Sustainable Solutions for Coastal Zone Management of Lowland and River Delta Coastlines

By

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Background

- In recent years, the impacts of natural disasters are more and more severe on coastal lowland areas and barrier islands. Furthermore the impact of anthropogenic modifications produce coupled coastal problems. In the future, the impact of global warming and climate change (sea level rise, storm surges, coastal floods) will become more critical. People are increasingly occupying low-lying areas that are exposed to flooding, thus exacerbating their vulnerability to extreme events. The importance and scale of coastal defense structures will increase accordingly, and thus potentially generating greater environmental adverse impacts.
- At a global scale, effects of accelerated climate changes was demonstrated in autumn 2010 when the storm Becky reached the Santander Bay, Spain with a peak of nearshore (significant) wave height of about 8 m, and a storm surge reached 0.6m. On the Nile Delta Coast, effects of intense winter storms on Alexandria coastline and its adjacent shores appeared in the last decade to be more progressive in 2003, 2006 and recently in December 2010. The latest storm in December 2010, which hit the Nile Delta showed that generated surges, up to 1.0m as well as a maximum of 7.5m in the offshore presented a major natural hazard in coastal zones. The recent adverse impact of Super Sandy hurricane in late October 2012 on the east cost of the US is living example of progressive global climate changes.

Presentation Outline

A. **Status of World's River Delta Coastlines, Barrier Islands and Lowland Coastlines under Global Climatic Changes.**

   Objectives and Methodology

B. **Case Studies; California-Pacific Ocean and France – Gulf of Lions.**

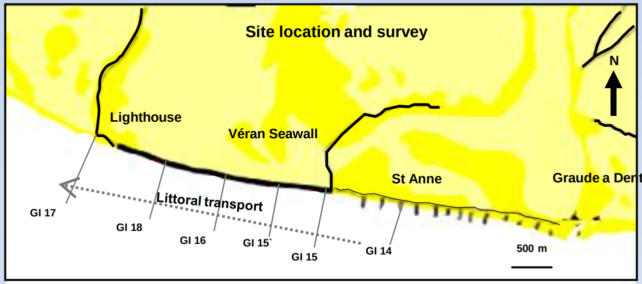
C. **Coastal Processes at Rosetta Headland and Seawall-Beach Interaction.**

D. **Prediction of Large Scale Shoreline Modifications, Nile Delta Coastline and Wave Overtopping.**

E. **Conclusions & Recommendations.**

A. Status of World’s River Delta Coastlines, Barrier Islands and Lowland Coastlines under Global Climatic Changes

Véran Seawall - France



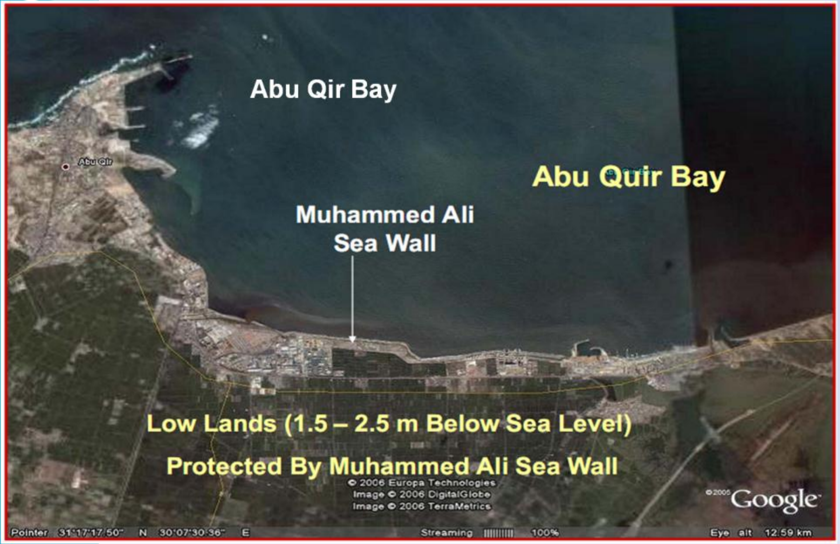
Mississippi River Delta USA
before 2005

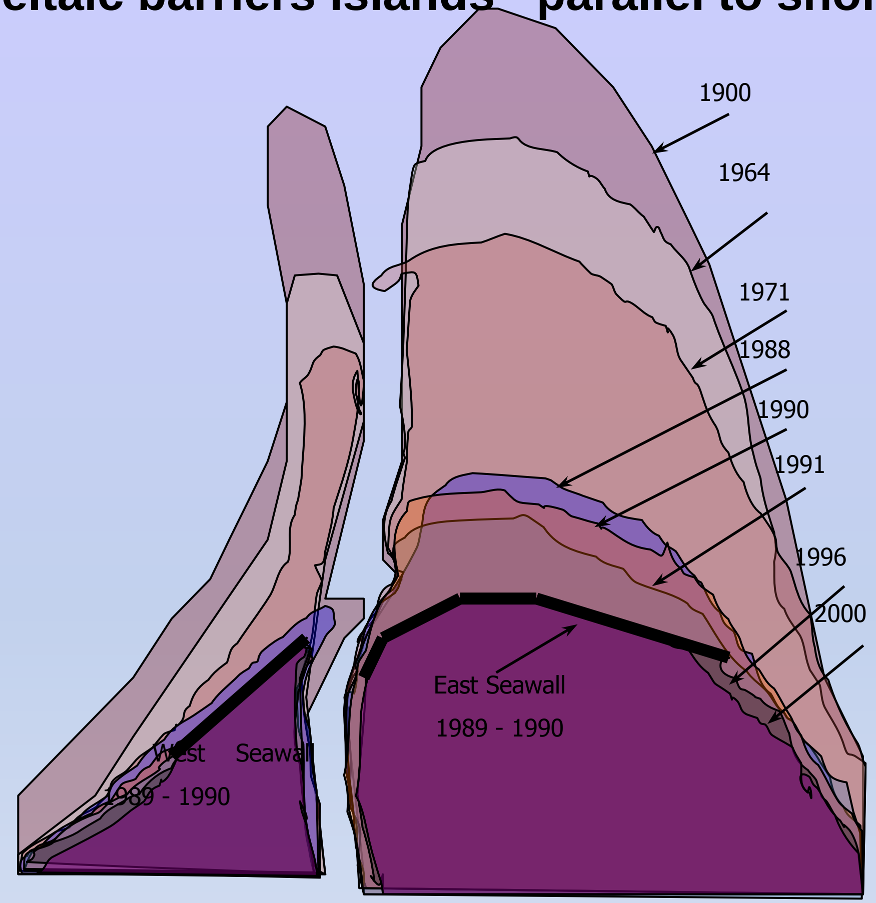
Location of case studies in the Gulf of Lions, France and the Gulf of Mexico, California, USA

