Beach-inlet Interaction and Regional Sediment Management at Pristine And Developed Barrier Islands

Ping Wang
School of Geosciences
University of South Florida
Tampa, FL 33620
pwang@usf.edu

Tanya M. Beck
U.S. Army Engineer Research and Development Center
Coastal and Hydraulics Laboratory

Outline

Introduction

Beach-inlet Interaction and Sediment Transport Pathways

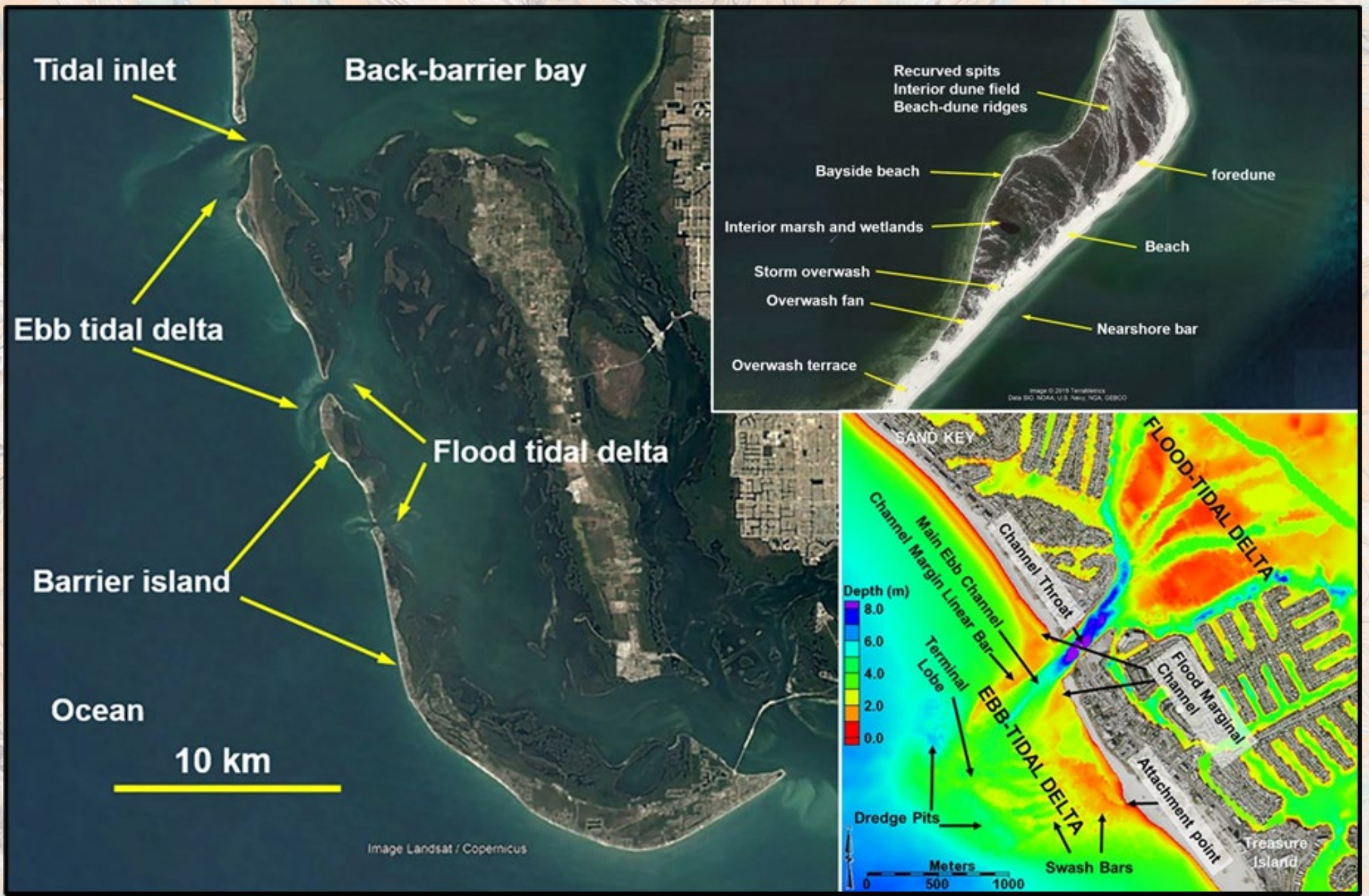
- Sediment transport pathways and dominant processes
- Conceptual models on beach-inlet interaction (FitzGerald et al., 2000)
- Numerical modeling of beach-inlet interaction

Regional Sediment Management (RSM) at Beach-inlet System

- Establishing and balancing sediment budget at beach-inlet systems
- A Regional Sediment Management Framework

