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Coastal changes mapping by mean of Topographic Maps, Remote Sensing and GIS techniques in Samborombón Bay, Buenos Aires, Argentina.

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Abstract: The study area is the Samborombón Bay in the Atlantic Ocean, at the outlet of the Río de la Plata (west coast) in Buenos Aires Province, Argentina. The region is one of the most extensive, rich and important wetland of Argentina. The Samborombón bay was declared Ramsar Site in 1997, specially as aquatic birds habitat. The coastal line in this environment experiments important variations by natural and/or anthropic actions. These changes can be observed and measured along decades.

The main goal of this study was to develop a methodology to estimate and identify the changes in the coastal line in Samborombón bay by mean of the integration of: historic topographic maps (year 1936-41/68/71), satellite charts (years: 1994-96) and multitemporal satellite images of Spot (year 1998), Landsat 5 TM and SAC-C (year 2005), the Argentinean satellite.

The steps to integrate the data were: 1) the data in analogical format was converted to digital format as the topographic maps and satellite charts; 2) the study area (coastal sector only,) was clipped from the original maps and images; 3) all the clipped material was georeferenced; 4) the topographic maps and satellite charts were mosaicked; 5) these three sources were integrated and analized in a Geographic Information System (GIS); 6) the coastal line was digitalized for the three temporal series of data: 1936-71, 1994-96 and 1998-2005 and the changes were estimated.

The results were different along the Samborombón bay: in the north (Point Piedras) the coast presented slight erosion, in the central portion (where the bay receive the main rivers) an important land increase was observed including new small islands, in the south (Point Rasa) an increase of the coastal line also was detected.

The applied methods and the obtained results were very useful to know the coastal changes and to update the cartographic information in this wetland, so important region from environmental point of view.

Introduction:

The swamps, plains and tidal channels are very sensible to small environmental alterations, dynamic, biologic and sediments properties conditions have an important role in marshes environment (Bértola *et al* 1993, Bértola 1994).

The coastal line in this environment experiments important variations by natural and/or anthropic actions (Conzonno *et al*, 2001; Conzonno *et al* 2002). The sea level variation is other factor that affect the shoreline, for the south hemisphere was registered an increase of 1.6mm/year (Lanfredi *et al,* 1988), these changes are less conspicuous.

In some littoral sites the processes of erosion and progradation for natural or human causes modify permanently the shoreline. This yields a sedimentary imbalance in the littoral of Buenos Aires Province (Samborombom Bay) (Marcomini 2006; Marcomini *et al*, 1997). All these changes can be observed and measured along decades

In the study area, Samborombón Bay, the geomorphology and sedimentology were widely studied by Bértola *et al* (1993), and Bértola (1994). These authors concluded, by mean of field trips, that the progradation is 6 m/year in the south of the bay and 1 m/year in the center (south of channel 15). These values are higher than theoretic values of sea level increase and also than the basin downfall (0.04 mm/year). Meanwhile in the north of the bay domains the erosion process (0.8 m/year). Other authors as Rosenthal and Ulibarrena (1966) have applied aerial photographs to describe the geology of this zone.

The main goal of this study was to develop a methodology to estimate and identify the changes in the coastal line in Samborombón bay by mean of the integration of historic topographic maps, satellite charts and multitemporal satellite images.

Study Area:

The study area is the Samborombón Bay in the Atlantic Ocean (Argentine Sea portion), at the outlet of the Río de la Plata (west coast) in Buenos Aires Province, Argentina. The bay is 135 km long and stretches from Point Piedras (35°27′ S - 56° 45′W) to Point Rasa (36°22′ S - 56° 35′W) (Fig. 1 y 2). The bay receives the Salado and Samborombón rivers, as well as other minor streams and canals. The region is one of the most extensive, rich and important wetland of Argentina and was

