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Coastal Use Conflicts: The Case of Hondarribia Inlet, Spain

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ABSTRACT

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The morphodynamics of coastal inlets are often modified by human action mainly by shoreline protection works and by inlet navigational improvements. Many old coastal features have disappeared due to this modification, but new coastal zones have also appeared. The human-imposed dynamics of these new areas condition their utility for human needs.

Changes to Hondarribia Inlet (Spain), due to protection works, have created a new coastal area. The use of this new area has produced conflicts. In this paper an overall proposal is presented which gives an harmonic solution to these conflicts.

ADDITIONAL INDEX WORDS: *Coastal uses, inlet evolution, inlet protection works.*

INTRODUCTION

The Hondarribia Inlet is a sandy inlet that has undergone a great amount of change during the past 50 years. These changes are the results of both natural processes and human influences. Shoreline protection works and navigational improvements for the inlet that include two jetties have modified the morphodynamics of the area. New coastal zones have appeared with new coastal-use problems. The dynamics of these new areas condition their utility for human needs. It is the objective of this paper to report the historical changes that have occurred to Hondarribia Inlet due to protection works, to show the new coastal area which has been created and to discuss its use, and problems.

PHYSICAL ENVIRONMENT

The North Coast of Spain consists of a series of pocket beaches separated by pronounced rocky headlands with zero or near-zero net littoral drift in between. The Hondarribia Inlet is located on the northeast coast of Spain, 10 km east of San Sebastían, Figure 1. The Hondarribia Inlet is a natural border between Spain and France, with the west side belonging to Spain and the east side belonging to France. The inlet geometry is determined by the west rocky headland (Cape Higuer) and the east rocky headland (Cape Santa Ana). Between these two cliffs there are two beaches, separated by the inlet entrance and the protective jetties, with different dynamics. The Hondarreta beach lies on the French side with a bay-bar origin whereas the Hondarribia beach, on the Spanish side, is of a sand-trap origin. Two fishing harbours occur on the Spanish side, one inside the inlet at the old town of Hondarribia. The other lies outside the inlet but is protected by Cape Higuer.

The mean tidal range at Hondarribia is 2.3 meters; the spring tidal range is 5 meters, and the tides are semidiurnal. The tidal prism is about 16×10^6 m^3. The total amount of material carried to the entrance, M_t, is about 10^5 m^3/yr, mainly due to longshore transport from Hondarreta beach. According to BRUUN (1968, 1986), the "overall stability" of a tidal entrance can be described by the parameter Ω/M_t. The Hondarribia Inlet Ω/M_t parameter is about 160, which means "fair conditions" and "tidal flow bypassers" with little ocean bar (BRUUN *et al.* 1978). Due to the location and configuration of the NE coast of Spain, waves arrive from the

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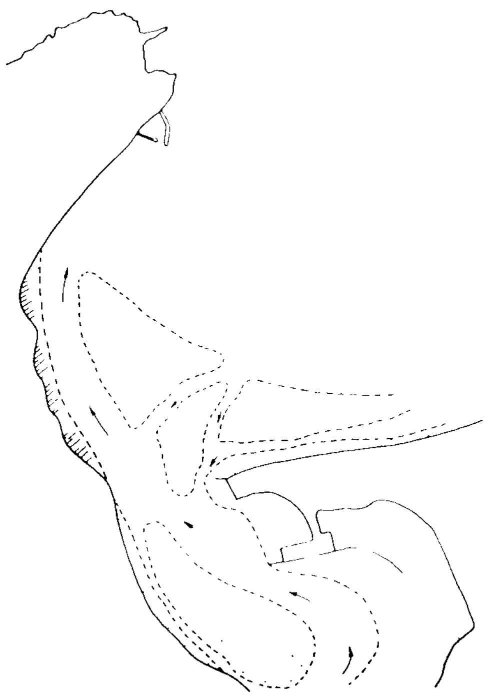

Figure 2. Hondarribia 1940.

