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Migration of Intertidal Sandbanks, Bahía Blanca Estuary, Argentina

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ABSTRACT

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Bahía Blanca is a mesotidal coastal-plain estuary characterized by a shore-connected ebb tidal delta closing the mouth of the Main Channel, an unusual feature in this kind of estuary. The study area comprises a series of banks and channels cut through the southern lobe of the ebb delta. The objective of the study is to determine the evolution of the banks in the last 160 years and to define their formation process.

To study the dynamic conditions of the area, a transport model was applied, considering the predominant tidal current. Seismic information was available to define the subsoil structure. Historical maps dated back to 1833 to present and currents were employed to determine the movement of the banks. The geoforms migrate toward the west up to the Main Channel where the stronger ebb currents prevent a westward transport of the sediments. The detected migration is only a local process. This observation rejects previous theory that supposed a large sand transport toward the west that might fill the estuary.

ADDITIONAL INDEX WORDS: *Ebb tidal delta, bank evolution, tidal currents, flood sinus, sediment transport, bank migration.*

INTRODUCTION

Some 30 years ago, OFF (1963) described rhythmic linear sand bodies around the world based on the study of detailed bathymetric charts. His work involved the coasts of Asia, Africa, South America, Australia, and it also considered the ridges on the approaches to Bahía Blanca, Argentina. Since then, specific studies have been done in different regions such as the North Sea (CASTON, 1972; CASTON, 1981); Moreton Bay, Australia (HARRIS *et al.*, 1992; HARRIS and JONES, 1988); Bristol Channel (STRIDE and BELDERSON, 1990, 1991; HARRIS and COLLINS, 1991), and Chesapeake Bay (LUDWICK, 1974).

Sand bodies parallel to currents have received different names: tidal current ridges (OFF, 1963), linear sand banks (CASTON and STRIDE, 1970; MC CAVE, 1979), sand ridges (SWIFT, 1975), sand bars (KLEIN, 1970). Although some authors considered those features as current-built, others attributed their occurrence to relic topography or structural control (SMITH, 1969). Several models have been proposed for the formation and maintenance of linear sand banks on both continental shelves and estuaries (CASTON, 1972; PINGREE and MADDOCK, 1979; MC CAVE, 1979; HUTHNANCE, 1982a,b). CASTON and STRIDE (1970) found that nearshore sand banks occur with wedge-interfingering channels; meanwhile further seaward the channels between sand banks are straight or slightly curved, almost parallel to one another, and without transverse obstructions.

URIEN and EWING (1974) described for the first time linear shoals on the Argentina shelf. PARKER and PERILLO (1976) and PARKER *et al.* (1978) detected shoreface-connected linear shoals on the inner shelf south of the La Plata River estuary that form angles with the coast of about 35°. SWIFT *et al.* (1978) suggested that these ridges are responses to intensive flow induced by the passage of "southeasters" storms, like the northeasters of the North American Atlantic Shelf (BEARDSLEY and BUTMAN, 1974; BOICOURT and HACKER, 1976; LAVELLE *et al.*, 1976). Linear shoals also form on the outer reaches of wide-mouth macrotidal and mesotidal estuaries (HAYES, 1975). They normally exhibit similar characteristics to those found on shelves. However, linear shoals have not been discussed previously in association with ebb-tidal deltas as the one observed at the mouth of the Bahía Blanca Estuary.

Study Area

Bahía Blanca is a mesotidal coastal-plain estuary located at the southern end of the Buenos Aires Province, Argentina (Figure 1). It consists of a series of NW–SE channels that cross extensive tidal flats and islands. The estuary behaves as hypersynchronous (PERILLO and PICCOLO, 1991) as tidal range and tidal current amplitude increase headward. In the study area, the mean tidal amplitude is 2.4 m. Prevailing winds are from NW–N for over 40% of the time while SE–S winds have frequencies about 10% (PICCOLO *et al.*, 1989). Wind is a major factor in the Bahía Blanca Estuary dynamics

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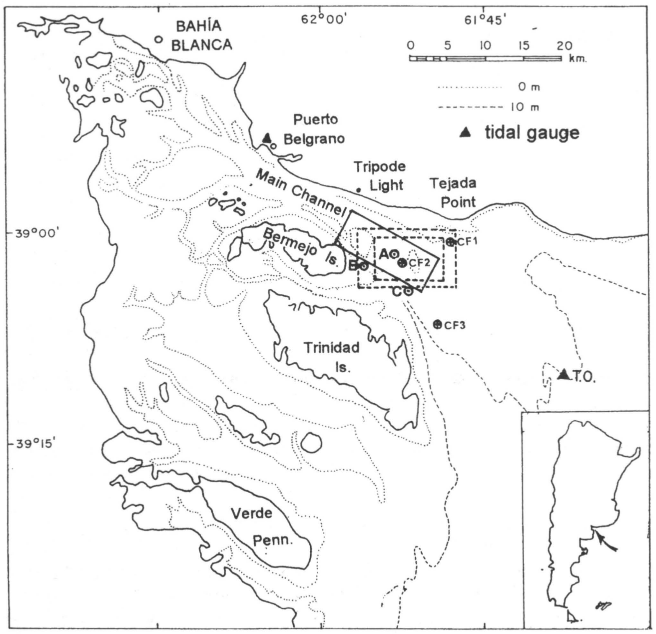

Figure 1. Location of the study area showing the position of three internal recording currentmeters (CF1, CF2, CF3) and three direct reading currentmeters (A, B, C). The areas covered by Figure 2 (———) and Figure 9 (– – –) are shown.

since it produces strong delays or advances of the tidal wave and large differences between the real and the predicted astronomical tides as discussed by PERILLO and PICCOLO (1991).

