STUDY OF LARGE SCALE TIDAL VORTICES THROUGH REMOTE SENSING

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INTRODUCTION

Coastal Zone management needs fall mainly into 4 categories. The first category is requirement of knowledge of the hydrodynamics of water concerned with diffusion, dispersion of dissolved and suspended matters which are indicative of the prevailing current patterns. The information requirements regarding nearshore bathymetry fall under second category. The third category includes identification of areas prone to excessive erosion and accretion due to interference caused by man made structures along the coast line. Under the fourth category the rdequirements are mainly concerned with fisheries, aquaculture development and intertidal region monitoring. It is a fact that the requirements mentioned above are interrelated and processes coming under one category have strong correlation to the processes listed under other categories. The analysis of the translation of these requirements primarily into engineering and then into remote sensing terms is a very important task. The Landsat series of earth resources satellites has been in operation for more than a decade. A Landsat image is a unique data set for the coastal engineer. The synoptic view which it provides though for all practical purposes one or two times in an year, of an estuary or coastal region, is something never possible to obtain using conventional methods. The main water parameter, suspended particulate content acts as a tracer and index to delineate several processes. One aspect is that it can be used to study the dispersal characteristics and identification of regions suitable for outfalls,next it can be used as a measure of evaluation of fishing potential and identification of zones which are prone to siltation and pollution.

STUDY OF TIDAL VORTICES

Out of the four requirements of the Coastal Zone management mentioned in the earlier section, knowledge of the hydrodynamics of water concerned with diffusion, dispersion of dissolved and suspended particles which are indicative of the prevailing current patterns is the first requirement. The tidal current is caused by the difference of the tidal levels between two regions. The stirring whirlpools are generated in the free boundary layers defined as the narrow water regions between the tidal current and relatively slow moving water regions. The engineering significance in study of the tidal vortices lies in the fact that the actual hydrodynamic mechanism contributing to the water mixing is expressed by transport terms, turbulent diffusion coefficients and the boundary conditions. Therefore the spatial distribution of these quantities relating to the mixing phenomena should be known fairly well for designing any ocean effluent manifested through particulate matter acting as tracer makes us to confidently use remote sensing techniques for flow visualisation. The presence of suspended matter changes the optical characteristics and it is these optical characteristics that are primarily recorded in terms of reflectance at a given wave length by any sensor like MSS on board Landsat satellite. Landsat MSS has four bands two in visible and two in near infrared region. The first two bands in visible region help tostudy the macroscale characteristics and the outfall system or dumping of any waste material in the region. Flow visualisation is the most attractive approach to get the complete picture of the hydrodynamic phenomena and tidal currents. The conventional flow visualisation through dye tracer methods is applicable only to laboratory experiments. A macroscopic view of such a wide flow field can be obtained by applying remote sensing. The basic fact that these flow fields can be two near infrared bands help to delineate land-water boundaries and identification of the extent of intertidal region. Using Remote Sensing data Maruyasu et al (1983) analysed kinematic characteristics of self propelled sea vortices based on remote sensing data. They observed on Landsat MSS 4 imagery of the eastern part of the Seto Inland sea, some vortices generated in the sea areas around the straits of Naruto, Akashi and Tomogashima. A formation process of an Oceanic vortex has been analysed by multi temporal remote sensing by Hatakeyama et al (1981). Maruyasu et al have proposed a kinetic theory called image effect theory to make clear the hydrodynamic characteristics of these self propelled marine vortices. An interesting image effect in the aerial flow field was studied by Barker and Crow (1977) relating to the problem of the aircraft turbulence. These two approaches can help in understanding the Kinematics of Vortex pair its formation and propulsion. This self propelled vortex is followed by considerable mass transport.