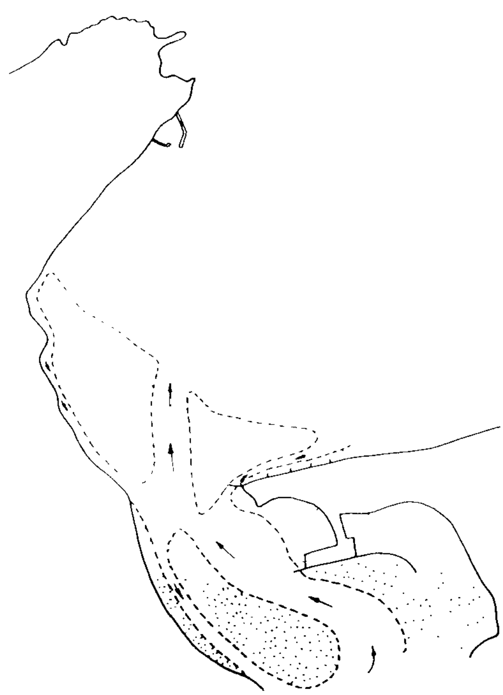

Figure 3. Hondarribia 1945.

years. Initially, the harbour was placed close to the old city inside the bay, and the inlet entrance was located on the west side of the cove and was protected against wave action by Cape Higuer. This situation probably continued until 1940, Figure 2. The situation in 1940 can be described as a sand bay bar with small longshore movements, but with important profile changes due to seasonal variations. Extended ocean shoals, emerged at low tide, almost closed the inlet entrance. These ocean shoal covered a rocky shelf of gentle slope (1:150). The navigational channel changed its depth and location as a function of wave action and flushing ability of tidal currents.

The apparent equilibrium was disturbed by the construction of a seawall along the bay bar (French side). The seawall was constructed so close to the high tide shoreline that winter storm waves could reach it, thus causing beach erosion. The seawall failed and several small groins, perpendicular to the seawall, were built in order to stop sand movements. As a consequence, the main entrance channel changed its location and moved eastward, Figure 3.

The groins were not able to stabilize the failing seawall so an entrance jetty was projected. This jetty attempted also to establish a new entrance channel that was slowly moving westward, back to its original location (Figure 4). The jetty acted as a sand barrier. A new beach emerged and covered the old groins. Later in 1951, a west jetty was constructed in order to maintain the entrance channel location. The jetty cut the entrance flows and improved the channel depth due to the concentration of ebb currents. This jetty created a protected area between it and Cape Higuer where sand quickly accumulated (Hondarribia Beach), as shown in Figure 5. In 1976, the east jetty was extended reaching its present length, Figure 6.

Presently, sand passes the east jetty and a spit has developed around it. Ebb currents remove sand from the spit and carry the material seaward. Most of the sand returns to the barrier but part is transported by diffracted waves to Hondarribia beach which acts as a sand trap. The amount of sand "trapping" has been estimated from sequential photographs and bathymetric surveys since the construction

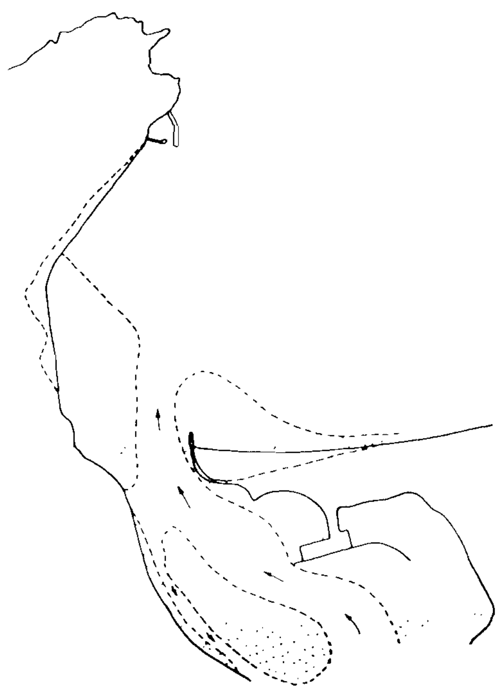

Figure 4. Hondarribia 1950.

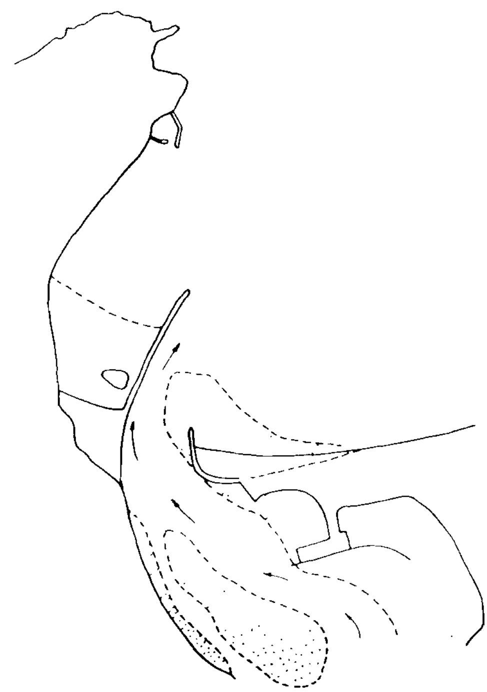

Figure 5. Hondarribia 1960.

