# CALIFORNIA COAST NEARSHORE PROCESSES STUDY

ERTS-A EXPERIMENT #088



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**16. ABSTRACT**

During the period 1 May - 30 June 1973 material was processed and interpreted for use in analyzing the three ocean seasons along the California coast. ERTS imagery from the first season of the year called the Davidson Current period was mosaiced and analyzed. The second season of the year, the Upwelling period, was mosaiced and interpretation was initiated. At the present time imagery for the third ocean season, the Oceanic period is being collected for future study. Comparison of these mosaics consisting of ERTS channel 4 imagery allows for detailed analysis of nearshore and offshore sediment transport and the currents affecting the California coast. Several features of significant interest were detected in making and studying the first two mosaics. The California Current is dominating the offshore movement of suspensates while the Davidson Current is influencing the majority of the nearshore sediment transport in the Davidson current mosaic. The location at which the south moving California Current dominates moved from the Lopez Pt. area (42 miles south of Monterey Bay) in November to the Pt. Conception area in March. Interpretation of the ERTS imagery was accompanied by analysis of CCT tapes, flying spot scanner film enhancement aircraft imagery interpretation and automatic radiance level contouring. This information was used in detailed looks at the nearshore processes.

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# PROGRESS REPORT TYPE I, NO. IV
# CALIFORNIA COAST NEARSHORE PROCESSES STUDY

## 1. OBJECTIVES OF STUDY

Multiple elements under the broad topic of nearshore processes are being studied with airborne and spaceborne sensor data coincident with sea truth. These elements include (1) nearshore currents, (2) estuarine flushing, (3) season river discharges, and (4) nearshore sediment dispersion. These processes are being studied primarily along the central and southern California coast. Sophisticated data processing techniques are being utilized to obtain the maximum information from available data, and to provide correlation and comparison when possible.

## 2. SUMMARY OF WORK PERFORMED DURING REPORTING PERIOD

During the period 1 May - 30 June 1973 data was processed and interpreted for use in analyzing the three ocean seasons along the California coast. This information will be utilized in the analysis and prediction of the transitory nature of current and sediment transport along California's Pacific shore. Two mosaics of the California coastal oceanographic seasons were compiled. The first from the Davidson Current period (November through February) was analyzed in detail and compared with the aircraft and seatruth that was simultaneously collected. The second mosaic of the Upwelling period (March to August) was just completed and is in the process of being analyzed. Isodensity line contouring from the computer computable tapes (CCT) supplied by NASA was carried out for selected sites. The reformmated CCT information was played back on a Flying Spot Scanner (FSS) for enhancement in nearshore process study. This results in detailed scene density differentiation which is then used in subtle feature interpretation. Aircraft information from the April flights were also used in the ERTS analysis. The first generation IR scanner data and 9 channel scanner data was played back from the recorded format to optimize tonal differences of nearshore features. Photographic data that included film and filter combinations for water penetration and suspensate detection was also utilized in the interpretation. Seatruth data from the U.S. Army Corps of Engineers, University of Southern California, University of California Santa Cruz, National Marine Fisheries Services and several historical publications was utilized as calibration at reference stations in the survey areas.

Davidson Current Period Mosaic - This ERTS imagery mosaic of channel 4 (5000-6000Å) illustrates in detail the nearshore transport of suspended sediments as influenced by the Davidson and California currents. The imagery used is from several orbits during the mid-November 1972 - February 1973. Frames utilized were those which showed the maximum nearshore sediment during clear weather. Although this California coast mosaic covers areas outside the designated test cells (Humboldt Bay, San Francisco, Monterey Bay, Santa Barbara Channel and San Pedro Channel) it was found that nearly

the entire coast must be analyzed in order to understand the cell nearshore features. The main influencing current on the coast is always the California Current which is a part of the great clockwise circulation of the North Pacific Ocean. However, during the period of approximately November to February each year the Davidson Current - a north moving counter-current is the dominant inshore transporter of water and suspensates.