REMOTE SENSING OF TIDAL VORTICES

Landsat 2 imagery No.159-047 of December 2nd, 1981 has been taken for this study. As already mentioned any application of optical remote sensing techniques to study marine tidal vortices is based on the principle of particulate matter acting as a tracer. The 4 major rivers discharge into Arabian sea near Gulf of Cambay considerable amounts of sediments in suspension. Also the large scale dispersion of the sediments in this region is unique in the tropical ocean waters as reported by Muralikrishna (1983). the slow flow near the coast and the fast moving currents are mainly responsible for such dispersal. When the tidal current coming in the direction of South or South-East the Coastal Water acts as a turbulent boundary layer between the land mass and tidal main current. The structure of this boundary layer is affected by topography of the coast. As this region has a gently sloping continental shelf a wall boundary layer develops which is filled with random turbulent eddies of rather shorter life. These turbulent eddies could form into a systematic structure of isolated vortices under favourable circumstances which are really not yet quantitatively identified. However in the MSS pictures shown in Fig. 1 (MSS 4) and Fig. 2 MSS 5) the counter clockwise vortex marked at A is to be considered as a marine vortex tube as the well known Helmholtzs theorm states that the vortex tube must terminate on the boundary wall of the flow field or must connect itself to form a closed loop. However the motion of the vortex cannot be interpreted directly on this Landsat imagery, because it gives only a temporal state of the vortex motion. Any details regarding the spatial distribution of the water surface depression along the centerline of the vortex require remote sensing using Altimeter as sensor. The absence of the concurrent sea truth measurements of the vortex formation phenomenon on the day of satellite overpass is the main reason that a detailed analysis of the hydrodynamic aspects of the problem under discussion has not been carried out. This paper only attempts in evaluating the Kinematics of the Vortex formation. In view of this the factors concerned with marine environment that are responsible for generation of large scale vortex and vortex tube are highlighted.

Fig. 3 is MSS-6 image which does not show any details in water buthelps in delineating features which are marked in MSS 4 and MSS 5 (Figs 1 and 2). Figs 4,5 and 6 are corresponding images of portions of MSS 4,5, and 6 which are shown in Figs 1,2 and 3. These figures (Figs 4,5 and 6) are obtained after applying