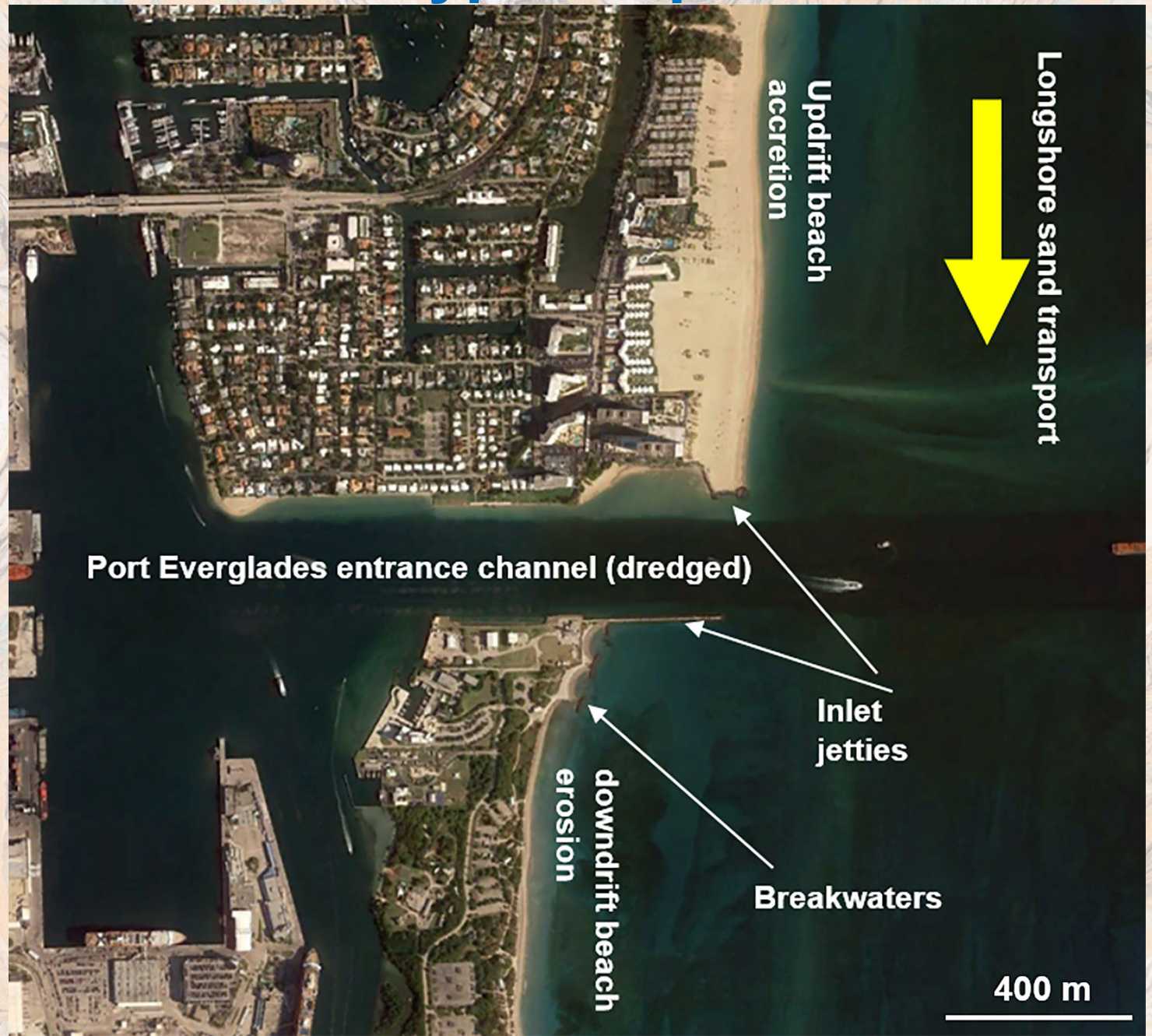
Summary

Introduction: morphological features in a beach-inlet system



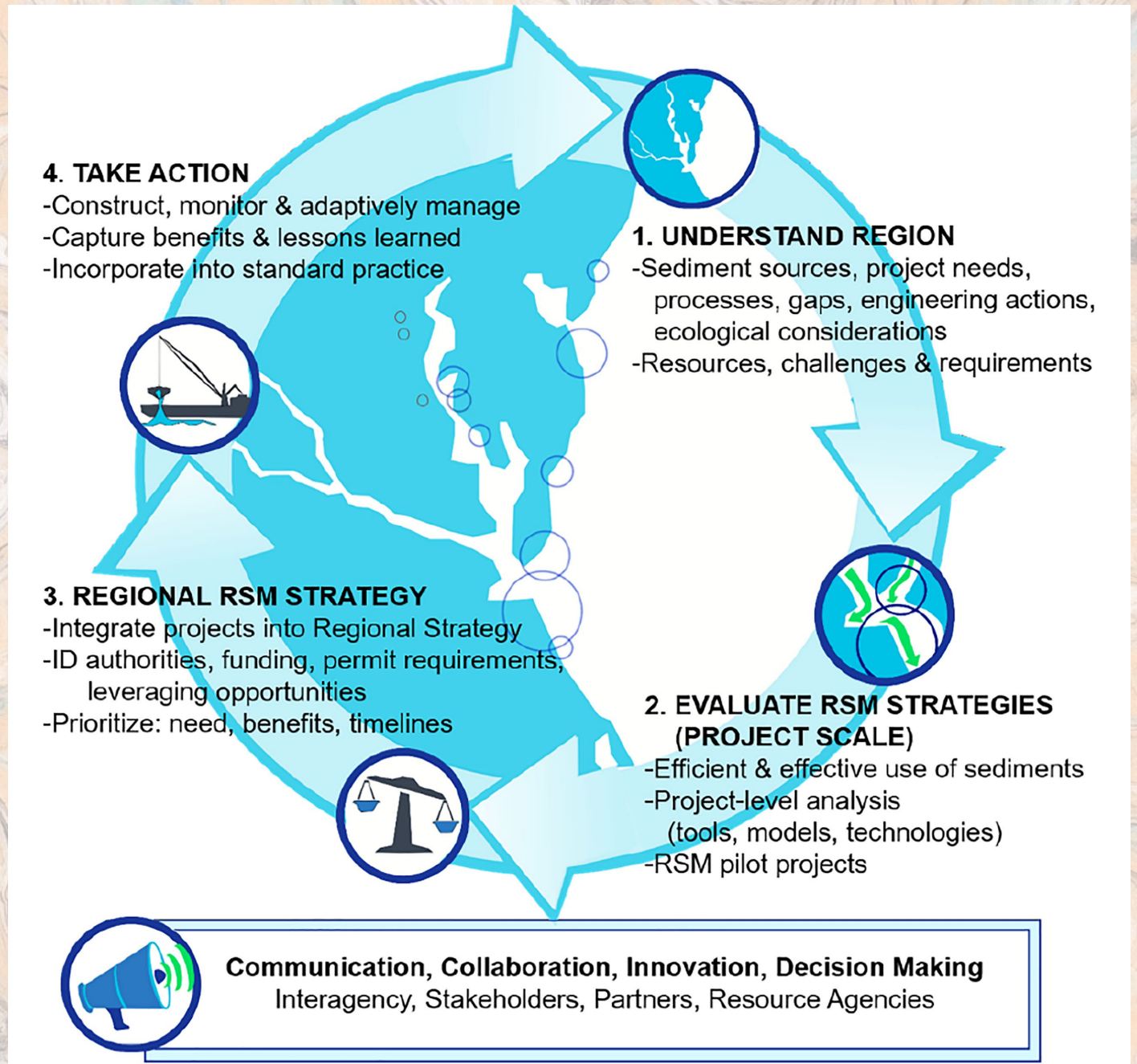
Managing sand movement, naturally or artificially, among the different features requires in-depth understanding of sediment transport/deposition and beach-inlet interaction

Introduction: a typical “problem” at a beach-inlet system



Balancing a relatively stable-wide beach and stable-navigable inlet is a complicated task, requiring collaboration among various entities.

Introduction: managing sediment at a regional scale

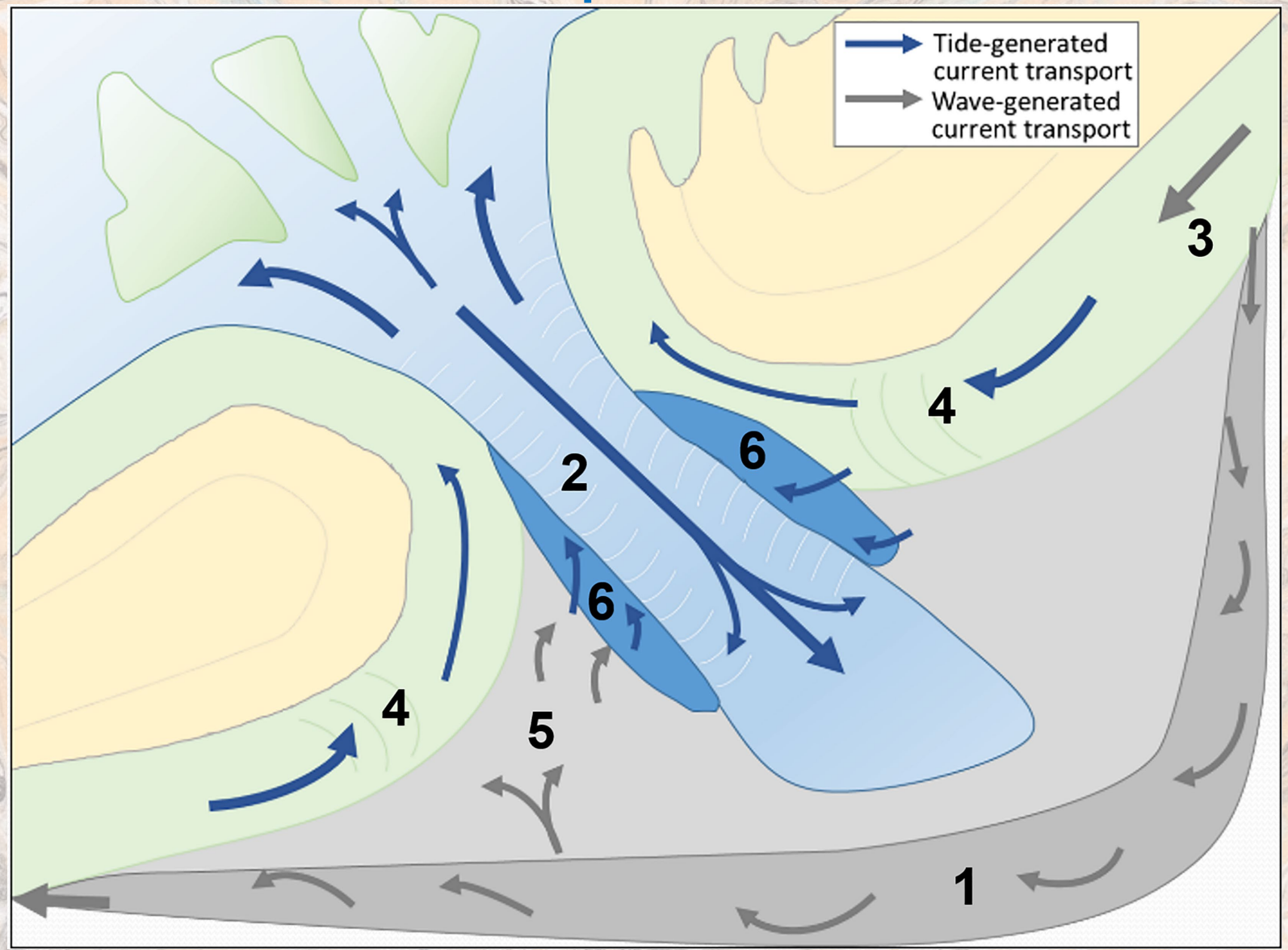


The USACE regional sediment management process (https://rsm.usace.army.mil/: RSM Book: Tools and Technologies).

