

**Natural Resources Canada  
Geomatics Canada  
Centre for topographic information  
Contrat 23258-055970/001/MTB**

# **Interpretation guide of natural geographic features from ETM+ Landsat imagery and aerial photography: Barrier beach and spit**

**Léo Provencher and Jean-Marie Dubois  
Geographers**

**Sherbrooke  
10<sup>e</sup> version, 17-06-2005**

## Table of contents

Introduction.....	3
1- Feature name .....	5
2- Hierarchy .....	5
3- Definition.....	5
4- Summary table of identification elements .....	5
5- Characteristics .....	5
5.1- Specific to feature .....	6
5.1.1- Form.....	6
5.1.2- Dimensions .....	6
5.1.3- Topographic position .....	6
5.1.4- Drainage.....	7
5.1.5- Vegetation.....	7
5.2- Related to feature dynamics.....	7
5.2.1- Means of formation.....	7
5.2.2- Status .....	7
5.2.3- Spatiotemporal variations .....	7
5.3- Related to the environment .....	8
6- Optimal conditions for identification.....	8
7- Examples .....	8
8- Interpretation .....	15
8.1- Critical path .....	15
8.1.1- Discrimination and delimitation .....	15
8.1.2- Identification.....	15
8.2- Verification with complementary sources of information .....	16
9- Elements of confusion .....	16
10- Bibliography .....	17

## Introduction

The purpose of this project is to create a visual interpretative guide to the natural geographical entities in the geospatial database (GDB) using Landsat7 ETM+ imagery and aerial photography. The methodology and information fact sheet were developed by Provencher and Dubois (2004a), and the application of this procedure to a test case has already garnered a consensus among the staff of CTI at Sherbrooke (Provencher and Dubois (2004b)). The meanings of the sections of the fact sheets are explained in the appendix.

The eight natural entities in the GDB (Centre for Topographic Information, 2004) fall under eight themes that are grouped into three domains: hydrography, landforms, and vegetation (**Table 1**). In practice, for interpretive purposes they are often subdivided further and represented by 17 fact sheets.

N.B.: Elaboration of the illustrative examples and potential elements of confusion was constrained by the limited time allocated to this guide. It is recommended that they be supplemented as other cases are documented, especially from Landsat ETM+ imagery.

Table 1: Hierarchy of natural geographical entities

Domain	Theme	Sub-theme	GDB entity	Fact sheet	
Hydrography	Watercourse	Perennial watercourse	Permanent water	Permanent water	
		Alluvium	Intermittent water	Intermittent water	
		Waterfall	Water disturbance	Waterfalls and rapids	
			Rapids	Water disturbance	Waterfalls and rapids
	Waterbody	Perennial freshwater body		Permanent water	Permanent water
			Alluvium, rocky surface	Intermittent water	Intermittent water
			Saltwater	Permanent water	Permanent water
		Alluvium, rocky surface (tidal flat)		Intermittent water	Intermittent water
			Reef	Water disturbance	Reef
			Wetland	Tundra pond	Saturated soil
	Palsa bog	Saturated soil		Palsa bog	
	Marsh, swamp, and uniform peat bog (wetland)	Saturated soil		Wetlands (marshes and swamps, peat bogs)	
		String bog	Saturated soil	Wetlands (string bog)	
Landforms	Glacial landform	Glacial debris	Landform	Glacial debris	
		Esker	Landform	Esker	
		Moraine	Landform	Moraine	
		Glacier, glacial ice cap, and ice shelf	Permanent snow and ice	Permanent snow and ice	
	Periglacial landform	Polygonal soil	Landform	Tundra polygon	
		Pingo	Landform	Pingo	
	Littoral landform	Barrier beach and spit	Landform (sand)	Barrier beach and spit	
	Eolian landform	Dunes	Landform (sand)	Dunes	
Vegetation	Wooded region		Wooded region	Wooded region	

## 1- Feature name

Barrier beach and spit

## 2- Hierarchy

Landforms – coastal – landform (sand) – barrier beach and spit

## 3- Definition

According to CTI, fine, hard, rock material, including raised beaches and dunes.

