Results of Cooperative Investigations — A Pilot Study of the Eastern Gulf of Mexico

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INTRODUCTION

The Loop Current of the eastern Gulf of Mexico is a mesoscale, hydrodynamic, temporal and spatial dependent phenomenon. In general terms, it might be described as a "river of Caribbean water" entering through the Yucatan Channel and proceeding northward into the eastern Gulf of Mexico, wherein it turns eastward in a semi-circular course until it flows southward along the western continental shelf of Florida to re-enter the Florida current in the Straits of Florida.

Over the last 30 years this "river" has been studied mainly by the physical oceanographers as a series of individual, independent cruises, rather than coordinated, cooperative, near synoptic investigations. A review of past studies indicates that this "river" may have eddies, which break off along its westward boundary to enter the western Gulf of Mexico. However, the extent and number of these eddies, their structural details, and their continuity throughout the year will require a more systematic, snyoptic type of approach. Too, if the varied effect of this "river" on the overall environment of the Gulf of Mexico is to be understood, additional studies must be conducted of an interdisciplinary, multiple-ship, cooperative nature.

Heretofore the current structure has been characterized by the classical definitions of geostrophic calculations, since adequate direct current measurements are extremely difficult and expensive to conduct. These calculations, as is true with many scientific methods, have inherent reservations which are dependent on the existing accepted methods, state-of-the-art of available equipment or instrumentation and operational factors. Ideally these calculations should be based on data where temperature is measured to within $\pm$ 0.02C and salinity within $\pm$ 0.03 parts per thousand ($^{o}/_{oo}$); with their profiles measured *in situ* and all relevant measurements made snyoptically. While oceanographic stations can generate this accuracy, only STD systems can provide *in situ* measurements.

Except for micro scaled pilot studies, no major attempts have been made to determine the structure and features of the Loop Current other than by the oceanographic station type of physical oceanography. No integrated, near-synoptic, interdisciplinary examinations have been made which would allow the inter-relationship of current with the other environmental features of the Gulf of Mexico.

During 1970, a set of unique conditions occurred which resulted in three such interdisciplinary studies of the Loop Current phenomenon. We feel these might be used as pilot studies for future interdisciplinary projects; too, they have served to generate background data for future detailed investigations in the field of physical, biological and chemical oceanography in the area. Members of the

U.S. Planning Group for Cooperative Investigations of the Caribbean and Adjacent Regions (CICAR) officially assigned the acronym EGMEX '70 to these expeditions. The conditions are: (1) The existence, in the State of Florida, of a coordinated oceanographic program and an agency, the State University System Florida Institute of Oceanography (SUSIO), to support cooperative activities between the various oceanographic activities in the State of Florida, with other oceanographic institutions outside of the state and at the federal level. (2) The ability to conduct the required coordinating activities at the working scientist level rather than the administrative level. This is, and was, vital. (3) The application in the planning of EGMEX of a total data management approach to the operation, data reduction and data documentation stages of the program. (4) The existence of a number of actively, or planned to be, funded individual projects to study this phenomenon. (5) The increasing awareness, within the universities, of the need for training graduate students in the requirements, problems of, and need for interdisciplinary programs.

EGMEX '70

EGMEX I '70

Under the State University System's FY '70 program, Dr. James I. Jones, Florida State University (FSU), submitted to SUSIO a proposal entitled, "Characterization, Definition, and Distribution of Selected Water Masses and Currents in Eastern and Central Gulf of Mexico and the Western Straits of Florida." This project required sampling across the Loop Current. Realizing the operational and financial limitations customarily imposed on the geostrophic method, he proposed to surmount these in part by using a biological indicator approach. Biological indicators were to be used in conjunction with geostrophic calculations to define the structure and location of the Loop Current.

In the past, Dr. Jones has related biological indicators to the results of direct current measurements in the Equatorial Atlantic undercurrent. This work has clearly shown that the concentrations of certain Foraminifera define the existence and location of the Equatorial Atlantic undercurrent (Jones, 1967, 1969). He has conducted a series of cruises on the Florida west coast continental shelf (Florida Middle Ground, 28° 30' N; 84° 20' W), in the Straits of Florida, and in the western Caribbean, which indicate that the same techniques could be used to define the location of the Loop Current (Jones, 1968). Based on the scientific merit of his proposal, it was approved by the Board of Regents Proposal Evaluation Panel for ship time, and his study was assigned to the R/V *Tursiops* (SUSIO FY '70 Program).

Dr. Jones, realizing that the study would require extremely close spatial sampling and near synoptic observations, requested that SUSIO attempt to arrange a multiple-ship operation across the Loop Current for this purpose. Fortunately, a series of events occurred which allowed SUSIO to arrange this: May 1-12, 1970, EGMEX I; June 1-14, 1970, EGMEX II; and October 24-November 2, 1970, EGMEX III. A listing of the vessels and their institutions or operating agencies, scientific parties, and industrial support is presented in Table 1.

Dr. Eugene Corcoran, University of Miami (UM), over the past decade, has been conducting a study of the discharge of trace elements and insecticides of the major river systems of the world. The final study in this series, the

Mississippi River, was scheduled for April-May, 1970, using the University of Miami's R/V *Pillsbury*.

Dr. Corcoran, during the EQUALANT cruises, had indications that the trace elements could be used as identifiers of the Equatorial Atlantic undercurrent. Based on these past observations, he believed that if the discharge from the Mississippi River was entering into the Loop Current the trace elements might be used as an indicator of this occurrence.