The wide mouth of the estuary is characterized by a shore-connected ebb tidal delta (Figure 1) that acts as a ridge closing the entrance (PERILLO and CUADRADO, 1991). Therefore, the exchange with the inner continental shelf is produced through a series of parallel NNW–SSE channels. Several elongated banks ranging from 1.5 to 3 km in length and up to 1.5 km in width separate the channels. One of these channels, El Toro (Figure 2), is part of the navigation route to the Bahía Blanca harbor system. This specific sector has to be dredged periodically to comply with security regulations. The maximum flood current at El Toro Channel is between 100–110 cm/sec; meanwhile, the maximum ebb currents are between 110–120 cm/sec. Over the years, several modifications of the navigation route have occurred at the El Toro Channel area, because of large geomorphological changes and occasional ship stranding.

MONTAÑEZ SANTIAGO (1972), after analyzing several nautical charts covering almost 140 years, supposed that the ebb delta was formed by the sand coming from Tejada Point located on the northern coast. In his thesis, tidal currents cut off the banks and the eroded material was carried inside the estuary to form the tidal flats, filling the bay at a later date. He also assumed that Del Sur Channel would close, and the Largo Bank would move toward the west (Trinidad Island) because of a general westward movement. A recent study of the southern part of the study area (GÓMEZ and PERILLO, 1992) reveals that the sediment transport is toward the east.

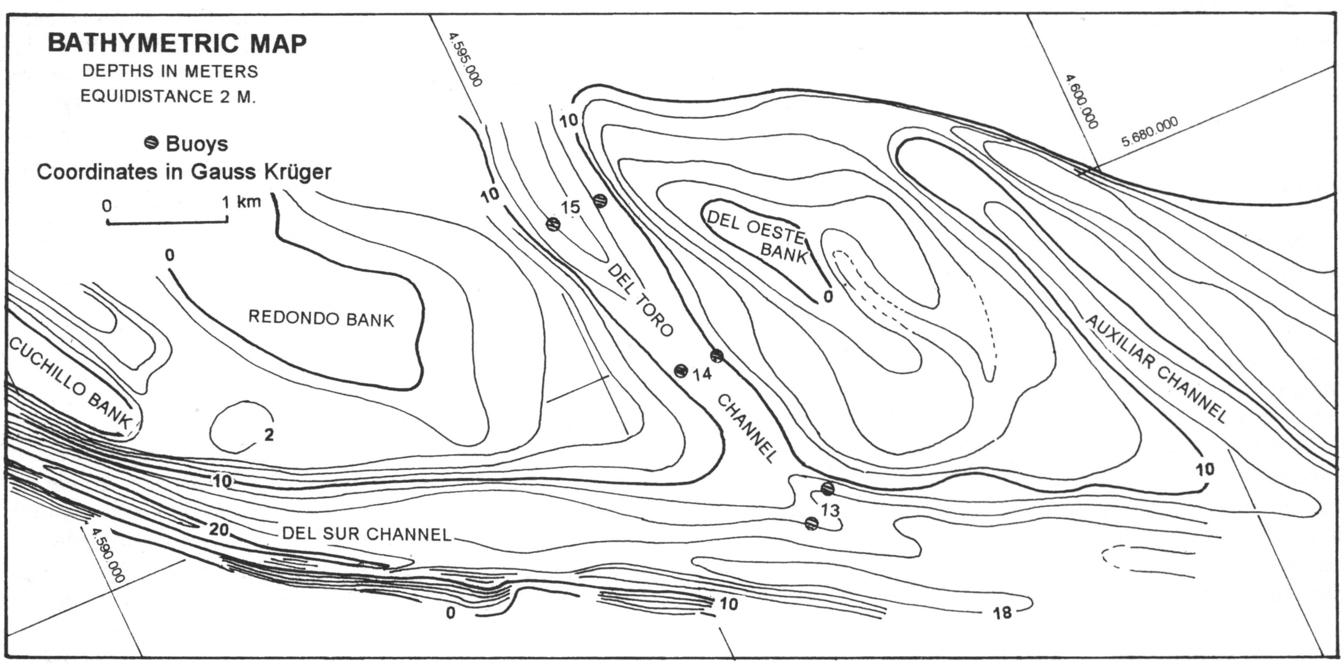

Figure 2. Bathymetric map of the study area.