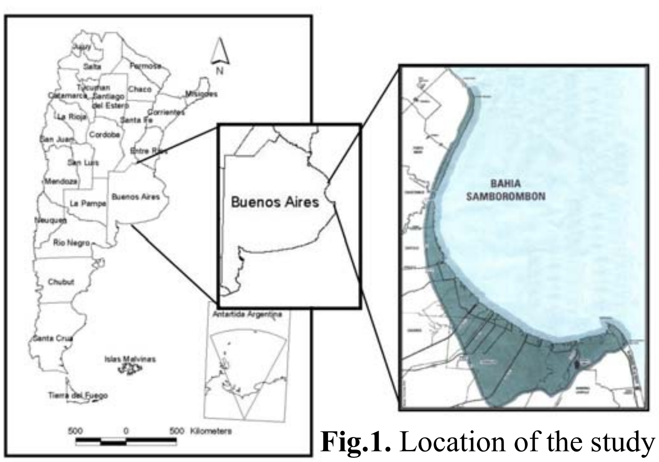
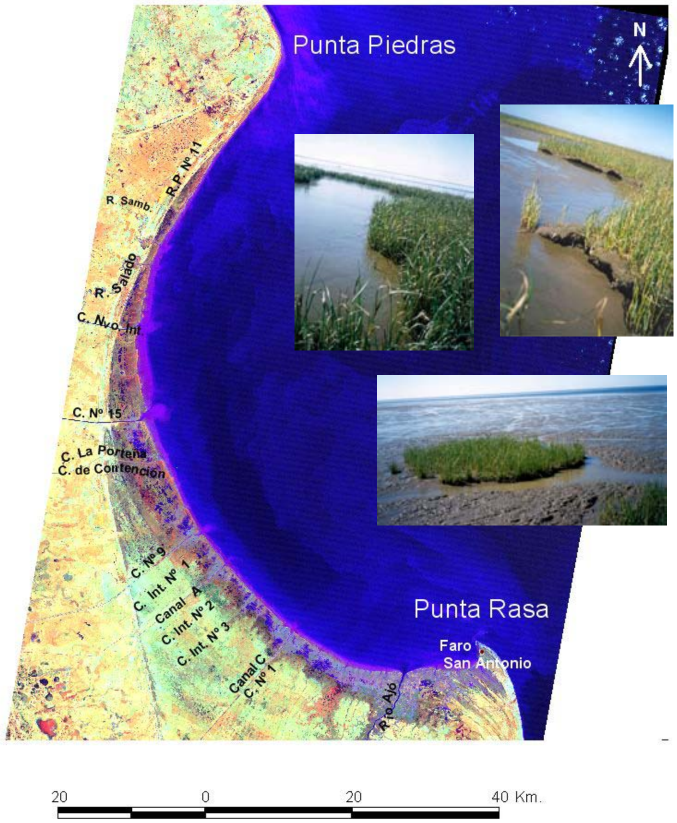


Fig.1. Location of the study area.

declared Ramsar Site in 1997, specially as aquatic birds habitat.



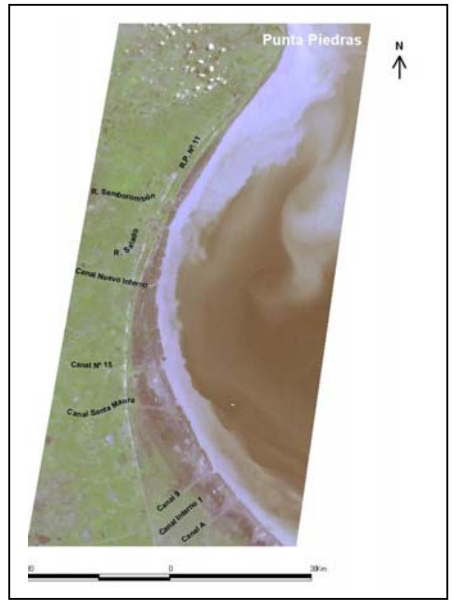


Fig. 2. Details of channels and rivers in the Samborombón Bay on the satellite images (2005) (Landsat 5 TM on the left (bands 453-RGB) and SAC-C (bands 321-RGB) on the right). Pictures of the coastal area.

Materials and Methods:

The Table 1 shows all the topographic and satellite charts (temporal series, chart type, name, code, date and scale) used in the study.

The Table 2 shows all the satellite images (temporal series, sensor, date, path/row and spatial resolution) used in the study.

