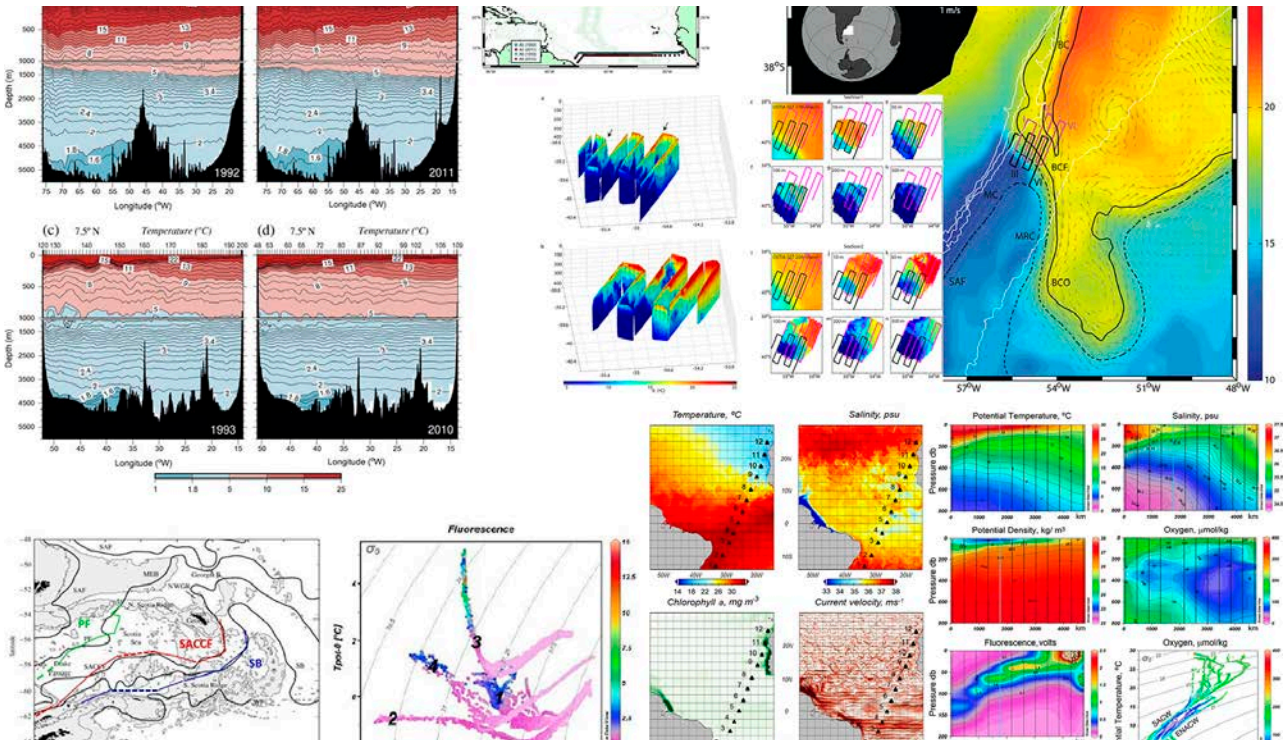

Figure 4. (Top left) Cruise tracks and full-depth transatlantic vertical sections along 7.5°N and 24.5°N in the periods 1992-93 and 2010-11, reproduced from Hernández-Guerra et al. (2014). (Top right) Sea surface temperature and velocity vectors with the undulating SeaSoar vehicle in April 2017; the inset shows the vertical distribution of temperatures along the vehicle's tracks, reproduced from Orúe-Echevarría et al. (2019). (Bottom left) Fronts in the Scotia Sea and fluorescence plotted on the temperature-salinity diagram for the region, reproduced from Dall'Osto et al. (2017) and Nunes et al. (2019). (Bottom right) Distribution of properties at the sea-surface and in a vertical section along an Atlantic latitudinal cruise track in April 2015, reproduced from Olivar et al. (2017).

trada, J. Font, E. García-Ladona, A. García-Olivares, M. Latasa, A. Palanques, A. Sabatés, R. Simó, P. Olivar, J.L. Pelegrí, P. Puig and A. Turiel. Roughly half of his 70 publications have been in physical oceanography and marine technology, while the other half are in the fields of fisheries oceanography, marine ecology and marine geology. Some of the results of his work in the western Mediterranean are illustrated in Figure 3 and those of his work in the Atlantic Ocean are shown in Figure 4.

FISHERIES OCEANOGRAPHY

Mikhail Emelianov has been a key collaborator in many marine ecology projects run by biologists at the ICM, particularly in the field of ichthyoplankton, food web dynamics and fisheries. An enthusiastic colleague both at sea and during data analysis, he is meticulous in data curation and analysis and proactive in identifying and proposing hydrographical variables that could help biologists explain ecological patterns.