PERILLO (1989) concluded that the tidal flats are remnants of a late Pleistocene-early Holocene delta complex and they are now under an erosional process. Accumulation within the estuary only occurs in very specific areas where dynamic conditions allow.

The tidal delta is characterized by ebb-dominated tidal currents and closed by a zone distinguished by an eastward sediment transport. Therefore, the objective of the present study is to determine the evolution of the banks located on the southern lobe of the tidal delta and to define their formation processes.

METHODS

To define the present geomorphology of the Del Oeste Bank area, a general survey was made on September 23–26 1986. A 208-kHz Raytheon echosounder was used to make the bathymetric profiles, and a microwave ranging device (Trisponder del Norte Tech) was employed as a navigation system. This instrument provided simultaneous measurements of distance from the survey boat to two slave antennae with absolute known positions. All depth values were corrected for the tidal variations to the Datum Plane based on simultaneous tidal records obtained at an Oceanographic Tower immediately offshore of the estuary (TO in Figure 1) and at Puerto Belgrano tidal station. To assess the evolution of the area, periodic bathymetric surveys have been made by the Dirección Nacional de Construcciones Portuarias y Vías Navegables (DNCPVN) providing an adequate data base for the present study.

Grain size (FOLK, 1974) was analyzed from 29 bottom samples extracted with a Shipek grab sampler. Three seismic profiles made by NEDECO-ARCONSULT (1983) were considered for studying the substratum of the area. Seismic charts were geologically interpreted with data provided by several vibracores and boreholes that reached depths of 3 and 6–8 m, respectively.

The tidal current field for the zone was obtained by three internal-recording currentmeters and three direct-reading currentmeter moorings made by NEDECO-ARCONSULT (1983). The internal-recording currentmeters were placed at the ENE of the Auxiliar Channel (CF1), at El Toro Channel (CF2) and at the S of the study area (CF3) (see Figure 1). Data collection spanned more than 20 days including a full spring and neap cycle. Each current vector was decomposed in a longitudinal component, parallel to the channel axis and positive in the ebb direction, with a transversal component positive to the right.

The direct-reading currentmeters were placed as follows: Currentmeter A at Del Toro Channel; Currentmeter B at Del Sur Channel mouth, south of the Redondo Bank; and Currentmeter C at the channel navigation south of El Toro Channel. The data were collected hourly during 13 hours at six points in depth, during spring and neap tides. The results are presented as depth-mean current vectors for each hour. Based on this information, the flood and ebb resultant was found (Table 1).

Estimate of the sediment transport for the area was based on the theory of BAGNOLD (1963) that assumes that the unconsolidated bed sediment transport is proportional to stream power (ω). PERILLO and SEQUEIRA (1989), who studied the inner part of the estuary, used an excess of stream power as an approximation to the bed load transport for the area. Excess shear stress was calculated to avoid the use of an efficiency factor as proposed by BAGNOLD (1966):

Table 1. *Flood and ebb currents in cm/s for the three currentmeter stations and the net value for each. The sediment transport in erg/cm² is also shown.*

Station	Flood	Ebb	Net	Transport
A	36.42	73.40	13.92	344×10^{-4}
B	55.21	58.59	2.22	142×10^{-4}
C	47.15	69.03	5.76	190×10^{-4}

$$\tau_0 = \tau_0^* - \tau_{0c}$$

an estimation of bottom shear stress (τ_0^*) is based on the quadratic law for shear stress:

$$\tau_0^* = \frac{f}{8}\rho|u|u$$

where ρ (1.02 g/cm³) is the sea water density, u is the depth-mean longitudinal velocity and f is the Darcy-Weisbach friction factor. Calculation of f was made employing the Manning-Strickler equation (SLEATH, 1984):

$$f = 0.122\left(\frac{k_s}{d}\right)^{\frac{1}{3}}$$

being $k_s = 2.5\ D_{50}$ (the median in the sand range) and τ_{0c} the threshold value for D_{50} obtained from Shield's diagram (BAGNOLD, 1966).

Similarly τ_0^* was calculated for the transversal component of the velocity and both components were composed in a unique vector. At each station, the excess of stream power was obtained as:

$$\omega = u\tau_0 \qquad [\text{erg/cm}^2\ \text{sec}]$$

Then, the net bedload for each station was found by integration over a tidal cycle of the (excess) stream power, resulting in vectors of ω in units of erg/cm².