Wave Dominated Nile Delta

Deltaic barriers Islands ~parallel to shore

Nile Delta, Egypt, as revealed by Satellite Imagery 1980



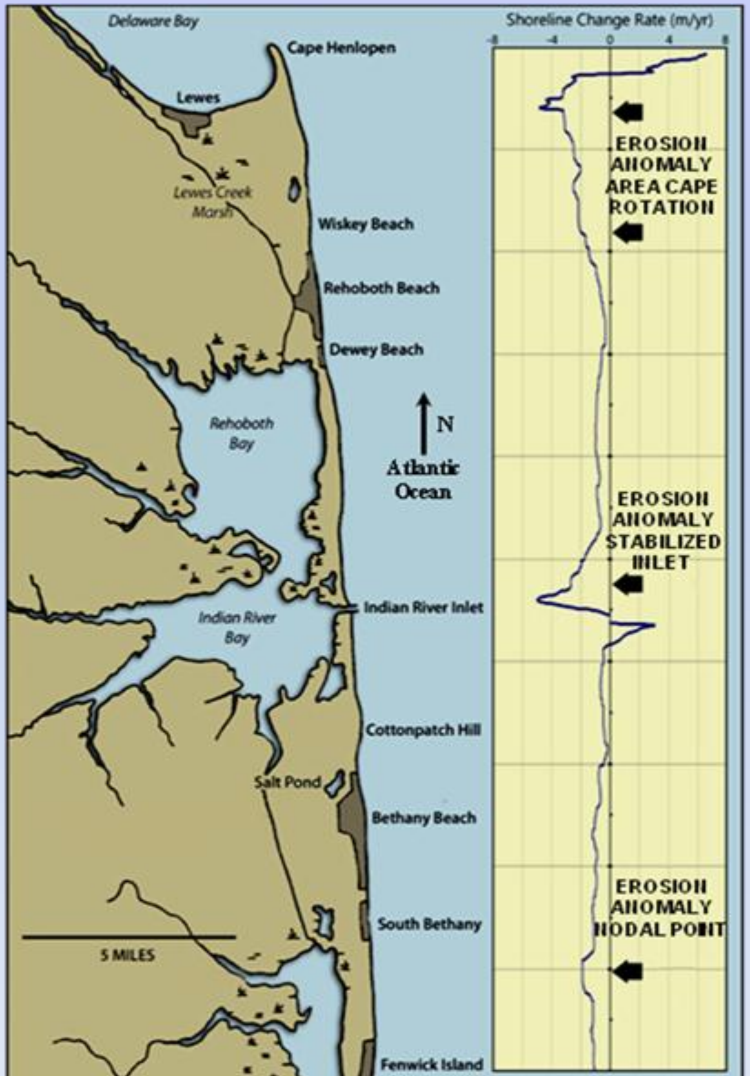


Rosetta promontory

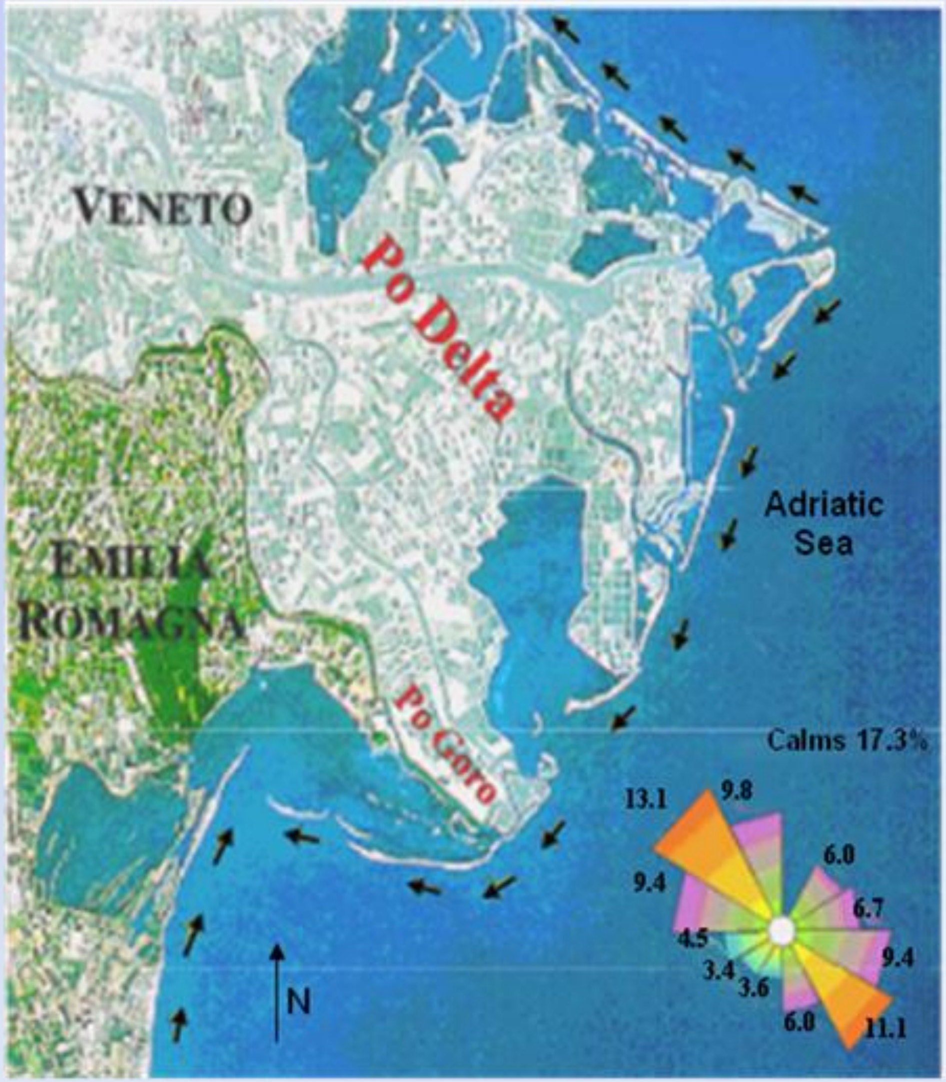
* 1800 to 1909
  Shoreline Advance (3.5 km)
  25 m/yr (E), 20 m/yr (W)
* 1900 to 1996
  Shoreline retreat 50 m/yr
  (4.8 km in 96 years)
* Operation of Aswan High Dam 1965

Coastal Retreat of Rosetta Headland (1900 to 2000) and M. Ali Seawall

Beach erosion at barrier islands, Delaware, USA, (Galgano, 2007)



Subsidence at Po river delta, Italy (Syvitski, 2008)



Impact of Global Climate Change on U.S Eastern Coastline

Beachfront road and boardwalk damaged by Hurricane Jeanne (Sept. 2004)

Damages by Super Hurricane Sandy (Oct. 2012)

Brilliance of the Seas Cruise Ship Faces Heavy Mediterranean Weather, Alexandria, Dec. 13, 2010

Mohamed Ali Seawall

Restaurants Complex, Alexandria Coastal Road , Dec. 2010

Beach segment after 2010 storm

Alexandria Coastal Road , Dec. 2010

Objectives & Methodology

- Assess the impact of anthropogenic modifications, such as the absence of river flow on coastal morphology of Deltas.
- Evaluate impact of recent storm surge and wave overtopping on upgrading of seawalls.
- The second aim is to highlight the opportunities to use coastal soft defense measures.
- Clarify literature controversial impact of the effectiveness of seawalls to slow, mitigate or increase coastal erosion at retreating shorelines.
- The derivation of the results is based on the examination of field data collected on the Nile Delta Rosetta seawalls, constructed in 1990, after the operation of the Aswan High Dam in 1965, as well as field data on seawalls in France and the USA.
- Use has been made of recent satellite remote sensing data for the Rosetta headland in 2007, 2008 and 2012, the numerical prediction of GENESIS, and scale analysis of the governing equations of the wave-river flow to obtain the length scale for reshaping of the Nile Delta coastline at Rosetta. Laboratory data are used for verification.

B. Seawall Case Studies

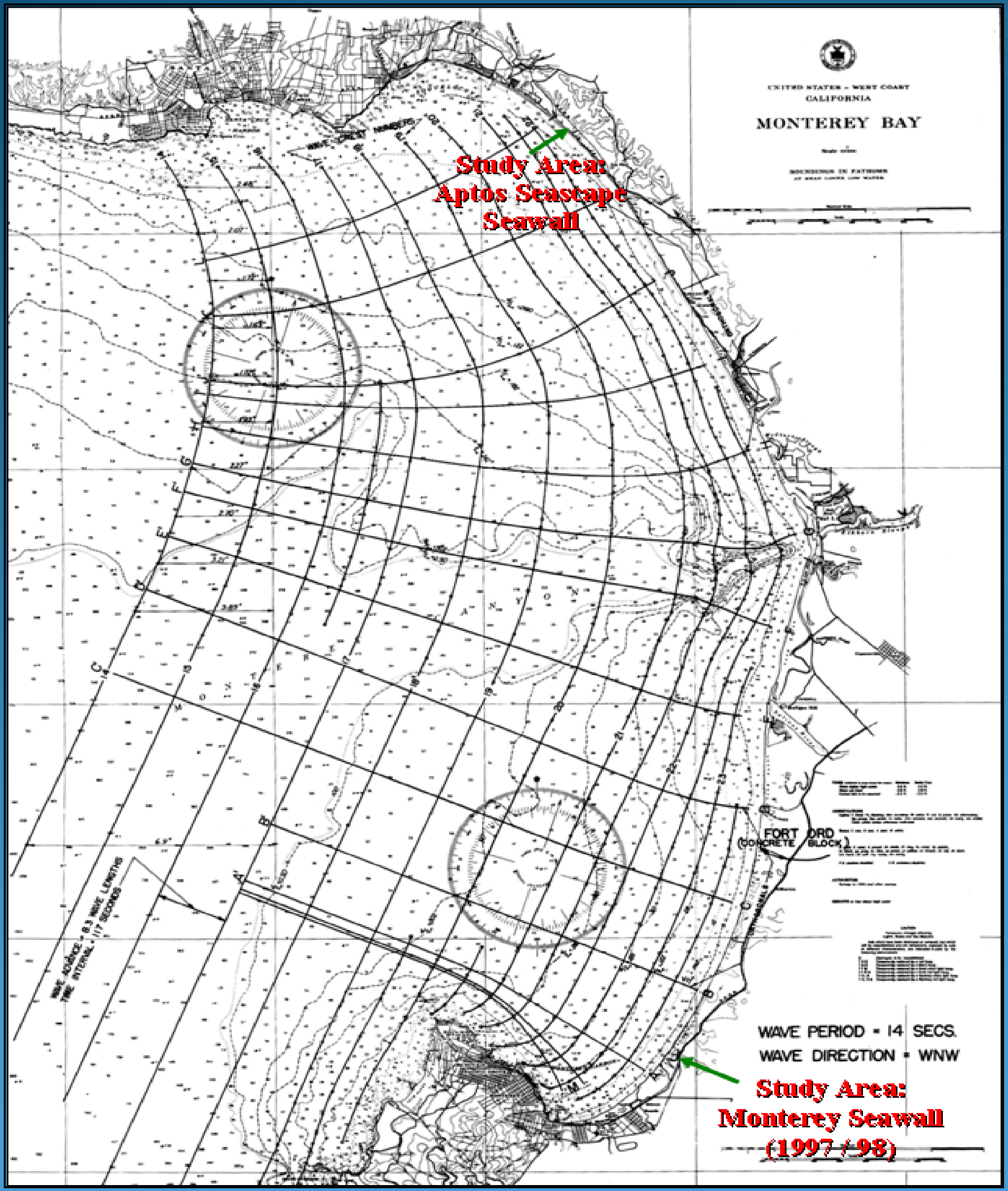
Essential Methodology

Review of previous case studies of field monitoring of coastal morphology modifications at two seawalls located in Monterey Bay, CA, one seawall located at Ventura river mouth, CA, USA and one seawall located at the Rhone river mouth, the Gulf of Lions, French Mediterranean coast.

CASE STUDIES I - USA

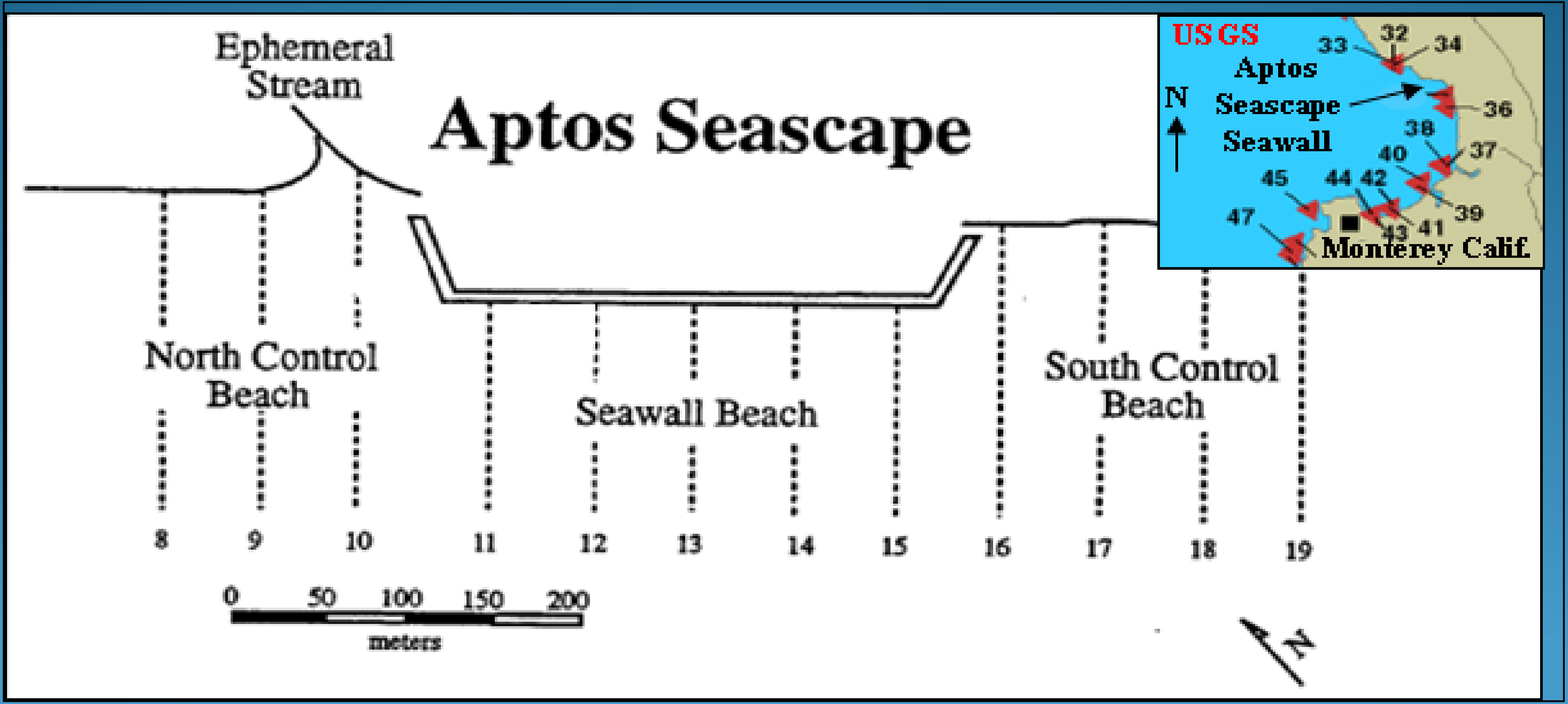
Seasonal and Storm Erosion Patterns

Interaction of Seawalls and Monterey Beach, Calif., USA



Wave refraction analysis:
for Monterey Bay, California
(From Johnson, O'Brien, and Isaacs, 1948 : Wiegel 1964)