In geomorphology, the term **raised beach** was used to refer to barrier beaches and, occasionally, barrier spits. It has been out of use for a number of decades.

A **barrier spit** is an elongated accumulation of sand, gravel, or cobble that is parallel, oblique, or perpendicular to the shore, with one free end, except in the case of a tombolo, which connects an island or islet to the shore.

A **barrier beach** is an elongated accumulation of sand, gravel, or cobble that is parallel to the shore. A **barrier island** is a large barrier beach that is connected to the shore only at each end, broken by inlets and enclosing a lagoon. It is often referred to as a *dune*.

## 4- Summary table of identification elements

**Table 2:** Summary of elements identifying barrier spit and beach

Form	Plan view: linear, usually parallel to the shore Cross-section: ridge with rounded, occasionally flat, crest.
Dimensions	Length: decametres to kilometres Width: metres to decametres Height: metres to decametres
Topographic position	Active form: offshore (spit) and backshore (beach) Ancient form: up to the level of the old shore
Drainage	Excellent, except in the trenches between crests
Vegetation	None or sparse herbaceous vegetation
Means of formation	Sand or gravel built up by the drift in the waterbody (spit) or by waves on the backshore (beach).
Status	Active or bare paleolandforms
Spatiotemporal variations	Decadal to centennial Decadal events causing modifications
Environment	Coastal or estuary shores; sandy or gravelly lakes
Identification in the image	Elongated form Along the edge of the shoreline Bands 4-3-2 with whitish tones
Identification in B/W aerial photo	Obvious linear form, especially with stereoscopy Along the edge of the shoreline Whitish tone Smooth texture
Elements of confusion	Intermittent water, dunes

## 5- Characteristics

## 5.1- Specific to feature

### 5.1.1- Form

#### A) Barrier spit

In plan view, a barrier spit has a relatively elongated, narrow linear shape whose free portion (usually towards the waterbody) can be fingered (**Figure 1** and **Figure 2**). Tombolos may be either simple (**Figure 4**) or double, widening either towards the shore or the island or islet.

In cross-section, a barrier spit has a slightly rounded or flat crest.

#### B) Barrier beach

In plan view, a barrier beach has a very elongated, narrow linear shape and runs parallel to the shore (**Figure 6**). Barrier beaches tend to occur in parallel groups separated by depressions (trenches) that may be wet (**Figure 8**).

In cross-section, a barrier beach has a rounded crest, which may be affected by the wind if sand is the constituent material (**Figure 7**).

### 5.1.2- Dimensions

#### A) Barrier spit

Length: several tens of metres to several kilometres.

Width: several metres to several tens of metres.

Height: several metres to about ten metres; the height may be greater if affected by dunes.

#### B) Barrier beach

Length: several tens of metres to several kilometres, even several tens of kilometres in the case of barrier islands.

Width: a few metres to a few tens of metres.

Height: a few metres to about ten metres; the height may be greater if affected by dunes.

### 5.1.3- Topographic position

A **barrier spit** develops in a waterbody, but relics may be found at any elevation formerly subject to water.

A **barrier beach** develops on the backshore but relics may be found at any elevation formerly subject to water.

#### 5.1.4- Drainage

Drainage of barrier beaches and spits is excellent because they are comprised of very permeable materials. The trenches between beaches can be wet, however, when or if the water table is high.

#### 5.1.5- Vegetation

In order to be mapped as sand, the barrier beach or spit must be bare or support only scattered or sparse herbaceous vegetation (**Figure 7**). This is the case with fresh forms along existing shorelines, older forms without vegetation in northern environments (**Figure 8**), or sandy forms whose vegetated surface has been reactivated by the wind as the result of natural processes or human activity.

