6° International Sednet Conference
Hamburg 7-8 October
The Role of Sediment in Coastal Management

Beneficial Reuse and Morphological Restoration

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Thetis Consorzio Venezia Nuova

- OUTLINE
- Morphological Restoration and **Nature 2000**
- Working with nature Sediment and confinement

  Examples from Venice

Bird and Habitat EU Directives

- **The Bird Directive 79/409/CEE**
  Protection of birds preventing loss or degradation of habitats
- **The Habitat Directive 92/43/CEE**
  safeguard of the Biodiversity through the conservation of habitats and flora and fauna
- **Natura 2000**
  European ecological network for the special conservation zones
- These directives are posing **strong constrains** on socio economical activities pressing for

- **Conservation of habitat**
  Compensantion and Mitigation
  *When there are no alternatives to an impacting plan or project to be applied for imperative reason of relevant public interest every **compensation** measures must be adopted.*
- The solution is Morphological Restoration in line with the co-evolution principle

A COMPLEX NATURAL AND SOCIAL SYSTEM


Fish farms

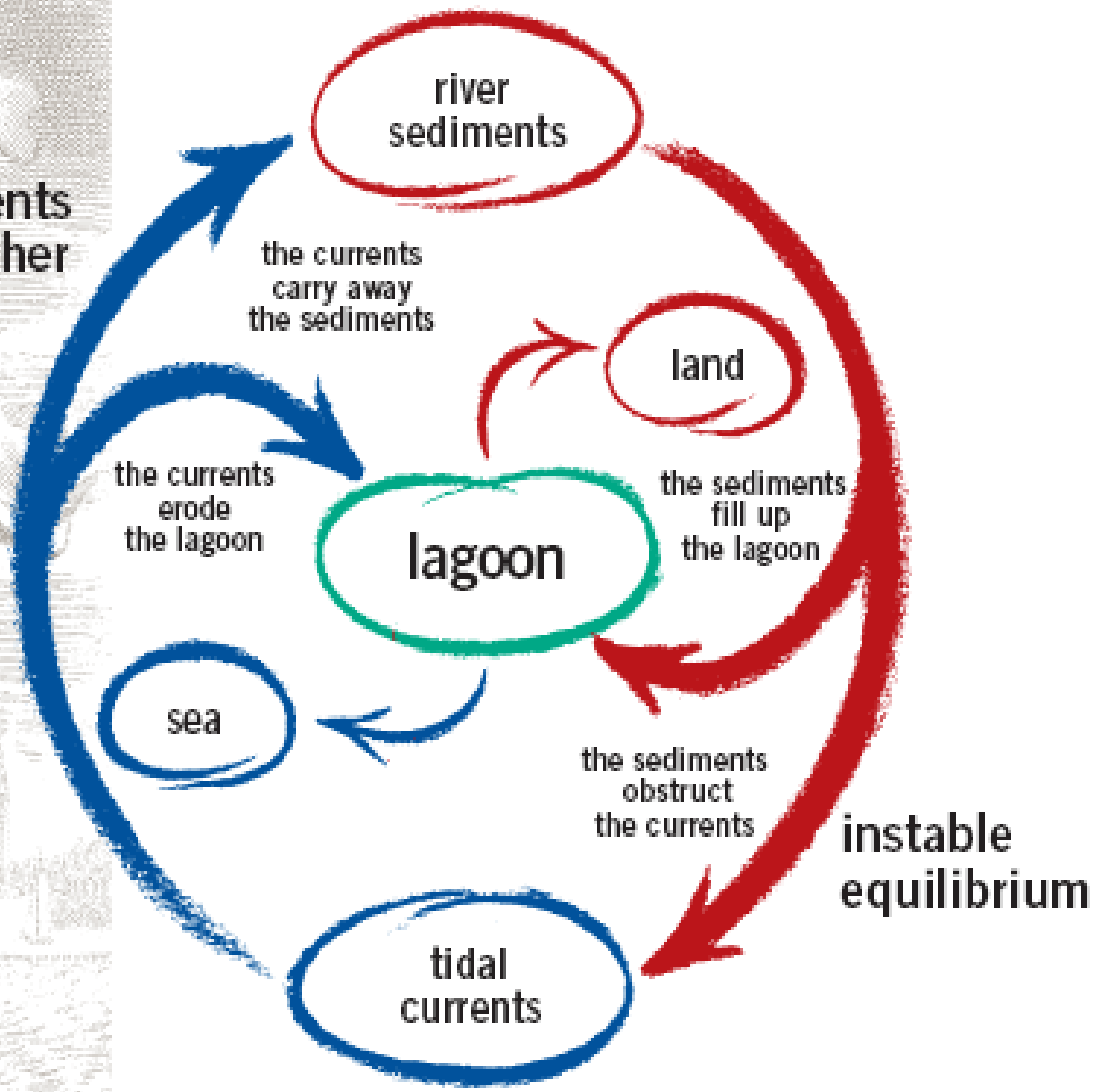

Historical places
Island of
Torcello year 900


Wetlands


Barrier Island

CO-EVOLUTION

XVI CENTURY ALLEGORY



Roughness on sandy soil provides a depositional environment for organic debries and a trap for alofitic vegetation seeds

CRACKS IN THICK MICROBIAL MAT

MICROBIAL MATS

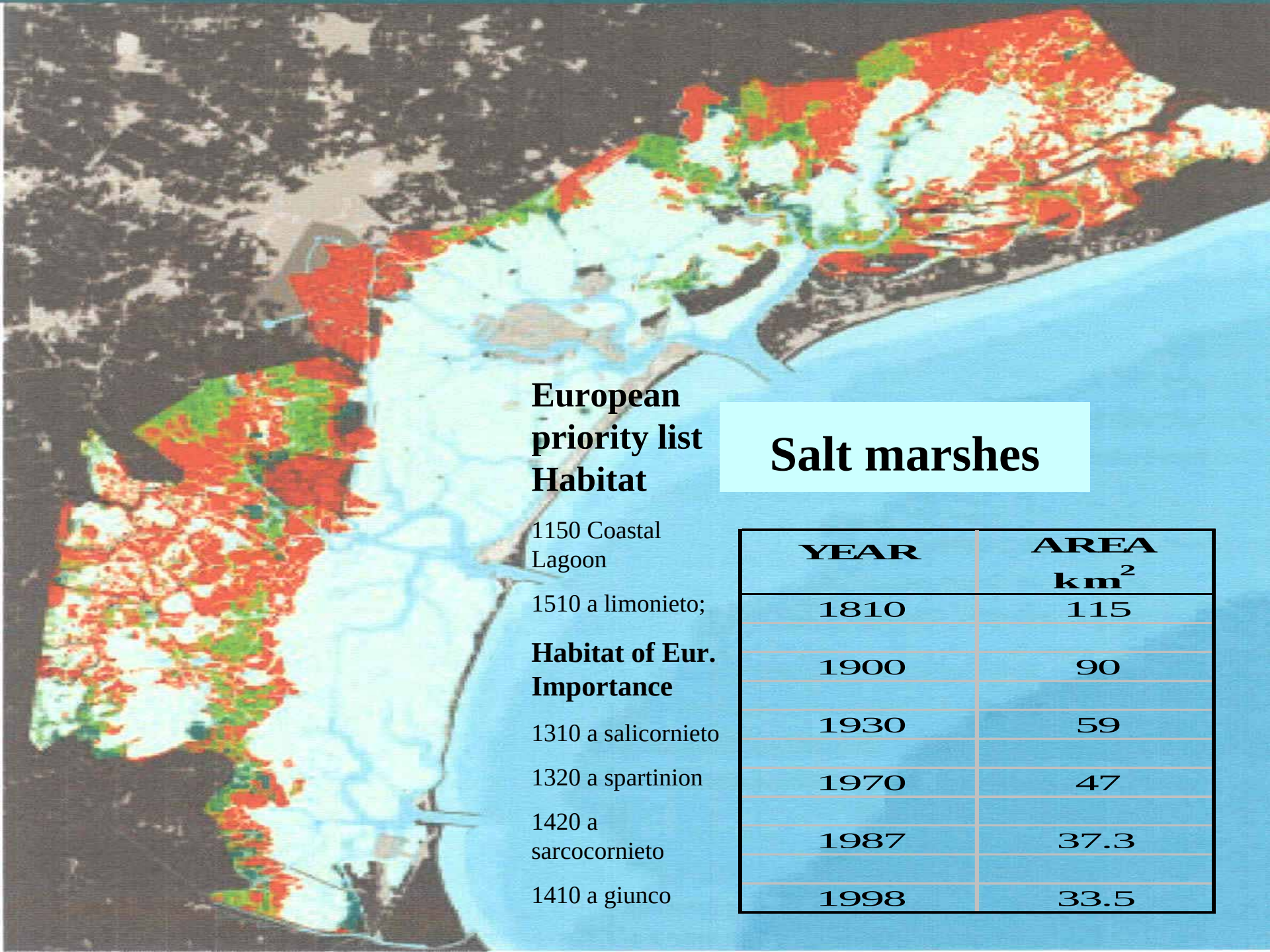
The first coloured presentation of a laminated microbial mat with individual oxygenic phototroph, anoxygenic phototroph and chemotroph layers (hand coloured micrograph, Flora Danica, 1813).

Microbial mat, siliciclastic intertidal zone. Blue green color derives from cyanobacteria (Spencer´s Gulf, near Port Augusta, South Australia).

Shoreline of a hypersaline lagoon. Mat made of coccidal and filamentous cyanobacteria over a small terraced cliff undermined by water agitation.