of the west jetty (Table I). If consideration is given to the fact that the east jetty was extended in 1958-1960 due to the spit, an average accumulation of 40.000 m^3/year can be estimated. This implies that the Hondarribia Beach advanced seaward about 5 meters/year. Logically, this advance is limited by the west jetty length. With the actual inlet geometry, the beach will be filled when the shoreline advances about 100-150 meters.

HONDARRIBIA INSHORE WATER QUALITY

During the last few summers a water quality problem has been reported by local authorities. In summer, when wave energy is low and the number of users increases, water exchange is basically due to tidal currents (outside breaking zone). One way of estimating water quality is to follow a particle path and measure the time that this particle remains inside the cove. A two-dimensional depth averaged numerical model was deployed in an effort to assess water quality. The numerical model solved the vertically integrated equations of continuity and momentum using an Alternating Direction Implicit (ADI) difference scheme. Special attention was placed on the modeling of the advective accelerations and lateral turbulent shear stresses in the vicinity of the groins. FALCONER *et al.* (1984, 1986) modeling of the lateral turbulent shear stresses was used. In this exchange analysis only tidal forces were taken into account, wave induced currents and wind currents were not included. This represents typical summer conditions with almost no wind or wave action.

Figure 7 presents lines of same-exchange-time (isochronous), *i.e.*, the time in hours that a water particle remains inside the cove. Actual geometry and 3−meter range tides are the conditions of the study presented in Figure 7. It is observed that the isochrons depend on boundary geometry (jetty, cliff, harbour, beach). Several geometries were studied in order to establish the influence of boundary conditions on the exchange time. It was found that the exchange

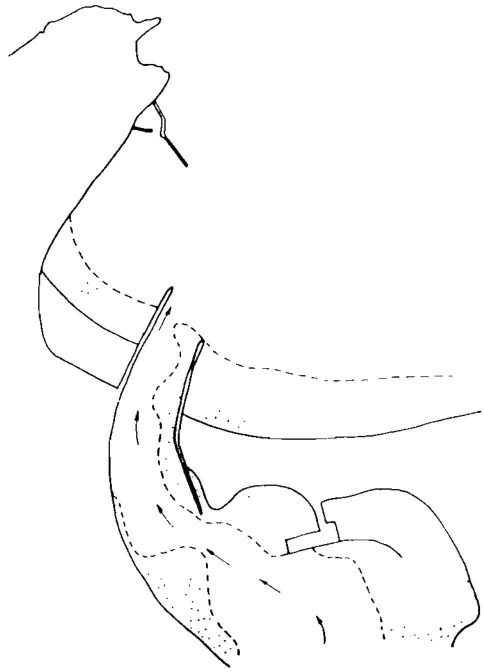

Figure 6. Actual configuration.

time improves by reducing the west jetty length, reducing the north breakwater length, and advancing the beach shoreline, and vice versa. The exchange time also worsens with the construction of the south breakwater presented in Figure 8.

Both reduction of the west jetty length and reduction of the north breakwater would adversely affect the navigational channel and the fishing harbour, *i.e.*, modify them in a way that would be unacceptable by users, mainly due to increased wave agitation. Consequently, the only practical way of improving water exchange involves advancing the beach shoreline about 100-150 meters.

Table 1. *Sand trapping at Hondarinbia Beach 1955-1985.*

Period	Sand trapping (m^3/year)
1955-1957	43,000
1957-1958	60,000
1958-1965	20,000
1965-1978	48,000
1978-1985	46,000

Figure 7. Same-exchange-time lines.

COASTAL USES

The west side of Hondarribia Inlet is a protected wave area with a sandy beach. Different human activities have developed in this region—beach uses, fishing industry and a recreational navigation area. All uses interact with each other and all users want to improve conditions.