The Davidson Current is generally a deep counter-current below 200 meters which flows to the northwest along the coast from Baja California to some point beyond Cape Mendocino. It brings warmer, more saline water great distances northward along the coast. When the north winds are weak or absent in late fall and early winter this counter-current forms at the surface,well on the inshore side of the main steam of the California Current. The evidence of this current is visible on the mosaic and indicated by the temperature contours and current measurements collected from this area. The temperature contours along the coast all bend to the north during the height of the Davidson Current activity with the most dramatic changes taking place in February.

In general the mosaic of this period illustrates the nearshore northern movement of sediments offshore to a distance of 3 to 5 miles. At several points along the coast the movement is blocked by large gyres which appear to carry significant volumes of sediment off coast where they are then transported southward by the California Current. At Pt. Conception a realtively small blockage takes place, but off Pt. Lopez 42 miles south of Monterey an extensive offshore movement of sediment takes place. Initial transport here is in the southwest direction to a point about 60 miles off the coast where movement changes to the south. From that point this plume of sediment is detectable being moved 160 miles to the south to the edge of the presently available imagery. At its southern extent this plume is 35 miles wide. The total area of this feature is approximately 2100 square miles. Similar gyres on smaller scales are present near: Pt. Ano Nuevo, Devils Slide, Pt. Arena, Pt. Delgada, and off Humboldt Bay. In each case a counterclockwise gyre is present which carry north moving nearshore sediments offshore into the south moving California Current. No attempt has been made to estimate the significant amount of sediment loss during the Davidson Current period.

In the Los Angeles Harbor area material from the Los Angeles, San Gabriel and Santa Ana Rivers are being moved offshore and westward by the influence of the Davidson Current. Inside the harbor itself an east-southeastward current is in effect. Once outside the Los Angeles breakwater a slow moving westward current appears to dominate the nearshore sediment movement. Off Santa Catalina Island, however, transport is in the southeast direction indicating a surface current reversal in the San Pedro Channel. Suspended sediments in Santa Monica Bay ring the bay with a 3 to 5 mile wide border. This ring of sediment appears to be escaping the bay area to the westward around Pt. Dume. This agrees with the general Davidson Current pattern.

In the Santa Barbara Channel between Port Hueneme and the Anacapa Islands the westward current domination is observed. The pattern with minor modifications continues to west of Carpinteria. A counterclockwise gyre is present just east of Santa Barbara which

is moving sediment offshore 4 to 5 miles where they are again moved to the west. Off Pt. Conception the California Counter-Current in the area between the mainland and the channel Islands appears to pick up these particles and transports them offshore in a complex pattern where they are influenced by the California Current.

The Monterey Bay surface waters are exceedingly uniform during the Davidson Current period. The extreme difference between any pair of stations averages a little less than (0.5°F). No regular pattern of temperature distribution is discernible. The general northern trend of the suspended sediment appears to continue in Monterey Bay. From the area of the Elkhorn Slough north and northwest to Santa Cruz a large gyre of material is present. Little of this material appears to be escaping the confines of the Bay, however. The blockage of suspensate movement from the bay appears to be blocked by the counterclockwise gyre activity that is present off Pt. Ano Nuevo.

In the Gulf of the Farallones which encompasses the majority of the San Francisco test cell, a complex surface current and sediment transport system is present. A large counterclockwise gyre is present off the Golden Gate Bridge reaching from the Lake Merced area northwest to the vacinity of Duxbury Pt. Near Lake Merced a nodal point is present separating the large gyre just mentioned from a smaller gyre present off the Devil's Slide. From Duxbury Pt. toward Drakes Bay the current appears to be moving sediment in a northwest direction. Near Drakes Bay this current meets a counterclockwise moving current which generally moves around Pt. Reyes. Just north of Pt. Reyes at the mouth of the Russian River the distinct northern effect of the Davidson Current is illustrated. The majority of the movement takes place within 3 to 4 miles of the coast.