As a member of the SUSIO FY '70 Proposal Evaluation Panel, he was aware of Dr. Jones' proposed study. And, since he had in the past participated in interdisciplinary studies with Dr. Jones in EQUALANT, he recognized the mutual gains that would result from a similar cooperative investigation of the Loop Current in the eastern Gulf of Mexico. He stressed to SUSIO the importance of such a study and agreed to participate in it if adequate ships could be rallied for the purpose.

TABLE 1
Participants in EGMEX '70 [1]

Vessel	Cruise	Operating university or agency	Scientific party
Alaminos	I–II–III	Texas A & M University	Texas A&M–FSU
Discoverer	I–III	National Oceanic and Atmospheric Administration	NOAA - FSU
Gulfstream	I–II–III	Nova University	Nova
Hernan Cortez	I–II	Florida Department of Natural Resources	DNR-NMFS-FSU
Island Waters	I–II–III	National Youth Science Foundation	SUSIO-USF-FSU HTI-UWF-NMFS
Joie de Vivre	I–III	Florida Institute of Technology	UF-UWF-FSU–HTI-NMFS
Peirce	III	National Oceanic and Atmospheric Administration	NOAA
Pillsbury	I	University of Miami	UM-AOML-FSU-HTI-NSF
Tursiops	I–III	Florida State University	FSU-UM
Virgilio Uribe	III	Mexican Government	Mexican Government

[1]The following organizations participated in EGMEX by loan of equipment or personnel not shown in Table 1: Bissett-Berman Corporation, CM2 Incorporated, General Oceanics and Mote Marine Laboratory.

During the period of discussion with Drs. Jones and Corcoran, SUSIO arranged with the National Youth Science Foundation (NYSF) to use its 82-foot *Island Waters* in the State University System of Florida Cooperative Oceanographic Teaching and Research Program. SUSIO then planned a three-ship operation.

SUSIO realized that in a cooperative investigation of this nature the density parameters, i.e., temperature and salinity, would represent a common environmental boundary condition to each of the interdisciplinary approaches. For this reason it was imperative that a thorough descriptive analysis be made of the geostrophic calculations and temperature and salinity distributions. SUSIO

contacted Dr. Saul Broida (UM) to determine if he would coordinate such a descriptive endeavor under his Office of Naval Research (ONR) funding. He expressed an interest, as an extension of his study of the Florida current, and requested permission to discuss the entire study with Dr. John Cochrane, Texas A & M University (TAMU) (a longtime investigator of the current), as he knew that the R/V *Alaminos* would be operating within the eastern Gulf of Mexico and Caribbean during the time of the proposed study. This type of response, incidentally, is a prime example of the benefits of coordinating at the individual working scientist's level. Dr. Cochrane realized that the simultaneous operation of four ships across the Loop Current represented a unique opportunity to obtain a near synoptic description of the density field. He agreed to participate in the program and assist in the geostrophic description of the Loop Current. He also agreed to conduct the necessary biological and chemical sampling in support of the interdisciplinary studies in return for the logarithmic increase in density measurements.

At this stage in the development of EGMEX, it was realized that a critical mass of vessels and personnel had been reached which would result in a major interdisciplinary study. SUSIO therefore arranged a meeting of the scientists in St. Petersburg to agree on: the necessary pre-planning responsibilities; a common environmental sampling program; proper documentation of the data collection methods; standard data reduction techniques of the common sampling program; and a definition of the responsibilities of the individual investigators in the final scientific analysis of the EGMEX data.

The scientists agreed on the necessity of a synoptic determination of the density field of the current. In order to get this as near synoptic as practical, they agreed to conduct a rapid STD survey. The resulting description of the density field could enhance the proper sampling of the biological and chemical parameters of the current by a follow-up survey. This would allow the geographic and vertical locations of these samples to be based on temperature and salinity distribution and on the major inflection points of their vertical profiles. In short, the biological and chemical sampling would be directly related to the geographical location and the physical properties of the current.

To assure that these data were actually collected at these critical points, it was agreed that the sampling depth would be based on STD lowerings. Biological sampling was to be conducted at selected inflection points by flights of six plankton nets fitted with opening and closing devices. Water samples were to be collected by 12 to 14 Niskin bottle casts at the major inflection points for oxygen, inorganic phosphate, insecticide and trace element analysis. As an example, the resulting data would then allow both Drs. Corcoran and Jones to inter-relate their individual studies with supplemental data of the density field. It would allow studies of the current, using data from geostrophic calculations and the distribution and concentration of both biological indicators and trace elements.

To reduce the loss of data due to improper STD sampling locations, it was decided that SUSIO should contact the U.S. Coast Guard (USCG) and request Airborne Radiation Thermometer Program (ART) overflight support. Examination of existing historical data from the National Oceanographic Data Center (NODC) files indicated a clear probability that the distribution of the surface isotherms in May could, in fact, depict the boundary conditions of the Loop Current. SUSIO was successful in obtaining USCG aircraft support operations during the period April 24-May 13, 1970.

At the completion of the meeting, SUSIO realized that the unique sampling

techniques and coverage would generate data of unusual importance to a number of organizations thus far not associated with this Loop Current study. Individual briefings were scheduled with the State of Florida Department of Natural Resources (DNR), National Oceanic and Atmospheric Administration (NOAA), Atlantic Oceanographic and Meterological Laboratories (AOML), National Marine Fisheries Service (NMFS), Hydrospace Technical Institute (HTI) of Florida Institute of Technology (FIT) and Nova University to explain this study of the Loop Current and the potential of the resulting data and samples for each of their organizations. From these briefings a number of agreements were made which resulted in the participation of these organizations in the sampling program; in the reduction, compression, and the analysis of the resulting data; the placing of personnel aboard vessels or aircraft; or by making available large amounts of equipment to the participating vessels.