Emelianov's expertise in physical oceanography and his insightful comments were fundamental to understanding the spatial patterns of a wide range of organisms and species, from large fish and decapod crustaceans to small phytoplankton, zooplankton, and even viruses. A large proportion of his scientific collaboration with marine biologists focused on how water masses and hydrographical structures influence the ecology and dynamics of nektonic organisms and their prey. He made particularly important contributions to the ecology of ichthyoplankton (fish eggs and larvae), a few examples of which are presented below.

Emelianov helped confirm the physical mechanism by which the hydrographical structure of the Ebro River plume favours the local development of anchovy (*Engraulis encrasicolus*) and sardinella (*Sardinella aurita*) larvae, sustaining enhanced biological production of surface waters during the otherwise low-productivity summer season in the oligotrophic Mediterranean Sea (Sabatés et al. 2009). He also played a key role in identifying how hydrographic variables—particularly temperature, salinity, potential density and dynamic height—shape the mesoscale structures that determine the patchiness of eggs and larvae of hake (*Merluccius merluccius*) (Maynou et al. 2006).

Emilanov's contributions also helped confirm the role of the shelf break front along the Catalan margin, a coast-to-ocean gradient that accounts for the spatial segregation of larvae of mesopelagic fishes from coastal fish communities (Olivar et al. 2010). While waters on the continental shelf along the Catalan margin are stratified in summer, with weak currents and a deep chlorophyll maximum at around 60 m, the autumn conditions are characterized by lack of stratification, a strong northern current and high chlorophyll throughout the water column. Emelianov helped deploy oceanographical instruments—conductivity-temperature-depth (CTD) probes, an undulating CTD vehicle (Nv-Shuttle) and an acoustic Doppler current profiler—to collect, analyse and characterize the hydrography of the water masses. Likewise, he helped biologists to interpret physical concepts and their relationship with larval fish assemblages (LFA), such as the stability of the water column and along- and cross-shelf transports. His work helped explain the structure and dynamics of LFAs and highlighted the contrasting life strategies of larvae of oceanic species, whose dynamics are tightly linked to physical processes, and larvae of coastal species, which are more influenced by the availability of trophic resources.

Emelianov also helped reveal the existence of spatially complex environmental structures and their role in the reproductive success of fish species, such as summer stratification during the spawning and early ontogeny of small pelagic fish species in the Mediterranean, namely sardinella and anchovy. Differential adaptation to oceanographic conditions likely reduces the ecological competition between the two species, as they show different responses to hydrographic parameters during the ontogeny from egg to juvenile (Maynou et al. 2008).

The role of water masses on the ecology of commercially important marine species as adults was also investigated. Emelianov provided data and helped characterize the evolution of the Levantine Intermediate Water mass in the Western Mediterranean (Emelianov et al. 2000b), which has become warmer and saltier since the 1950s. Changes in this water mass inhabited by the deep-sea red shrimp (*Aristaeomorpha foliacea*) resulted in its practical disappearance from the NW Mediterranean. Once abundant in local commercial fisheries before the early 1970s, this species has been captured only occasionally over the last 50 years (Cartes et al. 2014).

Beyond the Mediterranean Sea, Emelianov helped reveal the role of the Eastern North Atlantic Central Water mass in structuring the communities of mesopelagic fish species at transoceanic scales (Olivar et al. 2017). The intricate patterns observed are related to the existence of deep-water oxygen minimum zones, particularly off NW Africa, which favour the persistence of a few highly tolerant mesopelagic species.

MARINE ECOLOGY

Emelianov often explored how the physical ocean environment influenced marine ecosystems, helping decipher water-column processes that have a direct influence on species and communities. His involvement in marine microbiology started in the early 2000s with his contribution to the analysis of marine circulation in the NW Mediterranean during the winters of 1999 and 2000. In 1999, a persistent anticyclonic eddy with low-salinity Atlantic water occupied the centre of the Catalano-Balearic Sea and restricted deep mixing in the region. As a result, in the following winter bloom, the composition of the phytoplankton community in the eddy differed from that found in normal conditions, becoming dominated by flagellates instead of diatoms. These changes led to relatively low chlorophyll *a* concentrations, with profound implications for the functioning of the trophic food web (Estrada et

al., 2004). Emelianov also participated in a study on the enhancement of the phytoplankton and bacterial biomass in the area of influence of the Rhône plume (Berdalet et al. 2004).

Emelianov's involvement in the studies of the phytoplankton populations in the NW Mediterranean continued in March-April 2005 and in the spring and autumn of 2009, when he explored the southwestern part of the Liguro-Provençal basin, a region with depths greater than 2000 m that is typically subject to deep mixing in winter. Estrada et al. (2014) and Latasa et al. (2019) examined the hydrographical and biological variability during these cruises and found that the seasonal trend of increasing stratification between winter and late summer was accompanied by declines in chlorophyll *a* concentration, primary production and nutrient fluxes. In just a few days these variables showed large changes associated with the high mesoscale and submesoscale hydrographic heterogeneity in the region.