RARE PLACES IN THE LAGOON DOCUMENT MARSH FORMATION STAGES ARE ORGANIZED ALONG A TRANSECT FROM THE 50 YEAR OLD VEGETATED MARSHES ON THE RIGHT, TO THE 5 YEAR OLD ACCRETIONARY SHOALS ON THE LEFT

IN THE ARTIFICIAL MARSHES A SIMILAR PROCESS STARTS AFTER THE DEPOSITION-COMPACTION OF SEDIMENT IN THE CONFINED AREA



Salt marshes

European priority list Habitat

1150 Coastal Lagoon

1510 a limonieto;

Habitat of Eur. Importance

1310 a salicornieto

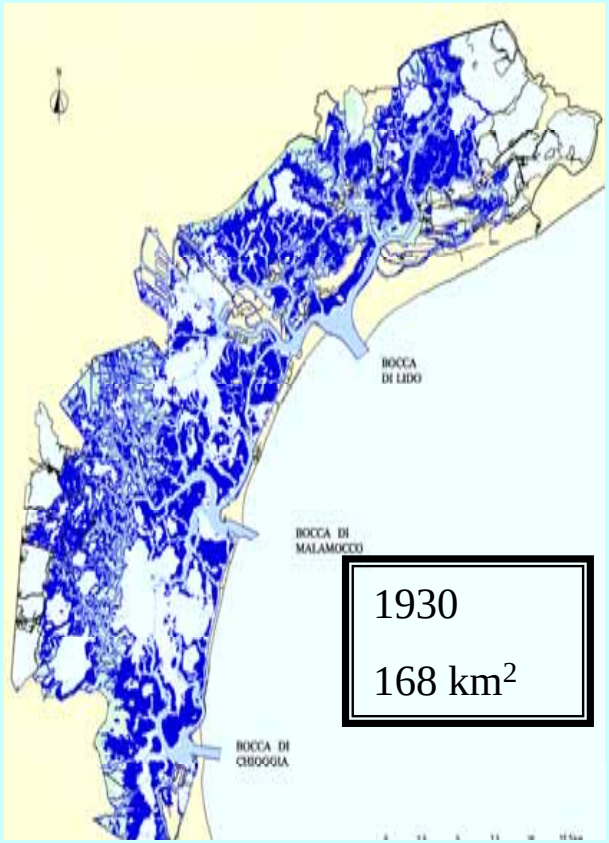
1320 a spartinion

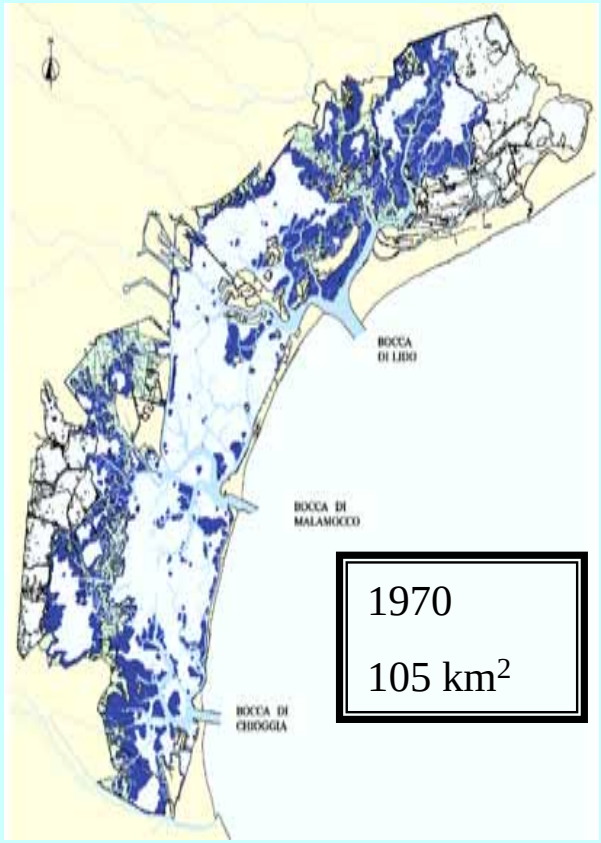
1420 a sarcocornieto

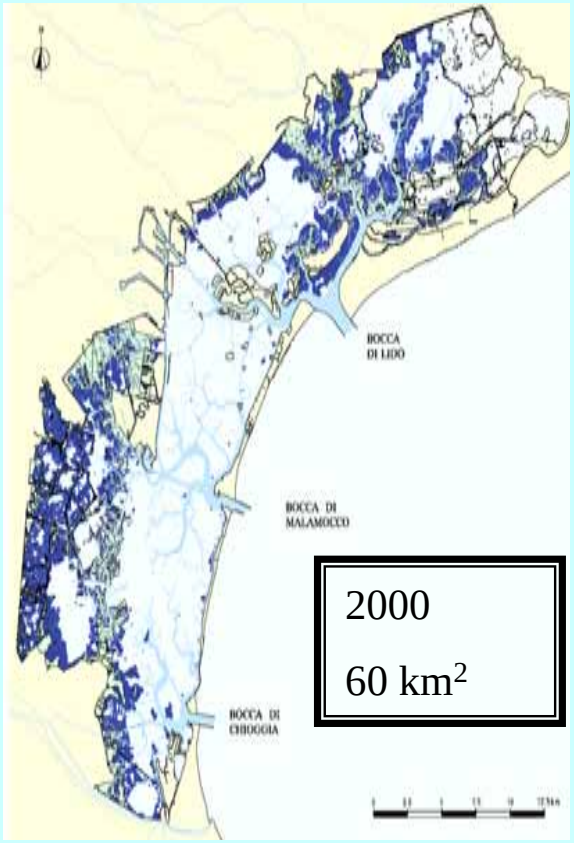
1410 a giunco

YEAR	AREA km^2
1810	115
1900	90
1930	59
1970	47
1987	37.3
1998	33.5

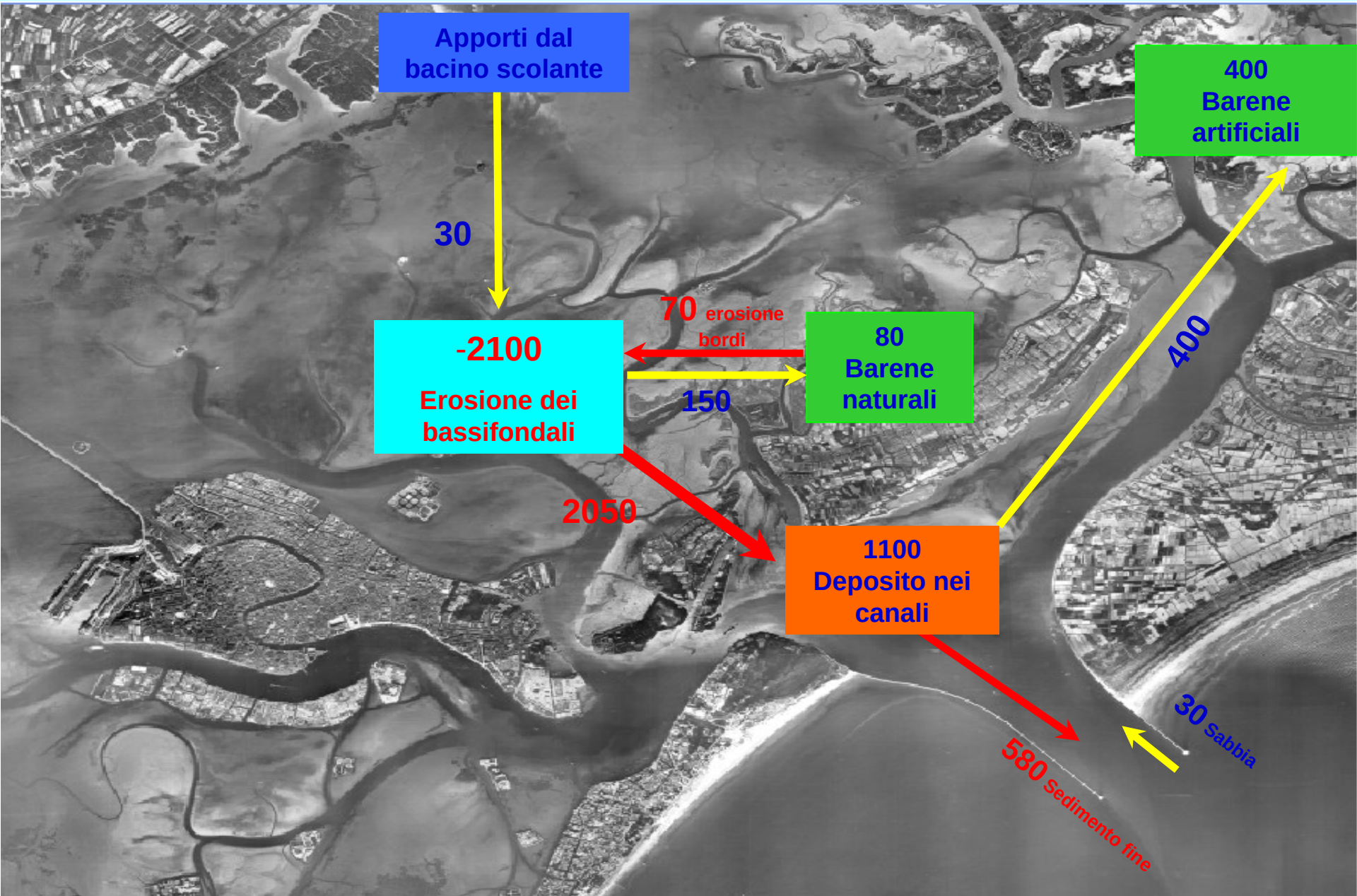
ATTENTION TO R.S.L.R AND LOSS OF INTERTIDAL HABITATS



