E7.3 10961
CR-133637

AN INVESTIGATION TO IMPROVE THE MENHADEN FISHERY PREDICTION AND DETECTION MODEL THROUGH THE APPLICATION OF ERTS-A DATA

Paul M. Maughan
Earth Satellite Corporation
1747 Pennsylvania Avenue, N. W.
Washington, D. C. 20006

September 1973
Type II Interim Report for the Period January - August, 1973

Prepared for

GODDARD SPACE FLIGHT CENTER

Greenbelt, Maryland 20771

E73-10961) AN INVESTIGATION TO IMPROVE THE MENHADEN FISHERY PREDICTION AND DETECTION MODEL THROUGH THE APPLICATION OF ERTS-A DATA Interim Report, (Earth Satellite Corp.)/4 ## p HC $3.00 CSCL 08A

N73-30303

G3/13

Unclas
00961

Introduction

Background information on the Menhaden fishery and this experiment were provided in the Type II Progress Report covering the period May to December, 1972. The reader is referred to that report for a general description of the fishery, experiment design and test area, as well as the analysis achieved and preliminary results obtained as of December, 1972. Although we continue to receive ERTS images and computer compatible tapes of the test area, no further image analysis has been performed subsequent to June 1973, as it has been determined that basic features such as islands, beaches, color fronts and turbid areas were obserable on all images and that, since no support data was forthcoming due to termination of all field activities in January, 1973, further attempts at in-depth analyses of images were invalid.

The majority of the analyses accomplished on remote and surface truth data during this period were achieved during the first and last two month periods. This was primarily due to the funding problem finally resolved in late June 1973. All analysis and results obtained prior to March, 1973 were included in a paper presented at the "Symposium on Significant Results Obtained From The Earth Resources Technology Satellite -1", sponsored by GSFC in early March. A copy of that paper is included as Appendix I. Material contained in that presentation is not repeated in the "Main Text" section, which pertains only to the analyses and results obtained subsequent to the contract extension received in June, 1973.

MAIN TEXT

Further Analysis

Continued improvement of the computer oriented data management and analysis system developed at Mississippi Test Facility as one portion of the cooperative ERTS-1 Menhaden Experiment led to a decision to re-submit portions of the surface truth data to regression analysis. Both "secchi disc visibility", a measure of transparency, and "sea surface temperature" were linearly regressed against "number of sets". Data were grouped by fishing week (usually Monday to Friday, but variable depending on weather, success, etc.), month, and season. In some instances, data from periods less than a fishing week were subjected to regression analysis.

Results of the linear regressions of surface truth measurements were being combined with multiple regression analysis of "secchi disc visibility" and "water depth" against ERTS image density in an attempt to construct a first order numerical model of the availability of commercially desirable schools of menhaden using ERTS-1 band 5 image density as the data source.

Significant Results

Linear regression of "secchi disc visibility" against "number of sets" yielded significant results in a number of instances. ~~These are summarized in Table 1.~~ The variability seen in the slope of the regression lines is due to the non-uniformity of sample size. The longer the period sampled, the larger the total number of attempts. Further, there is no reason to expect either the influence of transparency or of other variables to remain constant throughout the season. However, the fact that the data for the entire season, variable as it is, was significant at the 5% level, suggests its potential utility for predictive modeling. Thus, this regression equation will be considered representative and will be utilized for the first order numerical model.

"Secchi disc visibility" was also regressed against "number of sets" for the three day period September 27-September 29, 1972 to determine if surface truth data supported the intense relationship between ERTS identified turbidity and fishing effort previously discussed ~~(Type II report May to December, 1972). As shown in Table I~~, a very strong negative correlation was found. These relationships lend additional credence to the hypothesis that ERTS imagery, when utilized as a source of visibility (turbidity) data, may be useful as a predictive tool.

Other Results

Regression of "sea surface temperature" against number of sets yielded a very significant relationship for the month of July. This positive relationship was significant at the 0.5% level. None of the other groupings of these parameters produced significant relationships.

Table I: Results of Linear Regressions of "Secchi Disc Visibility" Against "Number of Sets"

Period	Slope	Correlation Coefficient	Significance Level	Degrees of Freedom
June 25-July 1	- 5.8	- 0.74	10%	4
July 9 - July 15	- 8.9	- 0.67	5%	7
July 30 - Aug. 5	- 3.3	- 0.87	1%	7
Sept. 10 - Sept.16	- 1.4	- 0.92	5%	3
Sept. 27-Sept. 29	- 2.6	- 0.81	5%	5
Sept. 28-Sept. 29	- 1.4	- 0.88	5%	4
August	-10.9	- 0.64	5%	9
September	- 2.9	- 0.48	10%	11
June-Oct.(Season)	-24.5	- 0.57	5%	13

New Technology

As of this reporting period, no new technology has resulted from this project.