Emelianov was also instrumental in interpreting the hydrographic conditions in four contrasting zones of the Atlantic sector of the Southern Ocean in January-February 2015. Several studies arose from extensive field work in which Emelianov played a key role. Nunes et al. (2019) characterized the dominant phytoplankton groups in different zones and assessed the light-stress conditions of the phytoplankton community—which can modulate dimethylsulfoniopropionate (DMSP) and dimethylsulfide (DMS) production—by means of a photoprotective pigment index. This index was positively correlated with the depth of the photic zone, the concentration of DMSP per unit chlorophyll and the DMS/DMSP ratio. Sotomayor-García et al. (2020) assessed viral abundance and composition, finding that their abundance was positively correlated with temperature, as well as with phytoplankton and prokaryotic abundance. These authors also found that viral communities, determined by a randomly amplified polymorphic DNA–polymerase chain reaction, could be grouped according to sampling zone, suggesting that different environmental situations select different hosts for viruses. Zamanillo et al. (2019) investigated the horizontal and vertical distribution of transparent exopolymeric particles (TEPs) and found that their abundance was affected by phytoplankton composition, proximity to sea ice and exposure to solar radiation. TEPs were generally enriched, relative to biomass, in the upper 10 cm of the water column, suggesting either upward transport or higher production at the water surface, possibly driven by light stress. Finally, Dall'Osto et al. (2017) showed that the microbiota associated with sea ice could be a significant source of atmospheric low-molecular-weight alkyl-amines and other organic nitrogen compounds.

In one of his last publications with biologists (Demestre et al. 2024), Emelianov ventured into the benthic realm, focusing on the characterization of Mediterranean maërl, a threatened habitat of high conservation value. Field sampling was done with a submarine remotely operated vehicle fitted with diverse sensors (including pressure, temperature, salinity and oxygen), which complemented the data obtained at hydrographic stations and aboard the vessel. Emelianov's technological expertise was key in setting up the sensors and in downloading and processing the data, effectively becoming the biologists' eyes for better understanding the marine physical environment.

MARINE GEOLOGY

Emelianov has also contributed substantially to our understanding of the hydrodynamics and sedimentary dynamics in submarine canyons. He first became involved in a large field effort that included participation in cruises and the interpretation of data from several instrumented moorings deployed between March and November 2001 in the Palamós (La Fonera) submarine canyon. He helped identify the canyon's hydrographic structure associated with increased suspended sediment concentrations, which led to the definition of two distinct domains: the upper canyon, from the head down to about 1200 m depth, which is strongly influenced by canyon confinement and enclosed circulation, and a deeper domain where circulation is more affected by the mean geostrophic flow linked to the shelf-slope density front. The study also recorded high near-bottom downward total mass fluxes and sharp increases in turbidity along the canyon axis, which were attributed to sediment gravity flows triggered by resuspension from bottom trawling activities along the canyon flanks (Palanques et al. 2005).

Emelianov also contributed to the study of other important sediment transport processes, such as the formation of deep dense water during unusually dry, extremely cold and very windy winters, which affect the deep-water thermohaline properties of the NW Mediterranean. During these events, open-sea convection takes place, with surface waters reaching the deep slope almost simultaneously with the onset of dense shelf water cascading episodes through the submarine canyons of the Gulf of Lions (Font et al. 2007). Emelianov participated in the analysis of deep CTD casts collected in the Western Mediterranean from 1998 to 2011, documenting the role of dense shelf water cascading in transporting suspended particulate matter from coastal regions down to the deep basin (Puig et al. 2013). These results revealed that the Western Mediterranean Deep Water can be periodically affected by the arrival of new dense waters laden with suspended particles, a key process that could ultimately affect deep-sea biogeochemical cycles in the Western Mediterranean.

Emelianov acted as a liaison with his Russian colleagues at the Shirshov Institute to acquire an Aqualog profiling carrier (Ostrovskii et al. 2013) for the ICM. This device can go up and down along a mooring line carrying several oceanographic probes to obtain time series of hydrographic profiles. It was first deployed in the Besós submarine canyon (Solé et al. 2016), providing a unique data set on the vertical evolution of water-column characteristics with unprecedented fine-scale spatial and temporal resolution. A subsequent deployment was conducted in the Foix submarine canyon (Arjona et al. 2019) to study the evolution of the distribution of suspended particulate matter throughout the water column and the formation of intermediate and bottom nepheloid layers caused by bottom

trawling-induced resuspension. Emelianov also participated in the deployment of the Aqualog profiler along with other instrumented moorings in the Palamós submarine canyon to study both natural and human-induced processes influencing sediment transport within this canyon. The results documented the conditions leading to increases in turbidity and sediment fluxes during major storms and dense shelf water cascading events and, notably, associated with bottom trawling along the canyon flanks (Arjona et al. 2021).