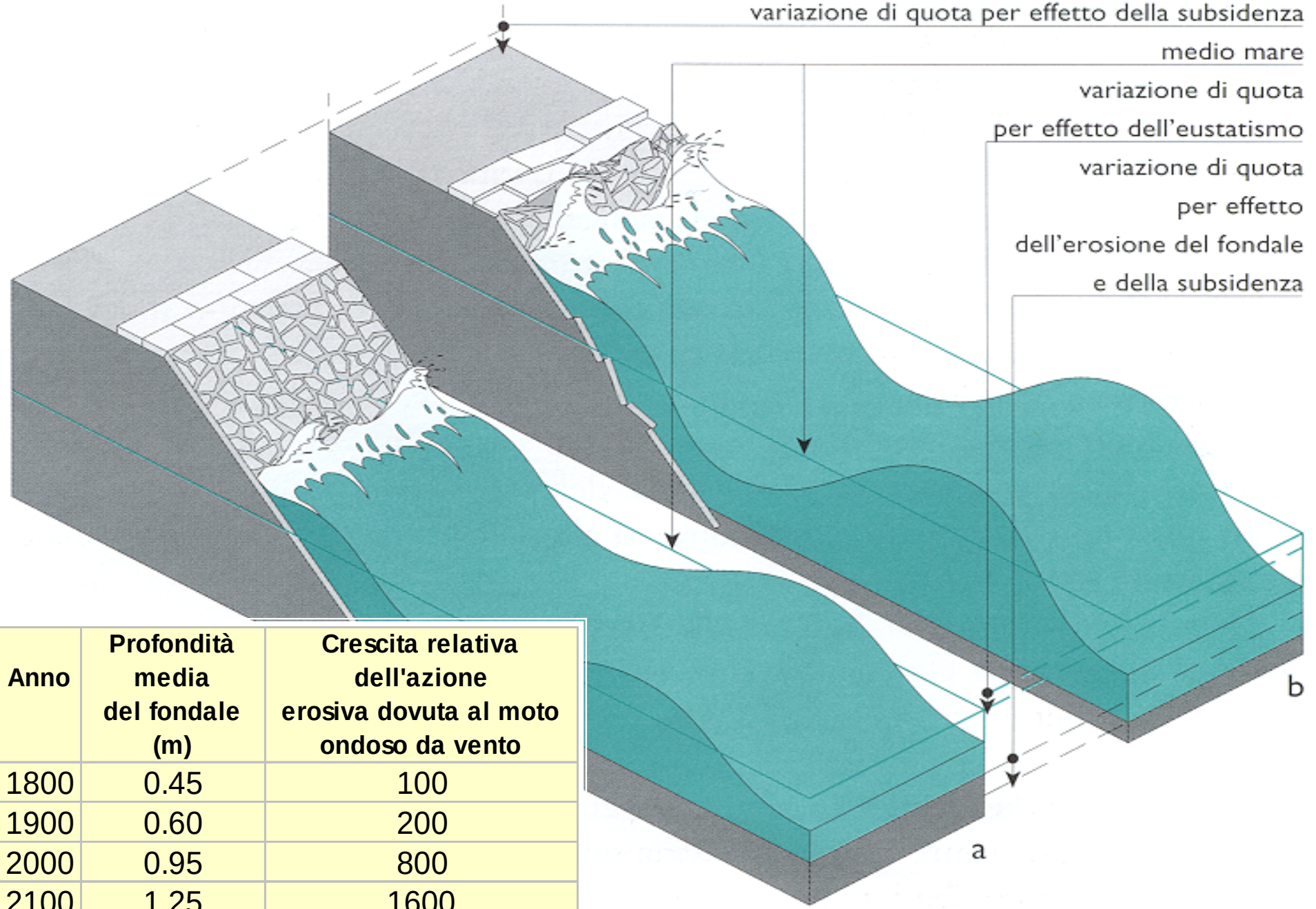




NEGATIVE BALANCE IN TERMS OF EROSION
THOUSAND OF m^3

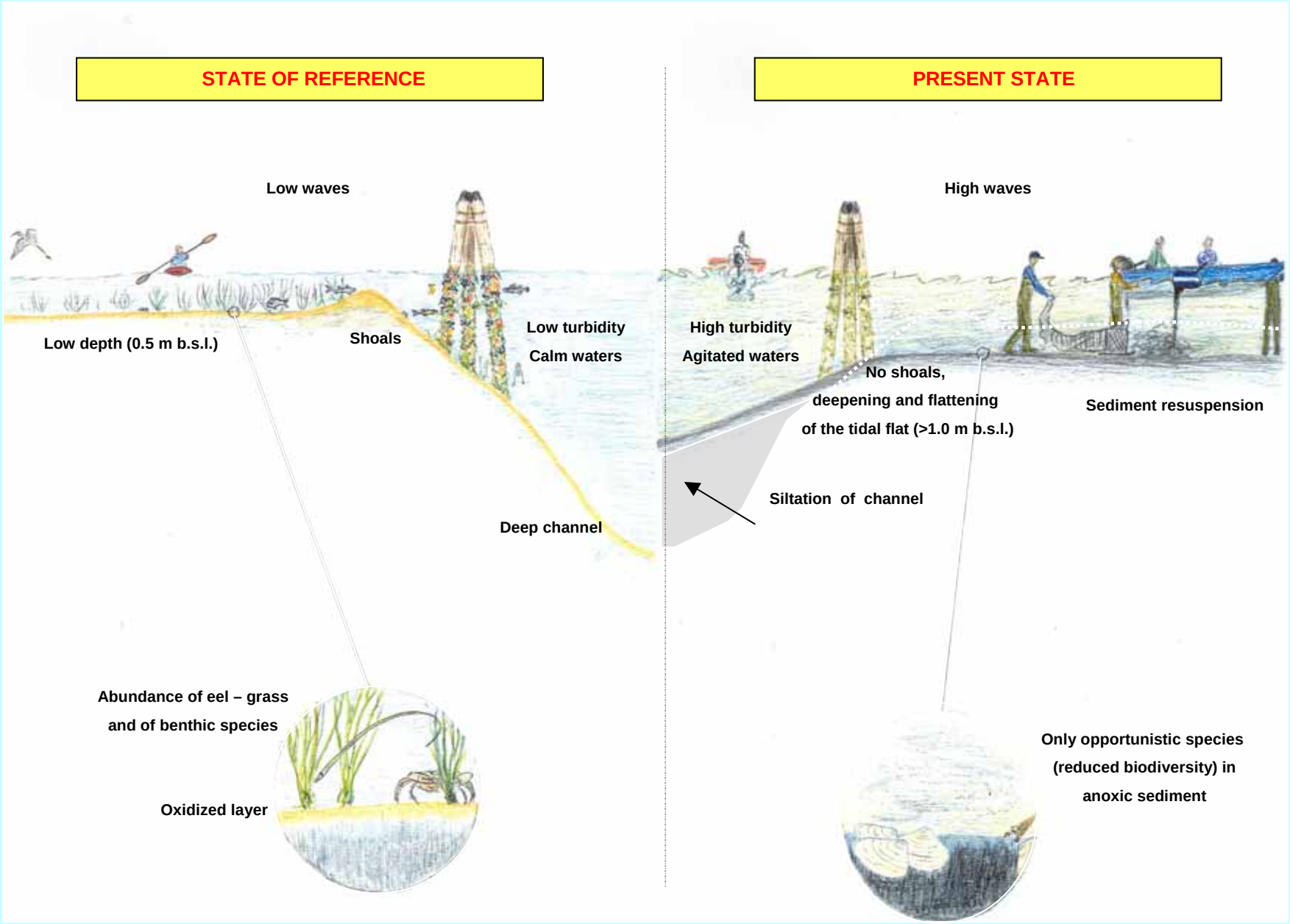


Exponetial effects on wave protections

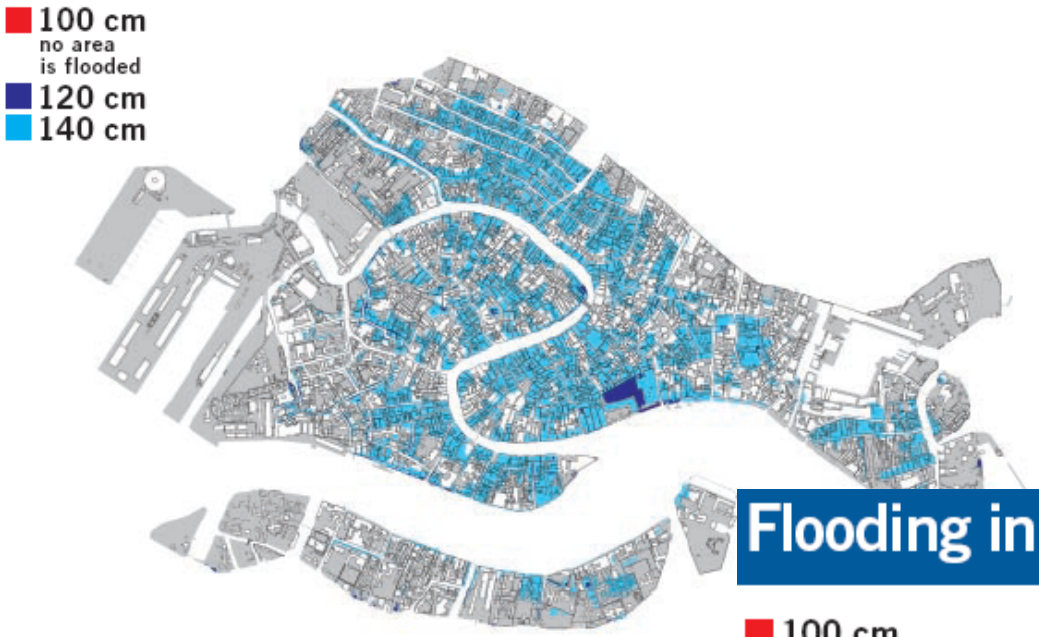


Anno	Profondità media del fondale (m)	Crescita relativa dell'azione erosiva dovuta al moto ondoso da vento
1800	0.45	100
1900	0.60	200
2000	0.95	800
2100	1.25	1600

HABITAT LOSS



Flooding in Venice at the turn of the 20th century



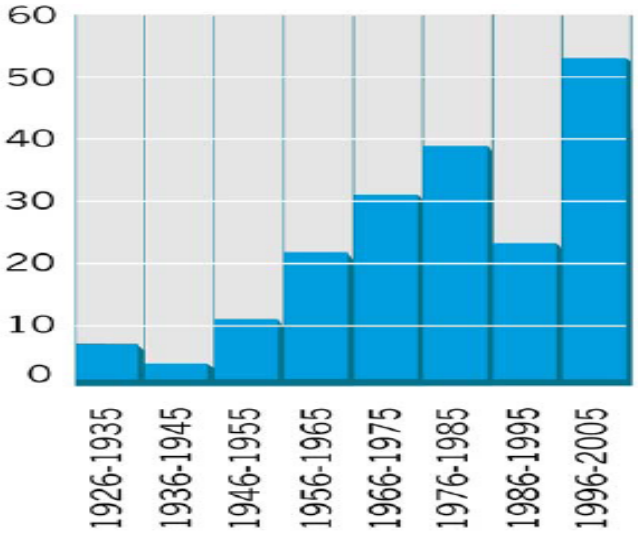
Flooding

> 140 cm

1 dicembre 2008…156

16 novembre 2002	**147**
6 novembre 2000	**144**
8 dicembre 1992	**142**
1 febbraio 1986	**159**
22 dicembre 1979	**166**
14 febbraio 1979	**140**
3 novembre 1968	**144**
4 novembre 1966	**194**
15 ottobre 1960	**145**
12 novembre 1951	**151**