### 5.2- Related to feature dynamics

#### 5.2.1- Means of formation

Barrier spits (including tombolos) and barrier beaches (including barrier islands) develop from the accumulation of sandy or gravelly sediments along coastal, fluvial, or lacustrine shores from watercourses, erosion of the coastal shoreline, or submerged beaches.

**Barrier spits** lying parallel or oblique to the coast develop from the accumulation of sediments in the direction of beach drift at the mouth of a cove, bay, or estuary (**Figure 1** and **Figure 2**). Barrier spits perpendicular to the shore develop from the accumulation of sediments along the convergence of two drift currents (**Figure 3**). If the convergence occurs behind an offshore island or islet, the spit forms a tombolo, which can be simple (**Figure 4**) or double. Emerging barriers may reveal several generations of spits.

**Barrier beaches** always form parallel to the shore on the backshore from the repeated accumulation of drift carried by storm waves (**Figure 6**). Barrier beaches usually occur in parallel groups ranging from several tens to hundreds along emergent coasts (**Figure 8**). Coasts with an abundance of sediment, often in regions of isostatic subsidence, form broad barriers on submerged beaches and barrier islands, which enclose lagoons connected to the sea by gullies (**Figure 5**).

Sand spits and beaches often have windswept crests. In such cases, they can have mixed appearance with a dune-like terrain evidencing more scalloping along the edges (**Figure 7**).

#### 5.2.2- Status

Barrier beaches and spits can be active or paleolandforms. Paleolandforms are rarely bare except in northern environments (**Figure 8**) or when the vegetation cover has been disturbed by natural processes (e.g.: fire): or human activity (e.g. excavation, denudation).

#### 5.2.3- Spatiotemporal variations

Barrier beaches and spits take decades or centuries to form. They can, however, change shape over short distances as the result of storm action or other events that affect water level or sediment supply. For example, a spit at the mouth

of a watercourse may elongate over several years as the result of increased fluvial drift. A barrier island can change considerably in appearance and its gullies migrate as the result of a single storm.

In marine environments, however, the shape of spits and small barrier islands can appreciably change size on a daily or seasonal basis due to water level at the time when the image or aerial photograph is taken.

### 5.3- Related to the environment

Barrier beaches and spits are only found in marine coastal, estuarial, and lacustrine environments with significant availability of sandy or gravelly sediments.

## 6- Optimal conditions for identification

Barrier beaches and spits are usually obvious forms in aerial photographs, especially if stereoscopy is used. Active forms are whitish in tone and smooth textured, whereas ancient forms appear as various tones of grey depending on vegetation type. These forms can sometimes be confused with longitudinal dunes, which have edges that evidence greater scalloping than barrier beaches and spits.

On ETM+ images, they can be identified by their elongated shapes in tones of white on or along the coastline in bands 4-3-2.

## 7- Examples



A)