RESULTS

Geomorphology and Sedimentology

The bathymetric map (Figure 2) is the result of the geomorphological survey made on September 1986. Depth values are referred to the Datum Plane for the area, which is 2.44 m below mean water level. The observed channels are from west to east: Del Sur, Del Toro and Auxiliar. In the same order, the banks are Cuchillo, Redondo and Del Oeste. Del Toro Channel is part of the main navigation entry to the Bahía Blanca harbor system and is marked by pairs of buoys at one nautical mile intervals. Within the study area, those buoys are used for descriptive purposes and indicated in Figure 2 as pairs N° 15, 14 and 13. This channel has depths of more than 10 m, except between buoys N° 13 and 14, where it has maximum depths of 10 m due to dredging. The Auxiliar

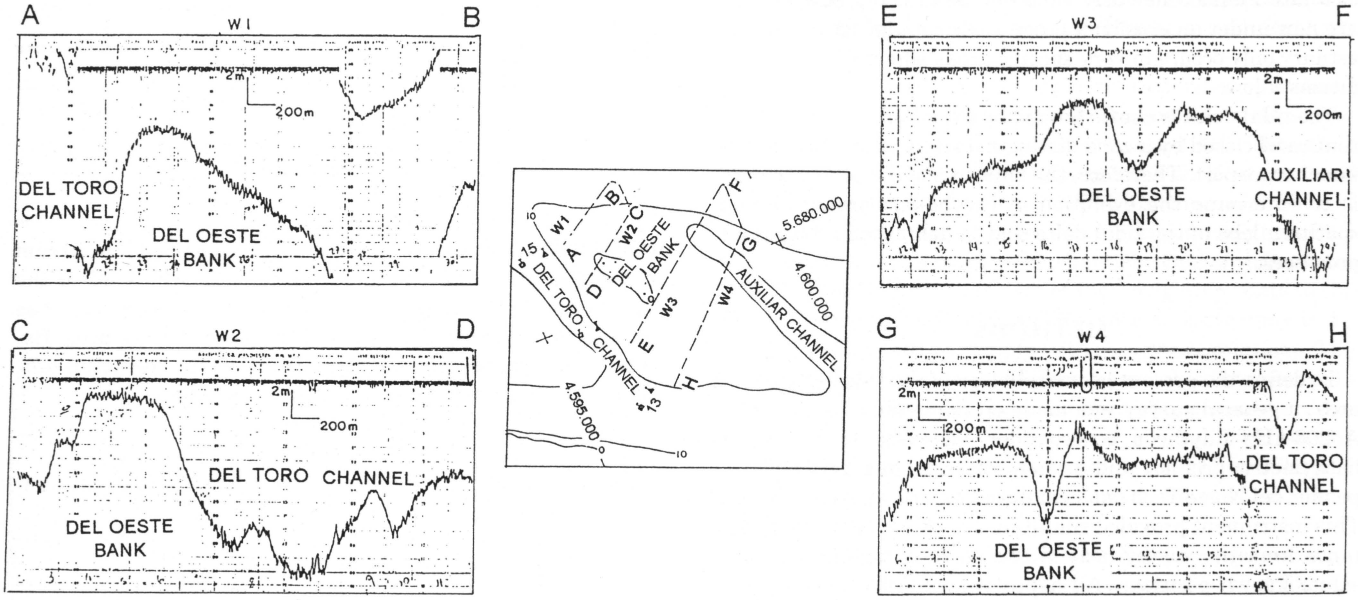

Figure 3. Bathymetric profiles for legs W1, W2, W3, and W4. The coordinates in the map are in Gauss Krüger.

and Del Sur channels have natural depths with 12 m and 22 m maximum values, respectively. They are closed on their northern end (Del Sur northern end is not shown here) by a relatively shallow sill that separates them from the Main Channel.

The banks have an elongated shape, in particular Cuchillo Bank, the largest. It is 3 km in length and 1 km in width; Del Oeste Bank is the smallest bank, 1.5 km in length and over 0.6 km in width. All of them have a NW–SE trend. They are submerged during high tide and exposed from mid-tide

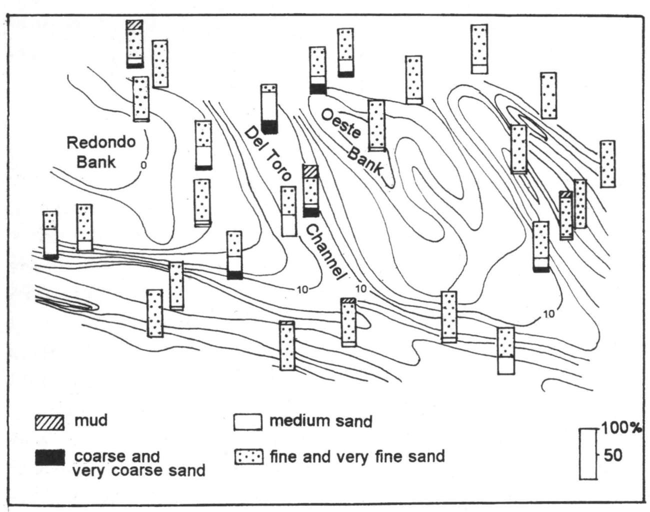

Figure 4. Grain size characteristics of the surficial sediment samples taken in the study area.

down to all tidal conditions. Del Oeste Bank is bordered by El Toro Channel on the west and the Auxiliar Channel on the east and has an apophysis at its southern end. In plan view its northern flank has a rounded shape with a slope angle of 1:200; the southern flank is narrow and elongated with a slope of 1:350. Using the terms head and tail as the opposite ends of the bank (CASTON, 1981), the Oeste Bank has a rounded head upstream and a tapered tail.