PHYSICAL AND TECHNOLOGICAL OCEANOGRAPHY

Emelianov's arrival at the ICM marked the start of a strong collaboration with Russian oceanographic institutions, particularly the Shirshov Institute. This collaboration opened a period of productive joint scientific and technological initiatives fostered through visits by professors A.G. Zatsepin and A. Ostrovskiy (at the time Deputy Director of Marine Engineering at Shirshov) and by the student V. Kremenetskiy (now Deputy Director for Ocean Physics at Shirshov-Moscow). These exchanges led to joint Spanish-Russian research projects and brought ICM technicians and researchers in contact with a range of new approaches and technologies for studying ocean processes.

Emelianov also helped initiate laboratory modelling at the ICM using a rotating platform (e.g. García-Ladona et al. 2003, Gómez et al. 2004, Stroganov et al. 2004) and introduced new observation platforms such as the Aqualog profiler to gather data on small-scale processes and variability (Emelianov et al. 2013, Solé et al. 2016). He contributed to field work for calibration and validation of the first long-running satellite initiative to measure sea surface salinity—the Soil Moisture Ocean Salinity (SMOS) mission (Emelianov et al. 2003)—and developed new sensors to retrieve data from the top centimetre of the sea surface. His interest in new observational technologies is clearly exemplified by the design of a tethered profiler for sampling hydrographic and optical properties (Ostrovskii et al. 2022) and by his work as editor of the special volume on *Technological Oceanography* together with Professor G.I. Shapiro (Emelianov and Shapiro 2024).

Emelianov's colossal work at sea is one of his most defining traits. His participation in 72 cruises—nearly eight full years at sea—clearly proves that, above all, he is a field oceanographer. Many of these cruises were part of interdisciplinary projects in which he provided essential environmental characterization, while others focused on physical processes spanning a wide range of spatial and temporal scales across numerous ocean basins.

During his period at the Shirshov Institute, he participated in projects that explored fine structure, frontal systems, mesoscale structures, eastern boundary currents and intermediate waters. During these initial years, Emelianov participated in 13 cruises on large oceanographic vessels such as the *Ernst Krenkel*, *Yakov Gakkel*, *Professor Shtokman*, *Akademik Kurchatov*, *Vozrozhdeniye*, *Sergei Dorofeev* and *Akademic Ioffe*. These cruises—some of them several months long—took him to the Black, Barents, Norwegian and Bering seas, and to the North Atlantic, West Indian, Pacific and Southern oceans.

With this extensive field experience, Emelianov became pivotal in implementing field-based physical oceanography activities at the ICM. In the second half of the 1990s, he joined cruises in the western Mediterranean aboard the Spanish research vessels (R/Vs) *Hesperides* and *García del Cid* and the French *Le Suroit*. During the 2000s, he continued participating in Mediterranean cruises, but his activities expanded to the North Atlantic, Southern and Pacific oceans aboard the Spanish R/Vs *Hesperides*, *Cornide de Saavedra*, *García del Cid* and *Sarmiento de Gamboa*, as well as the German R/Vs *Meteor* and *Poseidon*. During the 2010s and 2020s, he was a frequent participant in cruises aboard the R/Vs *García del Cid*, *Hesperides* and *Sarmiento de Gamboa* in the Mediterranean Sea, the North and South Atlantic and the Southern Ocean.

The range of physical oceanography topics addressed during these cruises was extraordinary, including circulation in the Western Mediterranean basin, mesoscale structures and frontal systems, oceanic seamounts, eastern boundary currents, shadow zones, tropical and equatorial oceanography, South Atlantic western boundary currents, thermocline structure in the North Atlantic, the Humboldt Current, Atlantic Meridional Overturning Circulation and deep-water formation in the Southern Ocean. As a result, Emelianov effectively contributed to many collaborative articles, often taking responsibility for real-time gathering and processing of the field data as well as the subsequent validation and analysis of results.

In addition to Emelianov's many contributions as a team member, he also led several innovative initiatives. One of these was demonstrating the potential of the Argo programme, using drifting profilers deployed in the western Mediterranean, to explore the "discrete-continuous" thermohaline structure of intermediate waters in the Western Mediterranean (Emelianov et al. 2006). The second was the use of high-resolution sea surface temperature to detect meddy-like anomalies in the Canary Basin, combining remote sensing with field data from a cruise on which he was the chief scientist (Emelianov et al. 2012).

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