Program for Next Reporting Period

Completion of all analyses and preparation of the Type III Final Report

Conclusions and Recommendations

A definite relationship is apparent between water transparency (turbidity) and the number of successful fishing attempts for menhaden in the Mississippi Sound. Further, an apparent relationship exists between Band 5 image density and water transparency. If these relationships can be further defined and refined, an ERTS type system will have a definite role in fisheries resource management.

Meetings and Papers

A paper describing this work was presented at the ERTS symposium held by GSFC in March. A copy is attached as Appendix I.

APPENDIX I

ERTS SYMPOSIUM PAPER

APPLICATION OF ERTS-1 IMAGERY TO THE HARVEST MODEL OF THE U.S. MENHADEN FISHERY

Paul M. Maughan, Allan D. Marmelstein, O. Ray Temple

Earth Satellite Corporation
1747 Pennsylvania Avenue, N.W.
Washington D.C.

ABSTRACT

Preliminary results of an experiment to demonstrate the utility of ERTS-1 imagery for providing significant information to the harvest model of the menhaden industry are reported. Fisheries and related environmental data were obtained discontinuously throughout the 1973 menhaden (a surface schooling, coastal species) fishing season in Mississippi Sound.

The unexpected complexity of the physical environment in Mississippi Sound precluded simplistic analysis of fish/environment relationships. Preliminary indications are that an association does exist between fish availability and differences in water transparency (turbidity) within the Sound. A clearer relationship is developing between major turbid features imaged by ERTS-1 and location of successful fishing attempts. On all occasions where relatively cloud-free ERTS-1 overflight days coincided with fishery activity, overlays of catch location on ERTS-1 images show an association of school position with interfaces between imaged turbid features. Analysis is currently underway to determine persistence of such associations in an attempt to define minimum satellite return time necessary to maintain continuity of associations.

Within the context of the menhaden harvest model, benefits which may accrue to the industry can be measured in terms of reduced dependence on spotter aircraft for generalized fish school location. The satellite repeat time is of critical importance to this application.

1. INTRODUCTION

Menhaden are small surface schooling pelagic fish which occur in the nearshore coastal waters of the Atlantic and Gulf Coasts of the United States. These herring-like fish support the largest volume fishery in this country. The fishery is divided into two regional units: one presently centered around the Chesapeake Bay and the other centered around the Mississippi River Delta

and the nearby areas east and west. The Chesapeake Bay fishery is the older and was formerly considerably more extensive, but lack of availability of the resource has caused a sharp decrease in the range and extent of the fishery. To the contrary, the Gulf of Mexico fishery is more recent and is considered to be an expanding, dynamic fishery.

Menhaden are fished by twin skiff, purse seine vessels assisted by spotter-pilots flying light aircraft, whose responsibility is to locate a commercially accessible aggregation of schools and guide the fishermen in their capture. The well-developed harvest technology of the menhaden fishery coupled with the inherent remote sensing aspects of the discovery and capture of the resource suggested its use as a demonstration for the applicability of remotely acquired oceanographic data as a complementary source of information for harvest and management decision processes.