The steps to integrate all the data (historic topographic maps (year 1936/37/38/39/41/68/71), satellite charts (years: 1994/95/96) and multitemporal satellite images of Spot (year 1998), Landsat 5 TM (year: 2005) and SAC-C (year 2005), (the Argentinean satellite) were: 1) the data in analogical format was converted to digital format as the topographic maps and satellite charts; 2) the study area (coastal sector only,) was clipped from the original maps and images; 3) all the clipped material (maps and images) was georeferenced in the following Cartographic System: Transverse Mercator (Gauss Kruger), Ellipsoid: International 1909, Datum: Campo Inchauspe, Zone 6, by Nearest Neighbour algorithm as resampling method with ERDAS Imagine software; 4) the topographic maps and satellite charts were mosaicked; 5) these three sources were integrated and analized in a GIS (ArcView 3.3); 6) the coastal line was digitalized for the three temporal series of data: 1936-71, 1994-96 and 1998-2005 and the changes were estimated.

Also a preliminary analysis of Seawifs images was carried out to evaluate the source of sediments responsible of the progradation in the central and south sectors of the Samborombón bay. An specific algorithm (K-490), with SEADAS software, was applied to visualize the suspended sediments in the study area.

Tabla 1. Topographic and satellite charts used in the study.

Temporal Series	Chart Type	Name	Code	Date	Scale
1936-1971	Topographic	Desembocadura Canal Nº 1	3557-3-4 Y 3-2	1937/36/65	1: 50.000
		General Lavalle	3557-10 Y 4	1938/39/41	1: 100.000
		General Lavalle	3557-10-1 y 4-3	1938/39/41	1: 50.000
		Cerro de la Gloria	3557-33	1968	1: 100.000
		Estancia Santa Lucía	3557-3	1968	1: 100.000
		Estancia Juan Gerónimo	3557-27-4	1971	1: 50.000
		Punta Piedras	3557-27-2	1971	1: 50.000
		Pipinas	3557-27-3	1971	1: 50.000
1994-1996	Satellite	Santa Teresita	3557-10 y 4	28/01/1994	1: 100.000
		Estancia Santa Lucía	3557-3	20/02/1994	1: 100.000
		Cerro de la Gloria	3557-33	20/02/1994	1: 100.000
		Estancia Juan Gerónimo	3557-27-4	20/02/1994	1: 50.000
		Estancia Rincón de Noario	3557-27-2	20/02/1994 30/03/1991	1: 50.000
		Pipinas	3557-27-3	20/02/1994 30/03/1991	1: 50.000

Table 2. Satellite images used in the study.

Temporal Series	Sensor	Date	Path/Row	Spatial Resolution
1998-2004	Landsat 5 TM	03/March/2004	224/85	30 m
	SPOT	03/May/1998	224/85	10 m
	SAC-C	26/Feb/2005	224	175 m/30m
	Seawifs	2004-2005 (8 images)	224	1000 m

Results and Discussion:

The following figure show the overlay of topographic chart (Fig.3-left) and satellite charts (Fig.3-right) on the Landsat 5 TM image. The sector of the bay with more changes in shoreline is showed in the Fig. 4 (center of the bay). In blue is represented the shoreline in 1968, and in red the shoreline in 1994, all overlaid on the Landsat image of 2005. It's possible to observe the coastal progradation and the formation of new small island along 37 years. The land increase along the central coast of the bay (difference between current shoreline and 1968) was measured, the minimum value was 456.57m, the maximum

761.53m, the mean value was 596.69m; and also the surface of the new islands was estimated, it reached almost 3.5 km^2. In the north of the bay non significative changes were detected, only a few sectors were affected by erosion processes.