During these briefings, members of the U. S. Planning Group for CICAR reviewed the planned Loop Current study and it was recommended and accepted as the first U. S. project of CICAR.

Because of the increased number of participants in EGMEX, a final planning session was convened in St. Petersburg by SUSIO to formalize an overall program management scheme. The delegation of responsibilities was agreed upon and accepted as follows: (1) SUSIO would coordinate the activities of the different vessels, the exchange of personnel and equipment between them, and transportation of the resulting samples or data. (2) SUSIO would document and transmit to the National Oceanographic Data Center (NODC) information on the standard data collection techniques and data compression methods. (3) SUSIO would coordinate through NODC the inventorying of all collected data on CICARDI forms and charts. (4) NODC would inventory the collections; it would key punch and process the resulting data for list-outs of Sigma T and dynamic heights, prepare a master list-out of station locations and samples, and would prepare plotting sheets compatible to a U. S. Coast and Geodetic Survey 1007 chart size (this would be furnished as part of the U. S. participation in CICAR). (5) To assure data verification for the common sampling program, it was agreed that certain organizations and individuals would be responsible for correcting, processing or analyzing the resulting data from certain collection systems. (a) Since the physical data would be used as the key to sampling in this interdisciplinary study, its compression procedures would have to reflect not only the density distribution but would have to meet the analytical requirements of the other disciplines. SUSIO would either compress or arrange for the compression of the STD data and its transmission to NODC. Since the data recording systems for STD's on the different vessels varied from analog alone to combination analog-digital type records, it was agreed, to assure data verification, that only the analog traces should be compressed. Digital tapes would be processed individually by the collector. Analog compression would consist of values for standard depths, half and whole degrees of temperature. 0.5 $^{o}/_{oo}$ salinity and inflection points of temperature profile defined by a linear relationship of $\pm$ 0.02C. The chemical profile would be reduced to observations at the depth of these STD values unless its profile showed an inflection point not defined by the density field. If this occurred, values for temperature and salinity would be entered for these depths. The processed and listed STD data from NODC would be sent to Drs. Broida (UM) and Cochrane (TAMU) and Mr. Austin (FSU) for geostrophic description of the Loop Current required by the other interdisciplinary studies. (b) Dr. Corcoran (UM) would supply all

collection equipment and sample bottles, with the exception of Niskin bottles, for the collection of trace elements and insecticides. All samples would be returned to him for analysis. (c) Dr. Jones (FSU) would supply all plankton nets, open-closing mechanisms, depth recorders, flowmeters, and sample bottles for plankton tows. He would sort the resulting samples for foraminiferans, radiolarians, and pteropods for his biological indicator research. He would also sort out fish larvae for Dr. Richards (NMFS-Tropical Atlantic Biological Laboratory [TABL]), who would further sort the larvae to family. Dr. Richards would then distribute certain families to other participating scientists. (d) Mrs. Williams (DNR) and Mr. Brucks (NMFS–TABL) would supply 8,000 drift bottles and would analyze the returns and prepare same for publication. (e) Dr. Hebard (NMFS–TABL) and Mr. Deavers (USCG) would analyze the ART overflight data. SUSIO would forward to them surface temperature data from the vessels. (f) Dr. Carder, University of South Florida (USF), would arrange for optical samples to be collected for the *Alaminos, Pillsbury, Island Waters* and *Tursiops.*

A number of other sampling programs and analytic efforts were added to the program in support of specific projects. The participating universities and agencies are so numerous that they are summarized in Table 2.

To ensure proper sampling across the Loop Current, a proposed standard grid pattern for station locations was established, based on the examination of historical data from NODC, and on discussions with scientists who had studied the phenomenon in recent years. It was agreed that unless the location of the current could be determined by advance ART overflight, satellite or vessel data, or a combination of these, sampling would occur at these locations.

Since a near-synoptic STD survey would be made of the Loop Current the participants felt that a sampling program on the western continental shelf of Florida should be made to relate the current's effect on this environment. For this reason, and to supply needed baseline data for future studies on the shelf, a series of sections was planned and assigned to the *Joie de Vivre* and *Hernan Cortez.* These sections were to be sampled for temperature and salinity data by either a shallow depth STD, or by Niskin bottle casts and oblique plankton tows to the bottom or the depth of the thermocline. If a thermocline was present, an additional plankton tow would be taken below its depth. The operational procedure, techniques and sampling instructions are documented.

The shelf sections were of major significance if attempts were to be made to relate the effects of the Loop Current on basic physical, chemical, biological, geological and fishery problems of this area. As such, the resulting data would have a very practical application to the universities, government agencies and industry of Florida alike.

The USCG provided 9 days of ART overflights during the period of April 25-27, May 4-6, and May 9-11, 1970. The results of the April 25-27 flights are shown in Chart 1. These data were very important to the study, since they allowed a determination of the boundaries of the Loop Current. The scientists' ability to examine these data before the departure of the vessels on the May 4-6 STD survey allowed them to revise the proposed tracks to cover the meandering of the northern edge of the current and concentrate stations within it.

