PRIMO-0 and related experiments

Claude MILLOT

Antenne COM-CNRS, BP 330, 83507 La Seyne-sur-Mer, France.

The PRIMO programme was initiated to coordinate the dynamic oceanographic studies conducted in the western Mediterranean Sea. Its objective is a better understanding of the circulation with emphasis on its seasonal variability. Most of the results obtained up to now from the programme's first experiment PRIMO-0, conducted in 1990-1991, as well as from some more recent experiments and theoretical works dealing with the general circulation, have been collected in this special issue to mark the first 10 years of existence of PRIMO.

The Intergovernmental Oceanographic Commission (IOC) of UNESCO held a workshop in Venice (23-25 October 1985) for the purpose of setting out the baselines for a future programme on the dynamic oceanography of the western Mediterranean Sea. It clearly emerged from that meeting that the prime goal should be to gain a more thorough understanding of the general circulation and its variability. Since most of the teams were engaged at that time in ongoing programmes, no further meetings were held for some two years. There was, however, a growing determination to embark on properly co-ordinated international action. A select group composed of both experimentalists and modelers met on three occasions in 1987 and discussions were widened to include other colleagues at La Spezia (29-31 March 1988). These meetings resulted in the drawing up of an International Research Programme in the Western Mediterranean (PRIMO in Italian, French and Catalan). The basis and strategy for PRIMO were set out in detail in preparatory documents (IOC/INF-772, Paris, 30 September 1988 and 25 May 1989). The programme was then also supported by the International Commission for the Scientific Exploration of the Mediterranean Sea (ICSEM). Both IOC and ICSEM provided funds for meetings, which allowed us to build up a homogeneous international group possessing the weight necessary to obtain backing from our national institutions.

Our strategy aims at focusing efforts on both experimental and theoretical studies dealing with some of the main phenomena underlying the circulation in the western Mediterranean, in order to answer specific questions such as, for instance: is the winter dense-water formation more efficient than wind stress in driving the circulation in the north ? or what mechanisms are instrumental in generating mesoscale turbulence in the south ? The approach adopted is an ambitious one, as it calls for very close interactions between observations and models. Indeed, data analysis can only permit the description of phenomena, the suggestion of relationships between parameters and the proposal of working hypotheses. Equations are needed then to demonstrate the relationships definitively and to obtain a clear understanding of the phenomena. Nevertheless, it was not easy task to get experimentalists and modelers to listen to one another. In this respect, I believe the PRIMO group to be an example of efficient relationships.

Now, let me comment on the two questions mentioned above and consider that, as in the case of most geophysical sciences, our knowledge is primarily based on observations. In some of the western Mediterranean basins, such as the Ligurian Sea, the Gulf of Lions and the Catalan Sea, the main features of the circulation, which is basically cyclonic along the slope, were correctly described long ago, thanks to the large number of observations made and the relatively stable nature of the circulation itself. Even so, this does not mean that the driving mechanisms can be easily understood as, according to models, all the potential mechanisms hitherto identified, such as wind stress, dense-water formation and density difference between these basins and the Tyrrhenian Sea, lead to a cyclonic circulation of surface water. In other instances, for example in the Algerian Basin, the space-time variability due to mesoscale structures makes it difficult to give a proper description of the circulation on the basis of the few existing data. This leads to an extreme situation where some colleagues believe the intermediate waters to flow eastwards along the Algerian slope while others claim that they are flowing westwards! It is clear that, before addressing the mesoscale, the mean paths of the water masses must first be defined. Uncertainties are thus relatively large and numerous so that, to obtain a definite understanding of the circulation, these questions must be prioritized.

As the Mediterranean Sea is a machine which basically transforms Atlantic into denser ones waters, mainly during the winter, we decided to launch PRIMO with studies concentrating on a better understanding of the seasonal variability of the circulation. Because these transformations mainly occur in the northern regions, which are also

those where the largest amount of data and efficient models is available and where most of the teams with efficient experimental means are located, the programme's first operation, PRIMO-0, was initiated there in 1990-1991. Now, the same questions about the seasonal variability of the circulation are to be answered in the southern part of the sea, as well, where the mean paths have also to be defined. Thus, a second operation, PRIMO-1, was begun in 1993-1994.