A difference on the slopes at both sides of the bank was detected only in the northern survey line (W1 in Figure 3) showing a steeper slope on the west side. The survey line continues into the Main Channel that reaches about 22 m in this area. The crest of the Oeste Bank is nearly flat, probably due to the wind-wave erosion during low-tide when it becomes exposed. Wind-generated surface waves increase turbulence and sand transport over the top of the banks at a shallow depth, flattening or lowering the crest (HUTHNANCE, 1982b). At W1, W2 and W3 (Figure 3), the crest has a flat shape coincidently with an aerial exposition of the bank; a peak that represents the bank crest was observed at the southern survey line (W4), the tail. It is important to point out that the tail is always submerged. The apophysis on the tail of the bank marks the western border of a flood sinus that deepens to the south up to about 13 m. The channel becomes narrower as it deepens, thus increasing the slope of the flanks.

Sedimentologically the area is characterized by fine to very fine sands (Figure 4). However, some differences could be detected between channels and banks. In the former, mean grain size is coarser than in the banks, but with unusual large mud content. Normally the mud is dark green or grey, having the same characteristics as the sediments found at

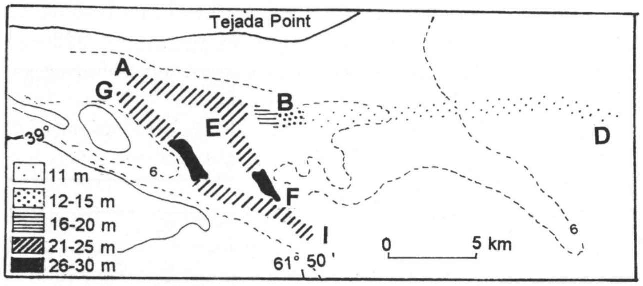

Figure 5. Depths of the Chasicó Fm. below datum level along seismic lines. Profile AD runs on the northern side of the study area nearly parallel to the coast; profile EF is along the Auxiliar Channel and profile GI follows Del Toro Channel. Note the sharp reduction near the point B where the ebb delta is located.

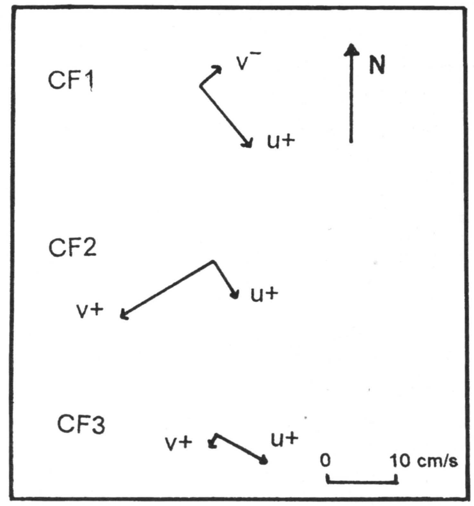

Figure 6. Mean longitudinal and transversal velocity components resulting by three internal recording currentmeters.

the bottom of the tidal channels occurring further south and associated with the erosional scarps described by GÓMEZ and PERILLO (1992). Clearly, such sediments are not in equilibrium with the present conditions and correspond to erosional areas (GÓMEZ, 1988). Within the banks, some grain size gradients were observed. In particular, Del Oeste Bank has coarser material at its head and decreases toward its tail.

Stratigraphy

The Bahía Blanca Estuary is within the Colorado sedimentary basin, which consists of Medium to Lower Cretacic sediments at its base, covered by Pliocene to Recent sediments (ZAMBRANO, 1971, 1972). Between the Pliocene Chasicó Fm. and the Pleistocene Pampa Fm., there is a marked erosional discordance that has been observed at different depths in the area. A series of terraces appears on the northern boundary of the area, at depths between 13 and 15 m. Such geoforms were found south of El Toro Channel and are described for the Largo Channel by GÓMEZ and PERILLO (1994). They can be clearly correlated with those described by ALIOTTA and PERILLO (1987) on the northern shore of the estuary near Puerto Belgrano. Always, these terraces are developed on partly cemented sandy material of the Chasicó Fm., covered discordantly by recent sediments.

The Chasicó Fm. is detected by three seismic profiles (NEDECO-ARCONSULT, 1983) at different depths (Figure 5). For most of the area, the top of the Chasicó Fm. is at depths below 15 m. However, at Point B (Figure 5), the top becomes shallower reaching only 11 m and maintaining that level for the rest of the run in the offshore direction. In two sectors corresponding to Del Toro and Auxiliar channels, respectively, the discordance was observed below 25 m, reaching a maximum of 28 m. Pleistocene sediments corresponding to the Pampa Fm. are on top of the discordance. They consist of sand, showing cross bedding structures. Although both formations have very similar characteristics, differences are identified by the presence of volcanic glass, over 15% of the younger formation.