This survey to 1,000 meters was conducted aboard the *Pillsbury, Island Waters, Tursiops* and *Alaminos.* Examples of the resulting sections of temperature are shown in Figure 1 across the meandering northern boundary of the current, and Figure 2 in the more steady state conditions to the south. It is most

TABLE 2

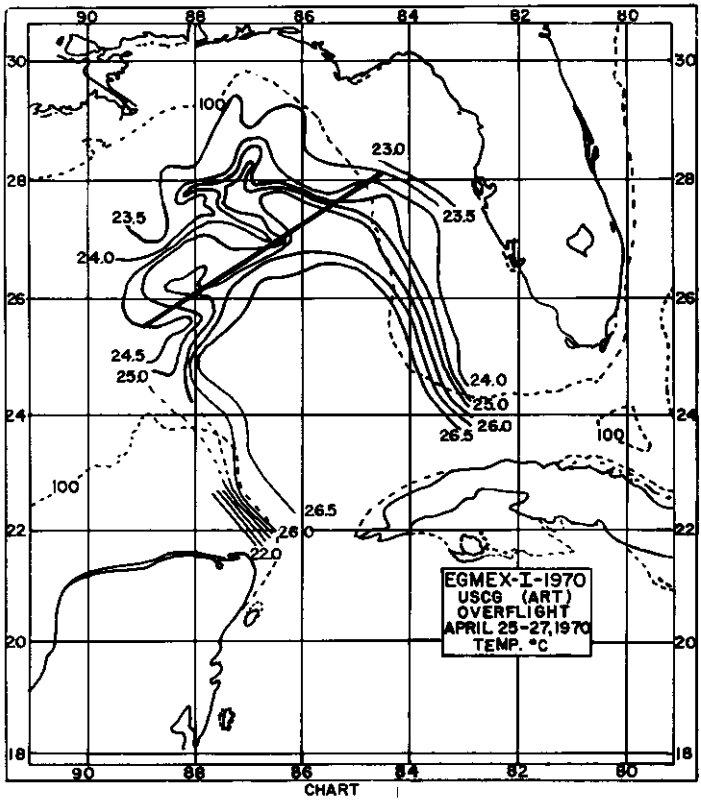
Sources of Data or Analytical Results from EGMEX '70
by Organization and Investigator

Florida Department of Natural Resources	
E. Joyce	Fish larvae; Hourglass study
S. Kennedy	Physalia
J. Williams	Drift bottles
Florida State University	
H. Austin	Biological indicators/Loop Current*; Loop Current description
J. Cruise	Sergisted shrimp distribution+
A. Hanke	Boron in sediments*
J. Jones	Biological indicators; Training personnel
L. Kadar	Copepoda indicators+
R. Thomas	Squid larvae distribution+
S. Williams	Middle Ground larvae+
Hydrospace Technological Institute (FIT)	
T. Tealey	Marine technician training
Mote Marine Laboratory	
P. Gilbert	Elasmobranch distribution and habits
NOAA - Atlantic Oceanographic and Meteorological Laboratories	
F. Chew	Loop Current drogue measurements
D. Hansen	STD data reduction; Direct current measurements; Yucatan Straits bottom current measurements
G. Maul	ART satellite
NOAA - National Marine Fisheries Service	
J. Brucks	Drift bottles
T. Costello	Shrimp larvae
J. Finucane	Threadfin herring and pompano larvae
P. Ford	Clupeid larvae other than threadfin herring
F. Hebard	ART overflights; Loop Current geostrophy; Shelf currents, temperature, salinity and oxygen
W. Richards	Tuna larvae

TABLE 2 (Continued)

Staff	CICARDI
	NOAA - National Oceanographic Data Center
	Nova University
W. Richardson	Florida current total transport
	St. Petersburg Beach Aquatarium
L. Kephart	Turtle migrations
T. Nickerson	Turtle migrations
	Texas A & M University
J. Cochrane	Direct current measurements; Loop Current; Caribbean currents, Campeche Bank upwelling
	U. S. Coast Guard
J. Deavers	ART overflights
	University of Florida
P. Brezonik	Inorganic phosphates EGMEX I
H. Brooks	Training personnel
J. Dinsmore	Sooty terns*
	University of Miami
S. Broida	Florida Current; Loop Current
E. Corcoran	Trace elements and insecticides; Inorganic phosphates*
E. Houde	Clupeid eggs, distribution and abundance
	University of South Florida
R. Baird	Midwater fish
K. Carder	Particle-biological relationships and distribution; Training of personnel
T. Hopkins	Micronekton
F. Schlemmer	Particle current indicator+
	University of West Florida
T. Hopkins	Training of personnel

*Subject for Ph.D. dissertation; +subject for M.S. thesis



significant that the surface temperature perturbations along the northern edge shown in the ART overflight data (Chart 1) are not merely a surface phenomenon. Figure 1 (taken along the heavy line on Chart 1) shows that this persists down to 1,000 meters. Without the change in the station sampling interval as the result of the ART overflight data, before this survey, these features might have been missed in the sampling.

On the basis of an examination of the vertical temperature and salinity section from this survey, the EGMEX station locations along the sections and section locations themselves were readjusted for the May 7-11 STD-biological-chemical survey. This allowed the appropriate sampling of the biological and chemical parameters across the current and in its well identified boundary areas. STD's, plankton tows, and oceanographic station casts were to a depth of 500 meters. Chart 2 shows the actual vessel tracks on EGMEX I '70. The flexibility of altering section locations and station intervals has been demonstrated in EGMEX.

The surface flow in the Loop Current is not a direct wind driven current. A 2 1/2-knot surface current was measured in one of these perturbations moving against a 25-knot wind. This indicates that the Loop Current is similar to the Gulf Stream in its perturbations and is a definite water mass in transit through an area.

Again, there is a most interesting correlation between the Loop Current and the biology of the Gulf, as most of the scientists felt there would be. Even in an elementary feature, such as standing crop measurements, there is an apparent relationship. Chart 3 depicts the surface distribution of biomass measured in total displacement, in milliliters, of plankton materials sampled per cubic meter of water. Note the association between the perturbations of Chart 1 and certain of the concentrations on Chart 3. The concentration on Campeche Banks will be discussed later.