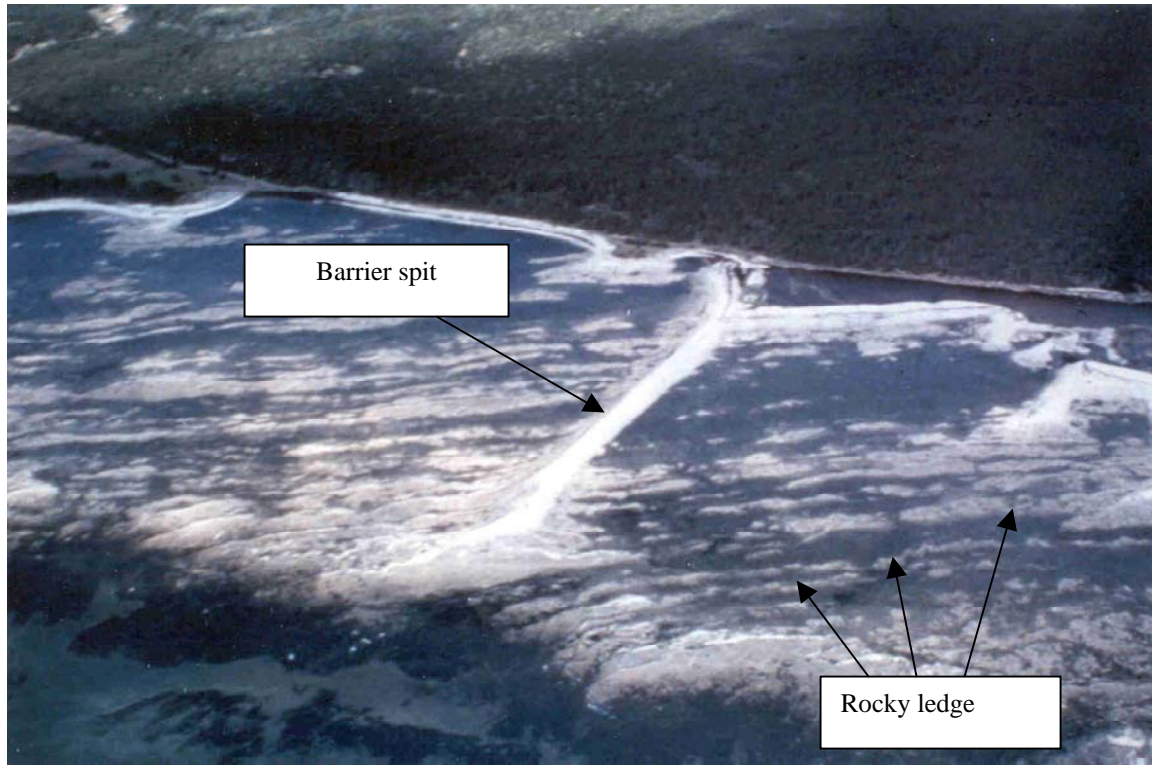
Source : photos J.-M. Dubois n° 74-1-13 and 75-10-19 St Lawrence River in Côte-Nord area

Figure 1: Examples of barrier spits at the mouths of watercourses A) Spit mostly denuded that could be interpreted as sand B) Vegetated spit surrounded by intertidal sand (Intermittent Water: Alluvium) that may be interpreted as a terrestrial environment



Source : photo A12704(201), T.S.C.A.P. 250, original scale 1 : 40 000, map 107E, 70° 25' N – 128° 10' O, Dalhousie Cape area (NWT.)

Figure 2: Example of a barrier spit with a scalloped (or fingered) end



Source : photo J.-M. Dubois n° 85-03-39 at Anticosti Island

Figure 3 : Example of a barrier spit in development on a rocky ledge (intermittent water), perpendicular to the shoreline