Beach-inlet Interaction and Sediment Transport Pathways

How do sediments (sand) move from one side of the inlet to the other side?

What are the dominant processes?



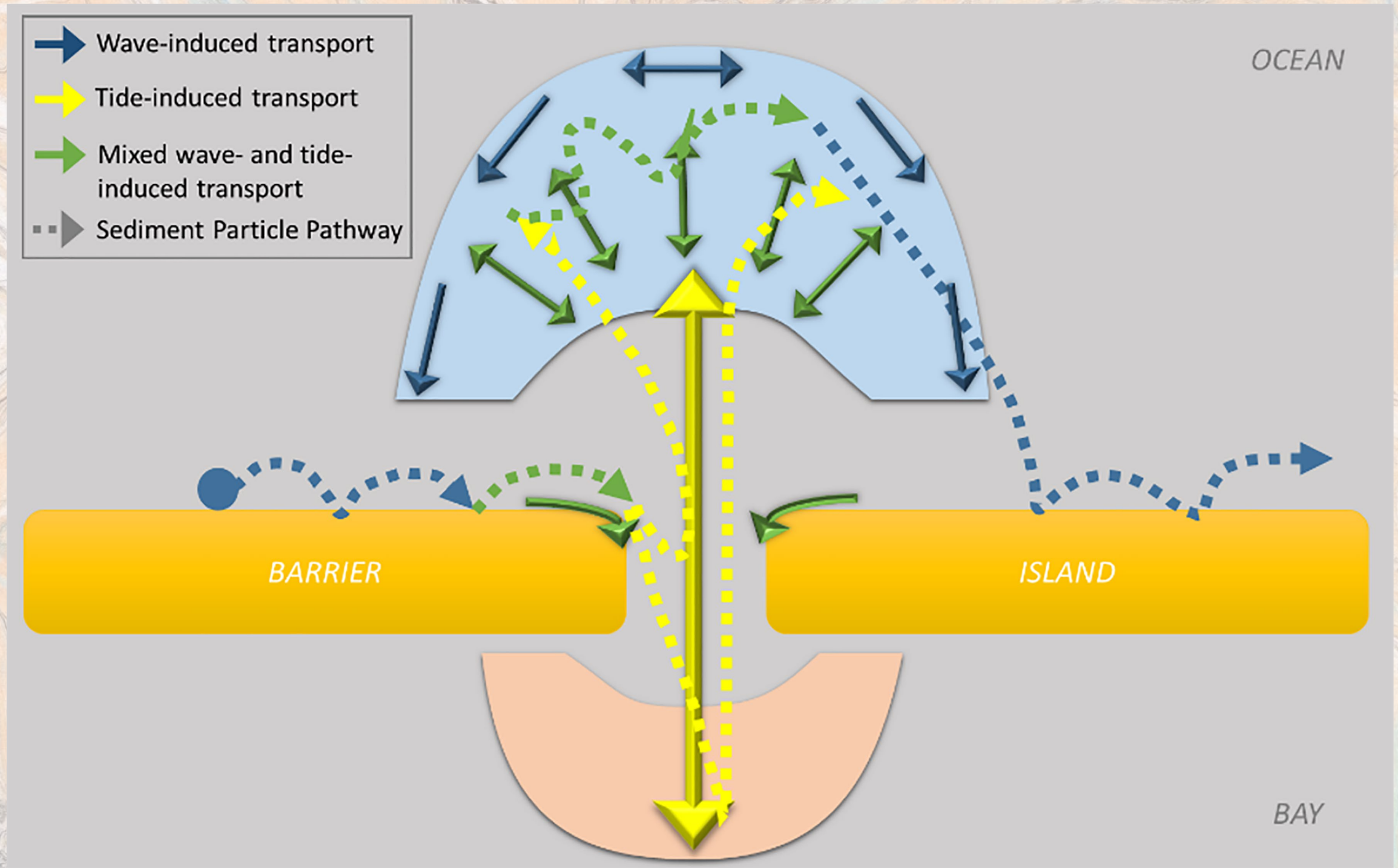
A conceptual model

1: terminal lobe or bypassing bar
2: main inlet channel
3: barrier island beach
4: barrier island beach
5: ebb shoal platform
6: channel margin linear bar

Beach-inlet Interaction and Sediment Transport Pathways

How do sand move from one side of the inlet to the other side?

What are the dominant processes?



A conceptual model

Beach-inlet Interaction and Sediment Transport Pathways

How do sand move from one side of the inlet to the other side?

What are the dominant processes?

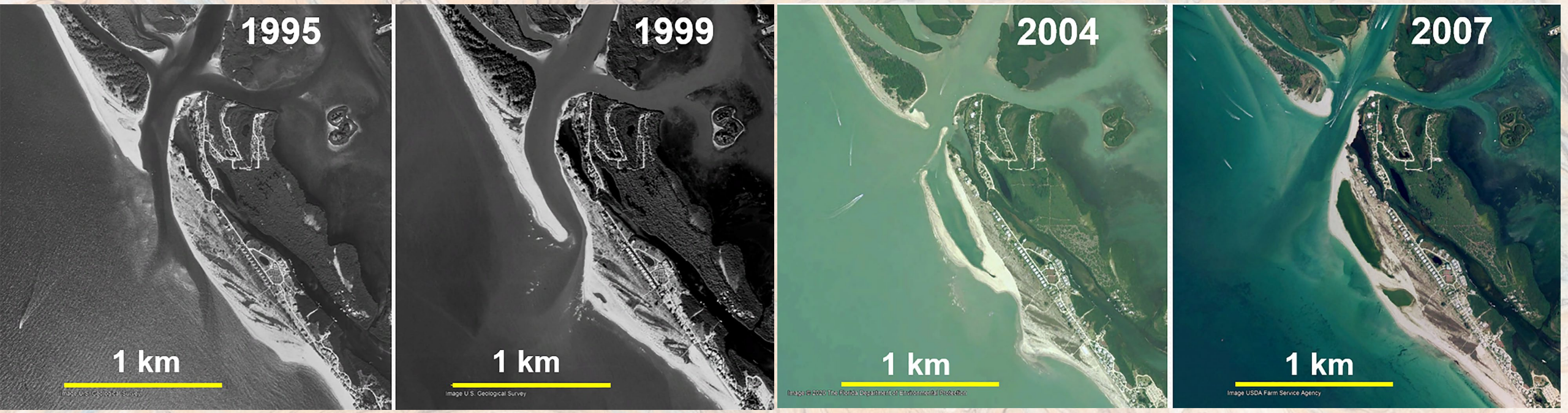
Illustrated via time-series aerial photos,

Katama Bay, Massachusetts, USA

Beach-inlet Interaction and Sediment Transport Pathways

How do sediments (sand) move from one side of the inlet to the other side?

What are the dominant processes?