According to the available observations and models, it is clear that the transport increases more or less during the winter; consequently, PRIMO-0 mainly focused on the period December-May (1990-1991). About 60 current meters (5 of which were Acoustic Doppler Current Profilers), plus tide gauges and sediment traps, belonging to teams from France, Germany, Italy, Monaco and Spain, were set in place in the Channel of Corsica and in the central part of the Ligurian Sea, as well as in the vicinity of Nice (where a CTD survey was also carried out twice monthly), and in the Channel of Ibiza. In summary, PRIMO-0 has deployed, in a unique effort for a unique scientific purpose, about twice as many current meters as any other experiment to date in the Mediterranean Sea.

Obviously, a definitive understanding of the basic functioning of the Mediterranean Sea cannot be obtained from a single experiment, especially as some data remain to be analysed, and closer comparisons made between data and models, and as we are gradually realizing how large the variability is from year to year. Nevertheless, we have the feeling that collecting the largest possible data set with a unique and common objective has proved to be a very efficient strategy. Moreover, we have worked in a spirit of friendly cooperation and close collaboration. For instance, French, Italian, German and Spanish instruments were deployed in the vicinity of Nice by a French ship during PRIMO-0, and the measurements collected there have been analysed mainly by a French student. Similar concerted actions have been organized for PRIMO-1, although naturally in a different order of responsibilities and between a larger number of teams. This is certainly one of the most important outcomes of the programme!

The same spirit probably incited several colleagues who did not participate in the PRIMO-0 experiment to publish their works together with ours in this special issue. Let me specify that even the colleagues with whom we disagree on some specific points have been sincerely welcome ! The instilling of such a spirit in a wide community is also one of the aims of the various initiatives conducted by the European Commission within the framework of Marine Science and Technology (MAST) and, in this regard, PRIMO and MAST overlap. Now, when we compare our relationships and the discussions held at the beginning of PRIMO in 1985 with those existing in early 1995, with the elaboration of the MAST-3 proposals, there can be no doubt that things have evolved in a very positive fashion, spurring us to increase our collaboration still further.

Acknowledgements

I would like to thank the following laboratories and institutions which have helped their teams to participate in PRIMO-0:

- Cabinet d'Etudes Techniques Industrielles et d'Innovations Scientifiques, Aix-en-Provence, France;
- Centre d'Essais de la Méditerranée, Le Levant, France;
- Centre d'Océanologie de Marseille, Marseille and La Seyne, France;
- Centre Scientifique de Monaco, Monaco;
- Centro dell'Energia Nucleare e delle Energie Alternative, La Spezia, Italy;
- Instituto de Ciencias del Mar, Barcelona, Spain;
- Instituto Espagnol de Oceanografia, Palma, Spain;
- Institut für Meereskunde, Kiel, Germany;
- Laboratoire d'Océanographie Dynamique et de Climatologie, Paris, France;
- Laboratoire de Sédimentologie et de Géochimie Marines, Perpignan, France;
- Stazione Oceanografica, La Spezia, Italy;
- Telespazio, Rome, Italy.

Support was also received from:

- Centre National de la Recherche Scientifique, France;
- Consejo Superior de Investigationes Cientificas, Spain;
- Consiglio Nazionale delle Richerche, Italy;
- Laboratoire d'Océanographie Physique du Museum National d'Histoire Naturelle, France;
- Institut Français de Recherche et d'Exploitation de la Mer, France;
- Institut National des Sciences de l'Univers, France;
- Service Hydrographique et Océanographique de la Marine, France.

The help of the sponsor organizations, IOC/UNESCO and ICSEM, has also been very much appreciated.