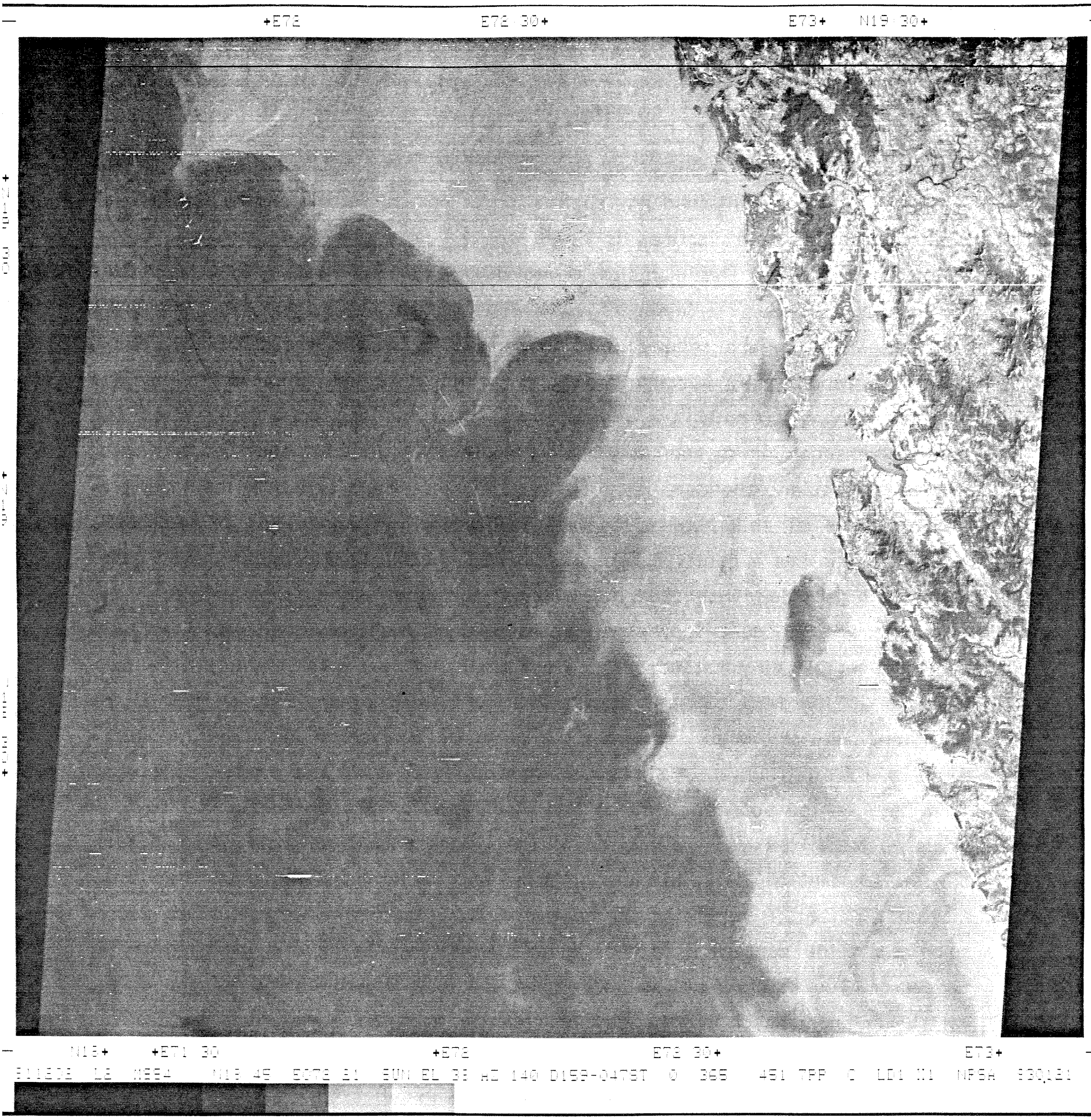

FIG 1 MSS 4 OF 159-047 OF DECEMBER 2ND 1981

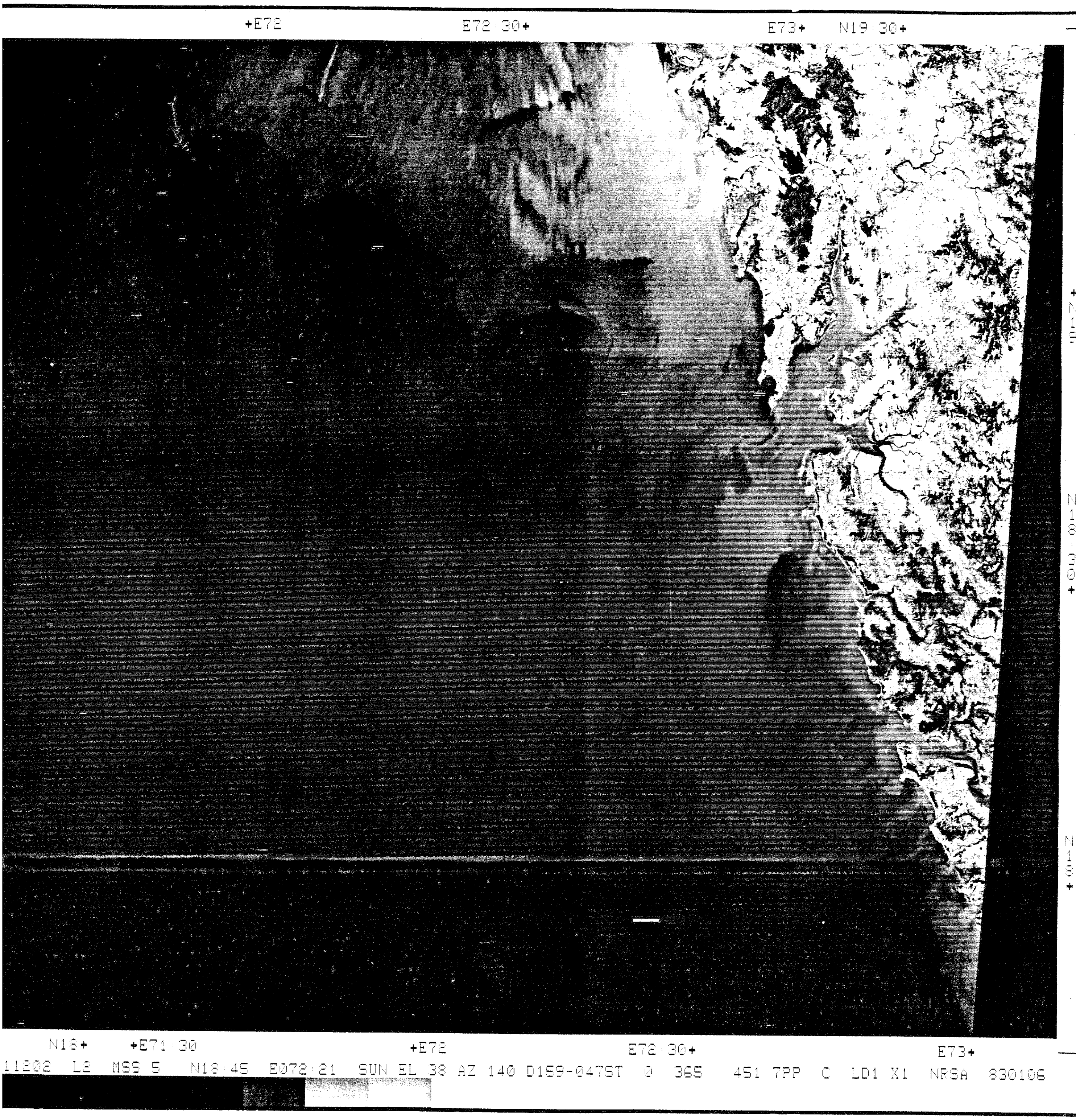

FIG 2. MSS 5 OF 159-047 OF DECEMBER 2ND 1981

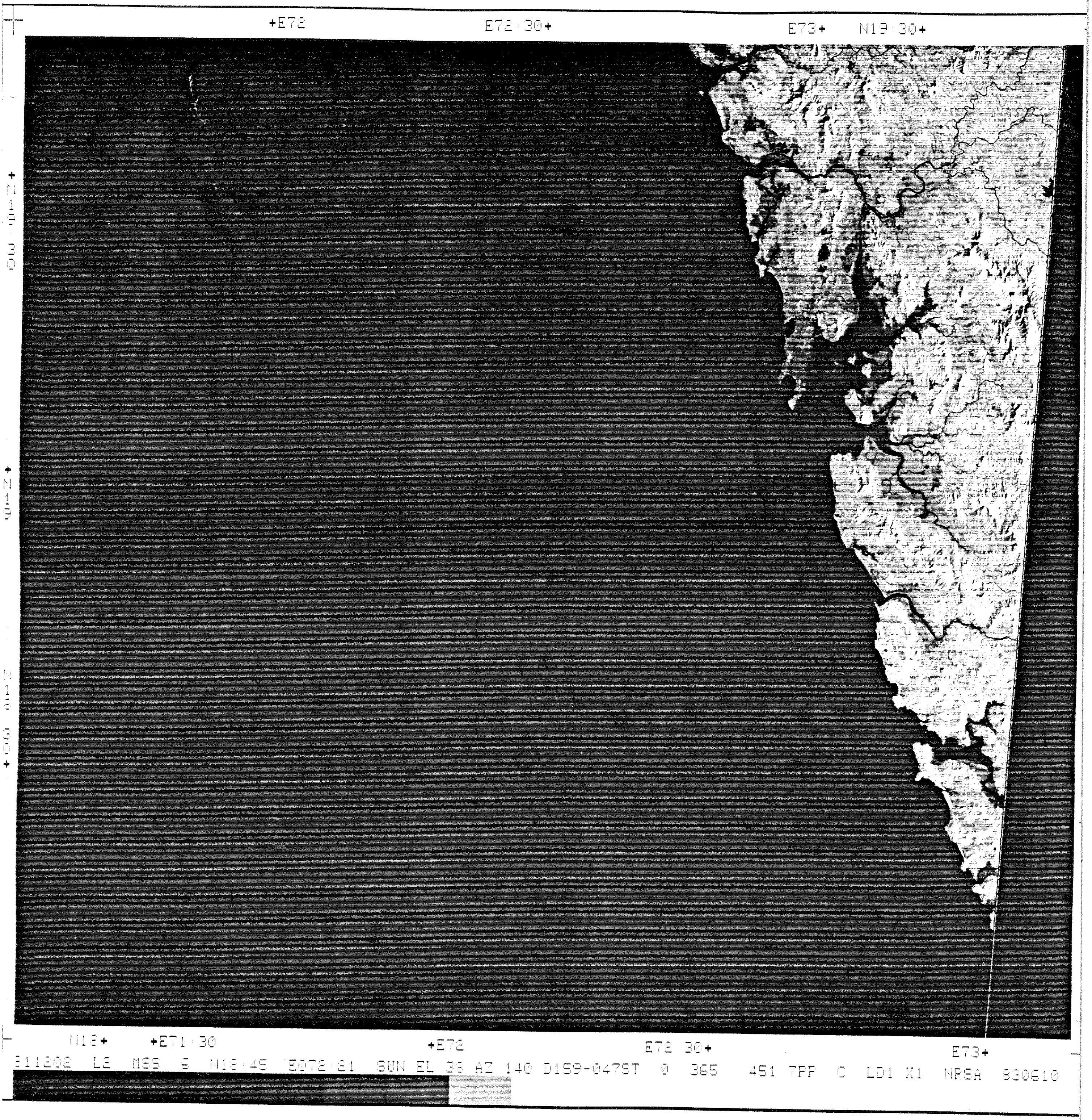

FIG 3. MSS 6 OF 159-047 OF DECEMBER 2ND 1981

FIG 4 PORTION OF MSS 4 IMAGE AFTER ENHANCEMENT
TO DELINEATE VORTEX RINGS

FIG.5 PORTION OF MSS 5 IMAGE AFTER ENHANCEMENT
TO DELINEATE VORTEX RINGS

FIG 6 PORTION OF MSS 6 IMAGE SHOWING LAND WATER BOUNDARY AND INTERTIDAL REGION

linear stretching techniques spreading the data over entire grey scale wedge. These figures after enhancement by stretching have helped to delineate the vortex tube and its possible interaction with sea bottom.

The tidal vortex generated due to the interaction of the one water mass coming from Gulf of Cambay slowly and carrying significant amounts of sediment and fast moving tidal current. Landsat MSS with resolution of about 80 meters can