Approximately 80% of the EGMEX I operation was successfully completed. The major deletions were not across the Loop Current itself, which was 100% complete, but in the work on the continental shelf. This was directly accountable to weather conditions and partial break down of one of the research vessels.

At NODC there is an inventory of all data taken during the cruises on CICARDI forms. In addition, there is a master station file. NODC has constructed Station Location Plotting Sheets for: (1) STD stations, oceanographic station casts, and expendable BT's; (2) drift bottle releases; (3) plankton tows; (4) geological samples. These can be obtained from SUSIO or NODC.

The physical data have been reduced and submitted to NODC with values at standard depths and at the selected temperature and salinity contour intervals.

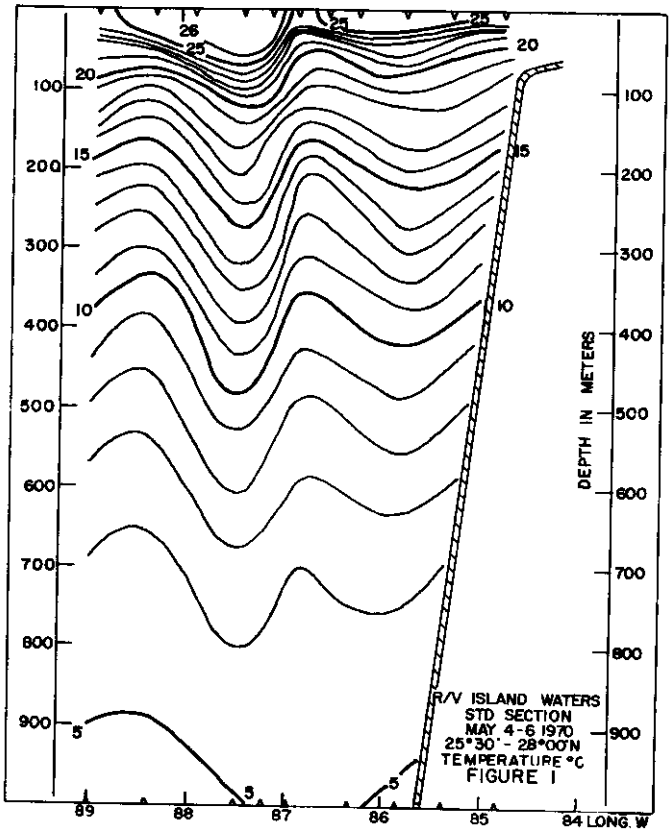
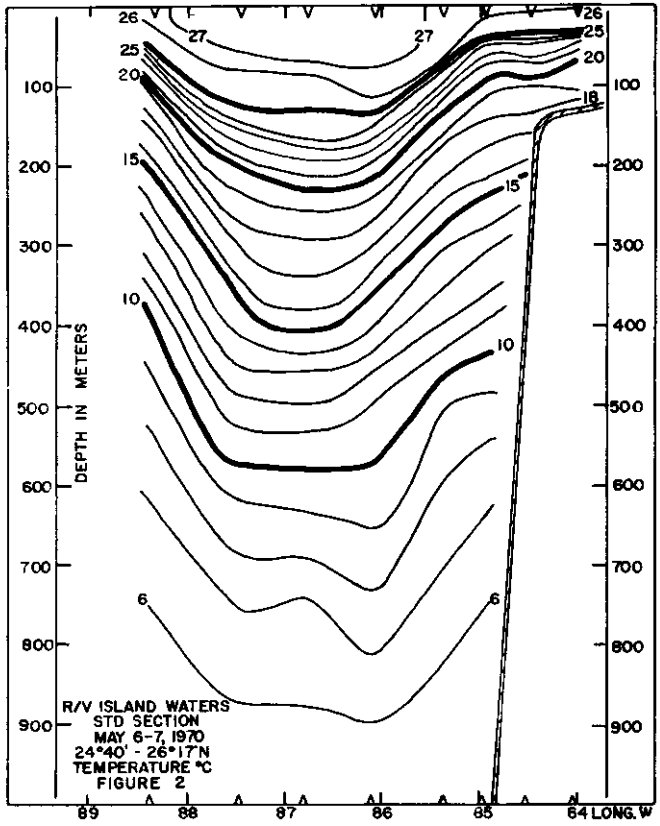


FIGURE 1



The drift bottle release locations have been inventoried and sent to NODC; copies to DNR and NMFS–TABL. The ART overflight data and surface temperature values have been sent to NMFS–TABL and the USCG for analytical work. FSU has sorted the plankton samples for the *Pillsbury, Island Waters, Tursiops, Hernan Cortez, Joie de Vivre* and *Alaminos* for foraminiferans and fish larvae. The fish larvae have been sent to Dr. Richards (NMFS–TABL) for reduction to families. The optical samples (particle) are under analysis by Dr. Carder (USF). Trace elements and insecticide samples are presently under analysis by Dr. Corcoran (UM).

The preliminary results of the physical data indicate that surface isotherms in May can be used as an approximation of the location of the Loop Current. While the boundaries are well defined in the southern extremities, the northern edge consists of fingers and eddies of considerable disconformity. These protuberances have relatively strong currents within their boundaries, up to 2 to 3 knots, and the water mass structure is affected to considerable depths. Since this is the first nearly synoptic study of the Loop Current the participants are most interested in determining its time variations, the degrees of its steady or non steady state, and movements of the fingers and eddies.