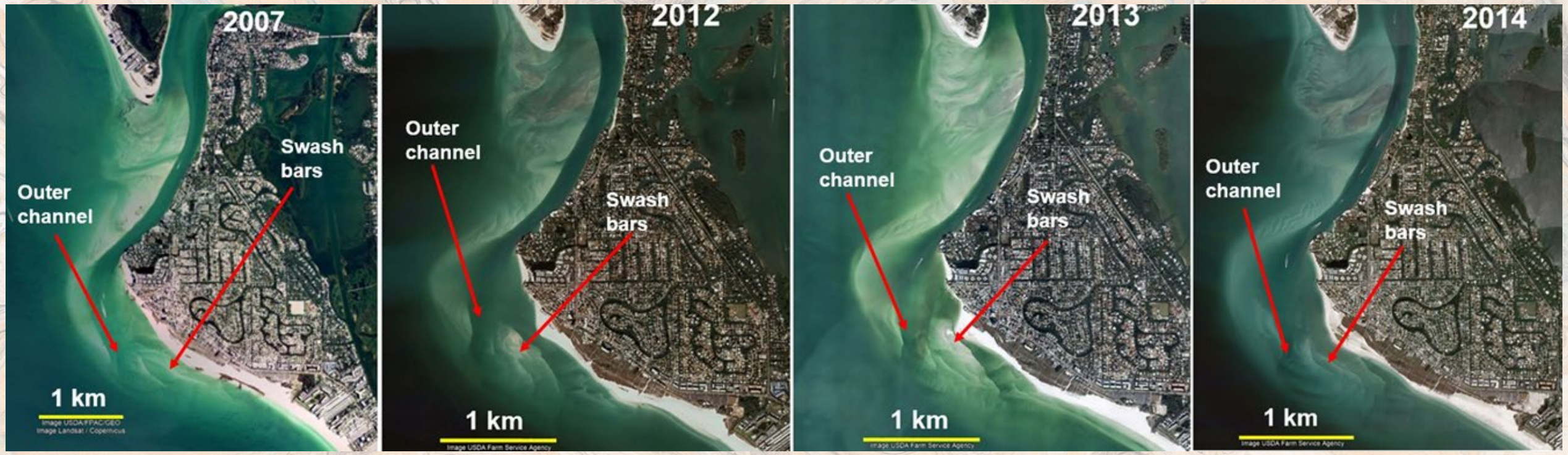


Illustrated via time-series aerial photos, Stump Pass, FL

Beach-inlet Interaction and Sediment Transport Pathways

How do sediments (sand) move from one side of the inlet to the other side?

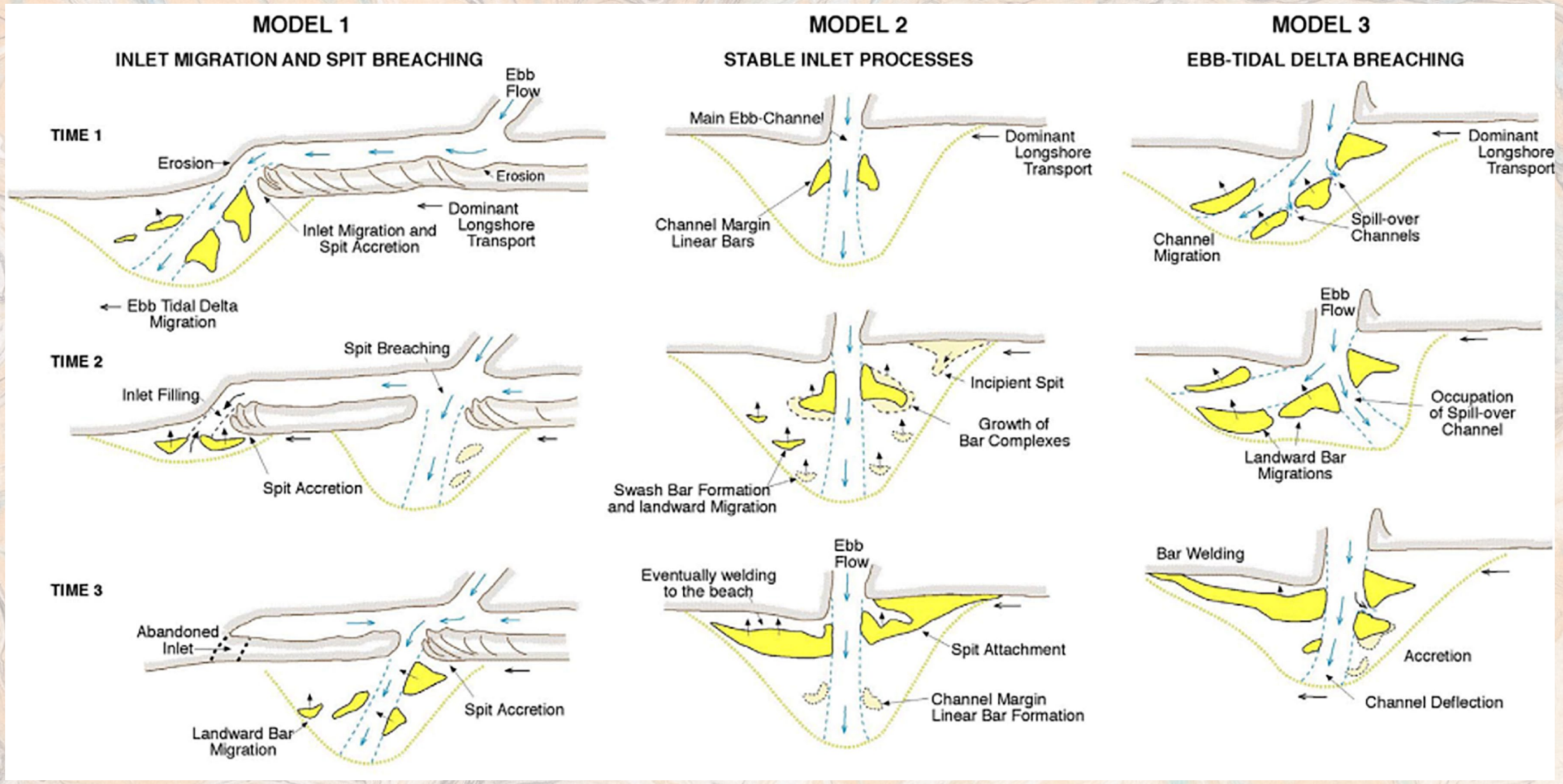
What are the dominant processes?



Illustrated via time-series aerial photos, Big Sarasota Pass, FL

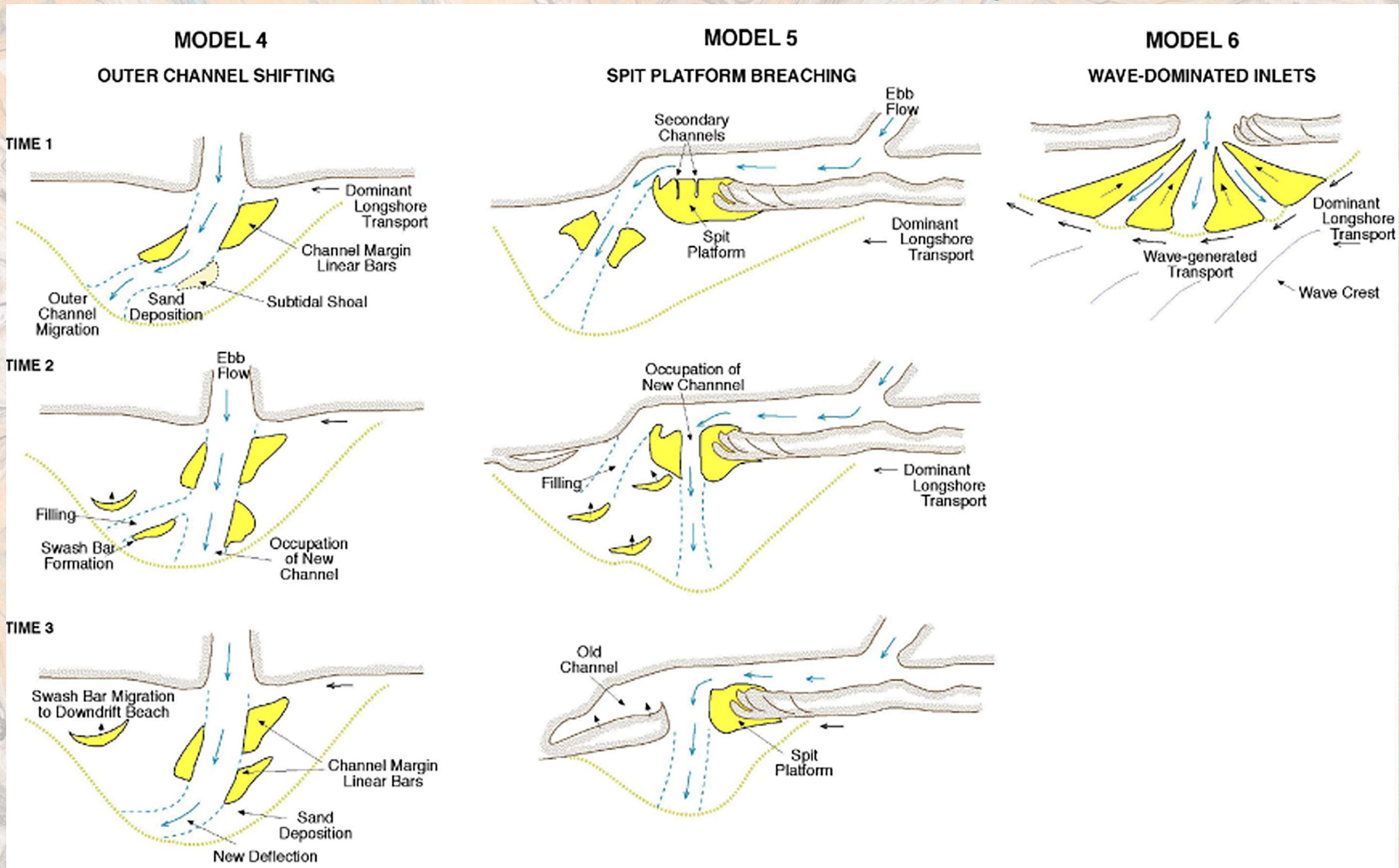
Beach-inlet Interaction and Sediment Transport Pathways