The overall affect of the current along the California coast can be viewed in detail on the ERTS imagery. Although the general changes in current direction have been known for some years the complexities within the general currents are not recorded in detail. Near the coast the effect of the irregular coastline and varying depth governs detailed transport and current direction. These and the winds, which sometimes reinforce and sometimes oppose the current, and the significant vertical motion in the regions of upwelling and the oscellations of internal waves, all combine to make the measurement of current complex. The synoptic ERTS view of currents as indicated by sediment tracers presents a unique capability to the coastal investigator.

## Upwelling Period Mosaic

This mosaic is made from ERTS channel 4 (5000-6000Å) frames for the March-April 1973 period. The frames used were picked for clarity and visible suspended sediment content which acts as a tracer for studying current movement. The Upwelling period takes place generally from March to August. During this period winds parallel to the coast move waters offshore allowing deeper ocean water to surface. This effect seems to be

intensified south of capes and points which extend out into the current stream and above submarine canyons. Thus Cape Mendocino and Pt. Conception and the numerous submarine canyons act as major upwelling locals. These colder upwelling waters are often rich in nutrients with the additional result that phytoplankton blooms often accompany this period.

As in the Davidson Current mosaic the major features visible are large offshore movements of sediment into the California Current. The main feature of this type is a large southern transport of sediment from the vicinity of Pt. Conception. This parallels the "Lopez Point" transport discussed in the previous mosaic discussion. The Pt. Conception feature, however, is 105 miles south along the coast. It stretches for 130 miles off the coast to the edge of the available ERTS imagery. The variation in this major feature represents a significant ocean seasonal change. In addition, a number of relatively minor offshore transport systems are present adjacent to: Half Moon Bay, Humboldt Bay, Eel River and Pt. St. George. Again the volume of sediment being moved offshore in all of these systems represent a major amount of loss from the California mainland.

In Monterey Bay suspended sediment from the Salinas River is moving northward to the vicinity of the Pajero River. Upwelling above the Monterey Canyon is resulting in the shoreward transport of sediment adjacent to Moss Landing. Similar upwelling also appears: south of Cape Mendocino, North of the Eel River, south of Half Moon Bay, and west of Goleta Point. The details of these features are still being investigated.

The Upwelling period is significant because of the water temperature changes, nutrient influx and effect on the coastal transport system as a whole. The majority of the nearshore current and sediment transport during this period is to the south parallel with the California Current. The wind direction during this period has a major contributing influence on the currents during this season.

## ISODENSITY LINE CONTOURING

Effort during this reporting period concentrated in the investigation and adaption of software systems and graphic techniques for the automatic generation of isodensity contour line maps from computer compatible tapes to aid in the interpretation of detailed coastal sediment distribution.

Sections of an existing contouring program were adapted for this purpose. This software package is comprised of several data entry, preprocessing, surface fitting and plotting subroutines which allow the investigator with various inputting and processing options. The program runs on the IBM 370 computer system and produces output on the FR-80 graphic display unit. Hardcopies obtained consist of 35 mm film chips and 8-1/2" X 11" copies prints.

In a typical ERTS application a Format C tape generated on the R-706 computer is sampled in the area of interest to obtain a maximum of 4900 points formatted for inputting as a rectangular array. This data is then smoothed by using a multiple regression surface fitting technique. The smoothing process eliminates scattering in the data in preparation for the generation of the contour maps.

Several output formatting parameters can be specified: 1) The labels on the grid may be stated in terms of latitude and longitude; 2) The ratios of X to Y dimensions may be changed to correspond to the distortions inherent to ERTS sensors and 3) The labels on the contour lines may be specified to correspond with physical characteristics of the data, i.e., reflectivity or sediment content.

Preliminary visual comparisons of automatically generated maps with much slower manually traced contours on enhanced photographs of the same area show excellent correlation of results.

## FLYING SPOT SCANNER - CCT IMAGE FILM RECORDING

Imagery recorded on the Flying Spot Scanner (FFS) from NASA supplied Computer Compatible Tapes (CCT) has been enhanced and improved for nearshore sediment detection and delineation. During the last two months an extensive analysis was directed toward improving the FSS system to provide better resolution of features made from the CCT. The major emphasis was the enhancement of coastal processes features.