There was feeling among some of the scientists that not only could the 22-degree isotherm, as represented by Leipper (1968) be used to locate the Loop

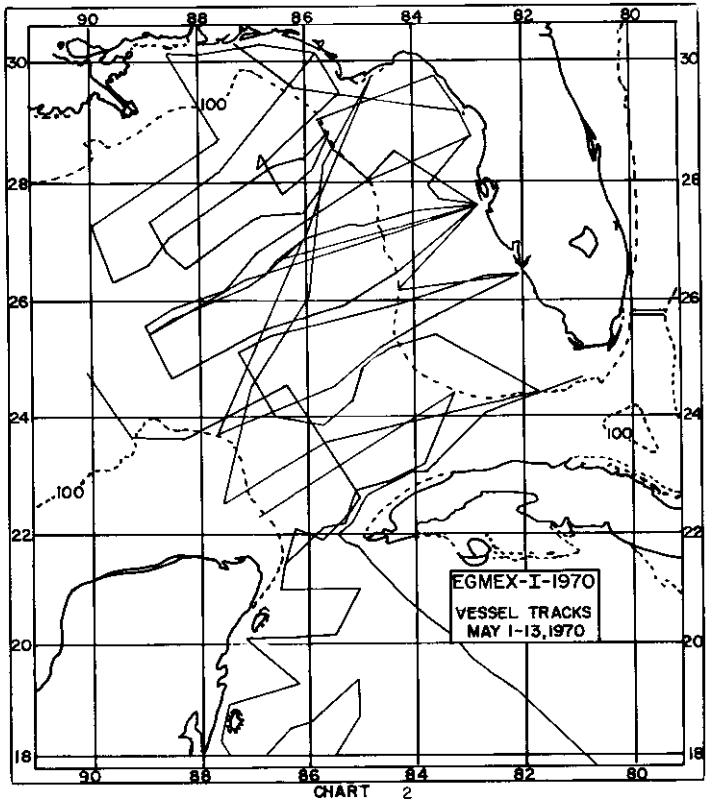
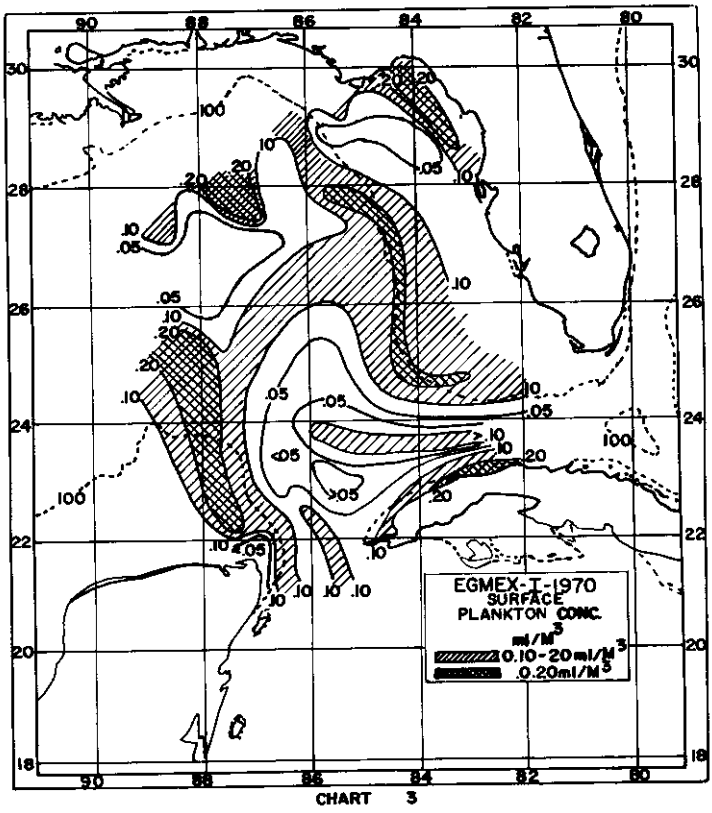


CHART 2

Current, but also possibly the 16-degree isotherm, when used in May. The existence of the perturbations and the associated concentrations of standing crops of plankton as biological indicators were very encouraging. The existence of shelf type foraminiferans at great depths along the western edge of the Campeche Banks and eastern edge of the continental shelf of Florida between Tampa and Ft. Myers indicates the presence of a phenomenon as yet unstudied. These concentrations of foraminiferans apparently have not mixed into the Loop Current, and yet were collected at a depth of 200 meters (personal communication, H. Austin).

The existence of a cold pocket of water on the continental shelf near the Crystal River area apparently represents a separation in the shelf transport. The preliminary results of an over 15% recovery of the drift bottles show that north of this pocket the bottles are drifting north and westward with recoveries as far west as Louisiana. South of the pocket the bottles are drifting southward and entering into the Florida current (personal communication, J. Brucks). This pocket of cold water covers an area known as the Florida Middle Ground, a major fishing area of Florida. For a period of some 18 months, a cooperative ecological study has been conducted at a fixed location, within these grounds, by Florida State University, University of West Florida, University of Florida and University of South Florida. The examination of the foraminiferans from

this area which indicates the periodic presence of Caribbean water was the basis for Dr. Jones' original request to SUSIO to study the Loop Current (Austin, 1970).



As was hoped, detailed information, as described above, of the association of the Loop Current with other environmental structures, will surely lead to new and varied types of investigations by the scientists in the eastern Gulf of Mexico. While the purpose of EGMEX I was to provide a monitoring of the Loop Current, it is these interrelated interface problems which represent the major interest within the State University System.