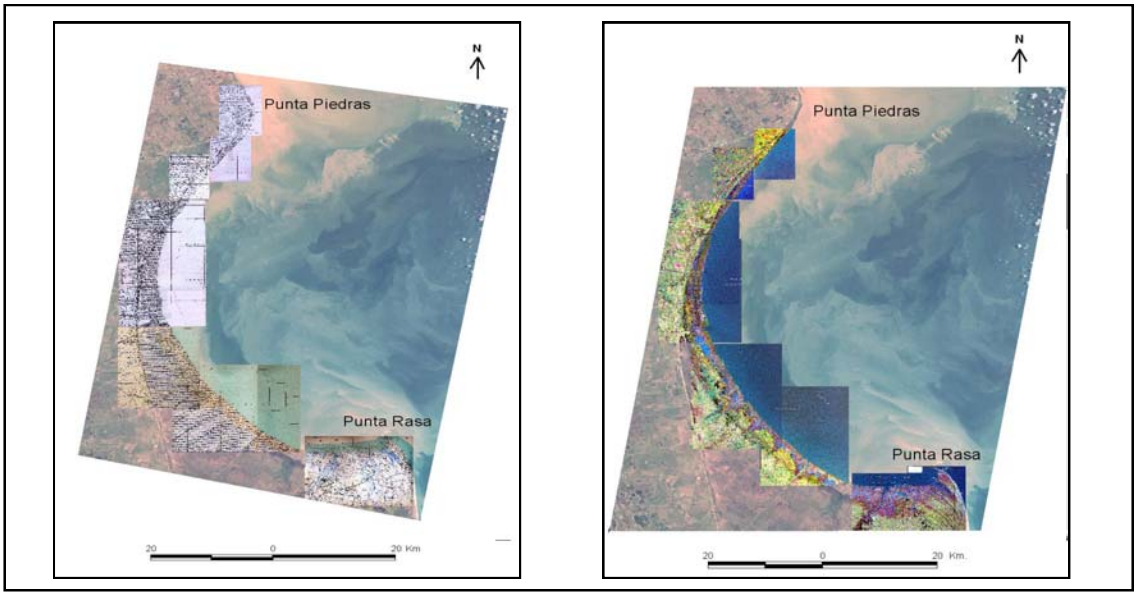


Fig. 3: The overlay of topographic chart (on the left) and satellite charts (on the right) on the Landsat 5 TM image (2005), bands: 3,2,1-RGB.

