COORDINATION: SOUTHEAST CONTINENTAL SHELF STUDIES

A PROGRESS REPORT SUBMITTED TO

U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

CONTRACT EY-76-S-09-0901

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BY

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INTRODUCTION

Contract EY-76-S-09-0901 (formerly E(38-1)-901) provides for coordination of ERDA supported oceanographic research in the U. S. Southeast Atlantic area. Under the obligations of the contract the following functions were assumed in December 1975.

1) To establish liaison between participating scientists through the mechanisms of meetings and data exchange.
2) To coordinate the use of ships and other major facilities.
3) To provide a summary synthesis of major scientific conclusions resulting from work in the area.

I. GENERAL OVERVIEW

The planning and management for offshore siting of reactors, deepwater ports, oil or gas drilling platforms and/or other man-made structures requires a basic understanding of geophysical properties of the continental shelf substrate and the effect that the operation of the facility may have on biological/chemical processes. Geophysical properties can generally be determined in a short time, the main concern being to assure stability of the structure. BLM (DOI) programs, contracted to the U.S.G.S. are currently treating this problem on a broad scale in the southeast. In the case of ERDA's interest it might be suggested that unless and until an active search is initiated for a specific site to locate a given facility similar studies might be deferred and then applied only to the area in question.

The second area of concern, prediction of the effects of the operation of facilities, wherever their location or whatever their discharge, on the biology of the continental shelf requires an understanding of (1) processes governing the natural variability of physical, biological, and chemical phenomena and (2) an estimation of the probable impact that additional loads of pollutants may have on the biota. In the simpliest sense these processes may be divided into critical areas of study which include determining the rates of input of target pollutants to the continental shelf, their flux, transfer, effect and ultimate fate. The above factors were considered at an ERDA sponsored meeting at the Savannah River Laboratory in 1974 and recommendations for study were subsequently published in ERDA-12. A contraction of the included recommendations proposed the following types of studies:

A. Physical Oceanography

1. Define advective regimes on the continental shelf
2. Define hydrographic regimes on the continental shelf
3. Determine tidal fluxes and how these influence the dispersion of pollutants
4. Describe meteorological regimes

B. Sediment Transport

1. Inventory of substrate
2. Determine Lagrangian current motions
3. Describe fine sediment transport
4. Describe sand transport

C. Geochemical Transport

1. Determine the effect of intrusions on nutrients and radioisotope/metal distributions
2. Determine the effect of runoff on nutrient and radioisotope/metal distributions
3. Determine the effect of estuaries on nutrient and radioisotope/metal distributions and cycling

D. Biological Oceanography

1. Describe the temporal abundance of marine organisms
2. Assess the role of water movements on the shelf and their influence on plankton distribution, production, nutrients and toxic materials.

On the basis of the above recommendations ERDA's oceanographic program in the southeast was expanded in 1975. The currently activated program addresses some of the study areas in part, neglecting others. In general, given current levels of financial commitment, priorities have been properly focused by implementing as many projects as possible which bear directly on one another, deferring until later those which do not require the same level of interdisciplinary support. Since the current program is driven by a large relative commitment to describing offshore physical oceanographic processes it is advisable to consider implementing new projects which require real time analysis of this information. Under this interpretation project support should emphasize studies in the areas of B (3), C (1) and (2); and D (2). Those projects currently being supported fit this criteria addressing specifically:

1. physical oceanographic factors forcing water motion on the continental shelf--the origin of Gulf Stream intrusions (Lee, RSMAS)
2. the physical oceanography and net motion of intrusions once isolated from the Gulf Stream (Pietrafesa, NCSU)
3. measurement of alongshore water motion, exchange between estuaries, and the flux and dispersion of radioisotopes in nearshore waters (Hayes, SRL; Blanton, SkIO)
4. nutrient fluxes induced by and chemical characterization of intrusions and the shelf in general (Atkinson, SkIO)
5. the role of pelagic microorganisms in the cycling, production and distribution of organic matter (Pomeroy/Wiebe, UGA)
6. the production, distribution and dynamics of phyto- and zooplankton associated with Gulf Stream intrusions (Paffenhofer/Dunstan, SkIO)
7. the distribution and rates of input of heavy metals to the continental shelf by rivers, atmosphere and intrusions (Windom, SkIO).

Without exception the above projects address questions of a generic nature which help to describe processes controlling the flux, distribution, cycling and fate of materials and/or organisms intimately linked to the motion of water. Other general categories of research which require knowledge of water motion but which are not currently funded include studies suggested under A (3) and B (3). Several deficiencies can also be identified which fall into the broad categories defined above but where only partial coverage now exists. Examples include a study of pelagic organisms larger than zooplankton which are transported by currents (i.e., icthyoplankton) and general strengthening in areas where efforts are currently inadequate (i.e., chemistry). Markedly lacking in the recommendations of ERDA-12, for instance, is a consideration of the residence time and degradation rates of organic pollutants such as hydrocarbons.

Other areas of emphasis outlined in ERDA-12 are neglected in the above discussion, as they do not require concurrent knowledge of offshore circulation. Under the constraints of overall level funding, research described under the general groupings of B (1), (2), C (3) and D (1), might be deferred until physical oceanographic research is directed toward determining the effect of tidal regimes, A (3), on the dispersal of pollutants and the production of organisms.

II. SUMMARY OF RESEARCH ACTIVITIES

The following summarizes the results and/or hypotheses developed during the past year which relate the investigations in the SE Atlantic Bight.