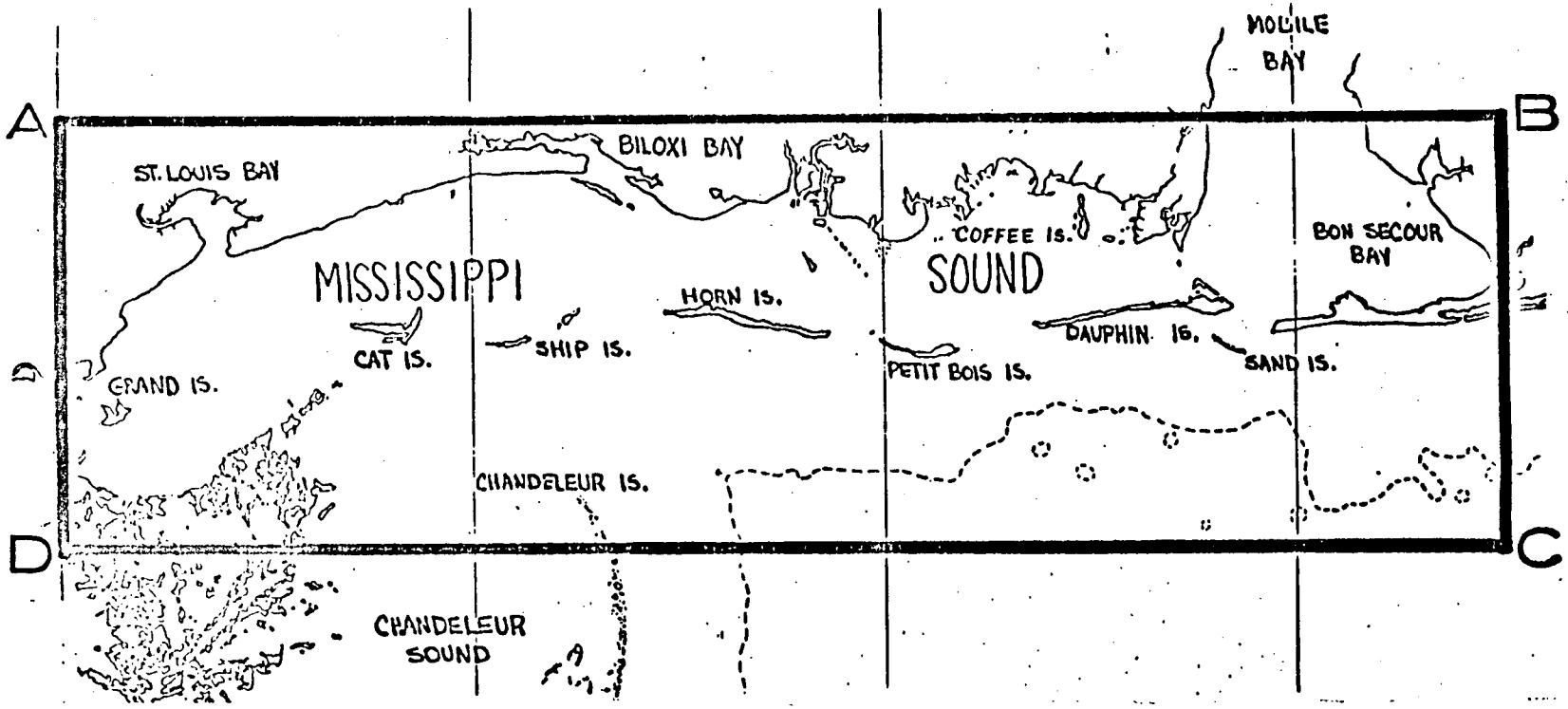
The research program reported herein represents a cooperative effort undertaken by EarthSat and the National Fish Meal and Oil Association, in conjunction with NASA Earth Resources Laboratory (ERL) and the Fisheries Engineering Laboratory (FEL) of the National Marine Fisheries Service (NMFS) colocated at the Mississippi Test Facility (MTF). Other NMFS participants included the Pascagoula Laboratory in southeastern Mississippi, the St. Petersburg Laboratory in western Florida and the Beaufort Laboratory in coastal North Carolina.

Four sub-experiments were designated which involved space applications, oceanographic applications, living marine resource applications and fishery utilization applications. Responsibility for the experiments was designated according to the individual objectives of each of the experiment participants, but acquisition and interpretation procedures were shared amongst all participants. This paper will concentrate on the fishery utilization sub-experiment.

2. EXPERIMENTAL DESIGN

The test site selected for the combined ERTS-1 experiment was an area bordering the Mississippi Gulf Coast, called Mississippi Sound (Figure 1). This approximately one hundred mile by ten mile rectangular area is a portion of the Gulf of Mexico isolated by a discontinuous series of barrier islands. It was selected as the test site for several reasons. First, it supports a large menhaden fishery which, during a typical year, produces 30% of the total Gulf of Mexico catch. Secondly, it was logistically simple in that all of the commercial fishing companies operating in the Sound utilized port facilities located at Moss Point, Mississippi. Further, the Sound is in close proximity to the Mississippi Test Facility and the NMFS Pascagoula Laboratory.

Data acquisition was to occur from a multi-platform, multi-level system, utilizing the ERTS spacecraft, medium and low altitude NASA aircraft, low altitude aircraft supplied by the National Marine Fisheries Service, spotter aircraft used by the fishing companies for locating the resource, and surface vessels of two types. Vessels chartered by NASA and NMFS occupied preselected stations on major data acquisition days. Selected commercial fishing vessels were utilized for discontinuous random data acquisition, keyed to the individual fishing efforts of the vessels chosen.