Eight Years of Field Monitoring (1986-1995) Gary Griggs, UC Santa Cruz, USA



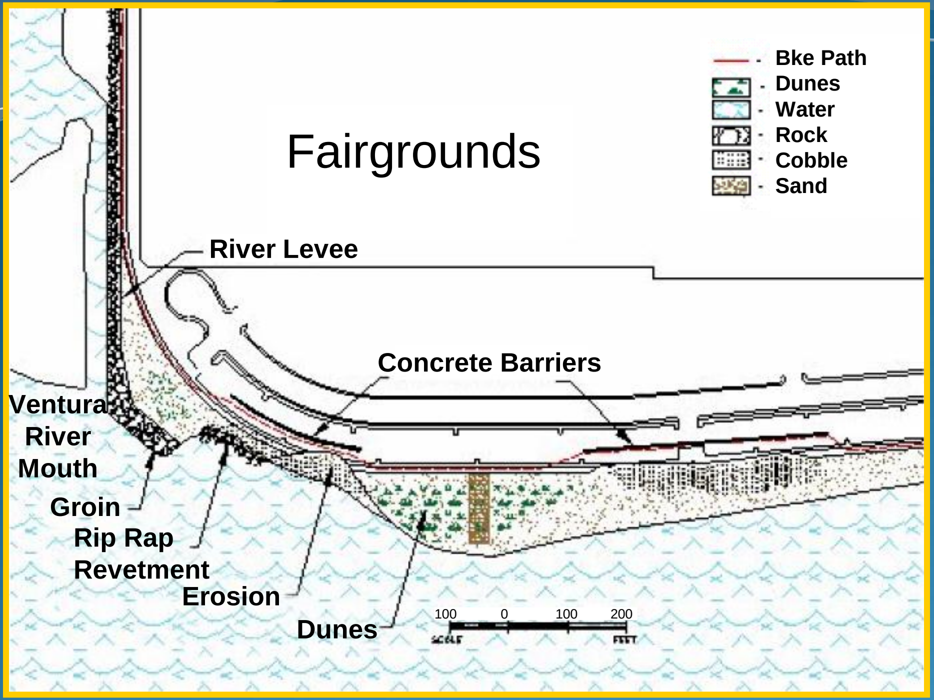
Seawall Location 41a, Monterey Calif. Winter Storm 10/97

Monterey Seawall, after Repair 4/98

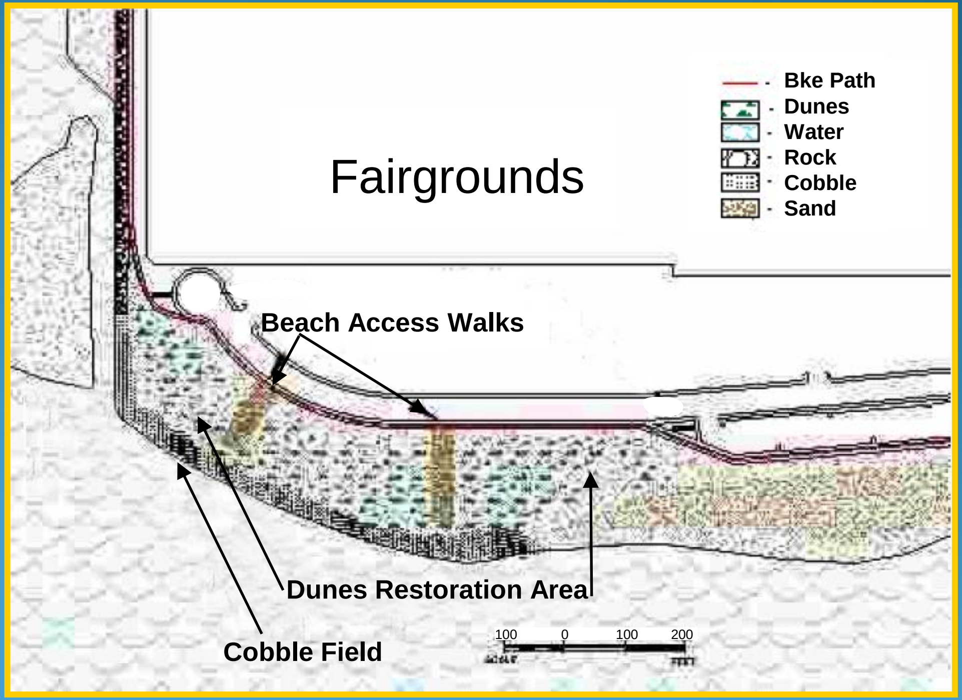
Ventura River Delta, California, USA (November 1999)

Parking Lot and Bike Path Near the Mouth of the Ventura River (1995)

Shoreline Erosion at Revetment, Surfer's Point, December 1996.



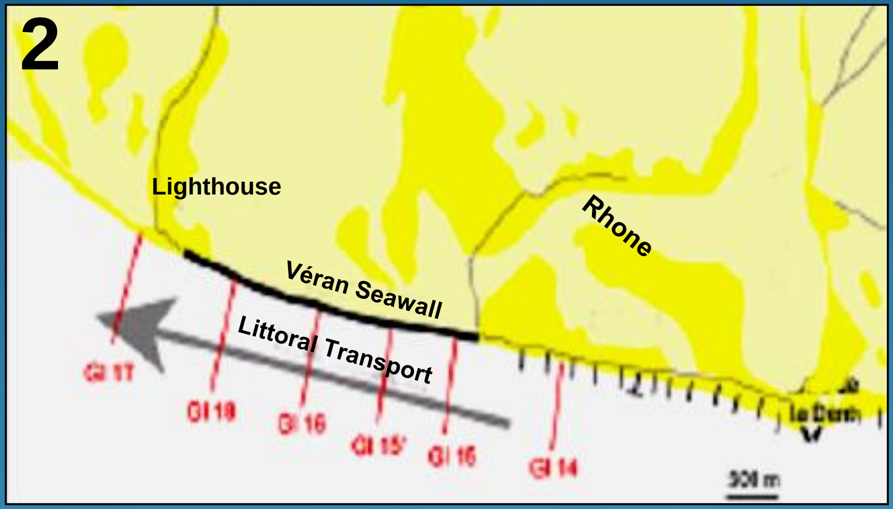
Sketch of Original Design at Surfer's Point.

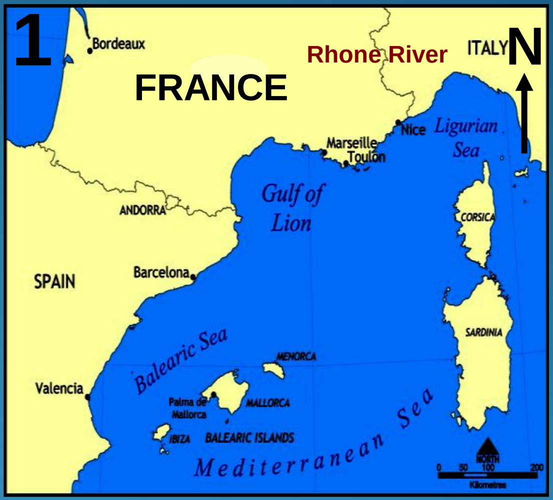


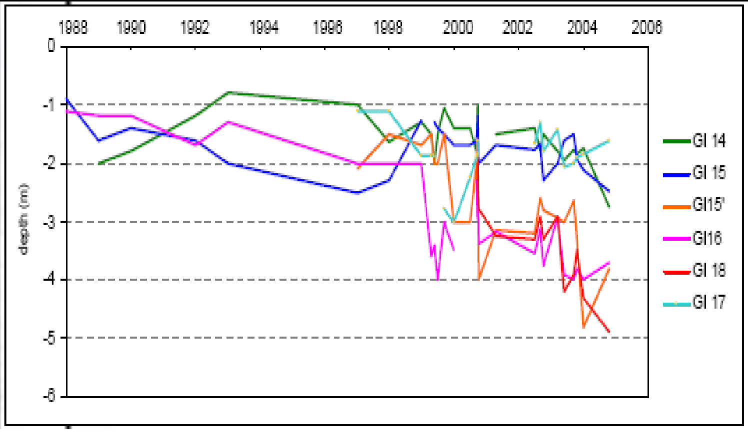
Managed Retreat and Restoration for Surfer's Point.