Circulation and Sediment Transport

The maximum ebb and flood current speeds were between 110–120 cm/sec and 100–110 cm/sec respectively for CF2 (El Toro Channel) (see Figure 1). The flood currents reached 90 cm/sec at CF1 and were smaller than 100 cm/sec at CF3. Meanwhile, the ebb current velocities were between 100 and 110 cm/sec for CF1 and CF3. The mean longitudinal and transversal components from the three currentmeters are presented in Figure 6; all mean longitudinal components are ebb directed. For CF3, the ebb currents feed the positive transversal component, but the flood currents feed only the negative component in almost the same percentage; the result is a small positive transversal component. The ebb directed longitudinal component is due to the higher velocities of these currents. For CF1, the results are similar to CF3 but the transversal component is negative. At CF2 (El Toro Channel), the flood currents feed only the positive transversal component, while the ebb currents feed both components. Therefore, the resultant transversal component is large and positive. The longitudinal ebb and flood currents are similar; but ebb currents are stronger. The ebb longitudinal resultant component is smaller than the transversal one. This fact is due to a hydraulic problem since the dredged channel orientation is not in equilibrium with the flood currents that are responsible for the large transversal component (PERILLO and CUADRADO, 1991).

Based on the sediment transport model proposed by BAGNOLD (1963), the stream power vectors (ω) were obtained for the zone (Figure 7). Orientation and gradients of stream power vectors along transport paths may suggest either erosion or deposition in the intermediate regions. That is, an increase in the transport magnitude between stations defines an erosion process, and the converse is also true. Erosion can be detected also in the divergence of vectors, while convergence can be assumed as a condition for deposition.

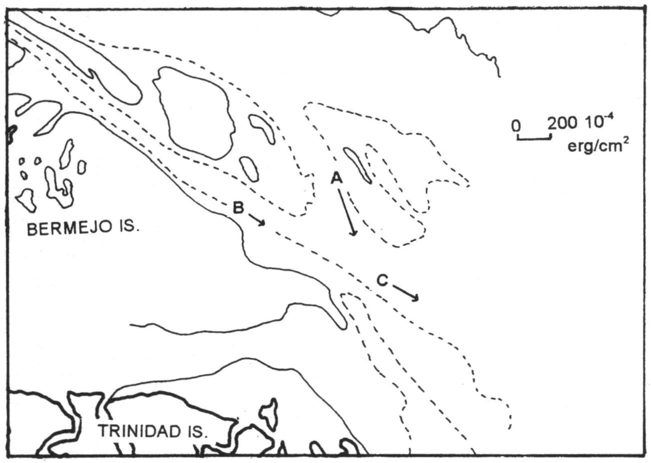

Figure 7. Stream power vectors (ω in erg/cm²) in the study zone as a result of the sediment transport model.

The potential net transport decreases between Stations A and C, suggesting the existence of an accumulation process in the navigation of El Toro Channel; this is confirmed by the continuous dredging that is required and accomplished by the DGCPVN in the channel. On the other hand, an increase of the transport between Stations B and C (the mouth of Del Sur Channel) represents an erosional zone (see Table 1).

DISCUSSION

The Pliocene Chasicó Fm. has been detected in all of the study areas at depths below 15 m, reaching maximum values at Del Toro and Auxiliar Channels. However near Tejada Point, the top of the formation becomes shallower, developing a topographic high that continues onto the inner shelf (Figure 5). It appears that the sill acted as a structural control at the mouth of the Bahía Blanca estuary, allowing the deposition of younger sediments and forcing the water to flow to the southeast. The particular bedding structures described for the Pampa Fm. (NEDECO-ARCONSULT, 1983) suggest that the deposition environment was highly variable; they represent the result of scour and channel-fill features (REINECK and SINGH, 1980). The sediments deposited formed the ebb delta extending to the south and southwest because: (1) structural control was provided by the Pliocene compact sedimentite to the east and (2) the fact that the capability of sediment transport of the Desaguadero River (that no longer flows into the estuary) decreased as the mouth became wider. Further development of the ebb delta occurred during the high stand of the sea level, between 6,500 yrBP and 1,000–1,500 yrBP (GÓMEZ and PERILLO, 1994).

Because of the occlusion of the main channel, the tidal interchange between the estuary and the inner continental shelf was produced through a series of parallel channels that intersected the banks. Thus, "drying shoals" dominated by wave processes (OERTEL, 1972) were formed. The northern shore acts as one margin of the ebb tidal delta and is called here a shore-connected ebb tidal delta.