Conceptual models on beach-inlet interaction (FitzGerald et al., 2000)



Beach-inlet Interaction and Sediment Transport Pathways

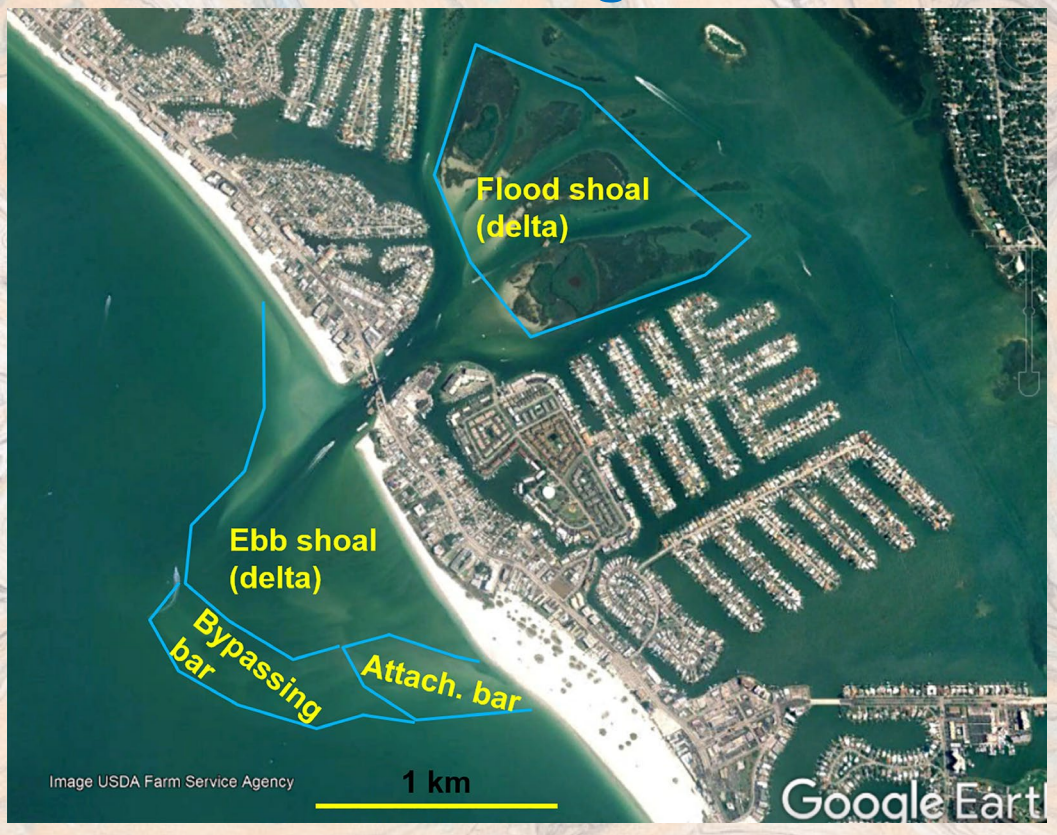
Conceptual models on beach-inlet interaction (FitzGerald et al., 2000)

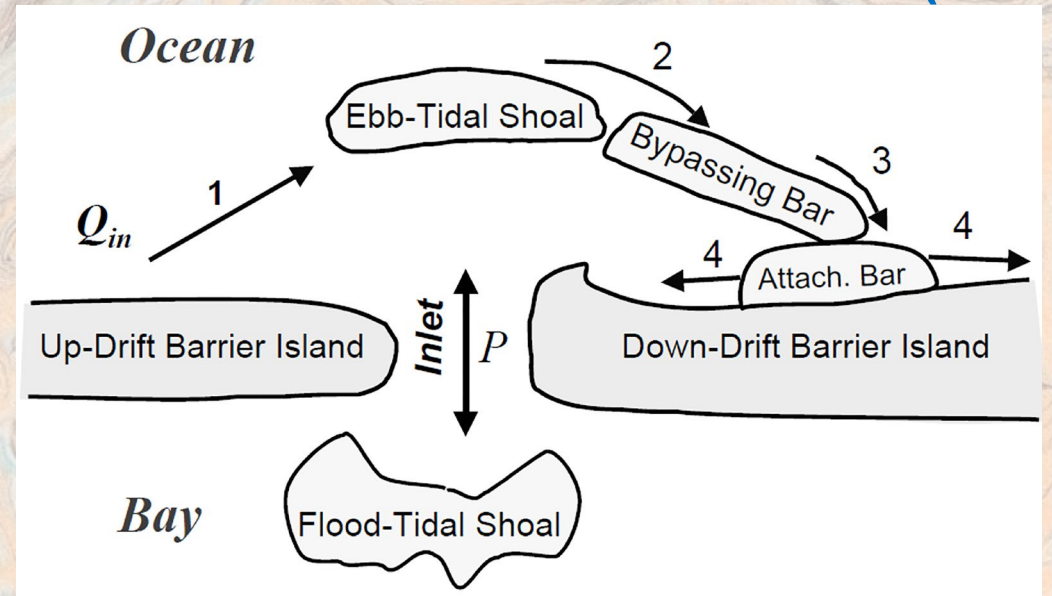


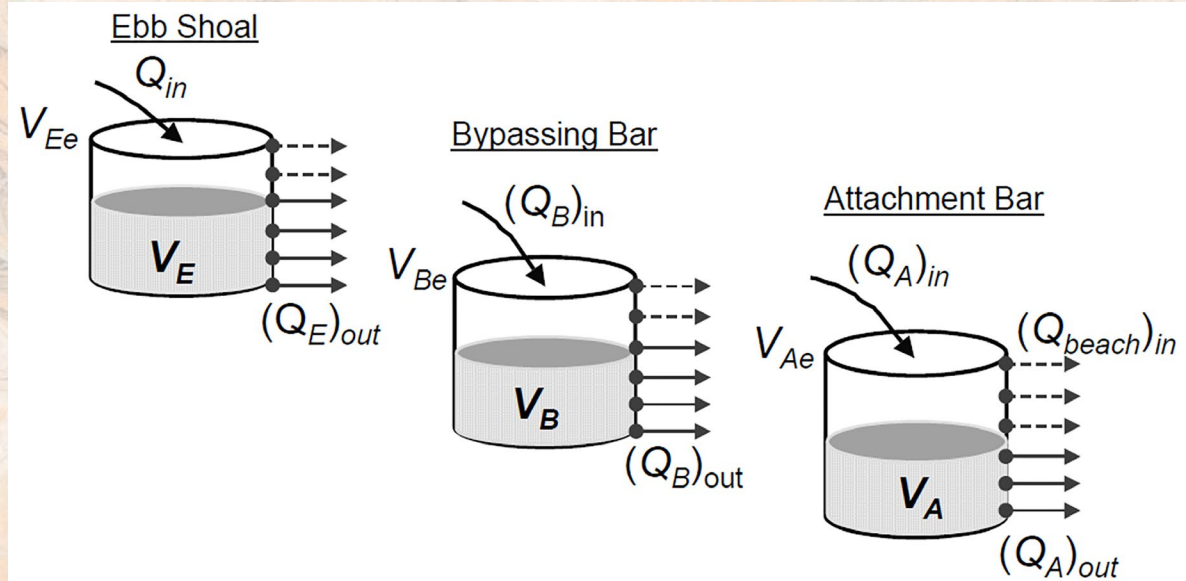
Sediment bypass is described and illustrated via movements of morphologic features