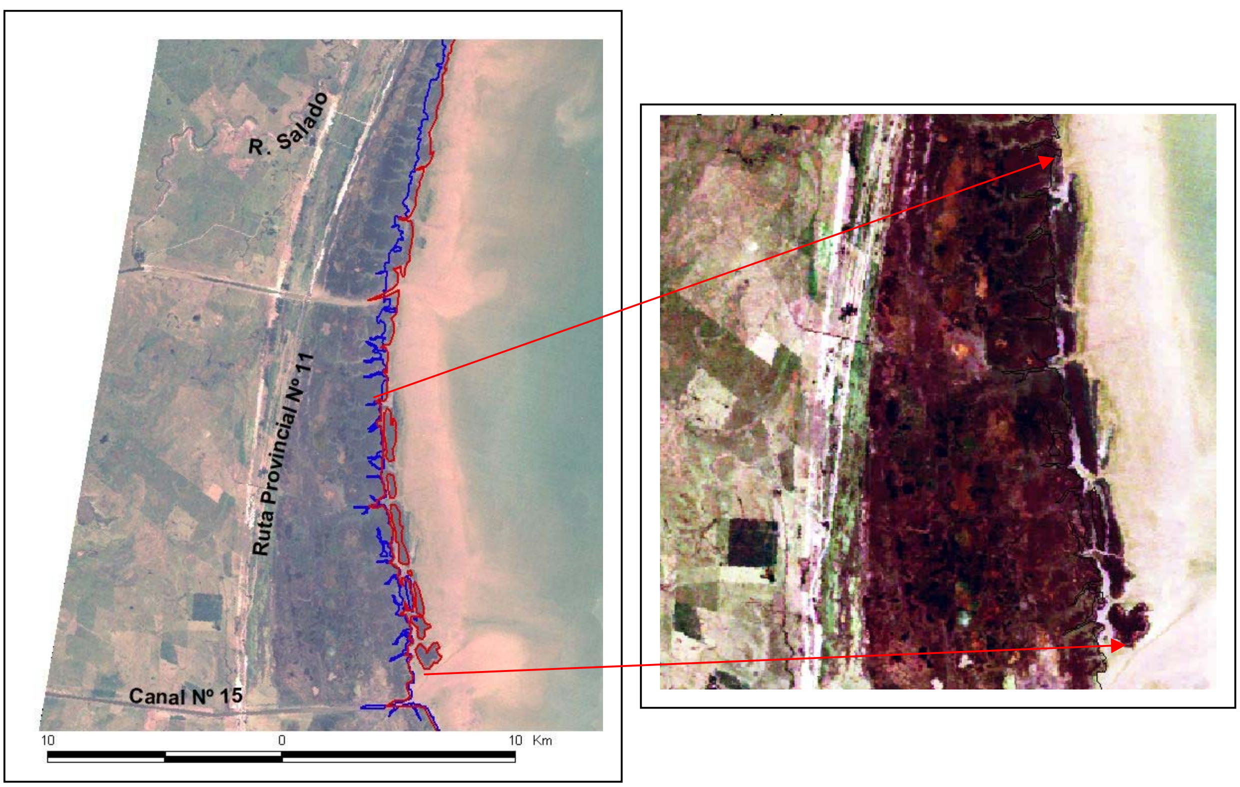


Fig. 4. The progradation in the central sector of Samborombón bay. On the left: in blue the shoreline in 1968, in red the shoreline in 1994 overlaid on Landsat image of 2005. On the right the details of the formation of new small islands.

The figures 5 and 6 show the changes in the south extreme of the bay (Point Rasa). The blue line represents the shoreline in 1938-1941 and the red line the shoreline of the year 1994, all overlaid on the Landsat image, 2005 (Fig.5) and on Spot images, 1998 (Fig.6).

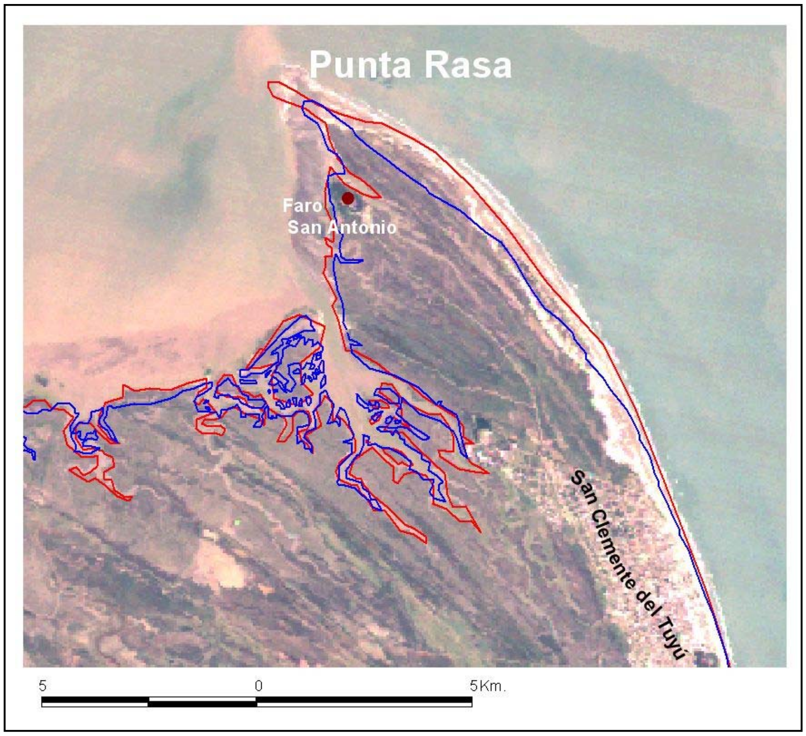


Fig. 5. The progradation in the south extreme of Samborombón bay (Point Rasa), in blue the shoreline in 1938-41, in red the shoreline in 1994 overlaid on Landsat images of 2005.