Increase in the frequency of flooding > 110cm

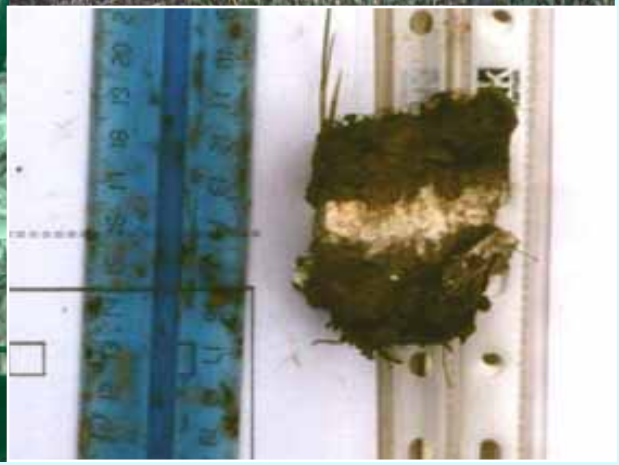


Flooding in Venice today

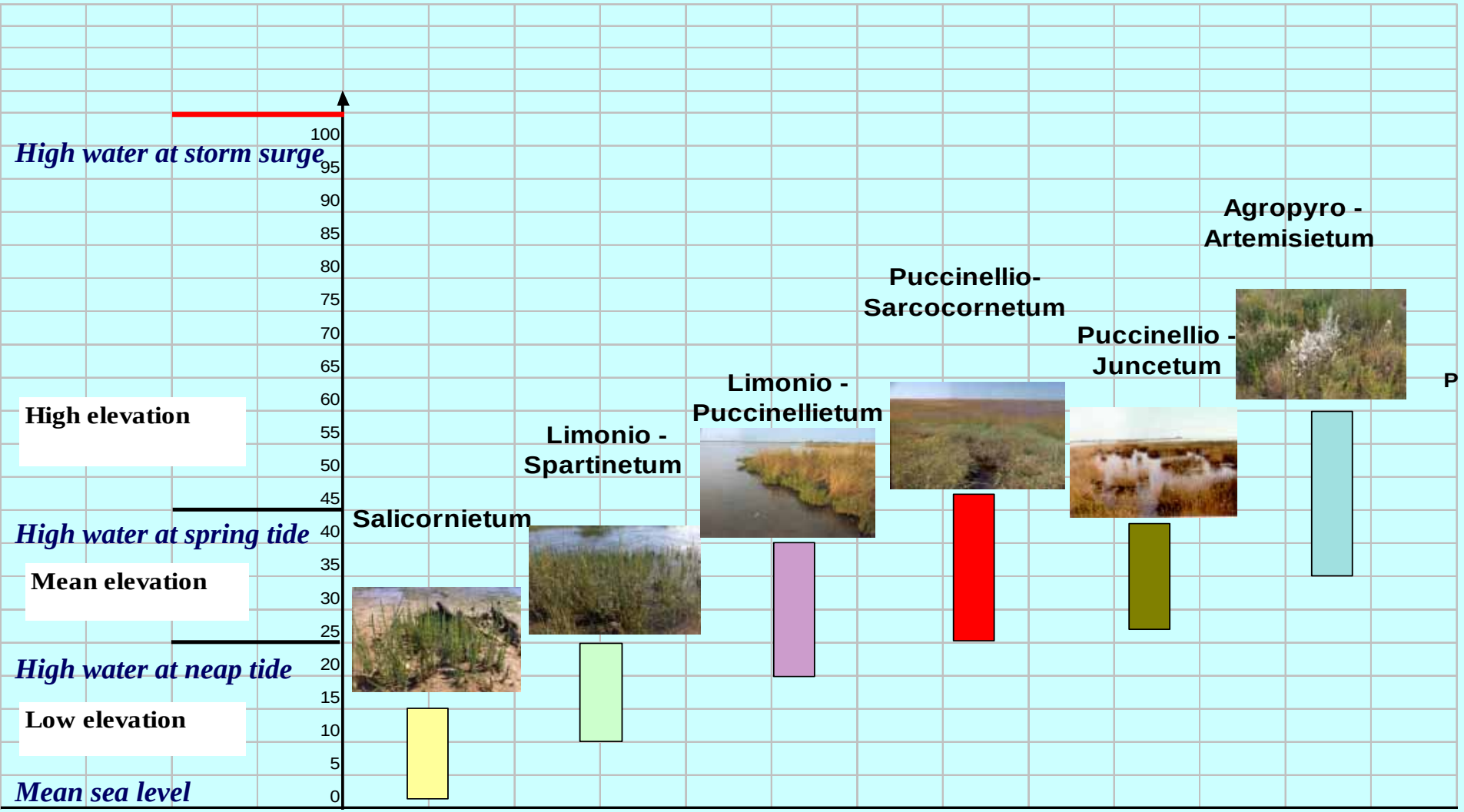
ADAPTATION IS LIMITED BY AVAILABLE SPACE AND VOLUMES

VECCHIO INTERVENTO DI RIALZO

4mm/year ACCRETION SALT MARSH ADAPTATION TO RSLR



SOIL ELEVATION AND ALOFITIC SPECIES



ENVIRONMENTAL RESTORATION
A compromise of openness and protection in:

- **Flooding of reclaimed land**

  Provide space to tidal transport in sheltered areas

  Realignment

- **Protections**

  Dissipation of wave energies and currents avoiding erosion

  Rocks, sea wall , wood piles, gabions, floating systems, geosyntetics, living shorelines (oyster shoals, plants)

- **Confinements**

  Reduction of wave energies and transport promoting sedimentation in sheltered places exposed to the transport

  Sediment fences, groins and inlet breakwaters

- **Artificial structures and Sediment Fillings**

  Exposure of sediments and rocks to coastal energies

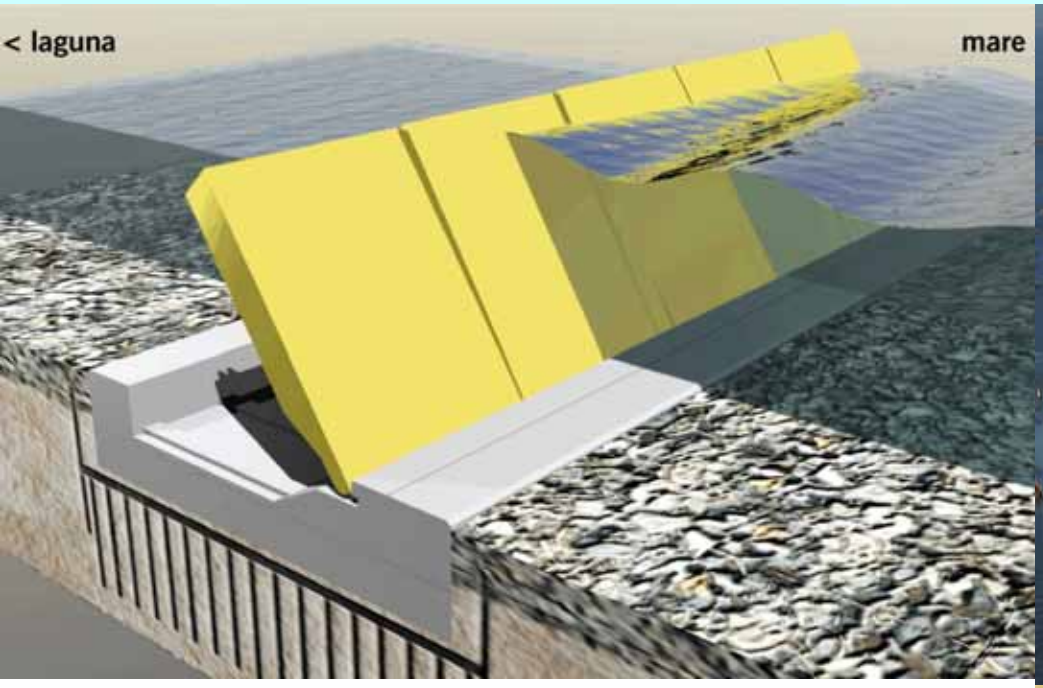
  Beach nourishment and dune management, sand by pass, constructed salt marshes re-using dredged sediments maritime defense structures, coastal reefs.

Services provided by Shoals, Salt Marshes, Beaches and Dunes

- Self-adaptation of elevation to relative sea level rise
- Development and stabilization of the network of tidal channels
- Wave Protection
- Sequestration of CO2, pollutants and turbidity from the water
- Support for the benthic species, juvenile fish, insects, birds

CONTROLL OF FLUXES

LARGE VOLUMES OF SEDIMENTS IN PARTIALLY CONFINED PLACES



PROTECTED BEACH NOURISHMENT

PELLESTRINA ISLAND AFTER 12 YEARS

SEDIMENT FENCES AND PLANT STABILIZATION

CONTAINMENT STRUCTURE

LOW ENERGY SITES

- Degradable Gabions

- Sediment fences

BUILDING WITH NATURE

LIVING STRUCTURES with MUSSELS and OYSTERS

Sediment fences with oyster cages

CONTAINMENT STRUCTURE

HIGH ENERGY SITES

•**Wooden pile** and geotexitele:

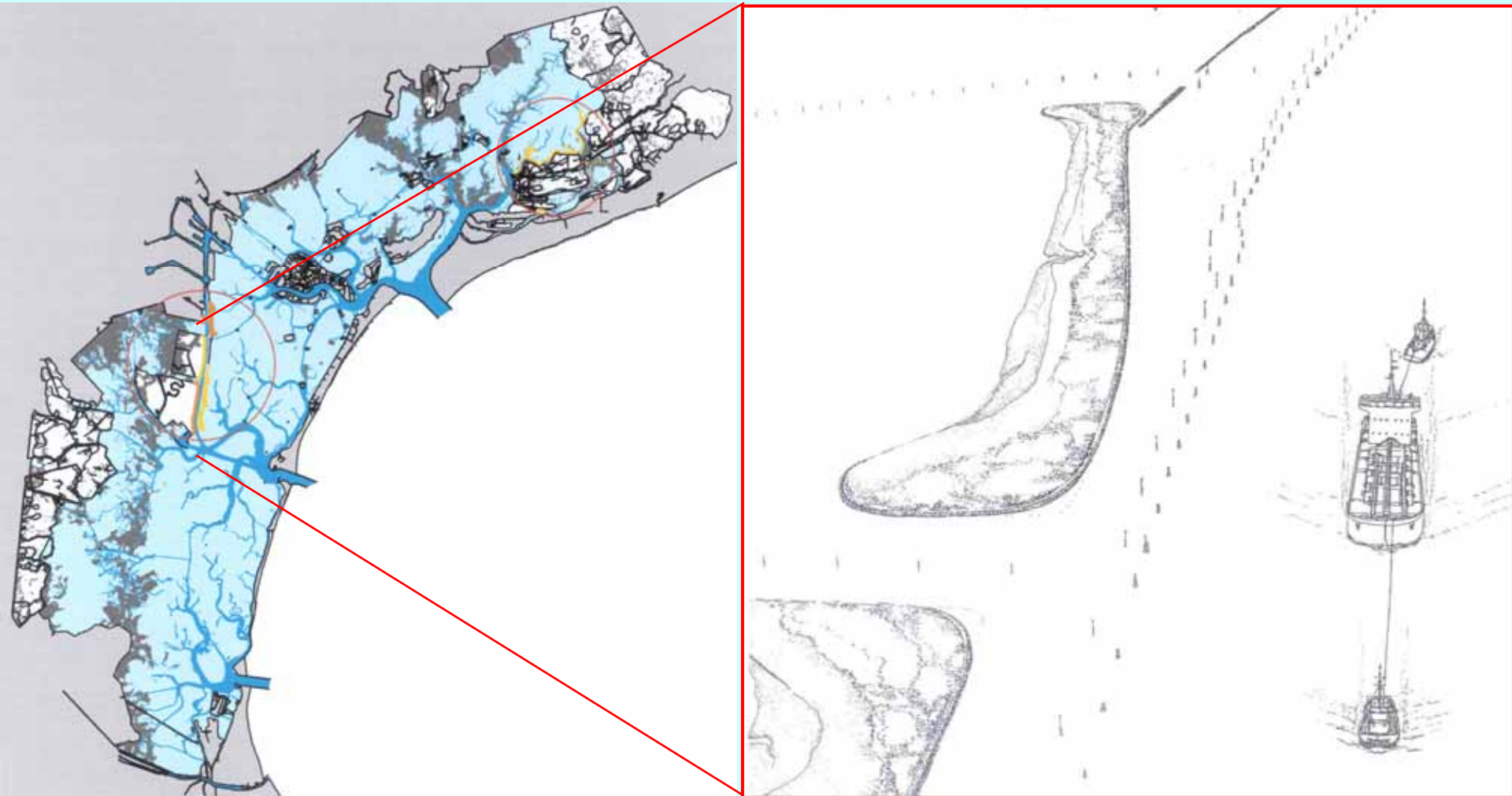
- •Degradation in lagoon environment due to *Teredo navalis* and waves