possibly catch the large scale vortices which have a space scale of several kilometers. In the nearshore region the influence of the sea bed slope resulted in the form of upwelling flow. This is due to the reason that when vortex approaches the upward slope, based on the rotation direction and the upward slope direction the bottom water mass climbs up and then damps its energy by producing the strong upwelling. This phenomenon could be observed on MSS 4 imagery (Fig. 4). The area mentioned here has high currents due to the rock out crops present in the northern region. This contracts the section of water course thus causing increase in the current speed. Thetidal currents run up and down with a period of half a day. The highest current speed increases to about 5-6 knots in the case of full moon day. These high speed currents produce systematic large scale tidal vortices as seen from Landsat imagery. On the imagery of Fig. 4 one can observe an anti-clockwise vortex marked 'A' in the centre of the figure which suggests that a pair of large scale tidal vortices are formed. These results demonstrated that for any hydrodynamical modelling and fluid mechanical study the synoptic and real flow conditions that could be delineated from remote sensing make significant contribution to define boundary conditions. In view of the limited spatial resolution of Landsat-MSS, the aerial remote sensing make significant contribution to define boundary conditions. In view of the limited spatial resolution of Landsat-MSS, the aerial remote sensing and the forthcoming series of satellites Landsat-D' with TM, SPOT and MOS with high spatial resolution would be very much useful for study of ocean hydrodynamics and for prescribing boundary conditions to solve the vertically integrated Navier-Stokes Equations.

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