CASE STUDY II – France

Seawall and Longshore Beach Erosion (Véran site, Gulf of Lions, France, Mediterranean), *Samat Olivier et al, 2005*







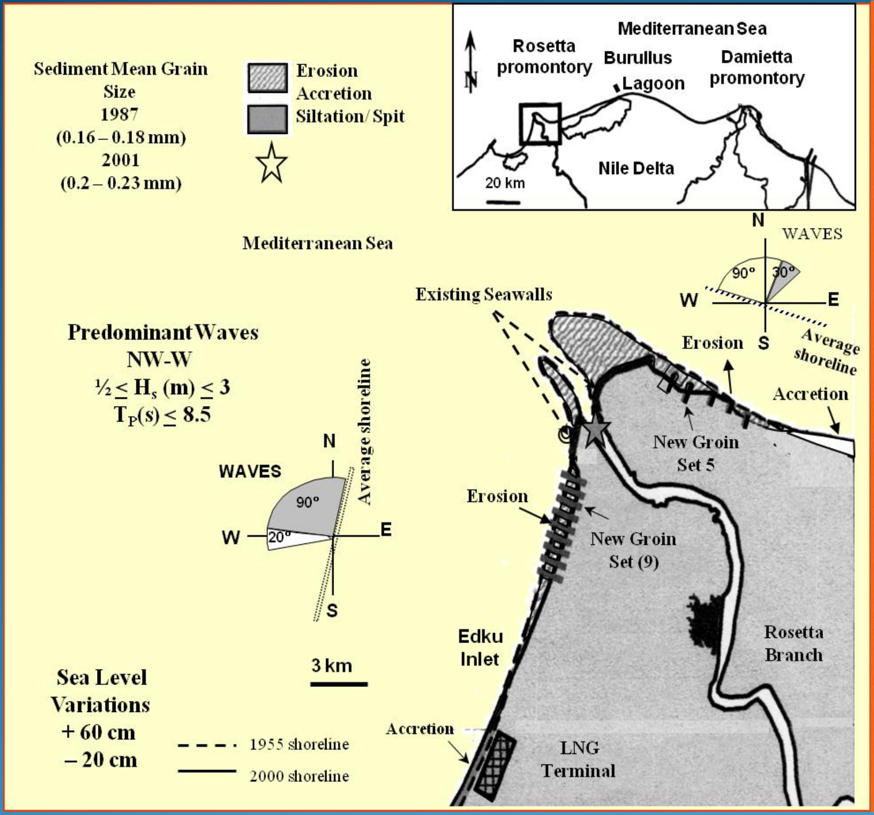
Cross Shore Depth Variation of the Inner Trough in front of Véran Seawall (Since 1988)

Site Location and Survey

Shoreline Retreat along Véran Seawall in the Long Term (1872-2004)

C. Coastal Processes at Rosetta Headland and Seawall-Beach Interaction

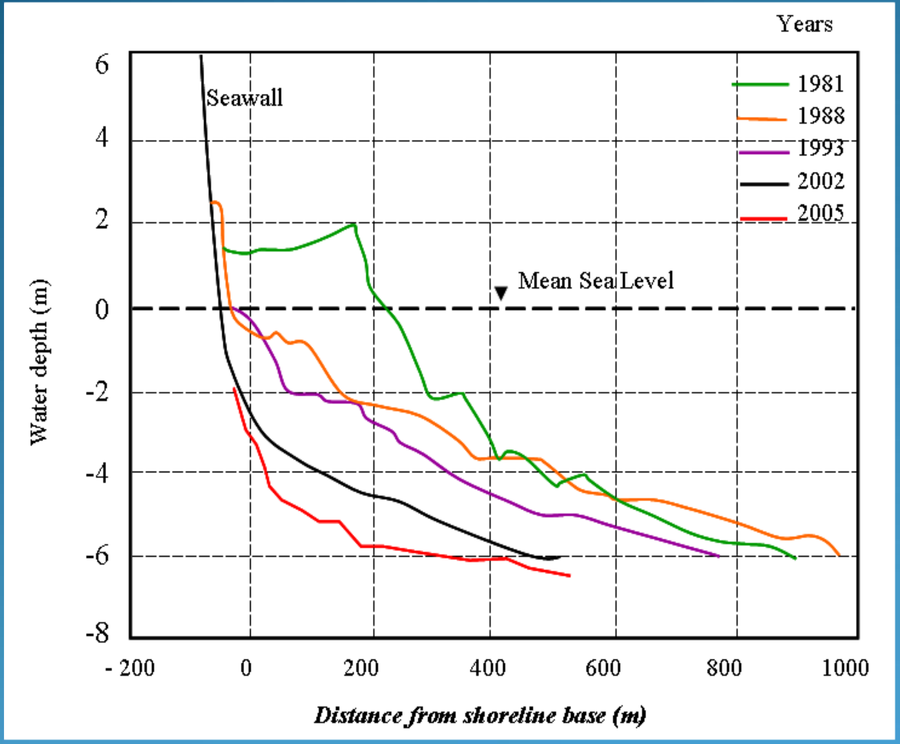
Morphological Changes at Rosetta Promontory Headland

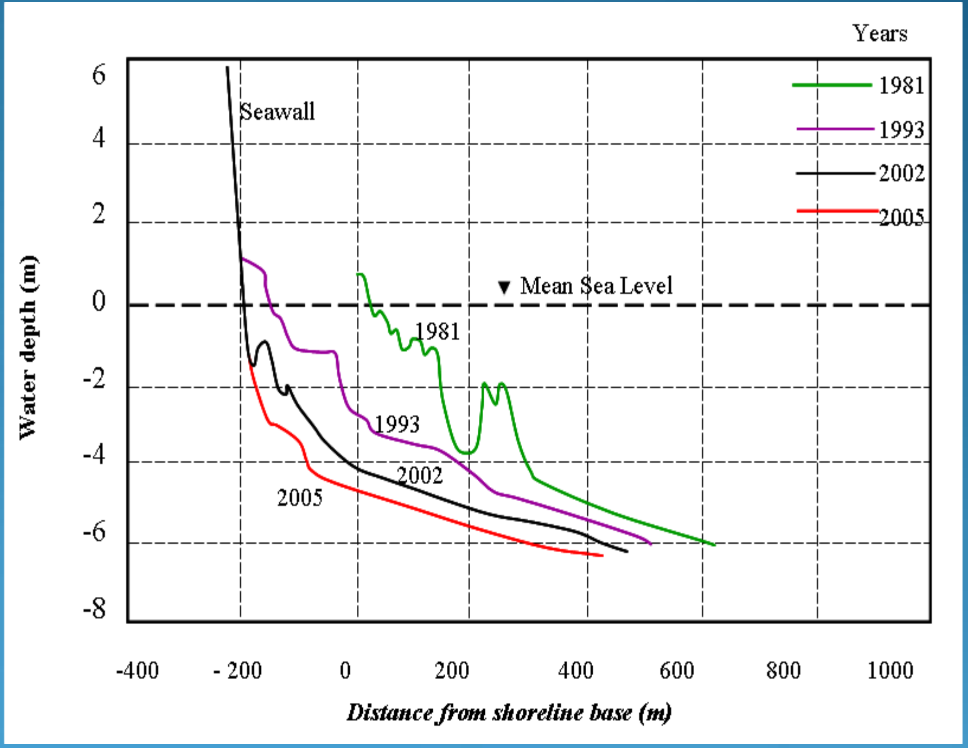


Essential Methodology

Analysis of the extensive field data collected by the Coastal Research Institute in Alexandria, Egypt and Coastal Protection Authority, Cairo, on the coastal changes astride Rosetta Branch, Nile Delta Coast. Use has been made of the numerical prediction of GENESIS to confirm the measured rates of long shore and offshore sediment transport in the vicinity of the Rosetta Western Seawall. A wave-current momentum index was used to estimate the length scale of the coastline reshaping.