Beach-inlet Interaction and Sediment Transport Pathways

Numerical modeling of beach-inlet interaction: inlet reservoir model (IRM)





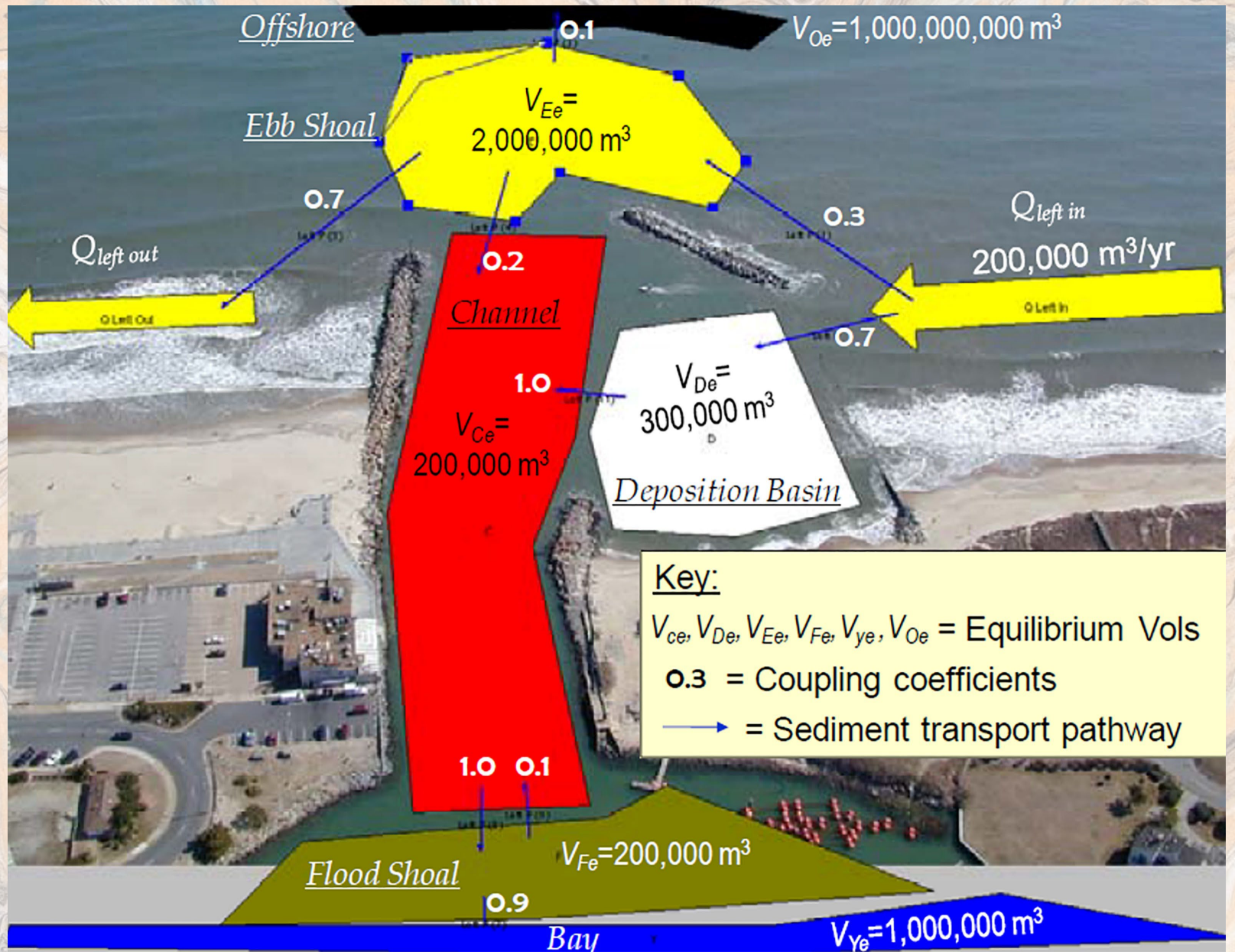


Key morphologic features are viewed as connected sand reservoirs, each has "an equilibrium volume".

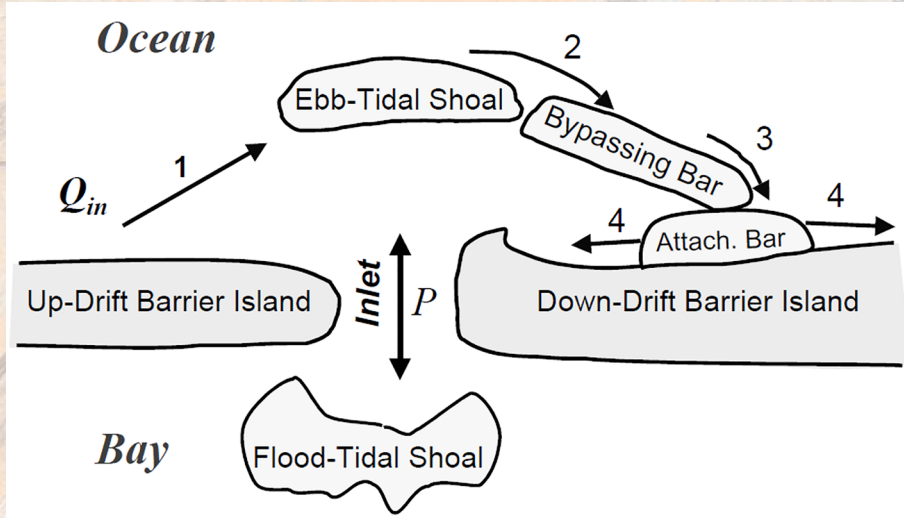
(Kraus, 2000)

Beach-inlet Interaction and Sediment Transport Pathways

Numerical modeling of beach-inlet interaction: inlet reservoir model (IRM)