EGMEX II '70

As EGMEX I neared completion, Dr. Cochrane (TAMU) felt that the preliminary results were scientifically interesting and operationally significant enough to warrant a follow-up study if practical. He contacted SUSIO to determine the acceptability and feasibility of having another interdisciplinary, multi-ship operation during June. He felt that the quasi-synoptic data resulting from the STD's and ART overflights on EGMEX type operations presented a unique opportunity to determine time changes in the boundary conditions of

the Loop Current, i.e., north-south seasonal movement and east-west displacement. SUSIO, by quickly polling other participants, learned this represented the consensus and interest of all.

Four ships, the *Alaminos, Island Waters, Hernan Cortez* and *Gulfstream,* participated in the study. Because of the reduced number of ships, the coverage and synoptic survey of the collections are not as complete as in EGMEX I, even though the data were taken over a 14-day period. The common sampling programs were the same as those in EGMEX I except for the deletion of inorganic phosphate and ART overflight.

Because of the limited number of vessels, it was agreed that the *Alaminos* would cover the western portion of the Loop Current while the *Island Waters* covered the eastern, and the *Hernan Cortez* sampled the low temperature pocket near Cedar Key. Modifications were made to the biological sampling program whereby samples were taken at fixed locations on the *Alaminos* sections, but varied on the *Island Waters* according to the results of the STD lowerings.

Although all areas were sampled, there was a subsequent modification to the *Island Waters* sections due to delays caused by the flooding of the STD unit; this mishap resulted in biological-chemical sampling along each section run, with their geographic locations dependent on examination of the observed vertical temperature and salinity field. The actual vessel tracks are shown in Chart 4.

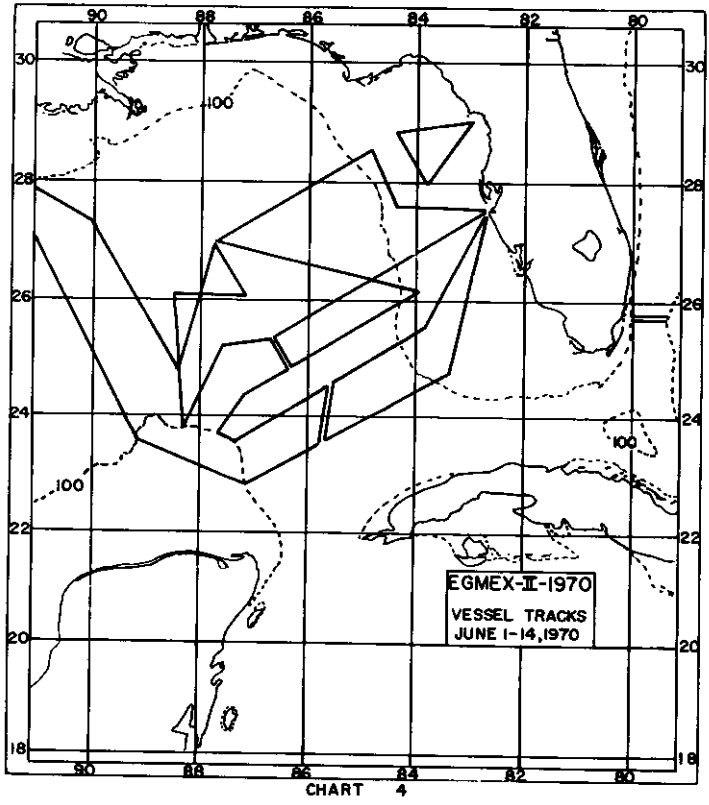


CHART 4

The results of EGMEX II are still under investigation. However, a rather detailed sampling of the unusual concentrations of foraminiferans described in EGMEX I by both optical and planktonic sampling has confirmed the concentration of shelf foraminiferans at 200 meters. This material is not mixing into the Loop Current. There is a similarity of the biological concentrations and the optical properties. This study has resulted in an accomplishment that SUSIO has continually fostered in the Loop Current investigations. Dr. Jones (biological indicators) and Dr. Carder (optical properties) have discovered that their work is complementary. The exchange of environmental information and proper sampling techniques have resulted in these two individuals realizing that to study this particular phenomenon it is beneficial, even essential, to coordinate their studies.

NMFS–TABL has agreed to sort all of the planktonic samples resulting from EGMEX II and III down to families.

The processing of the results of EGMEX II has been delayed because of a lack of adequate funds to reduce the data.

EGMEX III '70

Because of the successes of EGMEX I and II, NOAA-AOML requested a meeting of the participating scientists to determine if a multiple survey could be conducted during the period October-November 1970. This meeting was combined with the Physical Oceanographic Planning Section of CICAR. It was determined that a total of eight vessels was available for operation within the Loop Current area. Again, SUSIO was asked to coordinate the ship activities and assist in portions of the data reduction. At this meeting it was decided to repeat the sampling techniques and programs as conducted on EGMEX I and II with the following inclusions and deletions: (1) Deletion of the trace elements and insecticide program because of a lack of funds to reduce the data; (2) Inclusion of a joint inorganic phosphate program between the University of Miami and AOML; (3) Inclusion of a pre-EGMEX expendable BT and drogue measuring program by AOML to determine the location of the Loop Current in September; (4) The assumption by AOML of the reduction of the physical oceanographic data; and (5) The occupation of an inter-comparison ocean station at which simultaneous casts by the STD units and oceanographic station casts for temperature, salinity, oxygen and inorganic phosphate would be taken.

It was agreed that AOML would exchange with the participating vessels the results of their September XBT survey. On the basis of this survey the sampling program would be altered if necessary to coincide with the present location of the Loop Current.