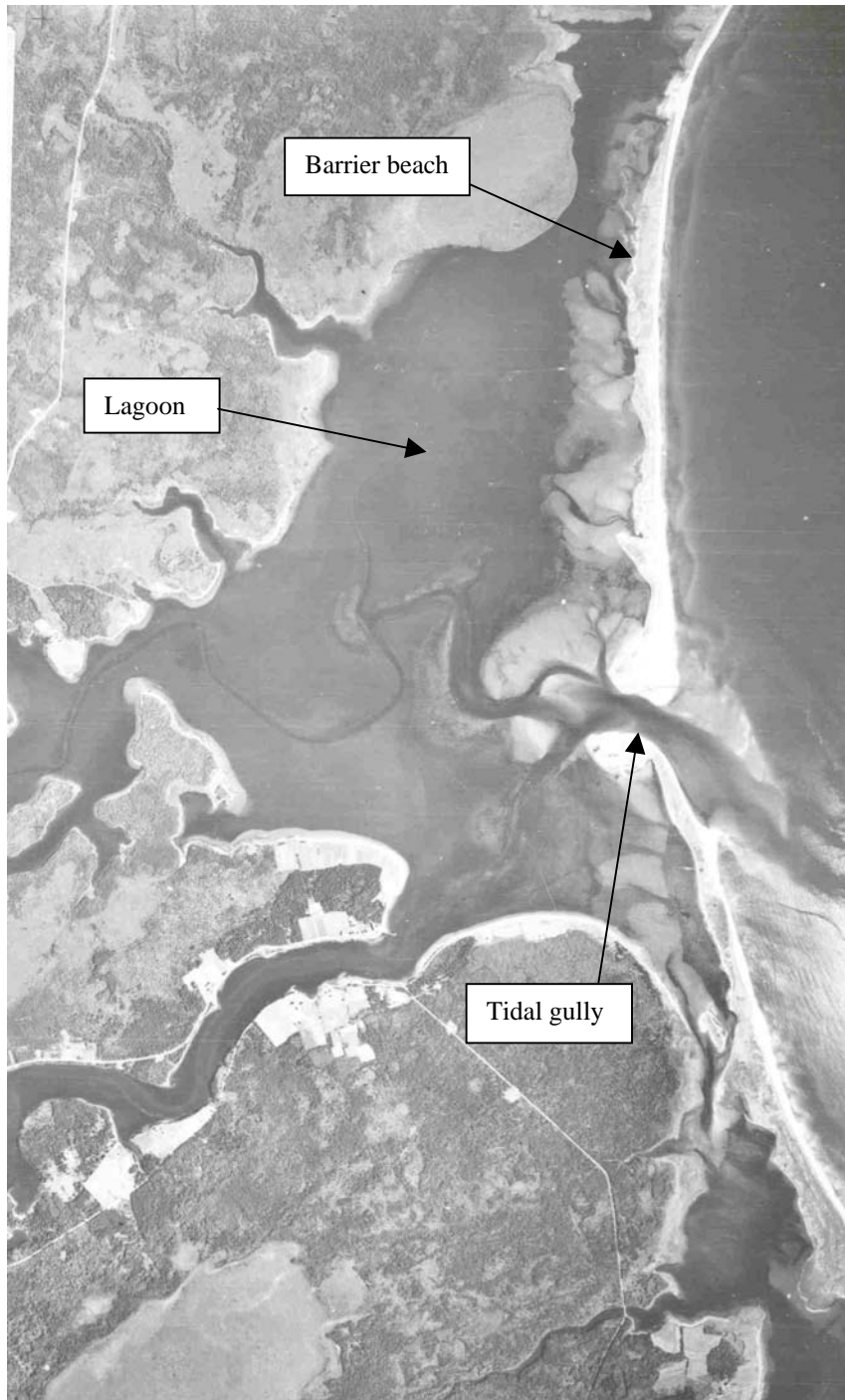


A)

Source : photos J.-M. Dubois n° 91-07-17 Îles-de-la-Madeleine et n° 74-9-32 Côte-Nord area on Saint Lawrence river