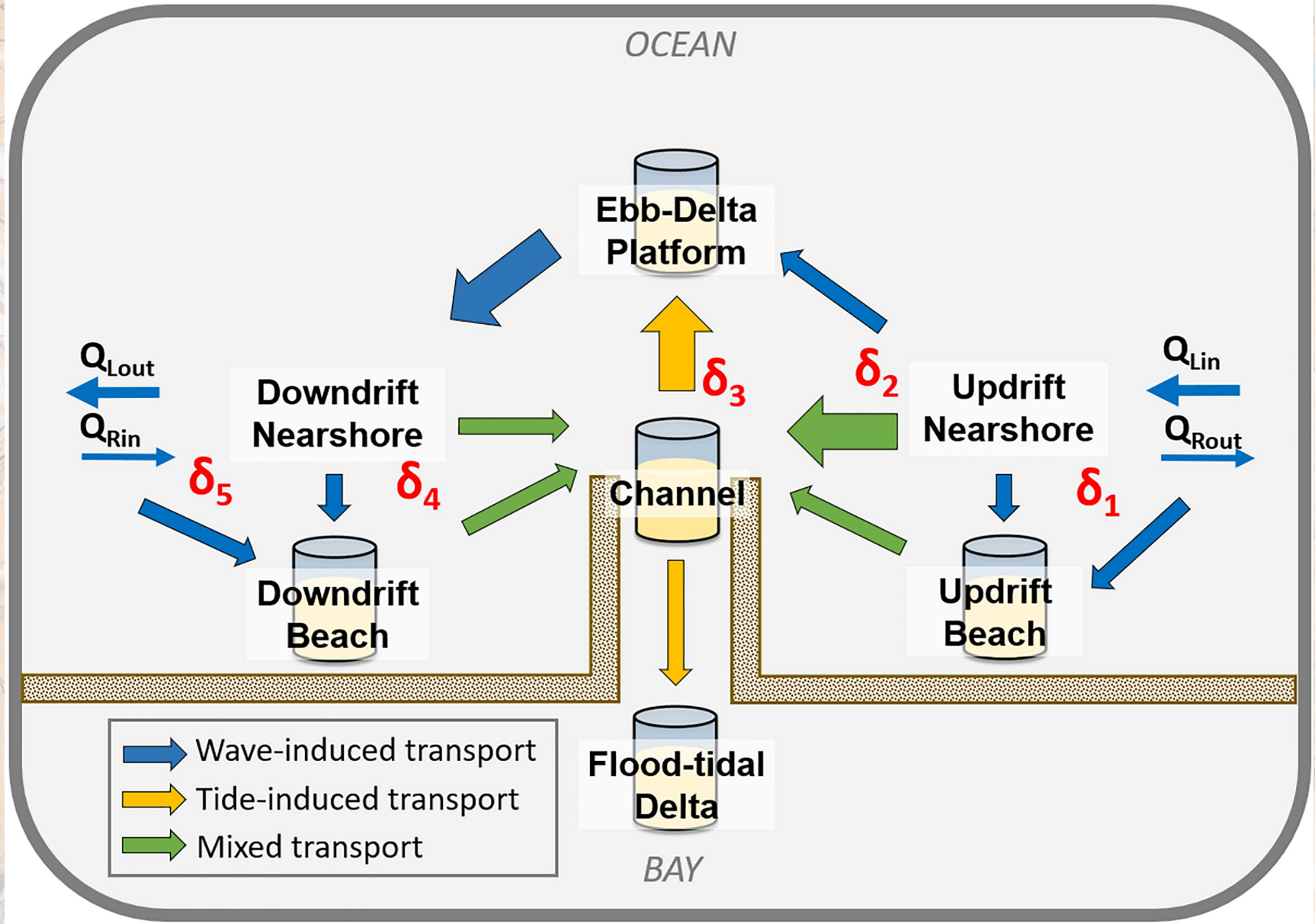


A multiple-pathway version of IRM (Rosati et al., 2011)



Beach-inlet Interaction and Sediment Transport Pathways

Numerical modeling of beach-inlet interaction: inlet reservoir model (IRM)

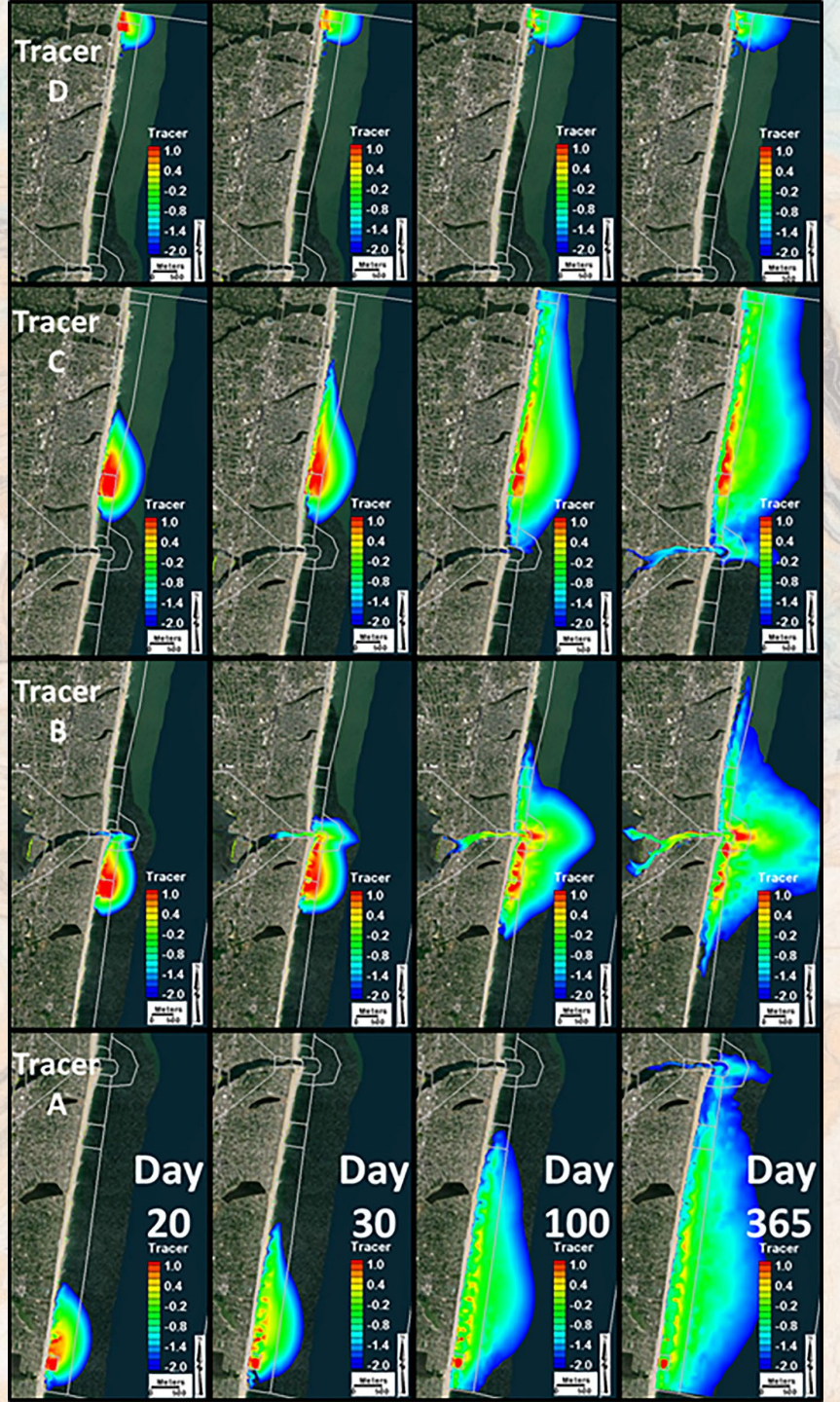


A multiple-pathway version of IRM

Beach-inlet Interaction and Sediment Transport Pathways

Process-based numerical modeling of beach-inlet interaction (CMS in this case)

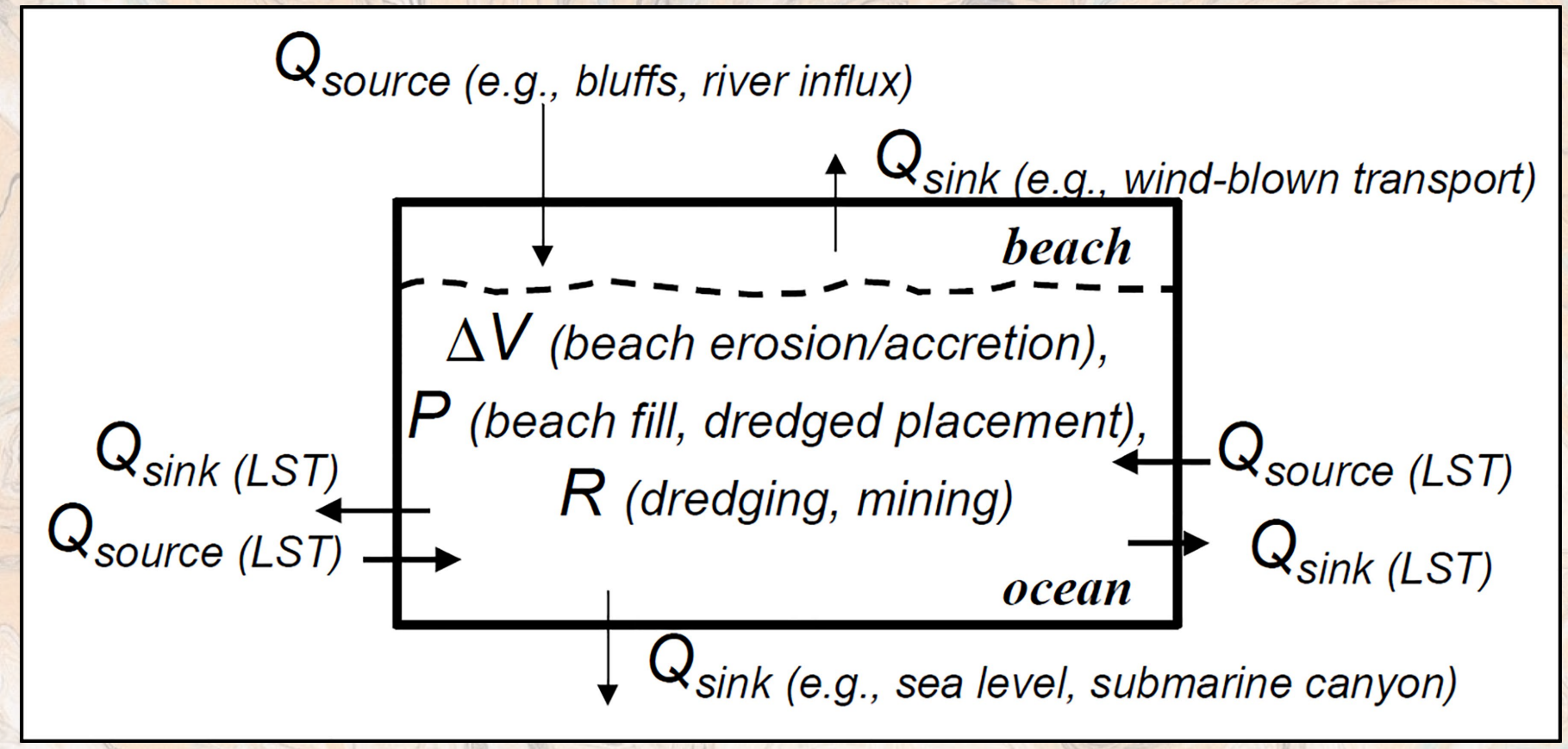
Traced sediment deployed at two nearshore locations each updrift (Tracer A and B) and downdrift (Tracer C and D) of Shark River Inlet illustrated as total tracer concentration (kg/m^2, log scale) throughout the bed layers at Days 20, 30, 100, and 365 (from Beck et al., 2020).