Evolution of Cross Shore Beach Profiles at the Western Seawall

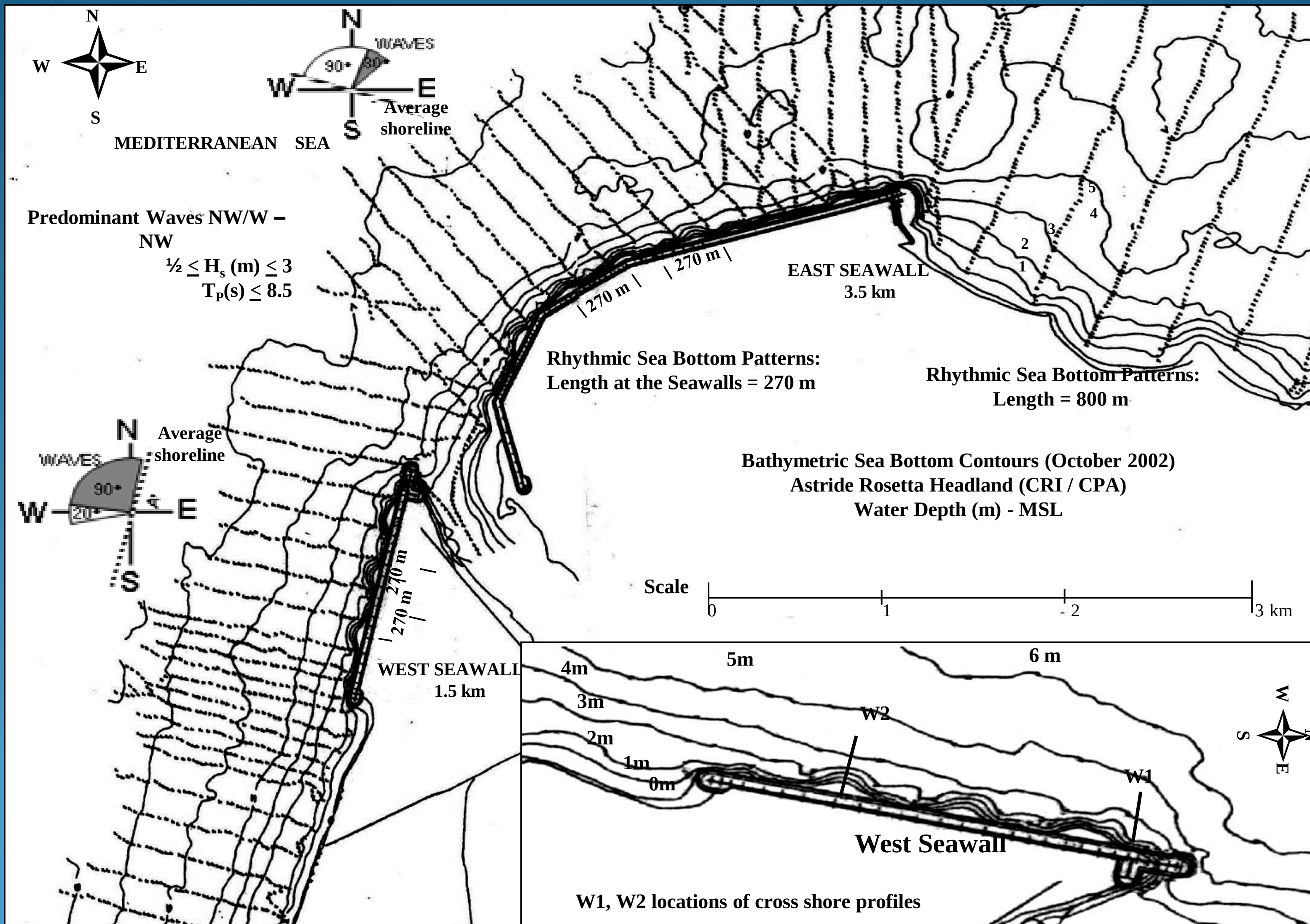




Section W1

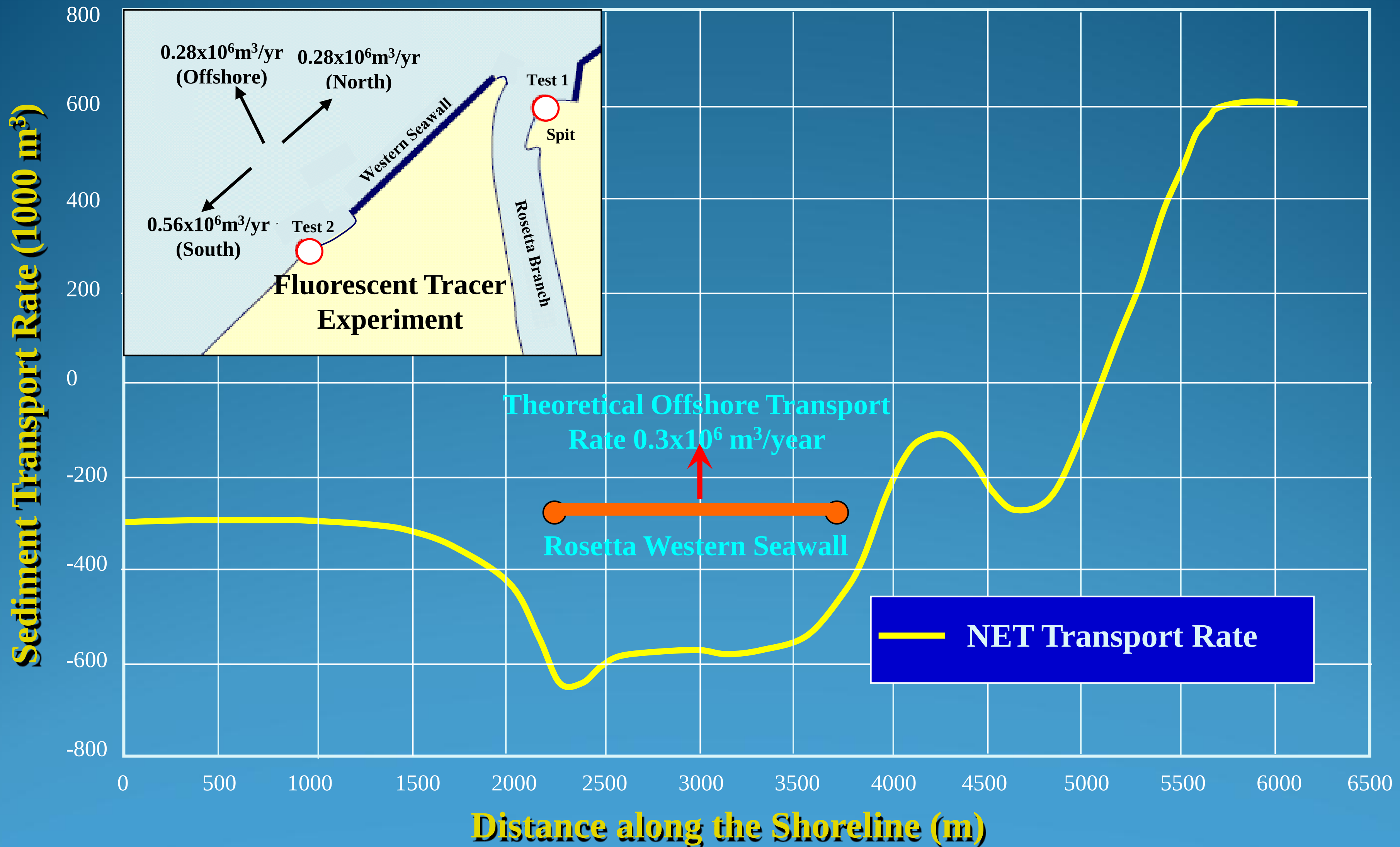
Section W2

Rhythmic Sea Bottom Bathymetry Patterns at Rosetta Seawall (Ismail and El-Sayed, 2007)

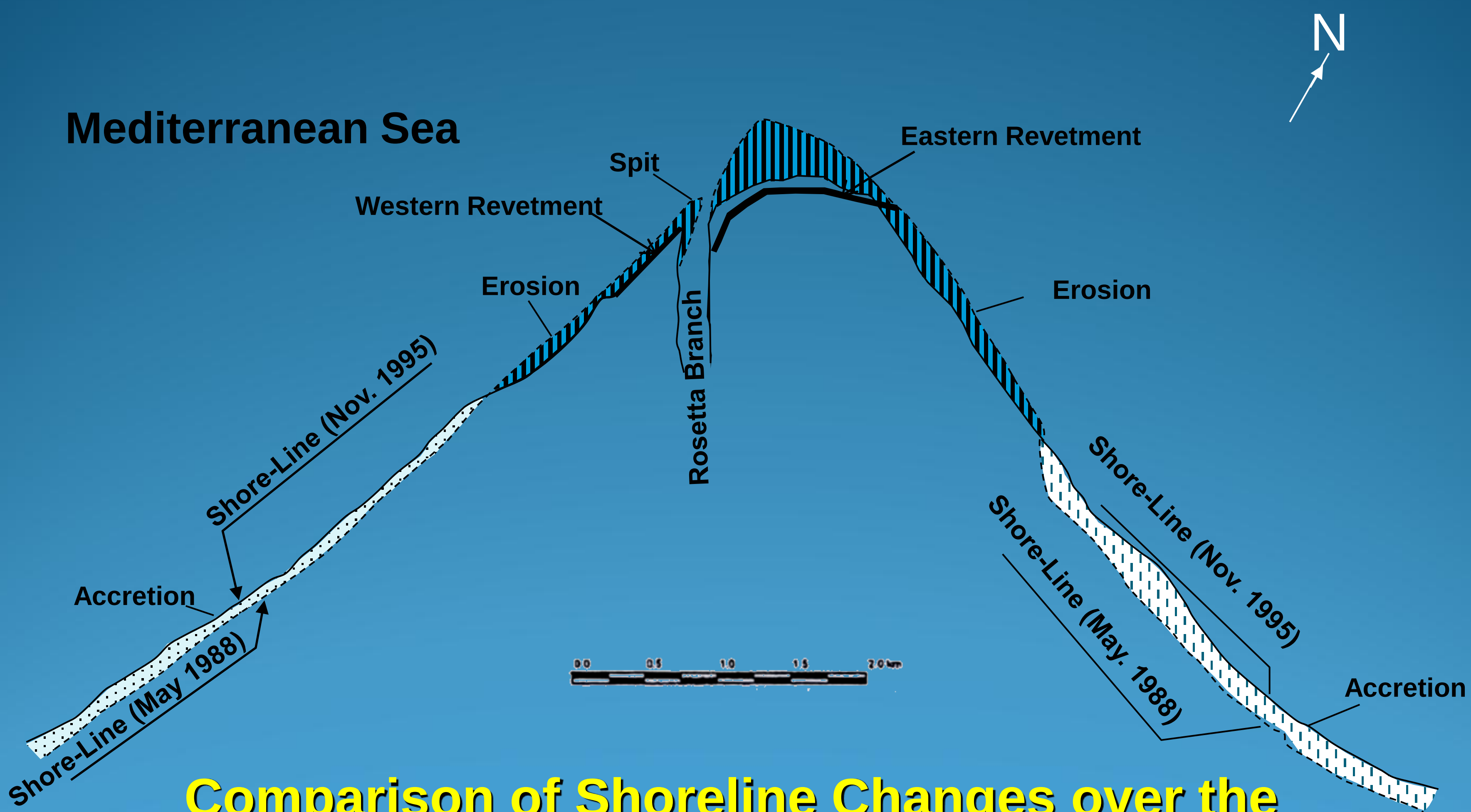


Major Results

Sediment Transport Rate (Genesis) along the Shoreline, West of Rosetta Headland for One Year Period (2003 – 2005 Wave Data)

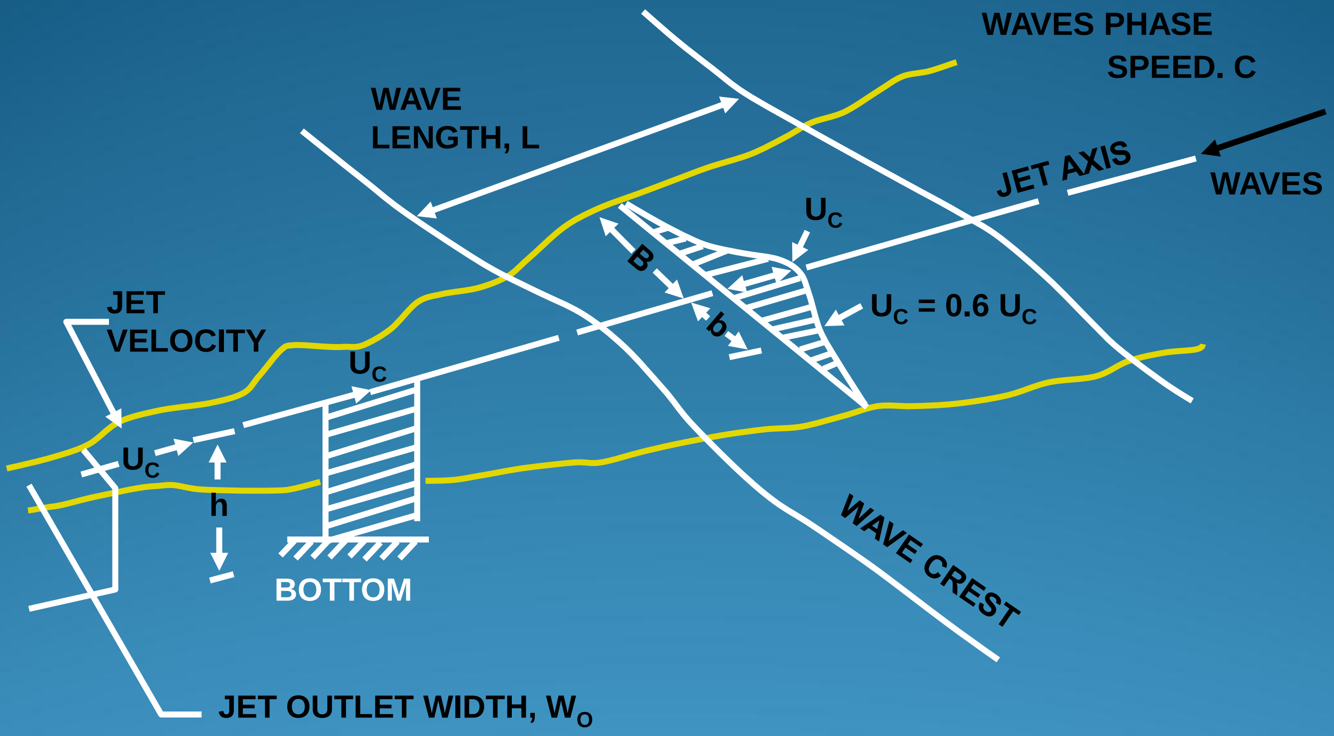


D. Prediction of Large Scale Shoreline Modifications



Comparison of Shoreline Changes over the Period 1988-95 for Rosetta Promontory

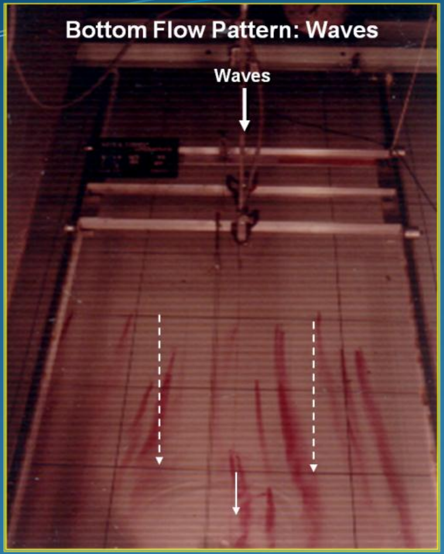
Characterization of Relative Strength of Wave Momentum Thrust to Jet Momentum Flux, R_{sm}