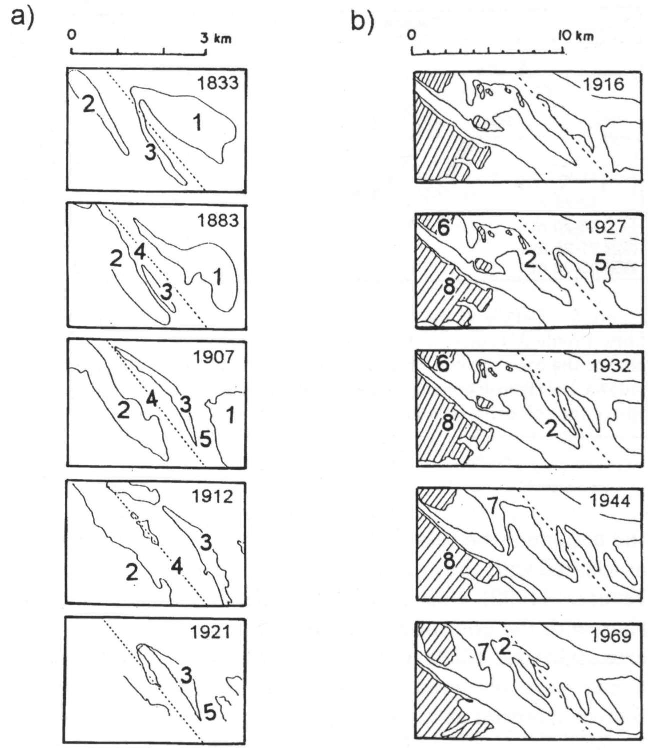

Figure 8. Historical hydrographic charts showing the evolution of the area (modified from Montañez Santiago, 1972). The dashed line is a reference with an azimuth of 140° respect the Tripode Light placed on land, and coincides approximately with the Auxiliar Channel. The shaded areas indicate exposed areas at low tide. Note that left graphics (a) are in different scale than the right ones (b). 1—Del Norte Bank. 2—Del Oeste Bank. 3—Del Este Bank. 4.—Auxiliar Channel. 5—La Manuelita Channel. 6—Cuchillo Bank. 8—Bermejo Island.

The general evolution of the area may be assessed using historical hydrographic charts following a chronological order. Two sets of charts published by MONTAÑEZ SANTIAGO (1972) are reanalyzed here (Figure 8). In all the graphics, there is a reference line showing the 140° azimuth line with respect to the Trípode Light (placed on land), coincident with the present Auxiliar Channel. For comparison purposes only, the 5.5 m isobath was employed in the analysis. The first set corresponds to four charts made from 1833 to 1921 (Figure 8a) with a scale of 1:150,000, covering a detail of the evolution of the Del Oeste Bank and the Auxiliar Channel. The second set (Figure 8b) is integrated by charts from 1916 until 1969 with a scale of 1:460,000, covering the whole study area from the Auxiliar Channel to the Del Sur Channel.

In 1833 (Figure 8a), Del Norte Bank (which no longer exists) with a parabolic shape was the main topographic feature of the area. A flood sinus largely incised the bank and left a wide bank to the northeast (Del Norte Bank) and another narrower bank to the southwest (Del Este Bank); both were connected on the northern end of the sinus. To the west, Del Oeste Bank appears as a long and narrow form that became wider and migrated to the southeast in 1883. Within the 50 yr period, the flood sinus cut through the northern connection and opened the Auxiliar Channel (used as a navigation channel since then); Del Este Bank migrated to the southwest and appears to have welded to the Del Oeste Bank in 1907. After the incipient flood sinus observed in 1883, a "new" Del Este Bank was formed acquiring an arch-like shape and developing the La Manuelita Channel. Curved shoals like the form described here were studied by CASTON and STRIDE (1970) in the North Sea; their study indicated that their evolution is toward the formation of a flood (in the present case) sinus. This situation is observed in the 1912 chart where a series of banks present a general horseshoe-shape that is connected below the 5.5 m isobath. Nautical information from that document said that the Auxiliar Channel was no longer used because of the shallower waters to the east of the 140° line. By 1921, the general structure of the area had evolved back to the shape observed in 1833; however, in 1916 (Figure 8b), the evolution was complicated by an intermediate step in which the sinus was filled with sediments.

The horseshoe-like bank was preserved in 1927 but was cut on the northern end in 1932; the western flank became longer and attached to the end of the Del Oeste Bank. This bank was originally connected to El Cuchillo Bank in 1916, but an ebb sinus was observed in all the charts until 1932. In 1944, this sinus cut the two banks and formed El Toro Channel, the present navigation entrance to Bahía Blanca harbor system.

The successive development of the flood sinus and the destruction of the parabolic terminal bank are the fundamental characteristics of the evolution of the zone. In 1833 and 1921, the charts show a V-shaped bank, suggesting that prevalent flood currents are inherent to its formation. Unless the ebb tidal currents were stronger in the Main Channel, the predominant flood currents at the Auxiliar Channel were responsible for the successive flood sinus formation over the previous 100 years. Presently, Del Oeste Bank exposes an apophysis (Figure 2) that represents the formation of an incipient flood sinus. This fact also points out the present predominance of flood currents at the Auxiliar Channel. PERILLO and CUADRADO (1991) detected that the flood currents are responsible for the accumulation of sediments on the El Toro Channel and the probable source of this sedimentation is the southwestern end of the Del Oeste Bank.