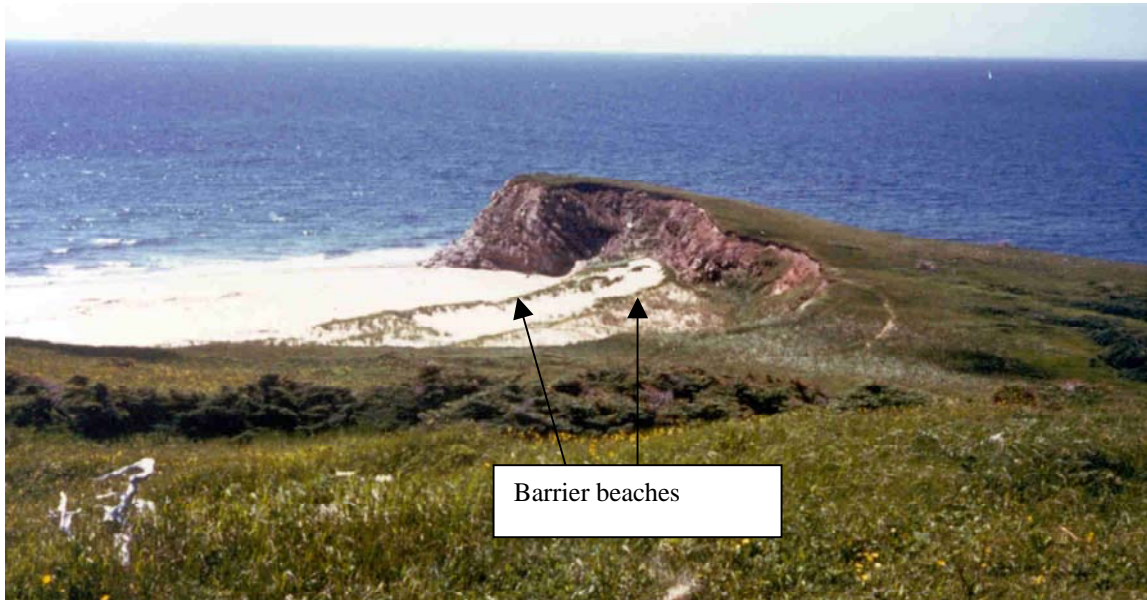
Figure 4: Examples of simple tombolos A) Active tombolo that may be interpreted as sand B) Older tombolo covered with herbaceous vegetation that may be interpreted as a terrestrial environment





Source : photo A12914 (3), T.S.C.A.P. 85, original scale 1 : 43 000, Map 21I/15, 46° 50' N – 64° 55' O, Pointe Sapin area (N.B.)

Figure 5: Example of barrier islands at the mouth of a bay or estuary with a barrier beach enclosing a lagoon and traversed by a tidal gully



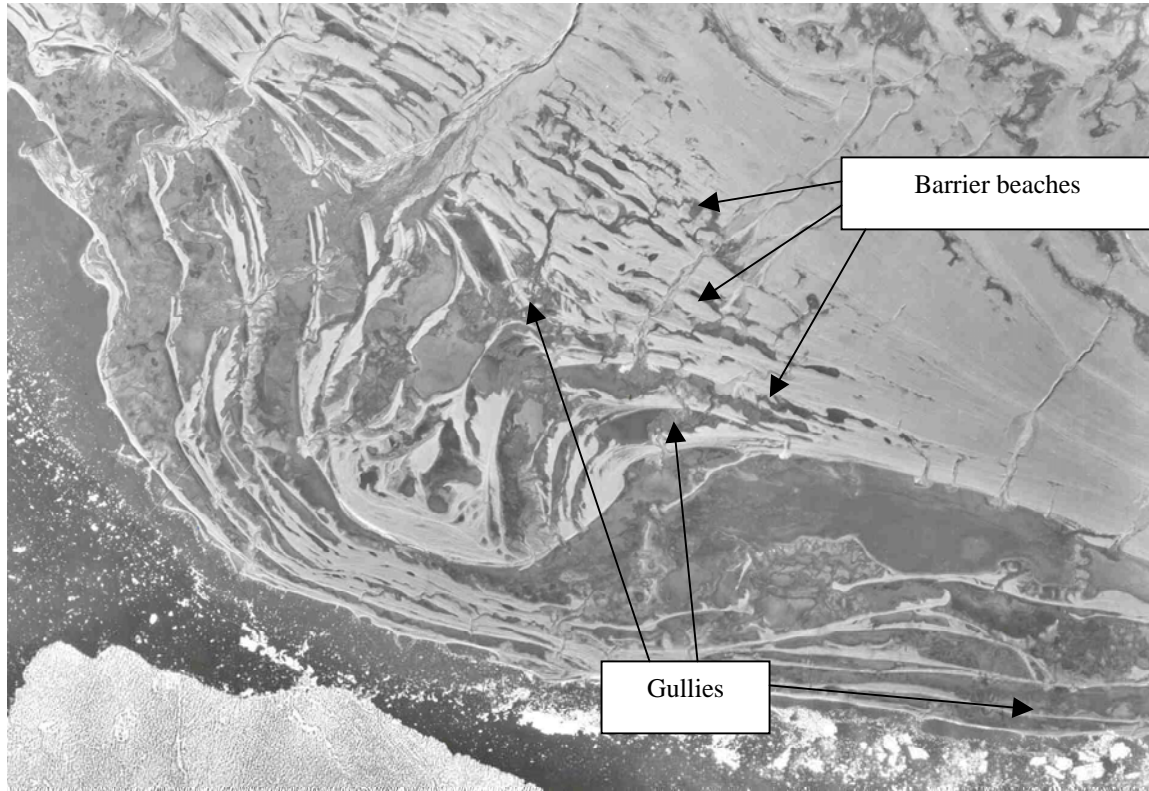
Source : photo J.-M. Dubois n° 91-08-06 Îles-de-la-Madeleine