A. The transport of energy-related contaminants in the vicinity of inlet mouths and their ultimate fate depends on processes that mix and exchange materials between the nearshore areas and the open continental shelf. Earlier a simple estuarine analogy was hypothesized whereby freshwater input is distributed offshore as it would be in a partially mixed estuary. Hydrographic and aerial surveys in 1976 revealed a complex series of recent and "relict" tidal fronts emanating from the inlets leading us to suspect that our early analogy was much too simplified. Using current meter and hydrographic data from an anchor station some 6 km off Ossabaw Inlet we have found that turbulence is sufficient to mix freshwater across isopycnals and is episodic in nature. A principal objective this year is to investigate the nature of this intermittent mixing.

B. Using current meter data in Onslow Bay a simple resident time model was tested to calculate the time necessary for Gulf Stream intrusions to displace all water in the Bay. The indicated displacement time of 30-60 days is approximately two times faster than flushing rates on the open continental shelf (see below). Another important result is that strong onshore flows along the bottom of Onslow Bay can occur without local wind forcing and are presumably related to Gulf Stream fluctuations. Variance in current observations induced by local winds remain to be separated from those induced by the Gulf Stream. Unquestionably the Gulf Stream influences processes along right shoreline of Onslow Bay.

C. Several offshore sources of nutrient enrichment to the continental shelf have been documented:

1. frontal instabilities may grow to spin-off eddies and upwell cold nutrient laden water onto the shelf;

2. east-west meanders of the Gulf Stream cyclonic front when meandering offshore causes upwelling, when meandering onshore causes downwelling;

3. under winter conditions wind-induced onshore/offshore transport augment upwellings due to Gulf Stream fluctuations.

Findings indicate that tides account for 5% of the variance in alongshore currents over the continental slope while direct wind forcing accounts for another 5%. Approximately 90% of the variances were due to Gulf Stream fluctuations such as meanders, instabilities and eddies. Variance in the cross-shelf currents were about 50% tidal, 5% wind and 45% Gulf Stream induced. At the shelf break (d = 50 m) alongshore shore currents were about 20% tidal, 50% wind and 30% Gulf Stream induced. Cross-shelf motions were mostly tidal (80% with only 8% due to wind forcing and 12% Gulf Stream induced).

D. River runoff extends, on the average, 56 km offshore in the north and 23 km in the southern portion of the SE Atlantic Bight. Conversely intrusions extend much further onshore in the southern than in the northern part of the area. Freshwater volumes off the Georgia, S. Carolina and northeast Florida coasts vary from 5 to 12 km^3 depending on the amount of local runoff. The flushing rate of the continental shelf calculated from the freshwater volume and runoff rates is relatively invarient at 2.7 months. This invariance implies a flushing rate independent of local runoff and leads to the hypothesis that Gulf Stream meanders are the prime forcing function. A simplified calculation involving the frequency of meanders and typical entrainment dimensions also yields a flushing rate of 2-3 months.

E. The residence time of trace metals on the continental shelf is 3 months, in remarkable agreement with flushing rate estimates based on water volume transport calculations. The most important input for these metals is from intrusions with the possible exception of mercury which has an equally important input from the atmosphere. Trace elements, along with organic matter, are regenerated at depth in the Gulf Stream (or water which it entrains) causing the enrichment of water which is later intruded onto the shelf. This is indicated by the fact that increased metal levels correlate with an increase in nutrient concentrations at subsurface depths in the Gulf Stream.

F. A portion of the trace metals transported to the shelf by rivers are lost from solution by incorporation onto particles. The relative importance of river transport for the trace elements considered is Ni>Zn>Cu>As>Hg which is in the same general order as their relative abundances in the ocean. Atmospheric concentrations of these metals over the continental shelf vary by about an order of magnitude, much of this variation depending on the past trajectory of the air parcel sampled. In terms of absolute input from the atmosphere Zn>Cu>Hg>Ni>As.

G. Most oceanic microbial communities are usually in a resting state. The outer continental shelf tends to be oceanic in character with occasional localized patches of high activity. These patches increase in frequency as one approaches the shore. Generally high energy charge ratios, indicative of exponentially growing microbial populations, occur in the first few kilometers from the shore and in the estuaries. This suggests that microorganisms may be substrate limited in outer continental shelf waters and grazer limited near shore. Nearshore activity is influenced by river flow in the S. Carolina-Georgia sector and by intrusions of deep Gulf Stream water in the north Florida and Onslow Bay sectors of the southeast Atlantic Bight.

H. The concentration of chlorophyll a, particulate carbon and particle volume increase near the bottom when intruded water masses underlay the surface water. In intrusions, chlorophyll concentrations are 5-10 times higher, while particulate carbon is 1.5 - 4 times higher than at the surface. Zooplankton biomass estimates show no accompanying differences in vertical distribution. This lack of correlation may result from time delays between the onset of plant production and the development of zooplankton populations, the inability of the zooplankton to feed on the type and sizes of phytoplankton produced, or a combination of the two. Because of geographic and small scale variability (patchiness) in the abundance of phyto- and zooplankton time series studies at given locations have not yet provided us with the type of information required to understand rate processes associated with intrusions. During August 1977 we will attempt to correct this by tracking a given parcel of intruded water for a period of two weeks (using drogues) to determine changes over time in the composition and abundance of microorganisms, phyto- and zooplankton populations.