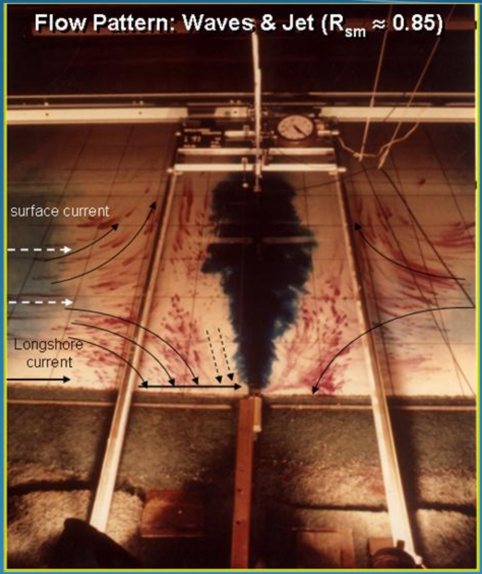
Velocity and length scales of wave-current system

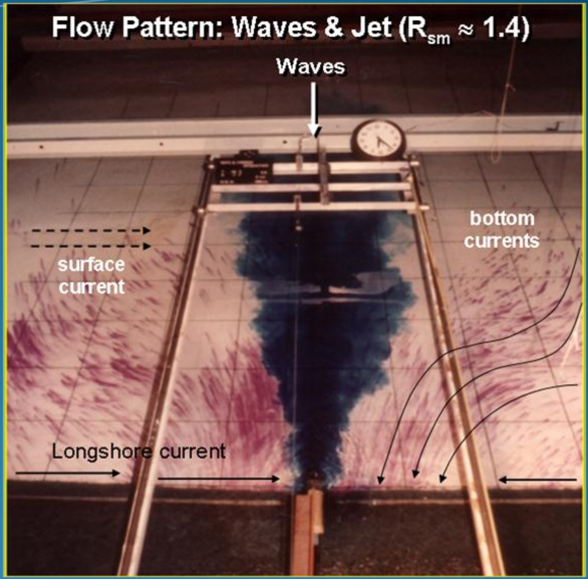
$$R_{sm} \approx \frac{\frac{1}{2}\rho_s a_0^2 g\left(\frac{L_0}{h}\right)C_g}{(C_0 - U)} / \rho_0 U^2 w$$

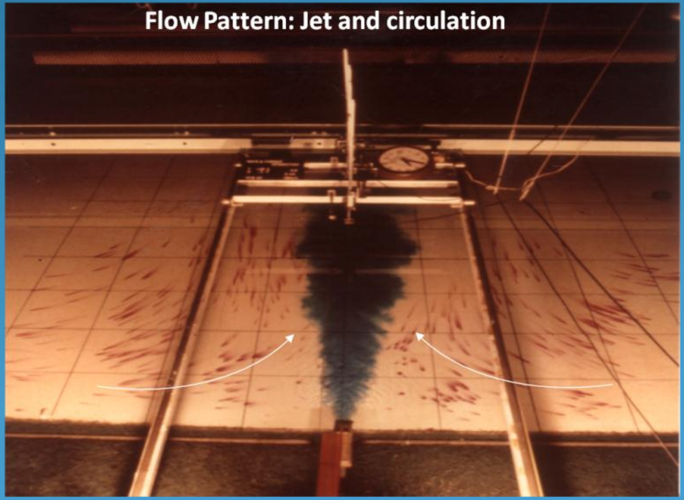
Effects of Wave & Current Interaction on Coastal Circulation



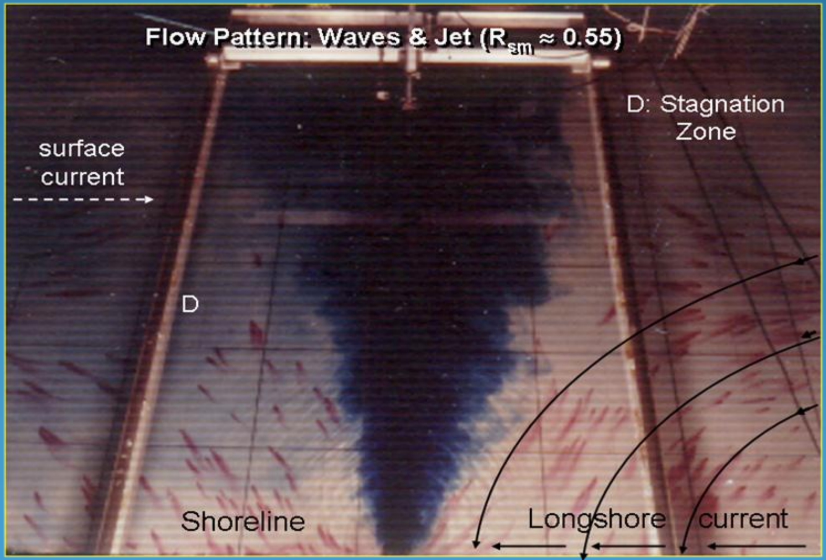
Flow Visualization of
Wave Induced Mass Transport Pattern (*Ismail, 1980)*







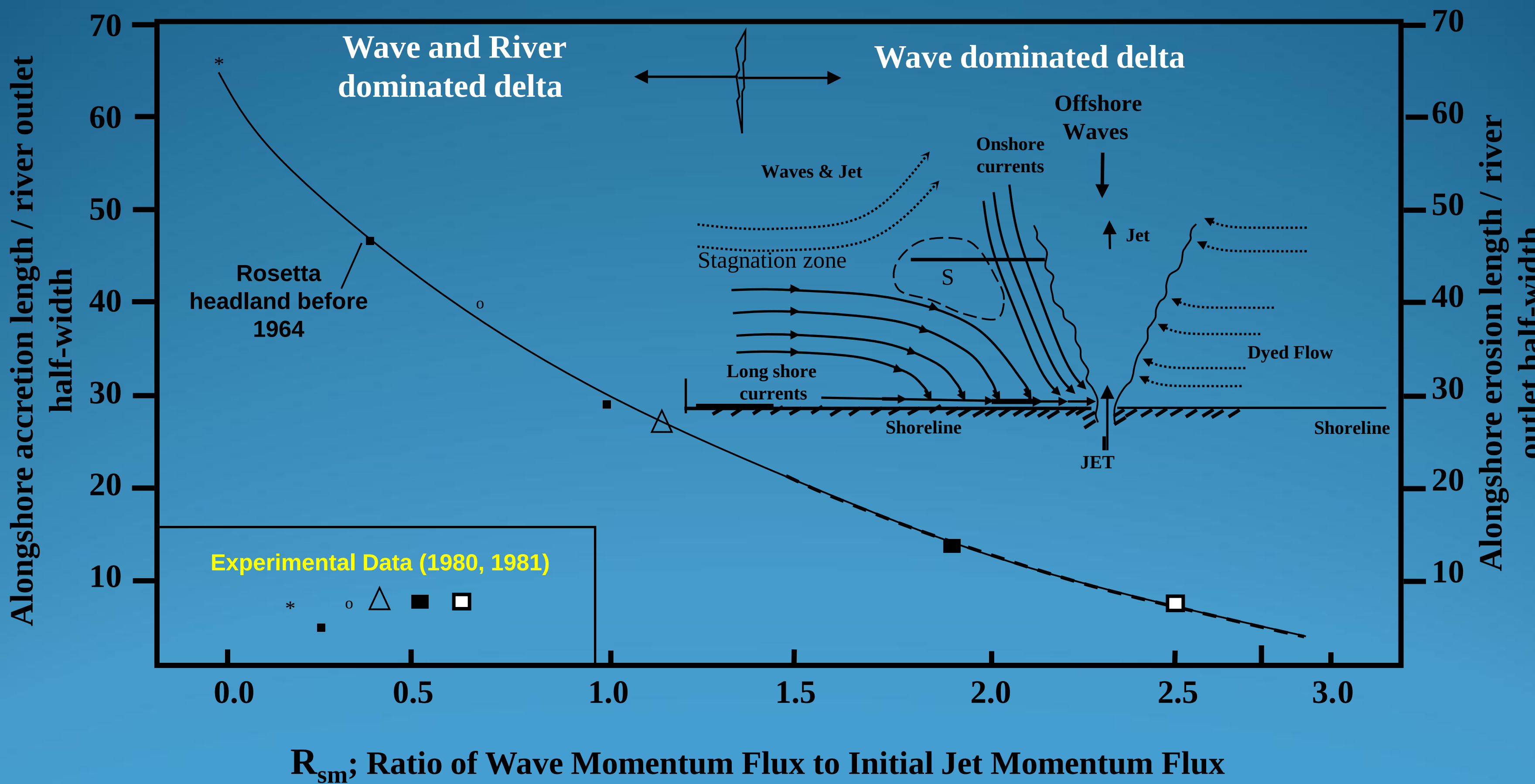
Flow Visualization of
Momentum Jet in the Absence of Waves (*Ismail, 1980)*



Flow Visualization of
Momentum Jet in the presence of Waves (*Ismail, Wegel 1981)*