SCALE

KILOMETERS 0 10 20 30 KM

NAUTICAL MILES 0 10 20 NM

STATUTE MILES 0 10 20 SM

FIGURE 1: TEST SITE

Routine surface sampling for the utilization experiment proceeded from May to October 1972. EarthSat personnel occupied positions as scientific observers aboard three commercial menhaden vessels continuously during the period June through September. These individuals obtained oceanographic observations each time a capture attempt was initiated upon a school of menhaden. At the time of capture or attempted capture, observations of temperature, salinity, secchi depth (turbidity), water color and associated meteorological data were obtained to coincide with fisheries data concerning the size of the school captured, its position and the time of capture. These observations were made the first three days of each fishing week except during periods where ERTS-1 overpass or major field activity occurred later in the week -- in which case the sampling period was extended for the entire week. All sampling was achieved so as to not interfere with first priority fishing activity.

Once weekly, throughout the season, a minor field exercise was undertaken -- termed a "secondary day" -- wherein an aircraft overflight was made of the prime fishing area in order to obtain temperature distributions as mapped by a thermal scanner. These flights were directed by the Earth Resources Laboratory at MTF. Simultaneously, an aircraft was dispatched from the Pascagoula Laboratory of NMFS to acquire aerial photography of fish schools and menhaden fishing activity. During these days, several charter vessels were utilized for transect ground truth.

At several periods during the summer, selected nominally to correspond with ERTS-1 overflight, major field exercises -- termed "main days"-- were undertaken wherein vessels chartered by NMFS and ERL occupied discrete positions along transect lines which were also overflown by the NASA NP3A aircraft operating from Houston. Additionally, those aircraft observations discussed above were also undertaken. Fishing activity proceded as usual with fish sampling occuring at random locations dictated by the location of commercially accessible fish schools. Where possible, increased numbers of EarthSat personnel were utilized to enlarge the number of vessels from which fishery sampling was obtained.

All data acquired through ground sampling programs were accumulated and held in a computer-operated data management system. As possible, remotely acquired data was transferred to computer-compatible format and entered into the same common data bank accessible to all participants in the experiment.

3. DATA ANALYSIS

Analysis of ERTS-1 imagery utilized the excellent properties of turbid feature dilineation possible from the MSS images. Overlays of geographic location of individual fish sets compared to turbid features visible from images have led to several potential relationships discernable from ERTS imagery. Such analyses were combined with an examination of relationship between known bathymetric features and areas interpreted as turbidity within the Mississippi Sound. Visual comparison demonstrates that in some cases the ERTS-1 images view bottom topography whereas in other instances ERTS-1 images apparently view turbid water features. Digital image processing and statistical routines are currently being employed in an attempt to segregate these effects. An analysis of these data shows that nearly all fish catches are made between the one to two fathom bathemetric contours. Sets almost always fall in or along turbid features.

In the analysis performed to date, the data generally can be grouped into two classes. In the first class of data catches appear to associate with the interface between areas of markedly different turbidity. Such sets also associate with shallower areas leading to the speculation that this turbidity is wave-induced in the shallow water. The reason for the association is not clear. In the second class, associations centered on plumes of turbid water which occur in depths of approximately two fathoms.

The 29th of September is an example of the latter class of data. Immediately behind Dolphin Island (Figures 2 and 3), an area was observed to contain numerous fish schools centered in a turbid feature. This represented a highly atypical situation in that generally catches in the eastern Sound slightly to the north associated with a large marshy island known to the fishermen as Coffee Island. On this date no fish were observed in the vicinity of Coffee Island which was extremely unusual, and all catches were made in the turbid feature in an area where few catches had been made over the previous three months of the fishing season. On the 29th of September two million fish were taken by three vessels from this area. Examination of catch records prior to this overpass demonstrate that an increasing association with this area occurred from the 27th to the 29th of September, indicating a possible persistence of this feature. Events after the 29th were not defined due to the cessation of fishing on the 29th, the end of the fishing week.

Statistical methods are also being employed to attempt to relate environmental observations such as temperature, salinity, and turbidity to the abundance and occurrence of commercially accessible menhaden. To date, such attempts have been largely unsuccessful due, we feel, to the perturbed nature of the environment. The Mississippi Sound is a naturally complex estaurine system and is heavily trafficed by commercial and pleasure vessels. The vessel traffic introduced artificial complications into the environment which make coherent sampling extremely difficult.