Figure 6: Example of a series of two recent barrier beaches partially covered with sparse herbaceous vegetation



Source : photo J.-M. Dubois n° 88-03-01 Îles-de-la-Madeleine

Figure 7 : Example of an active barrier beach being shaped by the wind



Source : photo A16195 (40), T.S.C.A.P. 398, original scale 1 : 60 000, Map 58B, 72° 16' N – 93° 22' O, **Creswell Bay** area (NWT)

Figure 8: Example of a series of old barrier beaches and spits with little or no vegetation, often separated by vegetated gullies, in a northern environment

## 8- Interpretation

### 8.1- Critical path

The critical path comprises two phases: discrimination and delimitation of the form as well as its identification.

#### 8.1.1- Discrimination and delimitation

Barrier beaches and spits are readily identified in aerial photographs, especially if stereoscopy is used. In ETM+ images, these features can be identified by their elongated shapes in bands 4-3-2.

They can be delimited accurately and easily if the images or photographs are taken at high tide. If the images are taken at low tide, there is a greater risk of including part of the sandy or gravelly foreshore flats if its color is close to the whitish tone of dry sand (**Figure 6**). In aerial photographs, foreshore flats are generally easily identifiable. In ETM+ images, band 5 can be used, which identifies moisture in most cases.

#### 8.1.2- Identification



The process for identifying barrier beaches and spits requires the analyst to deal with various elements of confusion and discrimination (Table 2). Discrimination accuracy is directly proportional to the analyst's knowledge and experience.

## 8.2- Verification with complementary sources of information

While no complementary sources of information are needed, more general information about barrier beaches and spits can be found in Paskoff (1994) and many examples within Canada in Mollard and James (1985).

## 9- Elements of confusion

**Table 3: Elements of confusion and discrimination between barrier beaches and spits and other features or forms**

Feature or Form	Elements of Confusion	Elements of Discrimination	Examples
Intermittent Water (Alluvium)	- Dry foreshore flats that are whitish at low tide	- Whiter tone in photos and band 5	Figure 9



Dunes	- Elongated form - Parallel to the coastline - Whitish tone	- Smoother texture - Less scalloping	
-------	---	---	--

Source : photo J.-M. Dubois n° 91-06-26 Îles-de-la-Madeleine

Figure 9: Example of a beach with a very wet lower part (Intermittent Water: Alluvium), fairly dry middle part (area of confusion), and dry upper part (sand)



## **10- Bibliography**

Mollard, J.D. et James, J.D. (1985) la photo-interprétation et le territoire canadien. Approvisionnements et services Canada, Ottawa, 424 p.

Paskoff, R. (1994) Les littoraux : impact des aménagements sur leur évolution. Masson, Paris, 256 p.

## **Appendix: the meanings of the sections**

### **1. Name of entity**

The name of the entity as it appears in the GDB and in Topolan7.

### **2. Position in hierarchy**

The position of the entity in the hierarchical structure of entities in the GDB.