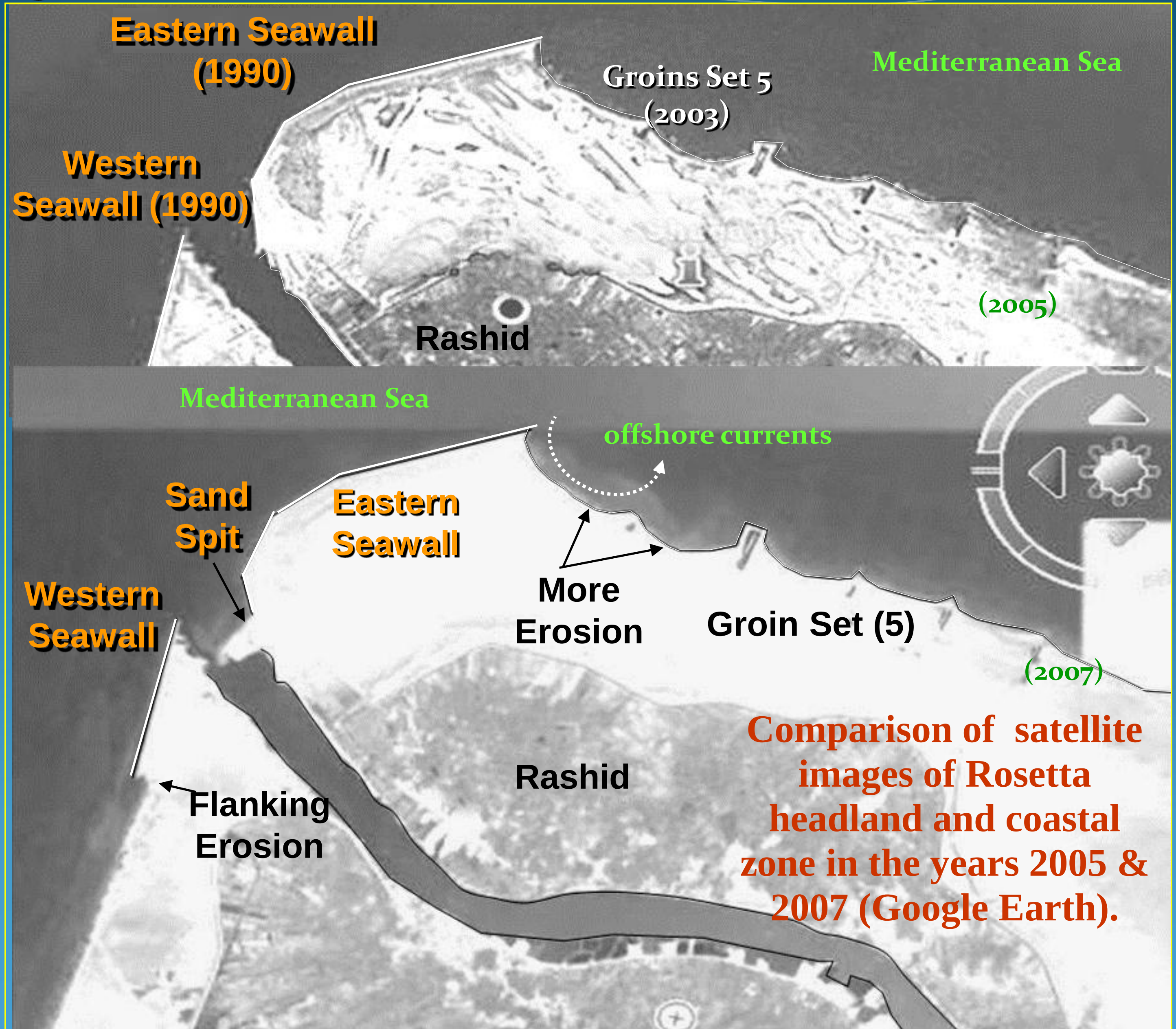
Major Results

Correlation between Wave-jet Relative Momentum Thrust and Length Scale of the Alongshore Zone of Accretion and Erosion



Major Results

Satellite Images of Rosetta Seawalls & the Extent of Coastal Erosion Down-drift the Headland



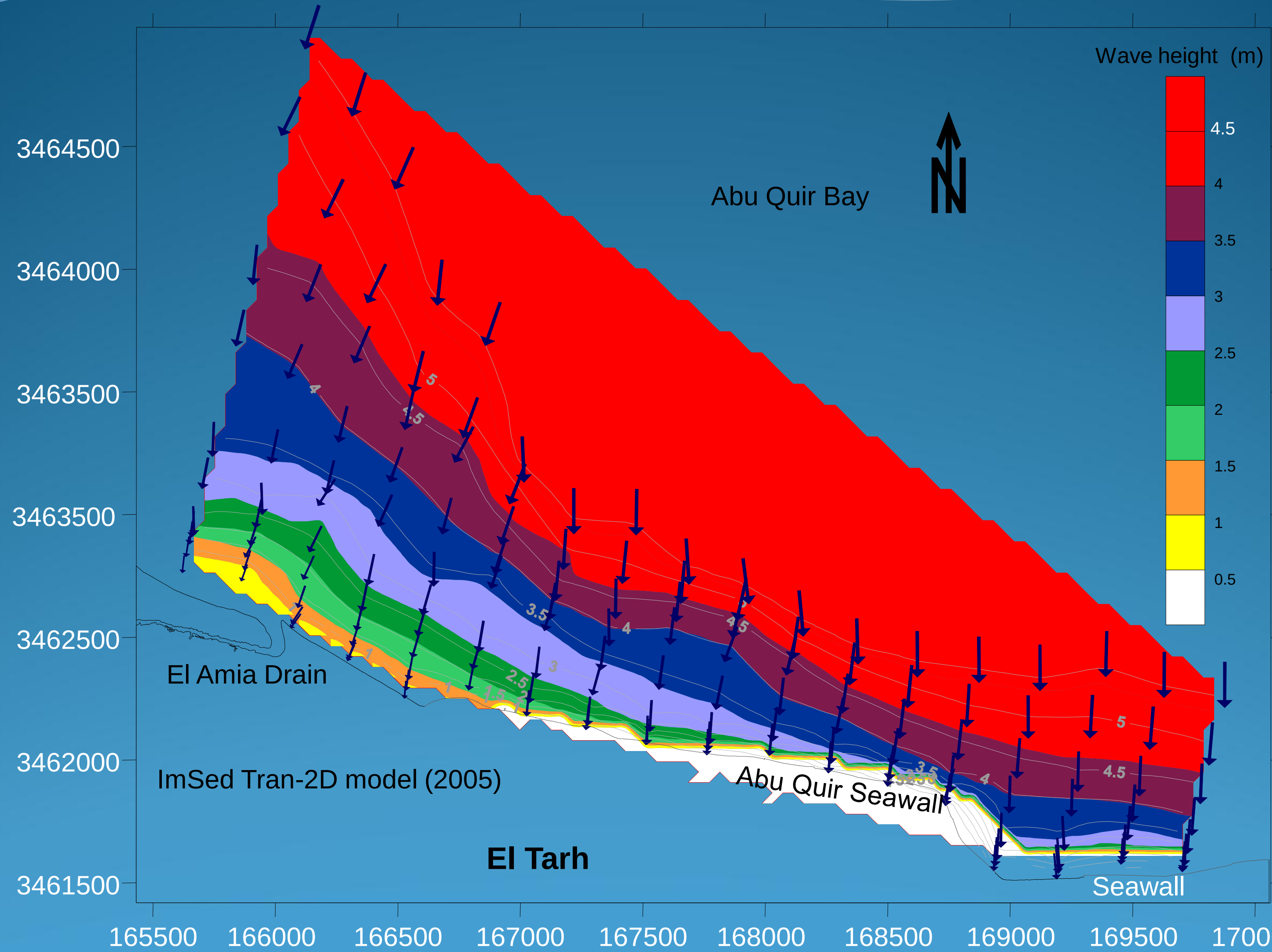
N. Ismail

Major Results

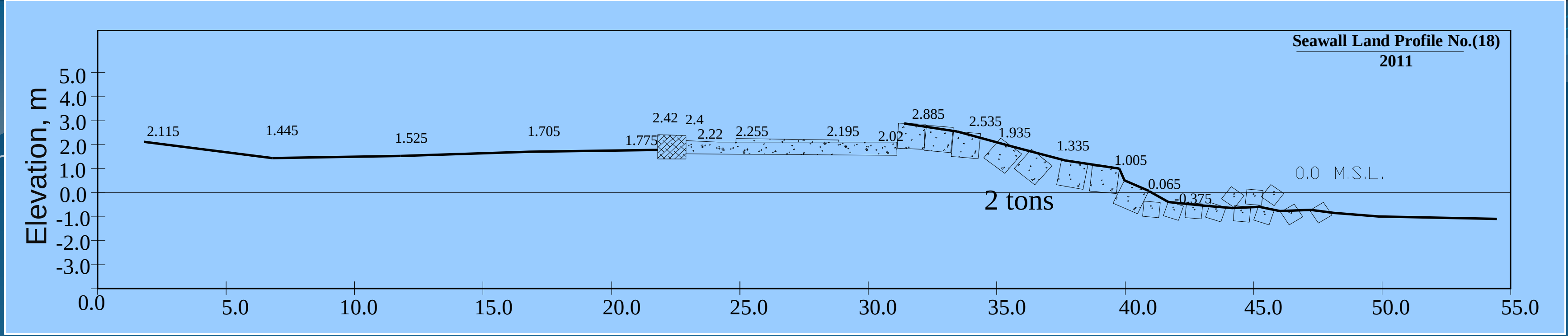
Satellite Images of Rosetta Seawalls & the Extent of Coastal Erosion Down-drift the Headland (2012)

N. Ismail

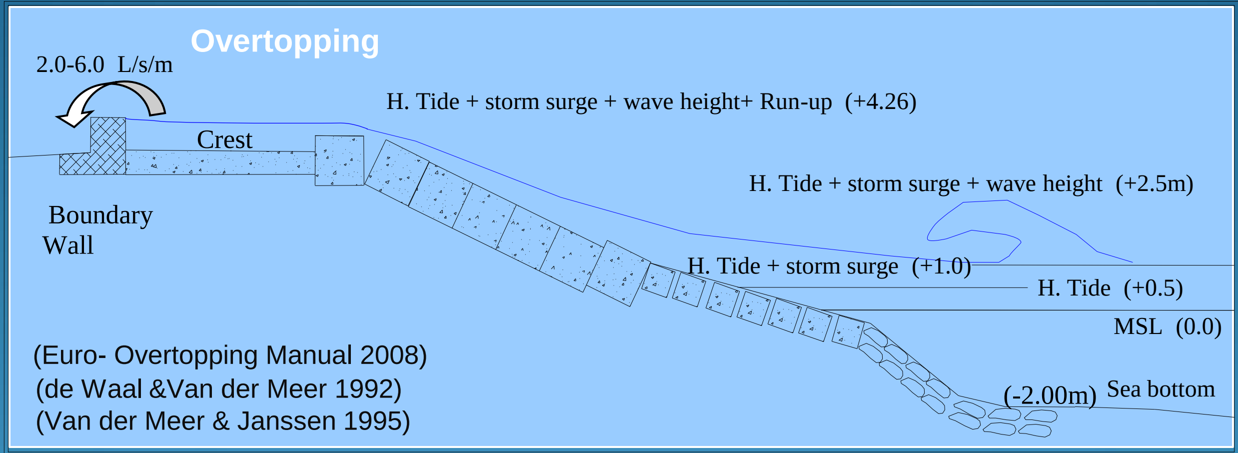
D1. Wave Distribution across Abu Qir Bay with the Future Sea Level Rise and the Maximum Yearly Wave Condition (Wave overtopping analysis)