• **Geotexitele gabions** with small stones, or sand, or cemented mixture of sand and shells, or consolidated clay.

- • better dissipation of wave energy
- • greater duration
- • removable elements
- • reduction of landscape impact (colonization of the gaps by animal and plants)
- •lower cost and

Sandy beaches for Wind wave protection

PROTECTION OF NAVIGATIONAL CHANNELS



Conclusion on Conservation of habitats through Morphological Restoration

- PROVIDE SPACE AND SEDIMENT VOLUMES FOR ACTIVATING hydro-morphological and biological structuring processes driven by
  - Natural Energies:
  - Wind, Wave, Tide (water and sediment transport)
  - Sun energy (organic production, biodiversity and food web in microbial mats, plants, carbon sequestration)

- From the single structure to an ensemble of structures

- The structuring capabilities are associated with the properties of COO Systems
  - Confined = sheltered
  - Ontic = capability to preserve identity
  - Open = to transport and natural energy

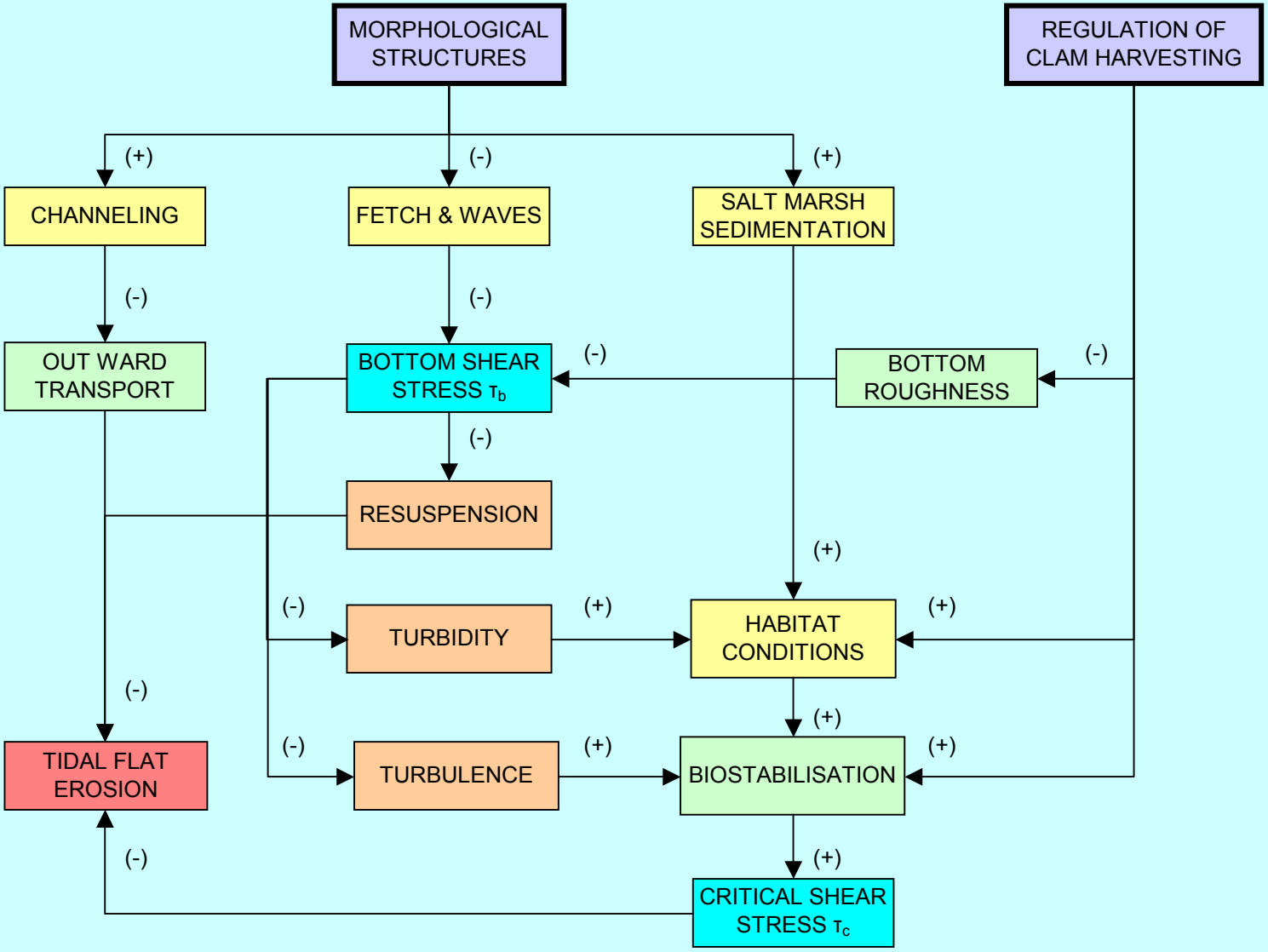
Morphological Restoration can be defined as the

Application of sediment and protection in such a way that natural processes produce a resistant/resilient landscape

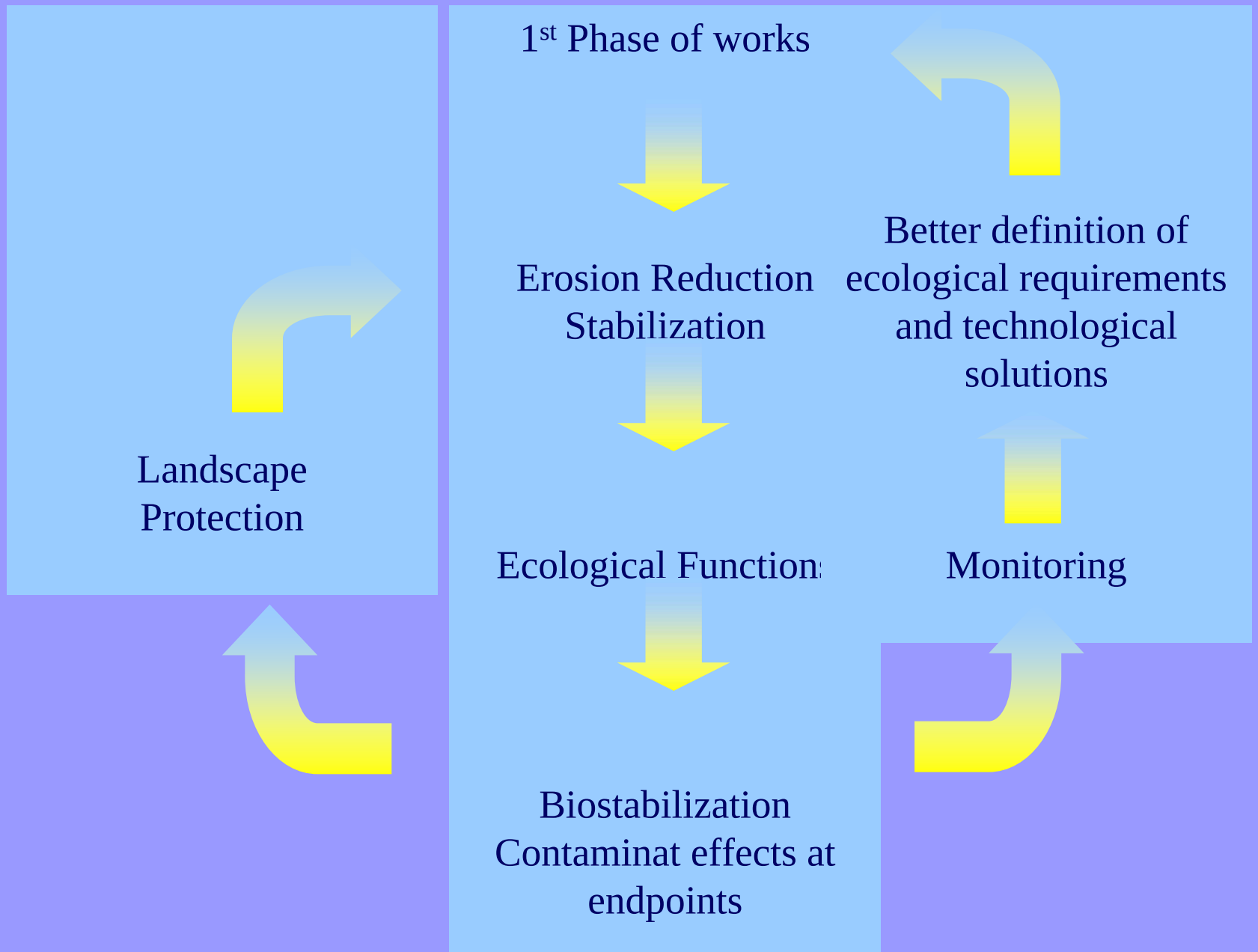
The new complex patterns in join venture with biota are able to adapt to energy variability sustaining biodiversity