Beach-inlet Interaction and Sediment Transport Pathways

Formulating and Balancing a Sediment Budget

$$\sum Q_{source} - \sum Q_{sink} - \Delta V + P - R = Residual$$

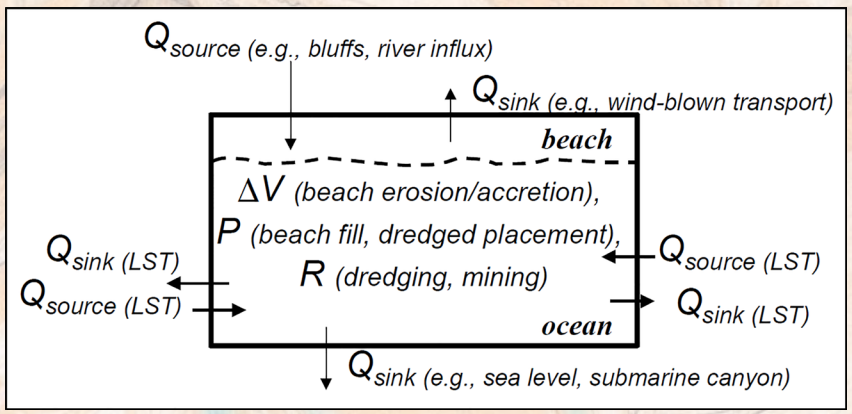


Sediment budget parameters entering and leaving a budget area. LST denotes longshore sediment transport (from Rosati, 2005).

Beach-inlet Interaction and Sediment Transport Pathways

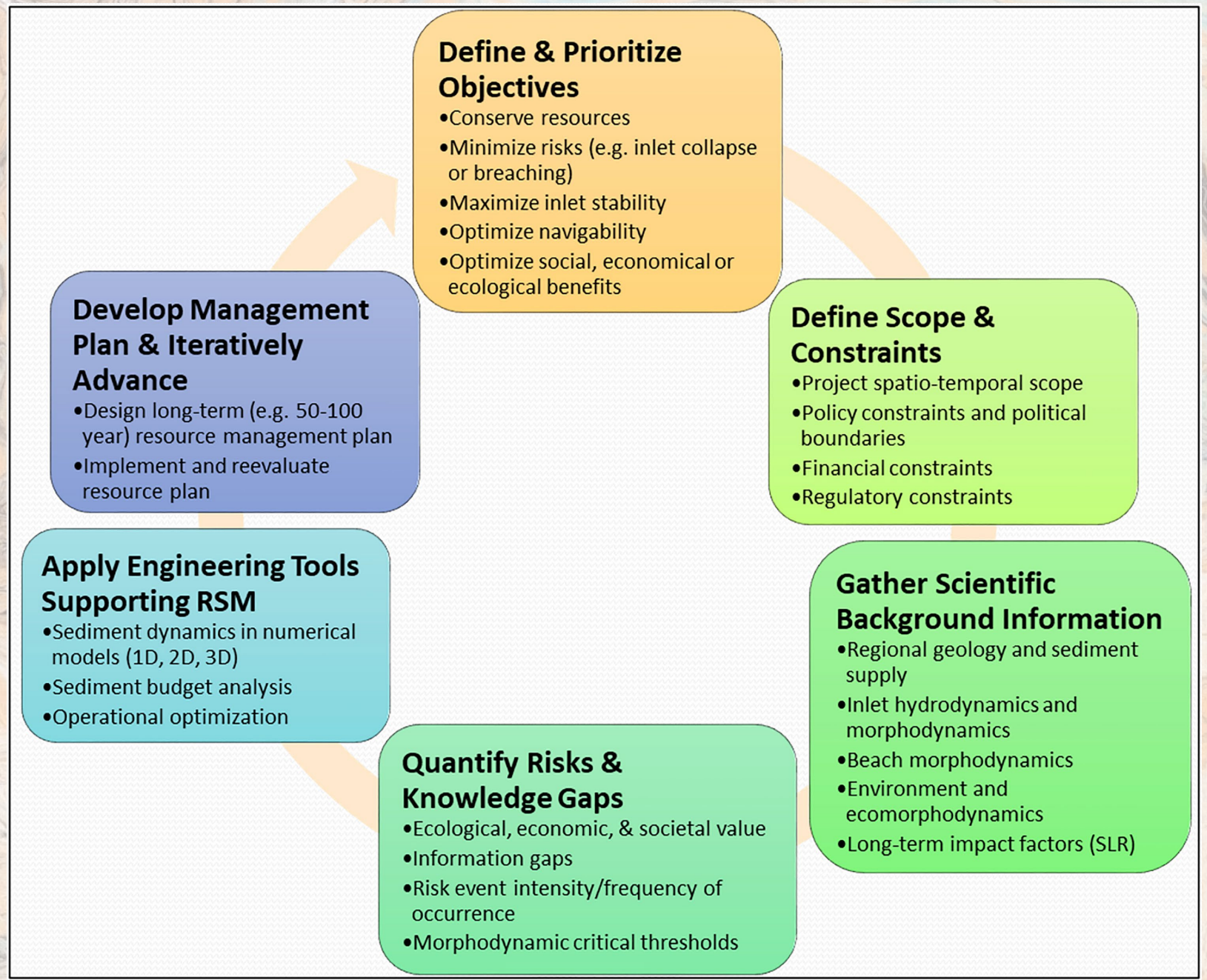
Formulating and Balancing a Sediment Budget: key considerations

1) Formulating and quantifying a sediment budget are often quite complicated, requiring practically everything we know about the system.
2) Determining the appropriate and efficient temporal and spatial scales.
3) Theoretically, long budget period (years to decades) is desirable. In reality, temporal scales are controlled by the availability of accurate data, and its applicability in representing future trends.
4) Spatially, it is desirable to have a sediment-budget area be defined by closed boundaries, e.g.,
   a) landward boundary: without significant riverine sediment input, in the back-barrier bay;
   b) seaward boundary: depth of closure;
   c) lateral boundaries:
      i) for rock coast: headlands;
      ii) section of beach where longshore transport rate is known;
      iii) tidal inlets with minimal or known sand bypassing rate



Beach-inlet Interaction and Sediment Transport Pathways

A Regional Sediment Management Framework



Beach-inlet Interaction and Sediment Transport Pathways

Summary:

A systems approach incorporating adequate temporal-spatial scales is essential for modern beach protection & restoration.

Understanding & quantifying sediment bypassing, associated pathways, and the temporal scales of their morphodynamics are key to the RMS of tidal inlets and adjacent beaches.

Many tools, conceptual and numerical modeling, have been developed.

Managing sediment resources at a regional scale through a balanced sediment budget constitute a major component in coastal resilience building.