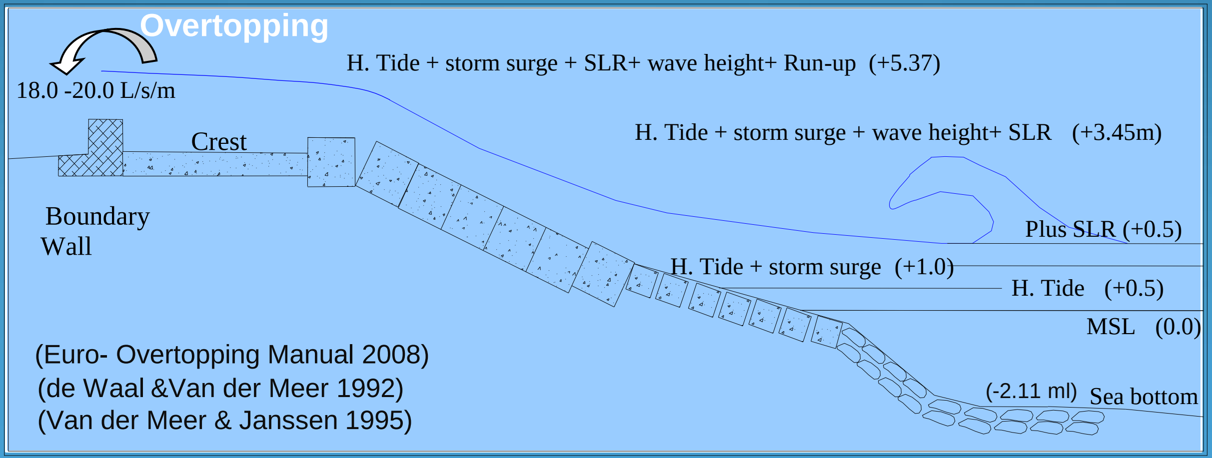
Wave height is denoted by the color scale in meters and wave direction by arrows.



New Cross Section of Seawall in 2011



Interaction between Abu Qir seawall and the sea in the current worst scenario.



Interaction between Abu Qir seawall and the sea in the future worst scenario due to sea level rise after 50 years.

E. Conclusions & Recommendations

- Modifications of bottom morphology in front of and astride seawalls depend on local wave climate and current conditions and sea level variations. Further, the increased rate of longshore sediment transport is strongly influenced by the cross-shore location of the seawall in the surf zone.

- Wave reflection and the generated wave patterns in front of seawalls enhance the rate of offshore sediment transport as well as the alongshore rate. This trend of increase was confirmed by the results of fluorescent tracer experiments at Rosetta Western Seawall as well as the reported results for seawalls located in France and UK. “Interaction of waves and seawalls influences coastal processes in front of the seawall”.

- The rate of scour in front of Rosetta Western Seawall appears to be diminishing currently after reaching a quasi-steady cross-shore beach profiles. The continuation of collecting field data at Rosetta headland is highly recommended to provide reliable basis for future coastal zone management of the Nile Delta coastline.

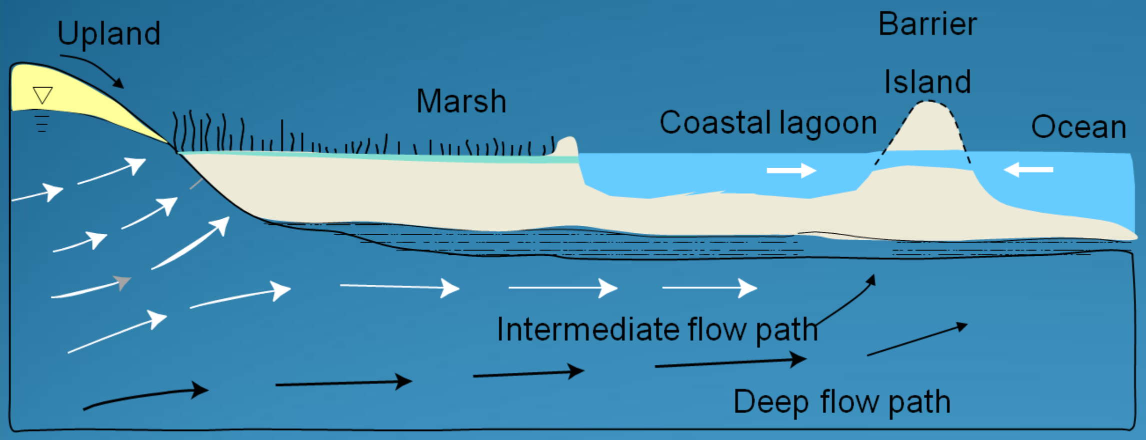
- The results show that current climatic changes and human interference require the improvement of existing coastal defense structures by upgrading, i.e. by elevating the top level of the rubble mound/armor revetments and seawalls as demonstrated from the analysis of the case study of Mohamed Ali seawall, Abu Quir. Further, it is becoming necessary to improve the stability of the cross shore-beach segment to create wave overtopping resistance conditions under future storm conditions.

- Despite the fact that low crested breakwaters proved to be successful in some coastal locations, the shoreline response to their placement needs to be identified. The results show that integrated-innovative systems, composed of hard and soft structures, should be explored to achieve the required level of coastal resilience.

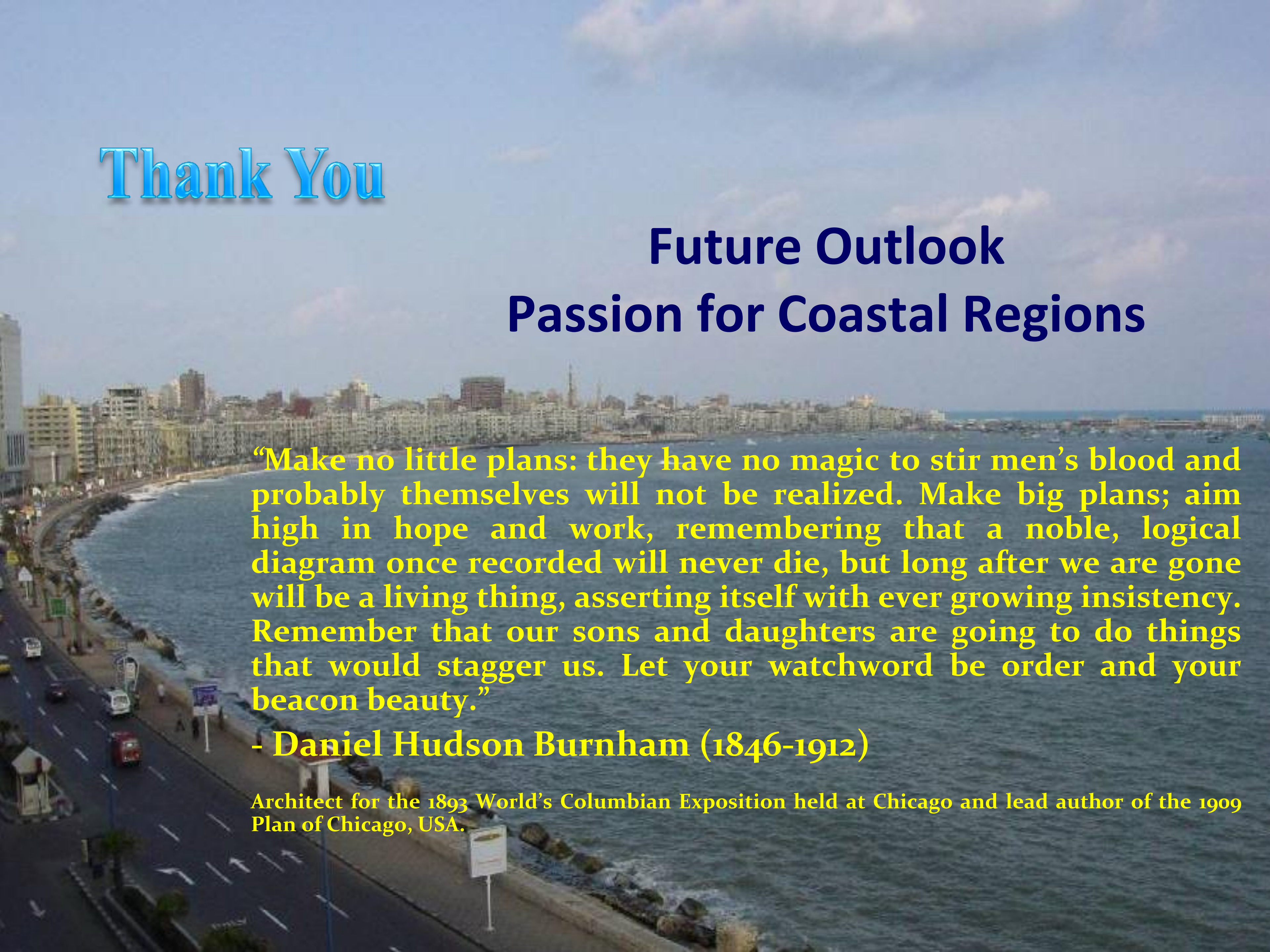
- Selection of soft protection alternatives for coastal zone management should be considered if the use of hard structures is proved to be adverse to the sustainability of the coastal zone.

- The soft engineering alternatives are such as beach nourishment, stabilized sand dunes and sustainable barrier islands and coastal lagoons. These natural systems would act as a buffer zone to defend main land. The sustainability of the integrated natural systems would require (1) barrier island with shoreline restoration and (2) quality management of hydrologic and vegetation restoration of coastal lagoons.

Highlights on Sustainability of Coastal Lagoons



Schematic of groundwater and surface water flow paths and discharge locations at a coastal lagoon



Thank You

Future Outlook
Passion for Coastal Regions

"Make no little plans: they have no magic to stir men's blood and probably themselves will not be realized. Make big plans; aim high in hope and work, remembering that a noble, logical diagram once recorded will never die, but long after we are gone will be a living thing, asserting itself with ever growing insistency. Remember that our sons and daughters are going to do things that would stagger us. Let your watchword be order and your beacon beauty."

- Daniel Hudson Burnham (1846-1912)

Architect for the 1893 World's Columbian Exposition held at Chicago and lead author of the 1909 Plan of Chicago, USA.