(a). The Beach

The beach is the foundation of a prosperous

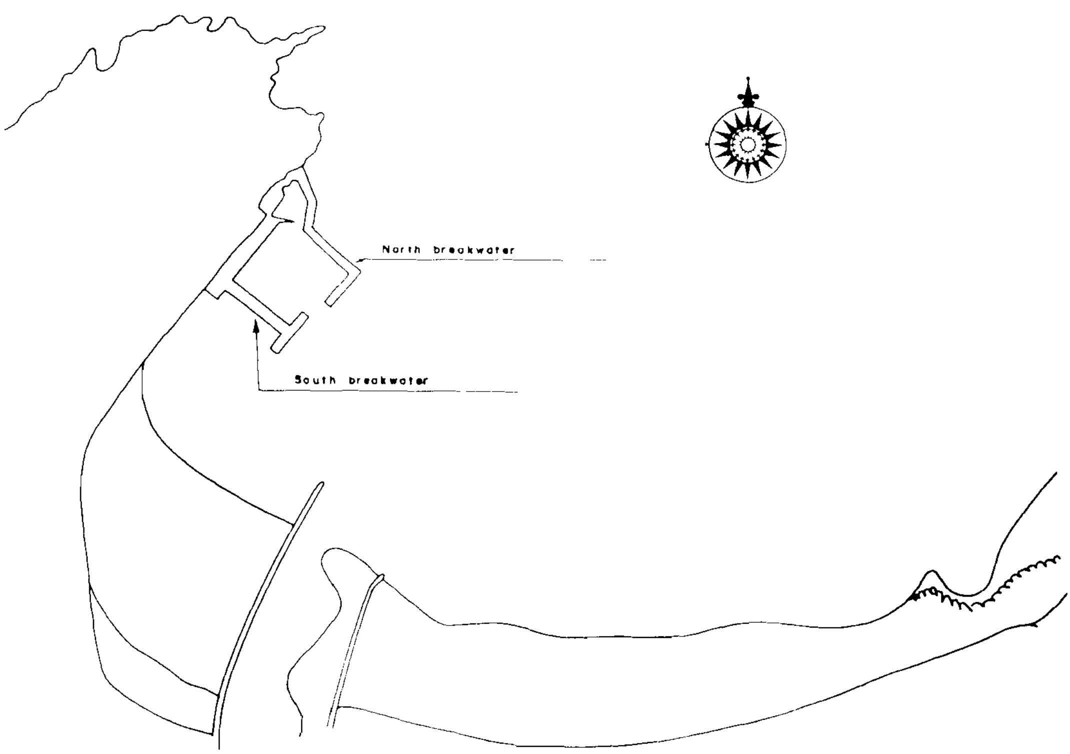

Figure 8. Planned harbour layout.

tourist industry, principally in summer. It has a large backshore with almost no use and an inshore with water quality problems.

(b). The Fishing Harbour

Prior to the construction of the two jetties, an old fishing harbour had been built. Later, the north breakwater was extended in order to protect harbour activities from NNW storm waves (see Figures 2 and 6). Actually, a south breakwater is proposed (about 250 m south of the north breakwater) in order to protect the harbour activities against local wind-waves, Figure 8.

(c). Recreational Navigation Area

About 500 vessels anchor between the fishing harbour and the beach, being protected by Cape Higuer, and also by the fishing north breakwater which also provides protection from wave action. This number increases in summer due to seasonal variations and the location of Hondarribia Inlet close to the French border. In spite of this large increase, there are few specific facilities for these vessels.

AN OVERALL USE PROPOSAL

An overall use of the cove must achieve the following objectives: (a) decrease wave action inside the fishing harbour, (b) provide facilities for recreational navigation uses, and (c) improve water exchange in the cove. The proposal (Figure 9) is based on advancing the beach shoreline 100 meters seaward, *i.e.*, accelerate the natural accumulation tendency of the beach. As the beach advances using backshore sand, a 100 meters length (600 meters width) area would be available for local needs. A marina could additionally then be built with a wide range of facilities. Wave action inside the fishing harbour could be controlled by construction of a 100-m length breakwater perpendicular to the north breakwater and a short south break-