The analysis resulted in isolating three major problem areas: 1) CRT dynamic focus; 2) recording lens; and 3) the recording film. The data from the CCT of frame 1183-18105-4 was used during the first test runs. These runs showed that signal level filtering was necessary for optimum coastal suspensate enhancement. To carry out the necessary filtering a signal limiter was incorporated into the video section of the FFS. This resulted in the ability to filter out the signal that exceeds .5v (which is the level correlating to the maximum desired density). The signal for that instant of time is clamped to zero volts. This clamping effect is displayed on the imagery as a fold over condition. As the signal level increases to the safety threshold the film image is increasing in density. Once the signal increases past this level the resulting density is folded over to clear and remains there until the signal level falls below the safety threshold level.

The incorporation of these modifications and procedures resulted in greatly improved FSS imagery. The new imagery display resolution is the same if not better than the NASA original imagery and the nearshore sediments are brought out in detail. This FSS enhanced data can thus be utilized by the investigator for making interpretation of features not possible with the original imagery.

## 3. SCHEDULE

The study is progressing as scheduled.

## 4. WORK PROGRESS

Analysis of coastal processes is progressing on schedule. Two mosaics out of three needed for analyzing of California coast have been completed.

## 5. RELIABILITY

Emphasis continues to make scientifically correct analyses and interpretations from the ERTS, aircraft and seatruth data.

## 6. FUNDS

At this time the scheduled funding for this study is adequate to complete the tasks required.

## 7. PERSONNEL

Personnel remains the same at the time of this report.

## 8. PLANNED WORK

During the next reporting period 1 July - 31 August 1973 analysis of the three ocean seasons along the California coast will continue. Aircraft imagery, seatruth and NASA CCT studies will be completed for use in the 6 month report due at the end of the next reporting period.

## SIGNIFICANT RESULTS

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Contract S-70257-AG

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1. Davidson Current Period Mosaic - This ERTS imagery mosaic of channel 4 (5000-6000Å) illustrates the nearshore transport of suspended sediments as influenced by the seasonal Davidson and permanent California currents. In general this November-February mosaic illustrates nearshore northern sediment transport. Several significant blockages in this pattern take place where counter-clockwise gyres are formed. This results from the irregular coastline and varying depths combined with the influence of the winds. Off Pt. Lopez 42 miles south of Monterey an extensive offshore movement of sediment takes place. The resulting sediment plume can be traced for 160 miles off the coast to the edge of the presently available imagery. Several smaller gyres of a similar nature are present off Pt. Ano Nuevo, Devils Slide, Pt. Arena, Pt. Delgada and Humboldt Bay. In each case a counterclockwise gyre is present which transports north moving nearshore sediments offshore into the south moving California Current.

2. Upwelling Period Mosaic - This mosaic was made from ERTS channel 4 (5000-6000Å) frames for the March-April 1973 period. During this period winds parallel to the coast move waters offshore allowing deeper ocean waters to surface. The Upwelling period takes place along the California coast from March to August but the maximum sediment that can be used as current tracers is present early in the season. Analysis of the mosaic indicated significant long-shore and offshore transport of sediment and several locations of upwellings. Off Pt. Conception a large plume of suspensate is visible being transported from the California Counter-Current into the California Current out to a distance of 130 miles off the coast. In the Channel Islands area a complex clockwise - counter-clockwise current system is present. Upwellings near the Eel River, Pt. St. George, Cape Mendocino, south of Half Moon Bay, at Monterey Canyon and west of Goleta Pt. are all actively affecting water movement in their respective locations.

3. Flying Spot Scanner (FSS) image film recording was reformatted and improved to significantly enhance offshore sediment transport features. Modifications were made to the CRT dynamic focus and the recording lens. The imagery playback from the reformatted CCT supplied by NASA displayed pictures of equivalent resolution, but they bring out subtle coastal processes in greater detail. This information is applied to the test site evaluation at locations of specific interest.