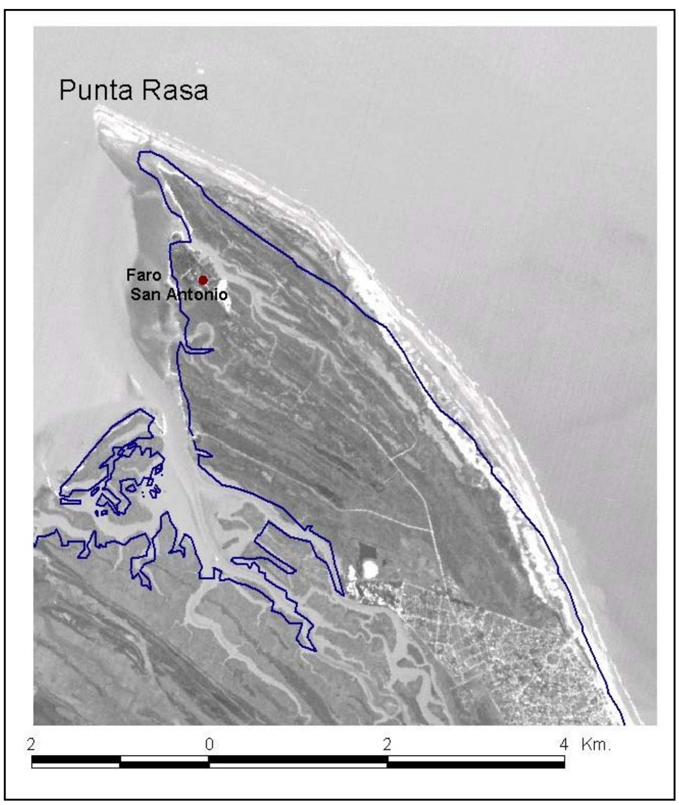


Fig. 6. The progradation in the south extreme of the Samborombón bay (Point Rasa), in blue the shoreline in 1938-41, overlaid on Spot images of 1998.

Also in Point Rasa was measured the shoreline changes between the two temporal series (current and 1938-41). The maximum land increase was 639.4m, the minimum value was 253.3m and the mean distance between the two shoreline was 456m.

The Fig.7 shows the result, on a Seawifs images, of the application of K-490. In yellow tones appear the sediments transported by de La Plata River flowing into the Argentine Sea (blue tones).

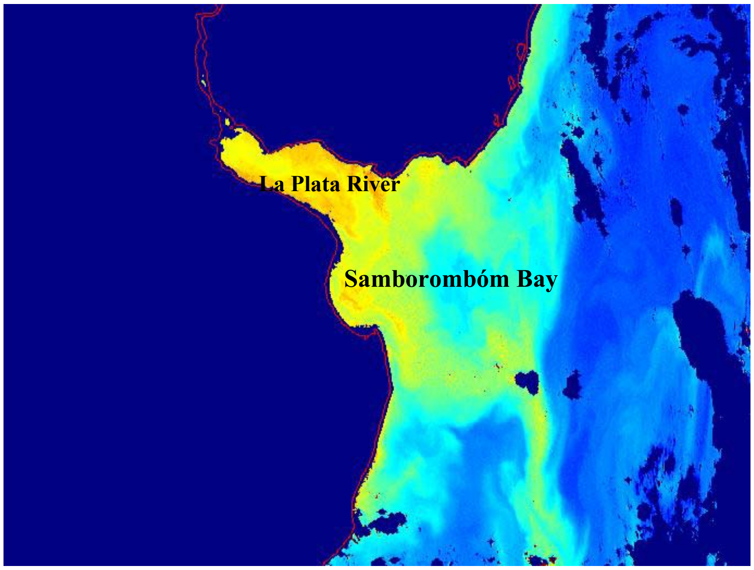


Fig. 7. Result of the K-490 algorithm on a Seawifs Image.

The obtained results in this study corroborate those of Bértola (1993,1994). This author evaluated the progradation and erosion processes along the bay with field analysis, we can verified with satellite images. In our study, as Bértola *et al* (1993) and Bértola (1994), few changes in the north sector of the bay was detected, these were affected by erosion processes. The central zone of the bay presented important features of progradation and formation of new small islands, and the same phenomenon take place in the south, Point Rasa. Also, they recognize four sediments sources responsible of the land increase in the bay (center and south): 1)sediments transported from the north by La Plata River, as we can observed in the Seawifs images, 2) from the south, littoral current transports the sand presents in Point Rasa, the Seawifs images corroborate this issue (this source is also corroborate by Dalmau, 1996), 3) “pampeanos” sediments come from rivers and channels in flooding periods, and by (4) eolic actions.

Conclusions:

The remote sensing tools and the methodology applied in our study were very adequate to evaluate shoreline changes and to update the cartographic information in this wetland, so important region from environmental point of view. It's important to distinguish that in the south of the bay, the topographic maps available have more than 60 years in a very dynamic area, and in the center have more than 30 years.

Our results corroborate the works of other authors as Bértola *et al* (1993), Bértola,1994, Conzonno et al, 2001; Conzonno et al, 2002) whose papers were done with *in situ* data, with difficult access in the field and with a high economic cost.

The use of Seawifs data must be deepen because the information of this type of data is very important to know the way of sediments and currents actions along the coast.

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