A characteristic of an ebb tidal delta is the prevailing ebb current at the main channel, while the flood currents enter the inlet throat via marginal flood channels such as the Del Sur and Auxiliar channels in the present case. The Main Channel is the northern limit of the study area and the Auxiliar Channel is almost in the middle of the zone. A westward bank migration was revealed by historical chart comparisons; this migration occurred when the bank was cut by a channel and attached itself to the southern portion of the Del Oeste Bank (1883 and 1932). At the present, such migration is exposed by the steep western slope of the Del Oeste Bank and can be paralleled to the migration of a large sand wave.

The ebb is a highly predominant current in the Main Channel. Thus, the detected westward migration reaches up into the Main Channel in opposition to Montañez Santiago's theory; he theorized a westward bank migration over almost all the tidal flats that form the estuary. He also supposed that the Largo Bank, situated south of the present study area, was approaching Trinidad Island and that the Del Sur Channel would close. However, GÓMEZ and PERILLO (1992) proved to the contrary that the Largo Bank is migrating eastward at about 37 m/yr, and the Del Sur Channel has a natural depth of 22 m.

Furthermore, the study of the dynamics of the beaches along the northern coast (GINSBERG, 1984) and the circulation of the inner shelf (PERILLO and CUADRADO, 1990; PÍCCOLO *et al.*, 1994), clearly shows that the transport is parallel to the shore and directed opposite the estuary. Also, the prevalent winds from the NW–N sector induced larger residual currents toward the mouth of the estuary and the migration of large sand waves in the Main Channel described by ALIOTTA and PERILLO (1987). Therefore, the supposition made by MONTAÑEZ SANTIAGO (1972) that the ebb delta is a spit coming out of the Tejada Point is not supported by current research.

CONCLUSIONS

The ebb delta that closed the mouth of the Bahía Blanca estuary, developed by the interaction of the outflow of the Desaguadero river during the Late Pleistocene–Early Holocene and a topographic high is present in the Chasicó Fm. Sediment was deposited in the area as the river lost transport capacity. Further development of the ebb delta occurred during the high stand of the sea level between 6,500 yrBP and 1,000–1,500 yrBP. During this stage, several channels were cut from the southern lobe and a series of banks were formed. The channel-bank system interacts with the tidal currents and evolves under their predominance.

Although the ebb currents are predominant, the flood currents are responsible for the formation of a flood sinus in the successive stage of the study area evolution. The western portion of the cut bank normally migrates westward until it attaches the El Oeste Bank, meanwhile the flood currents initiate a newer flood sinus on the eastern portion. The strong ebb currents are dominant in the Main Channel, constraining the westward sediment transport to the east. Bedform migration, both on the Main Channel and at the south of the study zone, shows an eastward sediment transport.

MONTAÑEZ SANTIAGO'S theory pointed out that the materials coming from the Tejada Point were transported toward the west, filling up the bay. However, the general circulation and the dynamics of sediment transport clearly reject this thesis. The division of the banks and their westward migration are only local processes created by flood predominant currents and limited by the strong ebb currents to the northwest and south of the banks at the El Toro Channel.

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□ RESUMEN □

Bahía Blanca es un estuario mesomareal caracterizado por un delta de marea de reflujo conectado a la costa, hecho poco común en estos ambientes. El área de estudio comprende una serie de bancos surcados por canales de marea. El objetivo de este estudio es determinar la evolución de los bancos en los últimos 160 años y definir el proceso generativo involucrado.

Para estudiar las condiciones dinámicas del área, se aplicó un modelo de transporte teniendo en cuenta la corriente de marea predominante. Para alcanzar los objetivos propuestos, es necesario además, tener un conocimiento de los sedimentos del subsuelo, y por medio de antiguos mapas esquemáticos que datan desde 1833 y un estudio de corrientes se determinó el movimiento que sufrieron los bancos.

Se arriba a la conclusion que las geoformas migran hacia el oeste hasta el Canal Principal donde las fuertes corrientes de reflujo impiden que continúe el transporte en ese sentido. Por lo tanto se determina que la migración detectada es sólo un proceso local. Este hecho refuta una teoría anterior que supone un transporte hacia el oeste que llenaría todo el estuario.

□ RÉSUMÉ □

L'estuaire du Bahía Blanca, du type mesomareal, est caracterisé par un delta du jusant lié à la côte, un phénomène assez rare dans ce milieu sédimentaire. Une série de bancs, qui sont traversée par de chenaux des marée ont été étudieé dans la région. Le but de ce travail est d'établir l'évolution des bancs pendant les dernières 160 ans ainsi que leurs processus de formation.

Un modèle de transport utilisant le courant de la marée dominante, a été utilisé pour l'étude de conditions dynamiques. L'objetif a été aboutis en étudiant les sédiments du fond, des cartes schématiques faites en 1833 et des études des courants.

On conclue que les géophormes ont migrés vers l'óuest jusqu'au chenal Principal où le transport de sédiments est arrête par le jusant. Ceci contradite une téorie qui soutient le remplissage de l'estuaire du aux transport des sables vers l'ouest.