4. DISCUSSION

Areas exhibiting turbidity in shoal water tended to be those areas which were previously well known as centers of fishing activity; for example, the area around Coffee Island. However, the one instance demonstrated in the September 29 image where fishing activity centered in a plume in deeper water represents a unique occurrence which when supported by repeated evidence, indicates the first instance where a satellite acquired image could be used as an input for management purposes. Persistent association of commercially accessible fish schools with such a feature provides the impetus for utilizing such interpretation as a management tool for restricting harvest efforts.

However, in general it must be said that the potential of these techniques lies more in management than in harvest in respect to the menhaden industry. The general high efficiency of search and capture exhibited by this fishery precludes a major input from remote sensing satellite systems into these activities. However, the potential for predicting on a longterm basis probable locations could greatly reduce the resource investment in search aircraft and time so employed. Further these techniques suggest a possible means of worldwide survey for potential fishing sites for similar species of Clupeoid fishes known or thought to exist in similar environments.

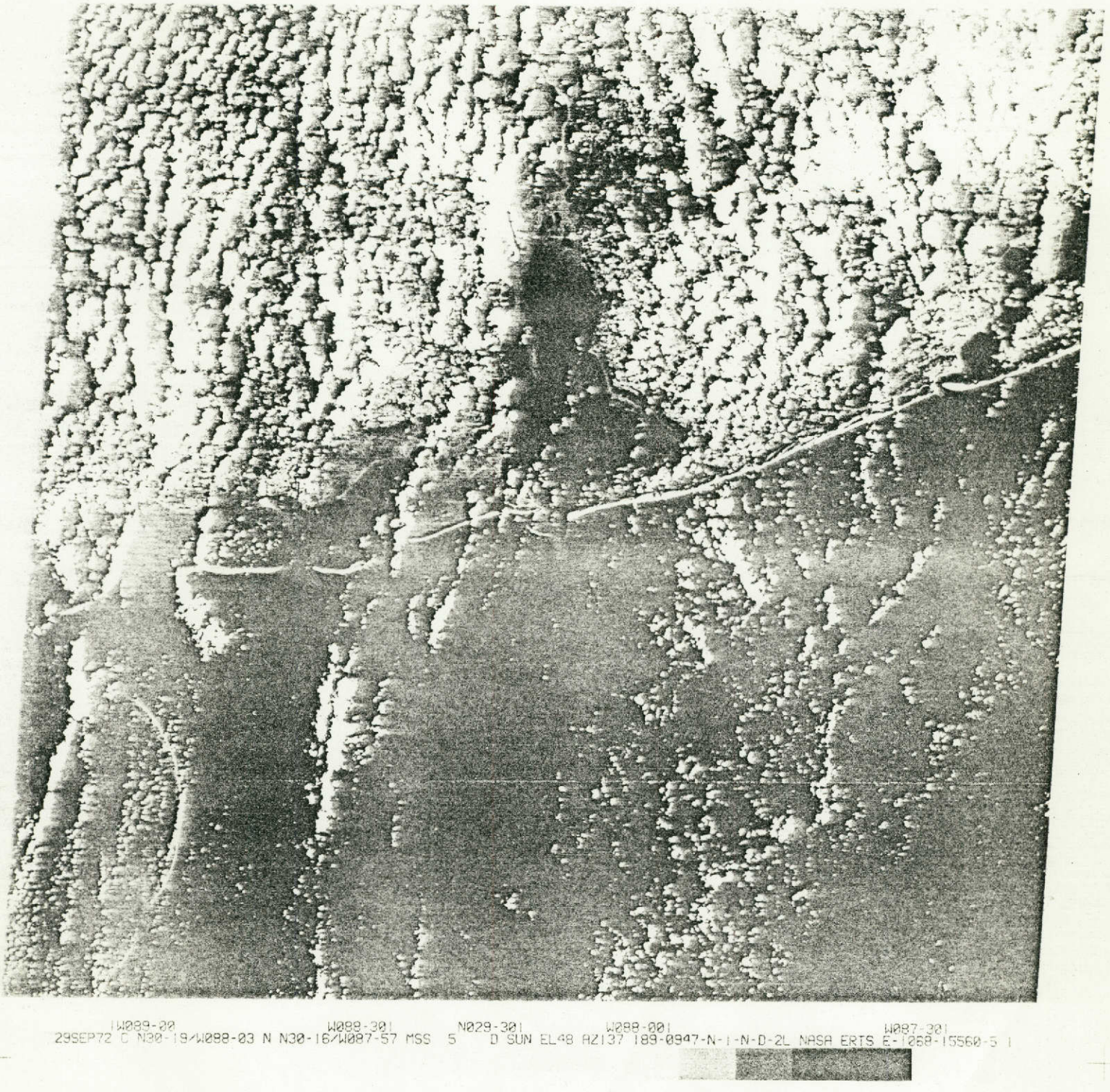
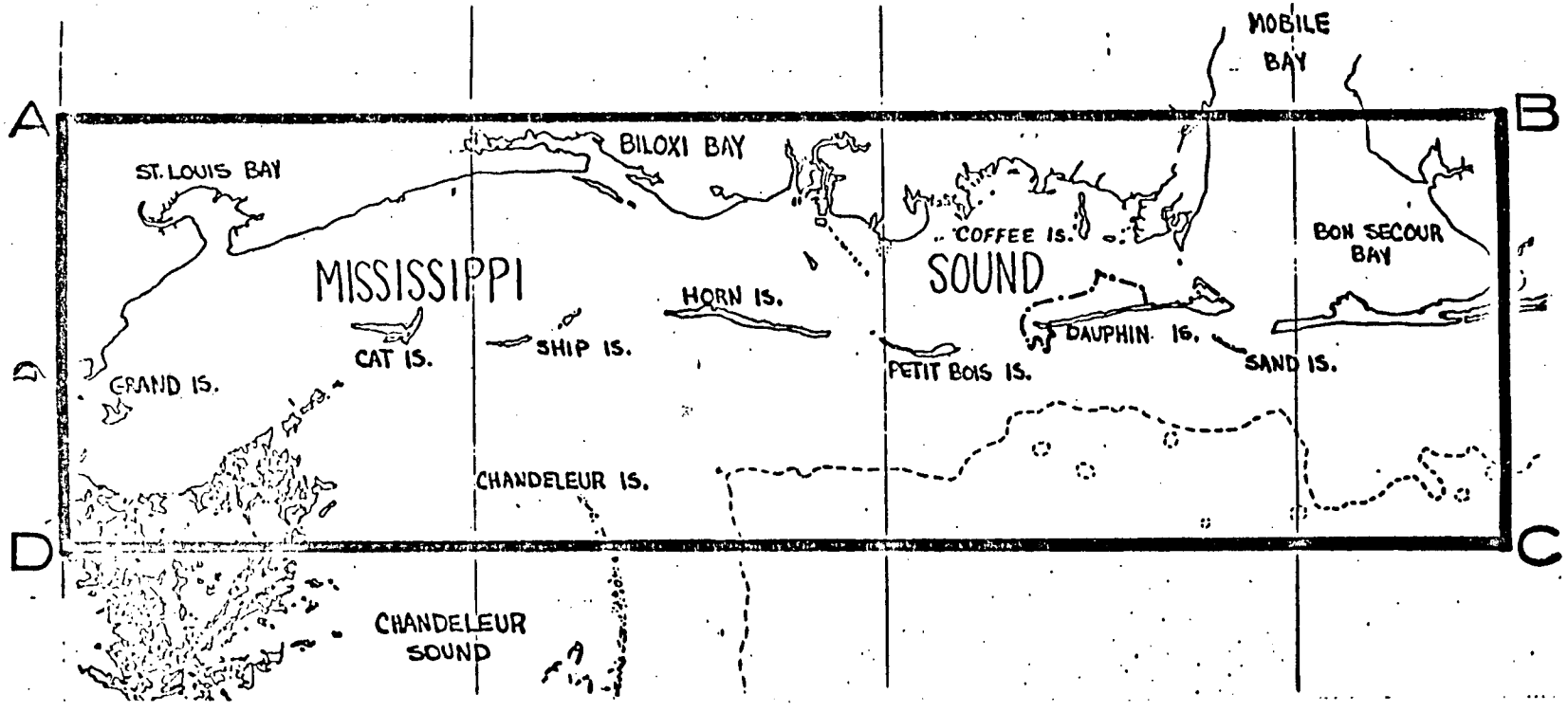


FIGURE 2: ERTS-1 MSS BAND 5 IMAGE, 29 SEPTEMBER 1972



—·—· POSITION OF TURBIDITY FEATURE

FIGURE 3: PLUME POSITION AS DERIVED FROM FIGURE 2

APPENDIX II

ERTS IMAGE DESCRIPTION FORMS

None Not Previously Submitted

APPENDIX III

Changes to Standing Orders

NONE

APPENDIX IV

Changes to Data Request Forms

NONE