Hydro-morphological and biological Restoration

Hydro-morphological restoration



Adaptive Management in wetland restoration and pollution controll



Coastal management-protection mottos

- **From:**
  Land reclamation
  Strong defense structures
  Low impact planning and design

- **To:**
  Stronger and earlier integration of nature conservation and economic development
  Sustaining ecosystem services
  Working / Building / Learning with nature
  Ecosystem approach and ecodynamic design

  Growing with the sea
  Space to water
  More space to more water
  The river that moves us
  Hand in hand
  Sand engine and beach nourishment
  Realignment
  Resilient flood protections

Island Pond Breaching San Francisco

Legend

- 2005 Marsh Edge
- 2006 Marsh Edge
- Breach Widths
- Marsh Loss Area
- Construction Impacts

Breach Name	Breach Widths	Construction Impacts	Marsh Loss from Scour
A21W	76 ft	0.11 ac	0.14 ac
A21E	32 ft	0.28 ac	0.05 ac
A20	76 ft	0.72 ac	0.00 ac
A19W	22 ft	0.03 ac	0.02 ac
A19E	110 ft	0.02 ac	0.03 ac

N

0 750 1,500 Feet

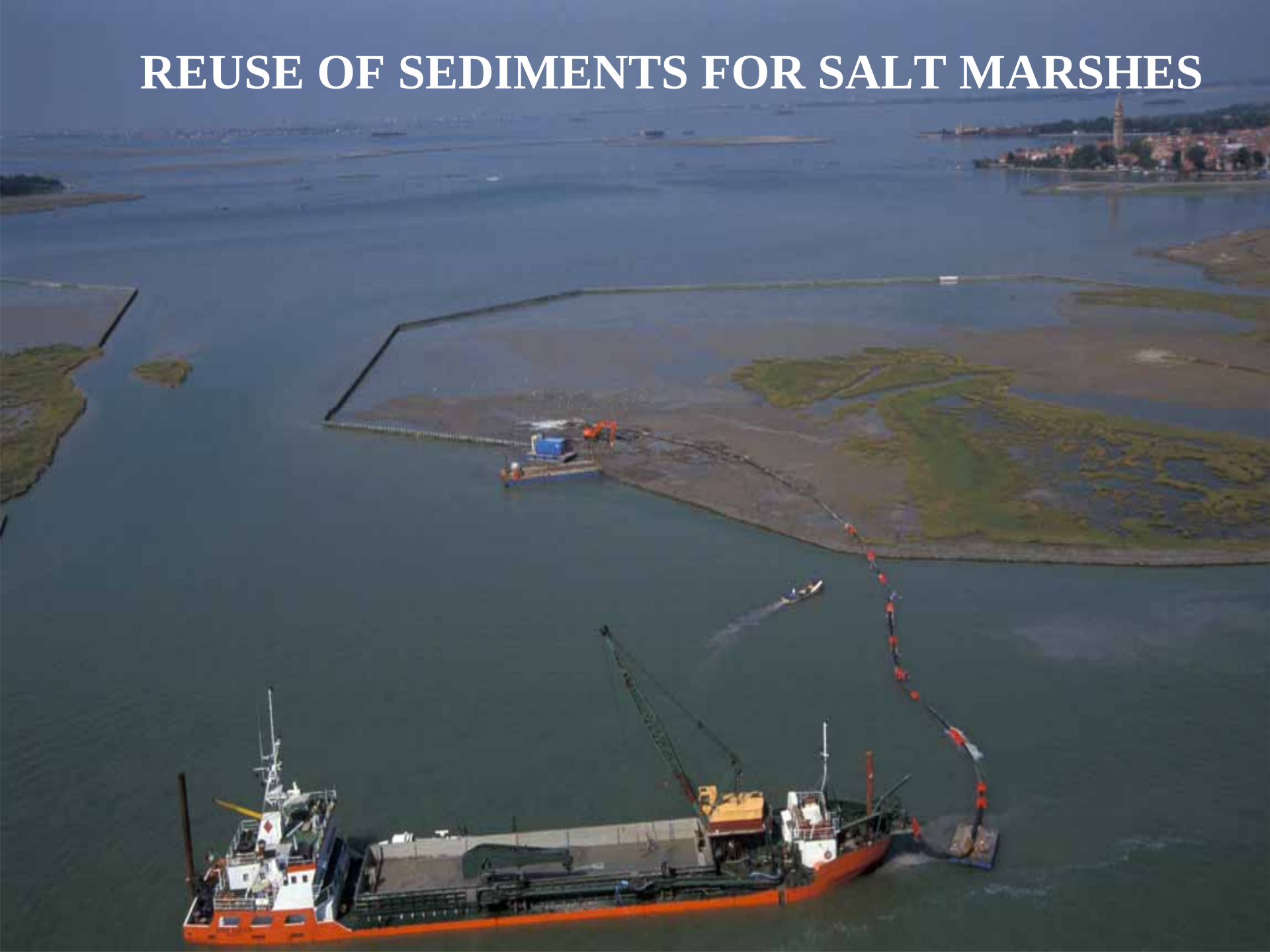
CIR Aerial Photo (8/12/06) provided by SCVWD

H. T. HARVEY & ASSOCIATES
ECOLOGICAL CONSULTANTS

Island Pond Post-Breach Effects

File No. 2456-02 | Date Jan. 2007 | Figure 13

REUSE OF SEDIMENTS FOR SALT MARSHES



COMPACTION 6 MONTHS

COLONIZATION 2-3 YEARS

RINATURALIZATION WITH TIDAL CREEKS AND PONDS >5 YEARS

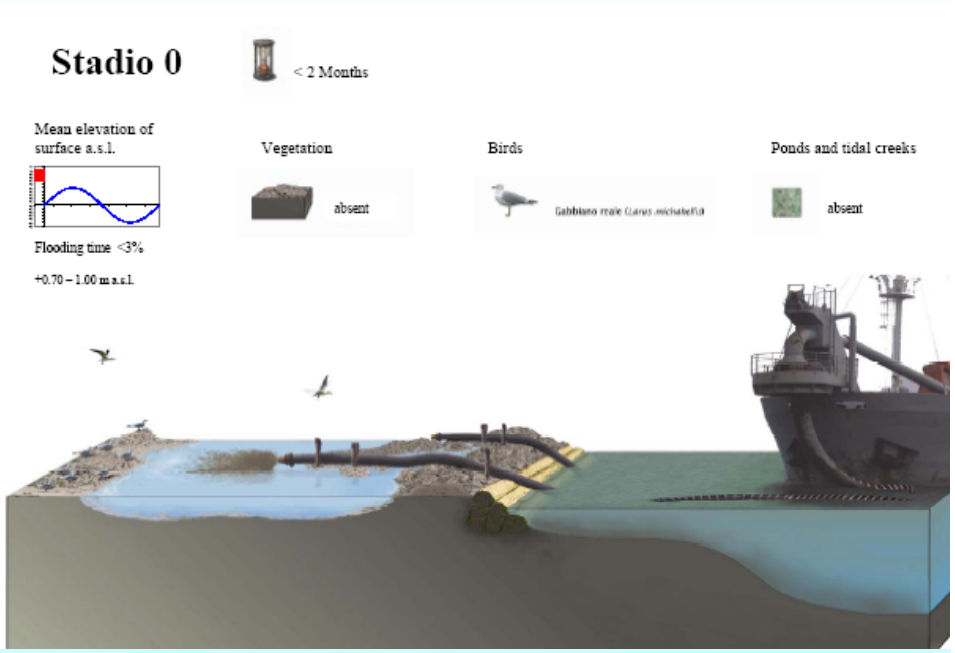
NATURALIZATION OF “Detregani marsh”

1 year

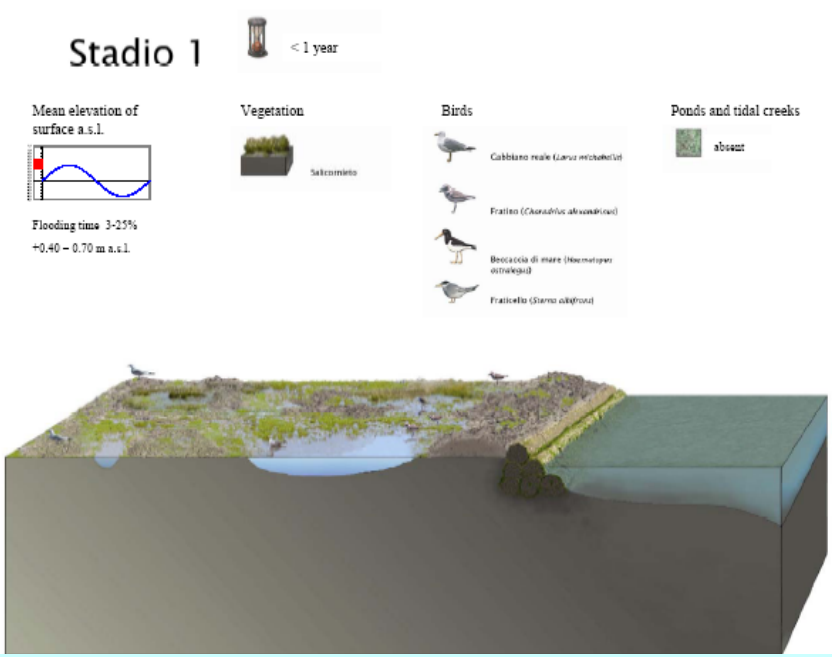
6 years

9 years

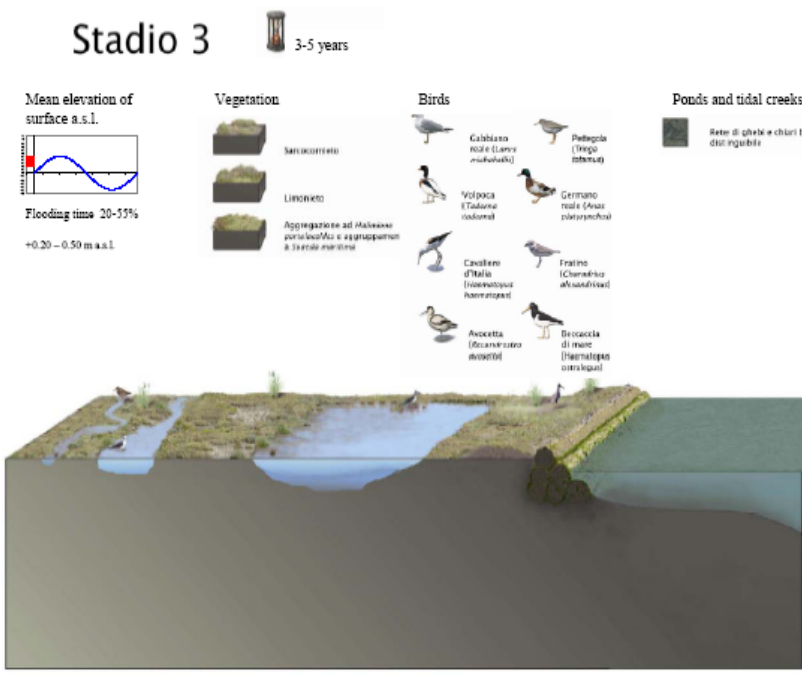
Evolution of a sediment fill as a neo-formation salt marsh: stage 0