### **3. Definition**

A brief description based on the entity's principal characteristics and allowing it to be distinguished from any other natural or manmade entity in the GDB.

Only the core features are part of the definition. A detailed description of the characteristics necessary for identification is given in Section 4.

### **4. Summary table of elements of identification**

Presentation of a table summarizing the entity's characteristics (Section 5), of the optimal conditions for identification on ETM+ imagery and black and white (B/W) aerial photography (Section 6), and of the elements of confusion (Section 9).

### **5. Characteristics**

Categorization and description of the characteristics useful for visual identification of the entity.

#### **5.1. Specific to the entity**

Characteristics unique to the entity that allow all aspects useful for its identification to be grasped.

##### **5.1.1. Shape**

Distinction between linear, point, and areal shapes, three-dimensional pattern of the entity.

##### **5.1.2. Dimensions**

Expanse (length, width, diameter) and height of the entity: minima, maxima, and means.

##### **5.1.3. Topographic position**

Location of the entity relative to major landforms: drainage basin, mountain, plateau, plain, valley, slope, etc.

##### **5.1.4. Drainage**

Surface moisture, outside of saturated zones, in connection with the texture of the materials in the entity.

##### **5.1.5. Vegetation**

Presence of vegetation typical of the entity or patterns of plant associations making it possible to distinguish the entity.

## **5.2. Relative to the entity's dynamics**

Characteristics pertaining to the origin and the state of the entity.

### **5.2.1. Emplacement process**

The agent or set of agents responsible for the entity's emplacement and evolution.

### **5.2.2. State**

Dynamic state of the entity: inherited or current. In the case of inherited features, we speak of paleolandforms; in the case of current landforms, we speak of their ongoing formation.

### **5.2.3. Spatio-temporal variations**

Variations in the entity or its appearance that are functions of cyclical conditions (seasonal, multi-year, etc.) or event driven.

## **5.3. Relative to the environment**

Characteristic of the conditions in the entity's milieu and its relationship with other entities or forms present in this milieu.

## **6. Optimal conditions for identification**

Drawing on documentary sources and the experience of the participants, establishment of the optimal conditions for visual identification of the entity. Using satellite imagery, determine the capability of Landsat7 ETM+ to capture the characteristics of the entity and identify the band or combination of bands best for visually distinguishing and identifying the entity. Using B/W aerial photography, identify the hues and textures that are most representative of the entity. In cases in which the relief may be significant, recommend the use of stereoscopy.

## **7. Examples**

Illustrating the entity with examples reflecting several of its aspects:

### **7.3. Land-based photography**

Photographs of the landscape that present one or several examples of the entity's aspects, as they might be seen from the ground.

### **7.3. Aerial photography**

Oblique or vertical aerial photographs that present one or several examples of the entity's aspects, as they might be seen from the air.

### **7.3. Satellite imagery**

Satellite images (from Landsat7 ETM+) that present one or several examples of the entity's aspects, as they might be seen from space.

## **8. Interpretation**

Identification of the entity proceeds from interpreting the information in the imagery or aerial photography and complementary sources of information. The quality of the outcome of this interpretive activity will depend upon the knowledge and the experience of the analyst.

## **8.1. Critical path**

Establishing a unique critical path of interpretation for each entity from the imagery or aerial photography on the basis of its characteristics.

### **8.1.1. Distinction and delimitation**

The possibility of distinguishing and delimiting the shape on the image or aerial photograph has been established and the criteria for success have been described.

### **8.1.2. Identification**

Contrasting the various elements of confusion and recognition with other entities or forms for purposes of identification.

## **8.2. Use of complementary sources of information**

Complementing or cross-checking the interpretation with additional sources of information that are easily accessible, such as those on known Internet sites.

## **9. Elements of confusion**

Identifying the entities and forms with which the entity in question can be confused in a table, along with the differentiating features.

## **10. Bibliography**

A list of useful documents quoted in the previous sections.