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PROJECT TITLE: Dynamic Exchange Measurements Through the Straits of Gibraltar and Sicily.
(Final Report)
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LONG TERM GOALS

The main goal of this research is to further our understanding on the dynamics of straits and their role in determining the dynamic characteristics of the basins they interconnect. In particular the Straits of Gibraltar and Sicily have a profound effect on the way the Mediterranean Sea responds to tidal and atmospheric forcings, quantifying and understanding the fluxes and structure of the flows through both Straits will permit us to model them correctly in future studies.

OBJECTIVE

The specific objectives of this research effort are: (a) Obtain long-term (>two-year) measurements of fluxes through the Strait of Gibraltar, (b) determine if the hydraulically controlled exchange at Gibraltar is always maximal, or switches at times to a submaximal showing evidence of a seasonal cycle in the exchange, (c) determine if the PTC and/or sea surface gauge array can be used for long-term monitoring of the surface flow through both straits, and (d) investigate the relation between the barotropic and baroclinic exchanges through the Straits of Gibraltar and Sicily and their effect on the circulation of the Mediterranean Sea.

APPROACH

The experimental design, as described in the original proposal, has consisted of three deep moored instrument sites in the Strait of Gibraltar: Two at the Camarinal Sill in 300 m of water; a bottom mounted ADCP and a conventional string mooring with a combination of Aanderaa current meters and Seacats measuring currents and temperature, conductivity and depth, and a mooring with 7 Aanderaa current meters installed at the center of the Strait between Algeciras and Ceuta at a depth of 900m. These deep moorings have been complemented by an array of four swallow pressure, temperature and conductivity (PTC) recorders at Pta. Camarinal, Tangiers, Ceuta and Pta. Carnero and an array of conventional sea level gauges, run by the Instituto Espanol de Oceanografia, at Malaga, Ceuta, Algeciras, Tarifa and Cadiz. In the Strait of Sicily there were two shallow pressure sensors across the Strait one in Mazara del Vallo, Sicily and one in Cape Bon (Ras El Tib) Tunisia, both at a depth of about 7 m. The measurements started in April/94 and ended in October/96. All instruments were serviced every six months.

TASKS COMPLETED

We finished our last recovery operation in October 1986 on board the Spanish Navy Hydrographic Ship Tofino. All the data has been checked and calibrated and is now being analyzed. We have prepared a data report that will be published by the Spanish Hydrographic Institute before the end of the year.

RESULTS

Although the main analysis is far from completed there are some interesting results starting to appear now. One of the most interesting ones is that a two-year time series of exchange through the Strait of Gibraltar shows no appreciable seasonal cycle Figure 1. However it is not clear yet if this lack of seasonal variability is being controlled at the Strait or is something imposed by the intrinsic Mediterranean Sea response to atmospheric forcing.

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IMPACT(S) FOR SCIENCE & TECHNOLOGY AND/OR APPLICATION

These new observations resulting from our observation in the Straits of Gibraltar and Sicily will help us reformulate our present models and conceptions of the dynamics of these important Straits and their role on the circulation of the adjacent basins they inter-connect.

RELATIONSHIP(S) TO OTHER PROJECTS OR PROGRAMS

Originally this program was done in coordination with the PRIMO-1 project, i.e. a two-year program (94-95) sponsor by the European Community to study the Western Mediterranean. Within PRIMO-1 concurrent current meter measurements have been done in the Corsican, Sardinian and Sicilian Channels, as well as a tomographic experiment in the Western Mediterranean Basin. We are in contact with our European colleagues (Claude Millot, Marseilles, France, Mario Astraldi and Gian-Pietro Gasparini, La Spezia, Italy and Uwe Send, Kiel, Germany) doing inter-comparative work between the different measurements gathered during this experimental period. In particular in collaboration with Gian-Pietro Gasparini we are calculating fluxes through the Strait of Sicily combining their current meter and our pressure sensor measurements.

Uwe Send from Kiel, Germany and Peter Woster from SIO did an ONR sponsored tomographic experiment within the Strait of Gibraltar in April 1996 in which we participated on board the R/V Poseidon. As part of the cruise activities, extensive shipboard ADCP measurements were done throughout the Strait. Relevant to our sill moored measurements were 12 consecutive across-strait crossings over the Camarinal Sill (Figure 2), which have revealed the rich across-strait current structure variability and have helped us do a better job at estimating transports from our central sill moored measurements. Also as part of this collaboration Uwe Send and Jesus Garcia La Fuente from the University in Malaga, Spain, provided two extra moorings, one to the North and one to the South of our eastern section (Algeciras-Ceuta) central mooring, from October 1995 to April 1996.

The results and information derived from these measurements are also being used in our modeling of the Mediterranean Sea within the ONR sponsored project "Response of Semi-Enclosed Seas to Atmospheric and Tidal Forcings". They have proved to be essential in understanding how to imposed the strait conditions to properly "open" the Sea to the exterior Ocean Basin.

PRESENTATIONS

- Candela, J., A. Ruiz, R. Limeburner and J. Rico, 1995. Recent flow observations in the Strait of Gibraltar. Rapport du XXXIVe Congres de la CIESM. La Valette (Malte). March 27-31, =20 34, 172, (abstract).
- Candela, J., 1996. The "Mad-Sea" Phenomenon in the Strait of Sicily Coastal Zone Canada '96, Rimouski, Quebec, Canada. 11-17 August, 1996, 37 pp., (abstract).