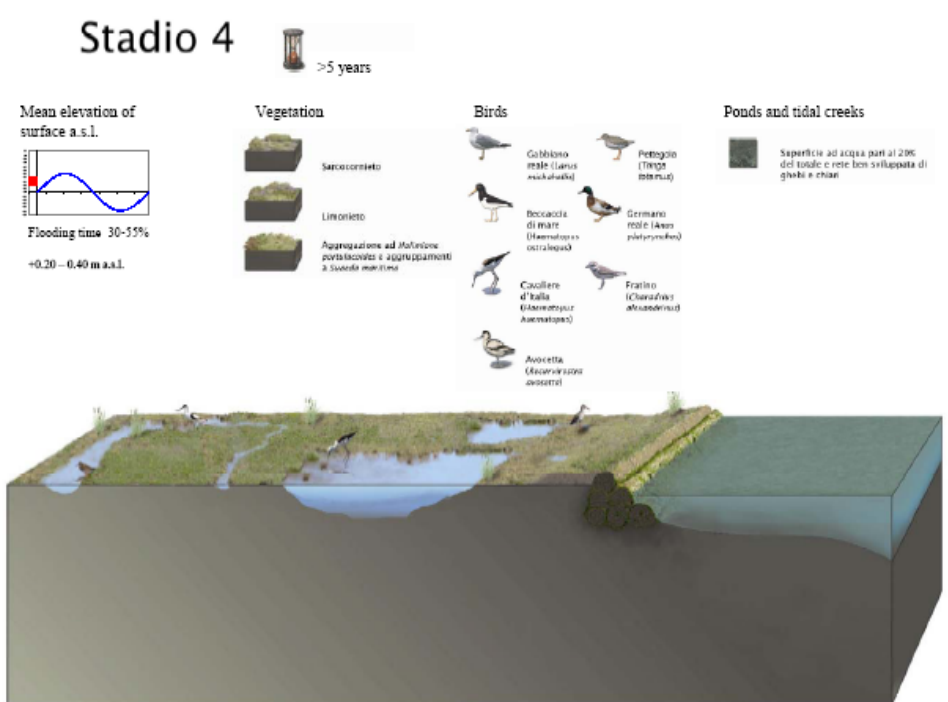
Evolution of a sediment fill as a neo-formation salt marsh: stage 1



Evolution of a sediment fill as a neo-formation salt marsh: stage 3



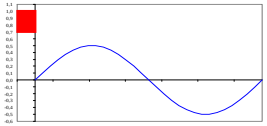
Evolution of a sediment fill as a neo-formation salt marsh: stage 4



Stadio 0

< 2 Months

Mean elevation of surface a.s.l.



Flooding time <3%

+0.70 – 1.00 m a.s.l.

Vegetation

absent

Birds

Gabbiano reale (*Larus michahellis*)

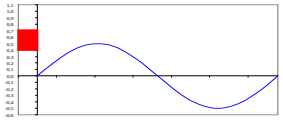
Ponds and tidal creeks

absent

Stadio 1

< 1 year

Mean elevation of surface a.s.l.



Flooding time 3-25%

+0.40 – 0.70 m a.s.l.

Vegetation

Salicornieto

Birds

Gabbiano reale (*Larus michahellis*)

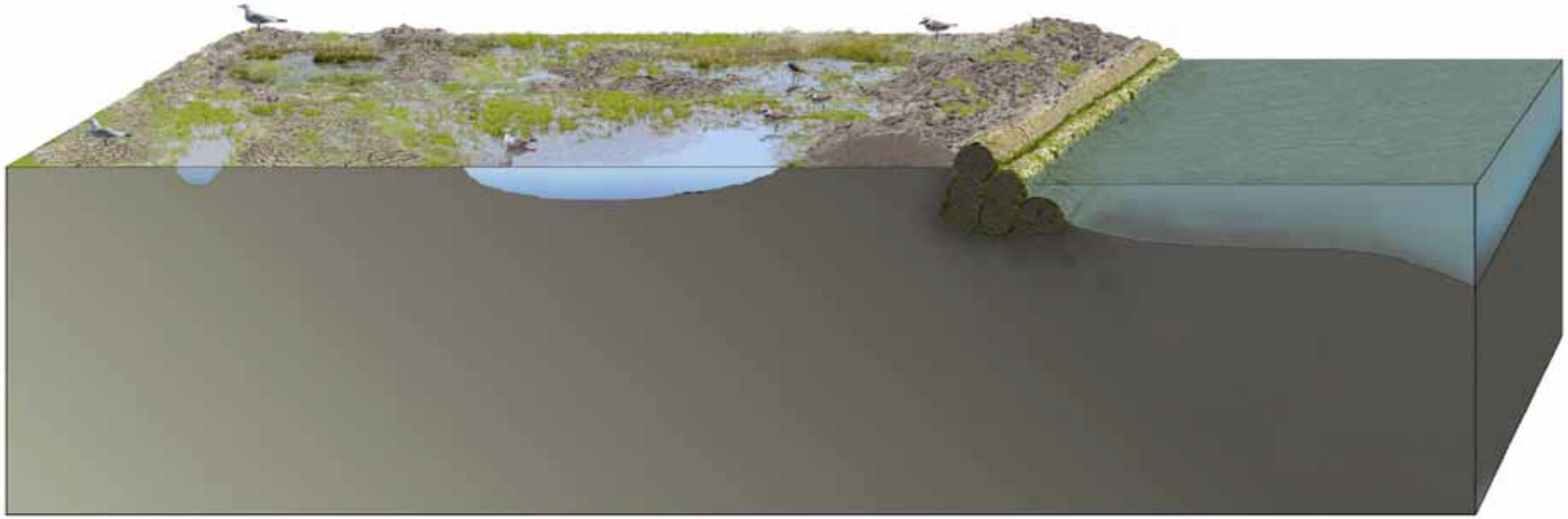
Fratino (*Charadrius alexandrinus*)

Beccaccia di mare (*Haematopus ostralegus*)

Fraticello (*Sterna albifrons*)

Ponds and tidal creeks

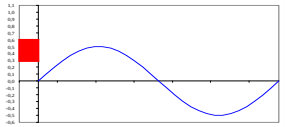
absent



Stadio 2

1-3 years

Mean elevation of surface a.s.l.



Flooding time 8-40%

+0.30 – 0.60 m a.s.l.

Vegetation

Salicornieto

Sarcocornieto

Birds

Gabbiano reale (*Larus michahellis*)

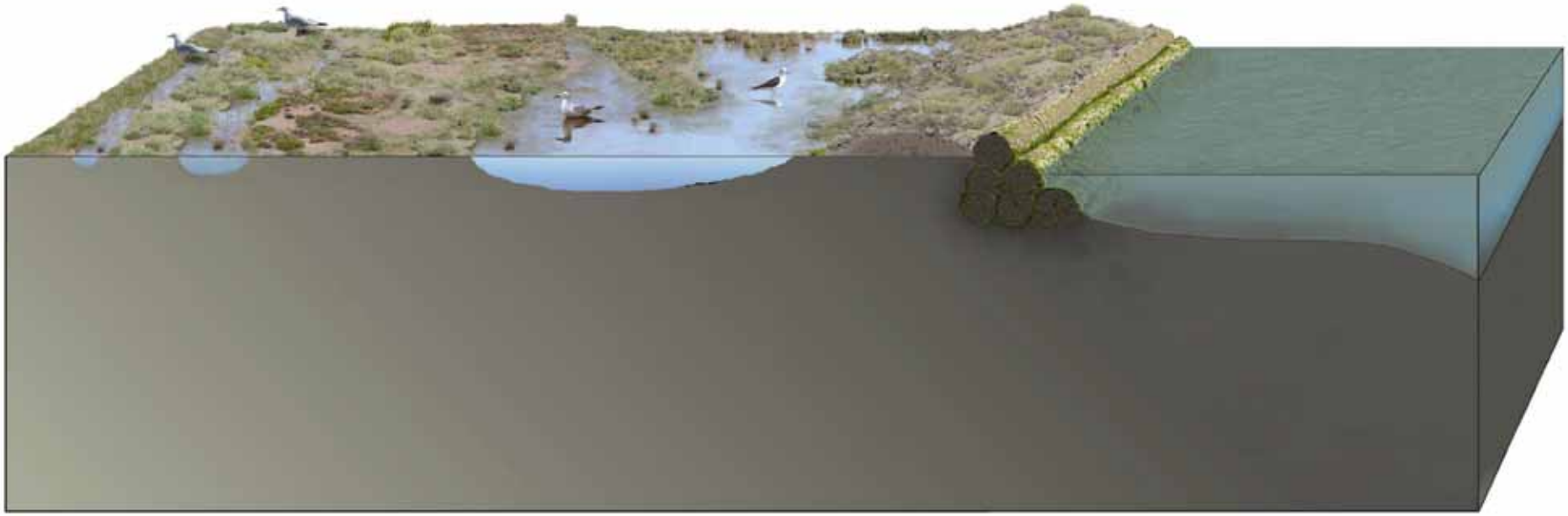
Fratino (*Charadrius alexandrinus*)

Beccaccia di mare (*Haematopus ostralegus*)

Fraticello (*Sterna albifrons*)

Ponds and tidal creeks

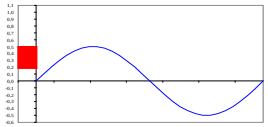
Rete di ghebi e chiari ben distinguibile



Stadio 3

3-5 years

Mean elevation of surface a.s.l.



Flooding time 20-55%

+0.20 – 0.50 m a.s.l.