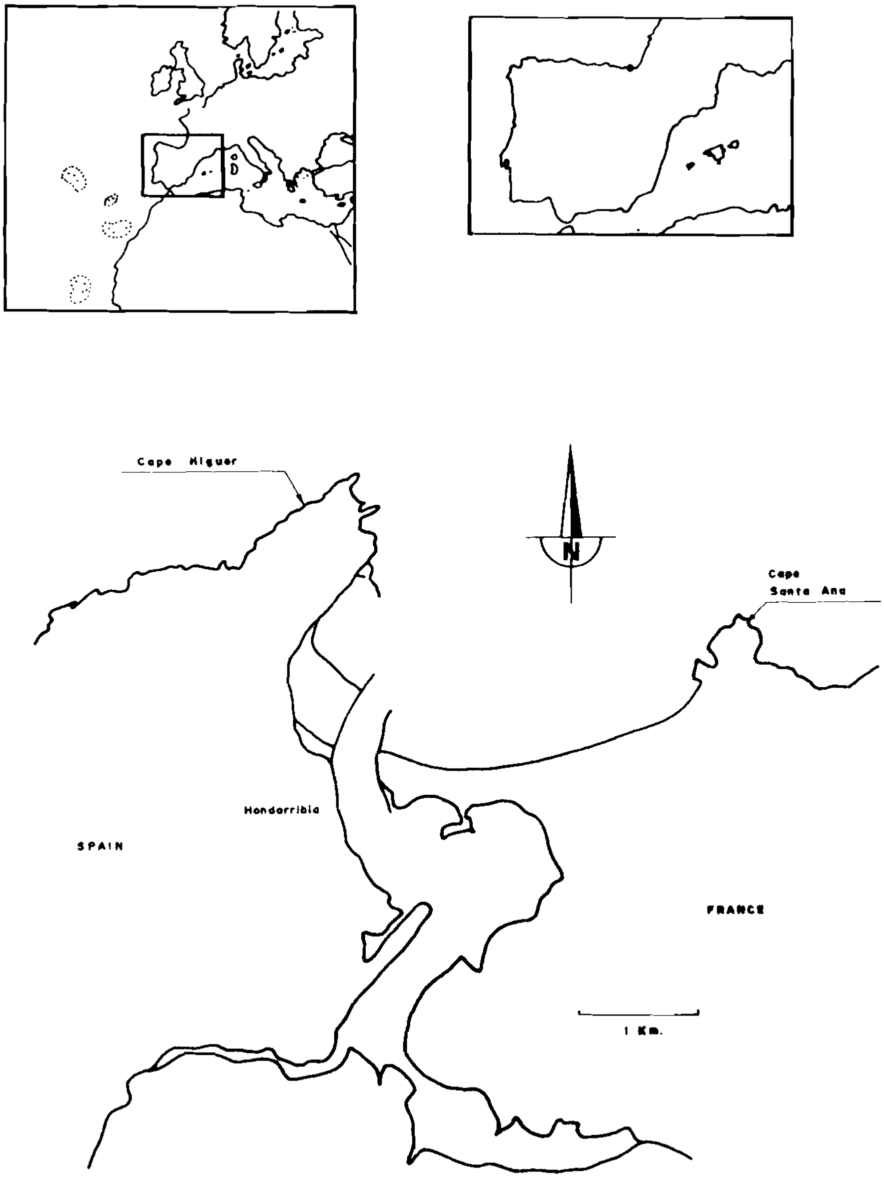

Figure 1. Location of study area.

NNW and have an annual average significant height of 1 m. The inlet sand size ranges from 0.18 to 0.30 mm. The continental shelf has an average slope of 1:150 and is sandy up to the 30 m bathymetric. The inlet communicates the sea with an inner bay where the river flows bounded by mash areas.

CIVIL WORKS HISTORY

Historical changes of Hondarribia Inlet have been determined from sequential photographs compiled by Iribarren.

According to historical accounts the inlet has been used for navigation for more than 400