EGMEX III was completed as planned, including the intercalibration stations between the *Alaminos, Discoverer, Island Waters,* and *Tursiops.* This operation has been completed such a short time that little or no results are forthcoming as yet. The processing of these collections is also limited by lack of funds to reduce certain of the physical, chemical and biological parameters.

Chart 5 shows the tracks of the vessels. The doubled lines are the sections on which plankton and oceanographic station casts were taken. The square is the location of the *inter-calibration* station. The dashed and dashed-dot lines represent the boundary of the Loop Current during September and October, based on the work of the R/V *Peirce* (October) and R/V *Island Waters* (October).

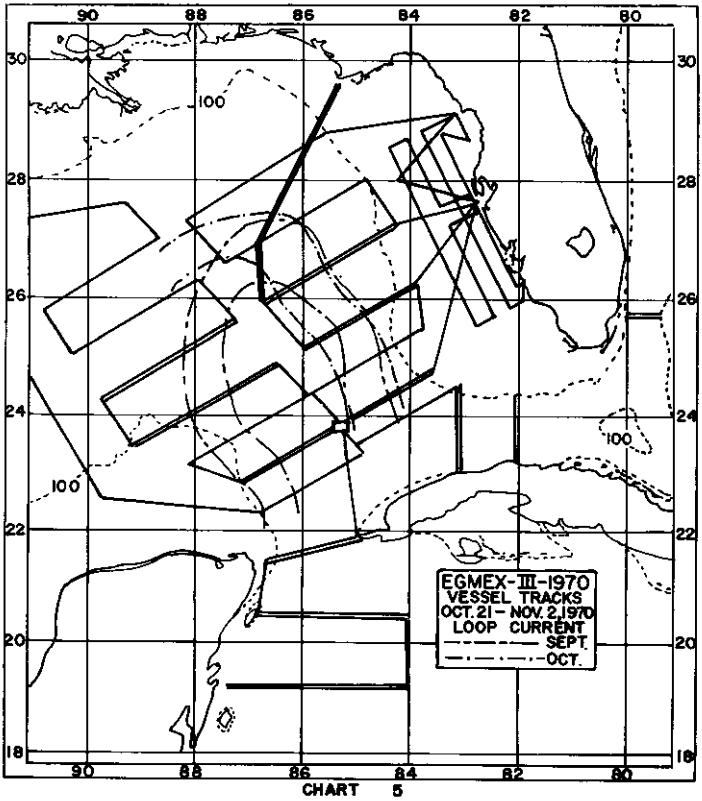


CHART 5

The importance of having a coordinating office whose principal purpose is to assist the scientists within the Gulf area has been adequately demonstrated by SUSIO during the planning and conduct of the EGMEX series. The removal of the major burdens of administrative and operational details from the participating scientists allows them to continue their productive work with minimal interruption.

Numbers of mutual gains have resulted from the EGMEX '70 series; some having been cited in preceding paragraphs. But to focus on the real importance of such studies to individual research scientists, let us use Dr. Jones, the initial instigator of the EGMEX operation, as an example.

Dr. Jones and his students now have data for geostrophic calculations having been collected with the required degree of accuracy of *in situ* measurements (each major vessel employed STD units); these are as near synoptic measurements as practical and can be used for inter-comparison with his biological indicators. In addition, he has received supplemental information that depicts the location and structure of the Loop Current derived from trace elements and optical clarity data.

An added feature of EGMEX is that arrangements have been established for loan of equipment between state and private universities, state and federal government agencies, and industries. And a liaison has been developed whereby

data and samples are exchanged for individual uses in specialized projects of respective mission orientation.

It is significant to reiterate that:

The EGMEX operation was designed by the investigators and participants or both.

Most of the participants in the study had already planned to be in the EGMEX area for teaching or research purposes, consequently, with the added ingredient of coordination, an important and productive comprehensive study was molded from a broad cross section of disjunct projects, schedules, interests and needs.

The participating vessels, aircraft and personnel were funded from a variety of sources. However, the whole result of their efforts is much greater than the independent parts; the shared samples and data far exceeded what the individual projects could have yielded separately. As a consequence, each sponsor received substantially more than had been initially planned. For example, trace element samples were collected over the entire eastern Gulf area by the assistance of the other participants -- samples not limited to the cruise track of principal investigator.

Academic, industrial and state and federal organizations took active parts in the study; they shared costs, funding, personnel, equipment, samples and data.

The study involved teaching and research; the research represents both basic and applied.

The samples and data were reported to NODC, thus other potential users of these will become aware of their existence and availability through NAMDI and CICARDI.

The biological specimens collected during the numerous plankton tows are being shared by public universities, private universities, state and federal laboratories.

The biological collections have complementary-supplementary chemical and physical data taken at the same time and location; all data are available to all participants through appropriate data management.

The 8,000 drift bottles were supplied jointly by a state and a federal organization, and these were disbursed by the participants over a widespread area during a short time period; the results will be published as a co-authored report by scientists of the two organizations.

The physical data will be published in a co-authored report by scientists of Texas A & M University, Florida State University, University of Miami, and AOML.

Within the State University System alone, samples and data collected during the study are being used as major parts of at least eight master theses and doctoral dissertations.

The ships had interdisciplinary and multi-organizational scientific parties -- better understanding of one another's work, interests and problems is being fostered.

Substantial amounts of scientific equipment were furnished by participants to one another in order to provide each ship with adequate equipment suits -- truly a joint involvement.

Additional points could be reiterated, however, it is apparent that much good will continue to come out of EGMEX; scientists will work together; cooperative programs can be developed with proper coordination. Samples and data can and will be shared for multiple purposes.

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