Vegetation

Sarcocornieto

Limonieto

Aggregazione ad *Halimione portulacoides* e aggruppamen a *Suaeda maritima*

Birds

Gabbiano reale (*Larus michahellis*)

Pettegola (*Tringa totamus*)

Volpoca (*Tadorna tadorna*)

Germano reale (*Anas platyrynchos*)

Cavaliere d'Italia (*Haematopus haematopus*)

Fratino (*Charadrius alexandrinus*)

Avocetta (*Recurvirostra avosetta*)

Beccaccia di mare (Haematopus ostralegus)

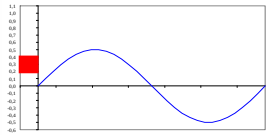
Ponds and tidal creeks

Rete di ghebi e chiari ben distinguibile

Stadio 4

>5 years

Mean elevation of surface a.s.l.



Flooding time 30-55%

+0.20 – 0.40 m a.s.l.

Vegetation

Sarcocornieto

Limonieto

Aggregazione ad *Halimione portulacoides* e aggruppamenti a *Suaeda maritima*

Birds

Gabbiano reale (*Larus michahellis*)

Pettegola (*Tringa totamus*)

Beccaccia di mare (Haematopus ostralegus)

Germano reale (*Anas platyrynchos*)

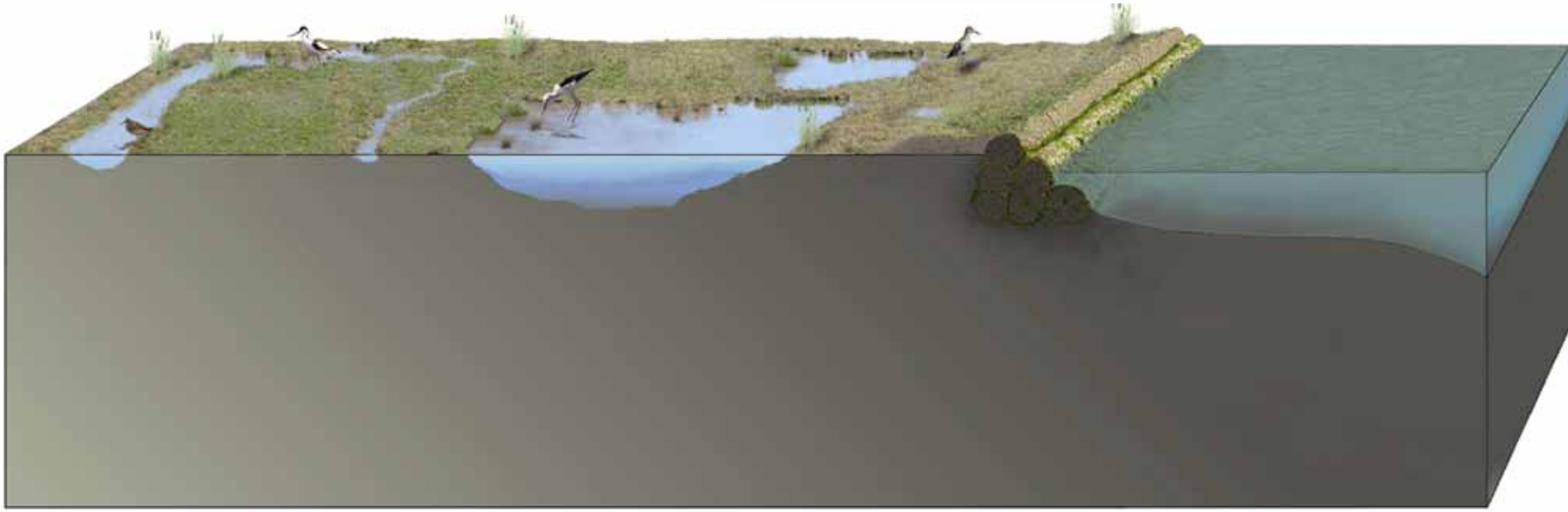
Cavaliere d'Italia (*Haematopus haematopus*)

Fratino (*Charadrius alexandrinus*)

Avocetta (*Recurvirostra avosetta*)

Ponds and tidal creeks

Superficie ad acqua pari al 20% del totale e rete ben sviluppata di ghebi e chiari



AGE (YEARS)

ENVIRONMENTAL VALUE OF CONSTRUCTED SALT MARSHES:

Green: in line with expectations;

Orange: naturalization work required

Red: change in elevation required

IN CORSO

DEVELOPMENT OF VEGETATION STRUCTURES

One year after constr. :
***Salicornia* Pioneer community**

Two year after constr. :
***Puccinellia*: more complex pioneer comunity**

Six year after constr. :
Assemblage of 7 typical salt marshes species
(max 10 species)

SALT-MARSH HABITATS

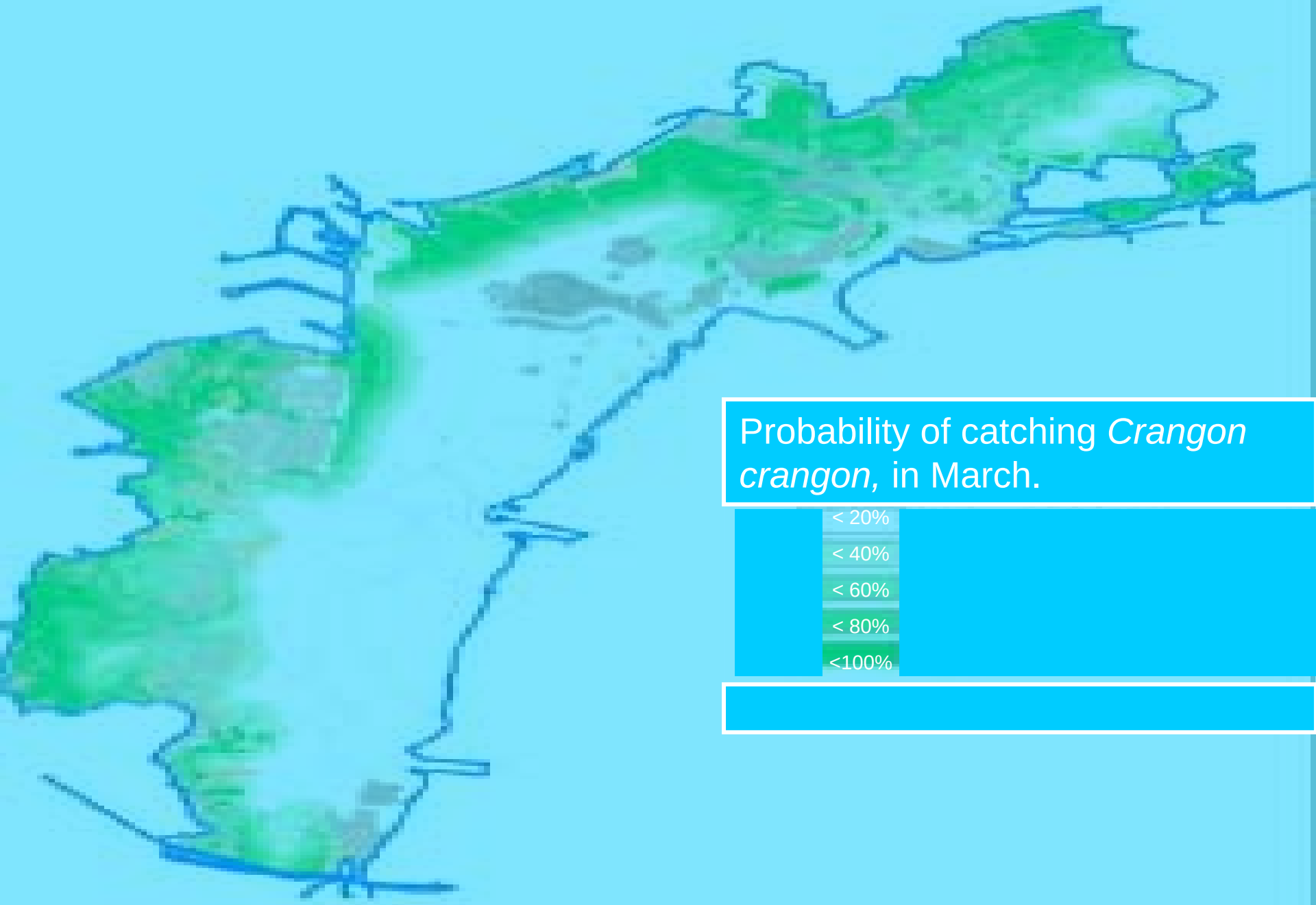
Chioggia B1: Rinaturalization with ponds and tidal creeks


Construction of pond and tidal creek


4 years after tidal creeks dredging


7 years after tidal creeks dredging


7 years after tidal creeks dredging


Probability of catching *Crangon crangon*, in March.
< 20%
< 40%
< 60%
< 80%
<100%

Common breeding species at constructed salt-marshes (years 2005-2006)

Avocet (39-44 pairs)

Redshank (94-136)

Black-winged Stilt (96-69)

Kentish Plover (34-71)

Oystercatcher (31-38)

Shelduck (12-17)

Little Tern (115-205)

Yellow-legged Gull (553-1057)

Environmental Value of

Constructed Salt Marshes and Beaches

Species	In Constructed marshes (n°of pairs)	In the whole lagoon Year 2007	Constructed Marshes/ Lagoon (%)	Constructed Marshes/ Italy (%)
Shelduck	12	50-60	24	4
Lapwing	5	10-15	50	<0.1
Oystercatcher	40	50	80	30
Black-winged Stilt*	62	300-400	21	2
Avocet*	35	200-300	18	2
Liitleringed plover	18	20-30	90	0.5
Kentish Plover*	131	170-200	77	8
Redshank	110	1400- 1600	7	7
Liittle Tern*	379	600-700	63	9

* Listed in the Birds Directive, appendix 1

BIRDS

Constructed salt marshes are extremely important for :

conservation of rare or endangered birds, expecially for reproduction.

at the National level for 7 species, 4 of which are specially protected by the European legislation.

the sites are used by species (such as Little Tern or Kentish Plovers) that find very few suitable habitats elsewhere (undisturbed tidal flat and beaches).

CONCLUSION

- **Sediments are a fundamental resource for habitat restorationin coastal areas, especially in places affected by sea level rise and erosion.**

- **Ecodynamic criteria: Confined Ontic Open Systems, COOS:**

  Wind, wave and tide driven sediments can settle and be stabilized by vegetation and other organisms creating a variety of structuring and self-preserving valuable habitats such as: beaches, dunes, salt marshes, eel-grass prairies, inter-tidal flats. At the same time the new structures can improve hydro-morphological complexity and resilience.

  Lack of sediment supply or insufficient confinement destroy the system and the sediments are washed away

- **There are plenty of possibilities for creating coastal COOS using large volumes of sediments from maintenance dredging for starting pilot projects and research on the fate of contaminants**

- **Needs of sharing risks when reusing polluted sediments**