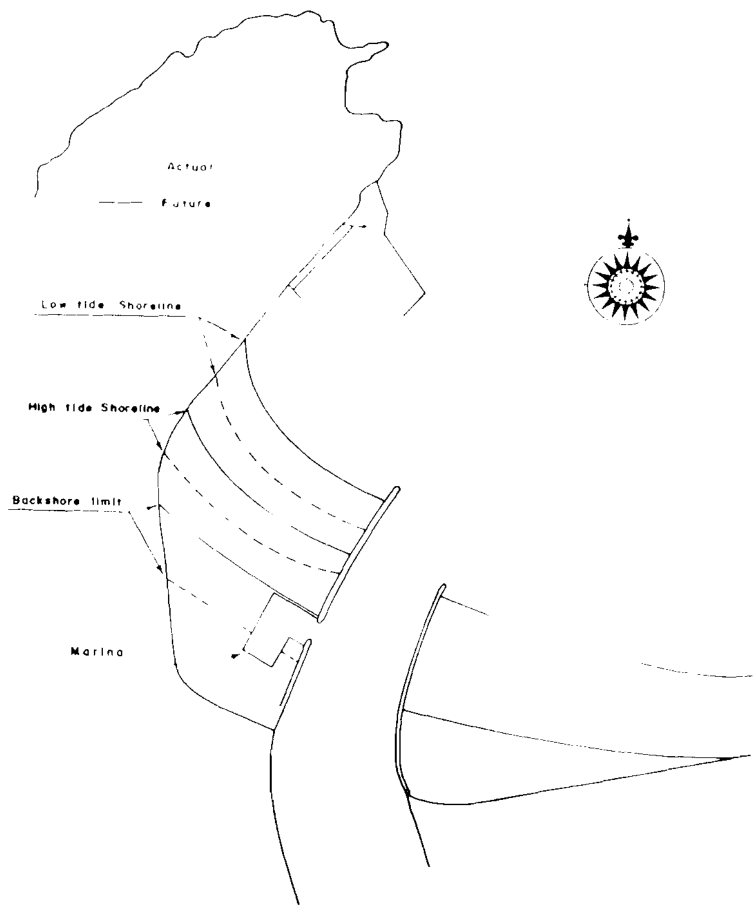

Figure 9. Proposal for modified inlet-harbour-beach design.

water. In Figure 9, the low tide shoreline, high tide shoreline, and the backshore limit are shown as dashed lines. A 25,000 m^2 marina is indicated for present needs but the new area can accommodate a larger marina. Consequently, this proposal satisfies the proposed objectives and furthermore provides (a) physical separation between fishing and recreational fleets while (b) establishing nearshore land for local management.

CONCLUSIONS

An overall proposal is presented for Hondarribia Inlet which takes into account the user conflicts. The proposal is based on an historical analysis of coastal evolution, and on the computation of water exchanges in the inner area. Both analyses were found to be efficient tools to achieve overall solutions to shoreline management in Hondarribia Inlet (Spain).

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□ RESUMEN □

La morfodinámica de los estuarios se modifica notablemente por la actuación humana, especialmente por obras de protección de costa y obras de mejora de las condiciones de navegación. Muchos antiguos elementos de la costa han desaparecido debido a estas modificaciones, pero también han aparecido otras nuevas zonas costeras. La dinámica de estas zonas, impuesta por el hombre, condiciona su posterior utilización.

En este articulo se presentan los cambios históricos ocurridos en la Ensenada de Hondarribia (España), debido a las obras de protección realizadas y la nueva zona costera creada. El uso de este nuevo área ha creado conflictos. En este articulo se presenta una propuesta que da una solución armónica a estos conflictos.

□ RÉSUMÉ □

La morphodynamique des côtes à goulets est souvent modifiée par les travaux de protection du littoral et par les améliorations de la navigation. Ces modifications ont pour conséquence la disparition des certains traits du littoral, et l'apparition de nouvelles zones côtières. L'homme règle la dynamique de ces nouvelles zones et conditionne leur utilité pour les besoins humains. Dans le goulet de Hondarabie (Espagne), des modifications sont intervenues après la réalisation de travaux de protection qui ont créé une nouvelle zone côtière. Son utilisation a engendré des conflits. Cet article propose des solutions à ce genre de conflits.—*Catherine Bressolier, EPHE, Montrouge, France.*

□ ZUSAMMENFASSUNG □

Die morphologischen Entwicklungen in "coastal inlets" (Gaten, Tiefs) werden oft durch menschliche Eingriffe beeinflußt, hauptsächlich durch Küstenschutzmaßnahmen und Baggerungen von Schiffahrtsrinnen. Viele ursprüngliche Küstenmerkmale haben sich wegen dieser Eingriffe zurückgebildet während andere neu entstanden sind. Diese durch den Menschen gesteuerten Umbildungen beeinflussen auch die Nutzungsmöglichkeiten der veränderten Küstenabschnitte. Kütenschutzmaßnahmen am Hondarribia Inlet in Spanein haben diese Küstenlandschaft verändert. Die Nutzung des neu entstandenen Gebietes hat Konflikte erzeugt. Es wird ein Gesamtvorschlag gemacht, der eine harmonische Lösung dieser Konflikte ermöglicht.—*Reinhard Dieckmann, WSA Bremerhaven, West Germany (FRG).*