Nature-based solutions and climate-adaptation for west Mediterranean urban beaches

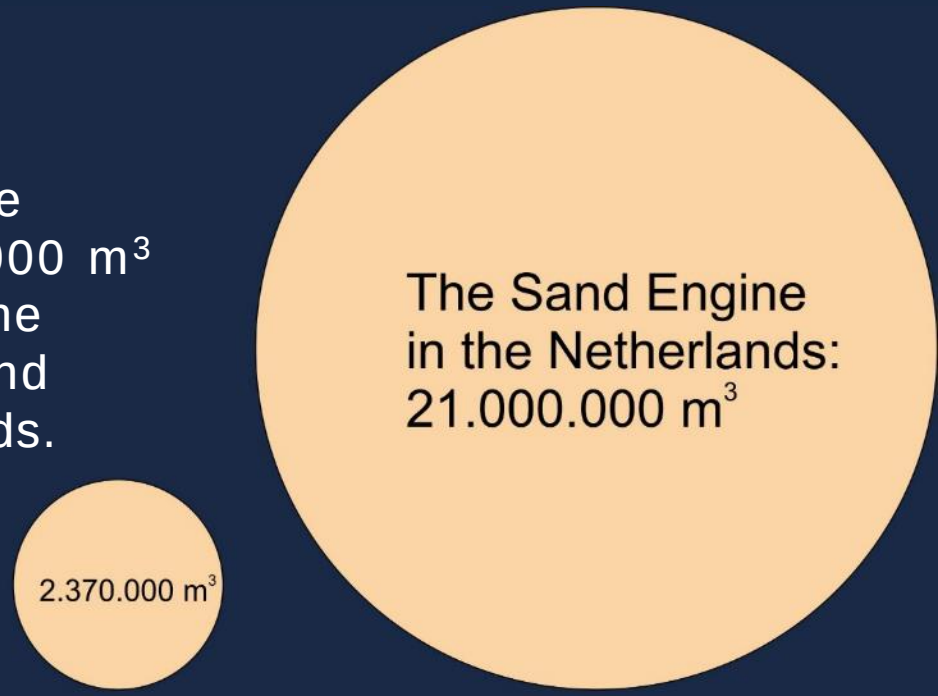
OPERAs @volemdunes S·G·M

Rationale:

- Beach sand: a scarce natural resource, within an altered morphodynamic environment, providing huge amounts of ES, but without an comprehensive integrated management plan.
- Current management system does not include emerged sand management.
- Recent storm events show a relevant vulnerability that will increase with climatic change.

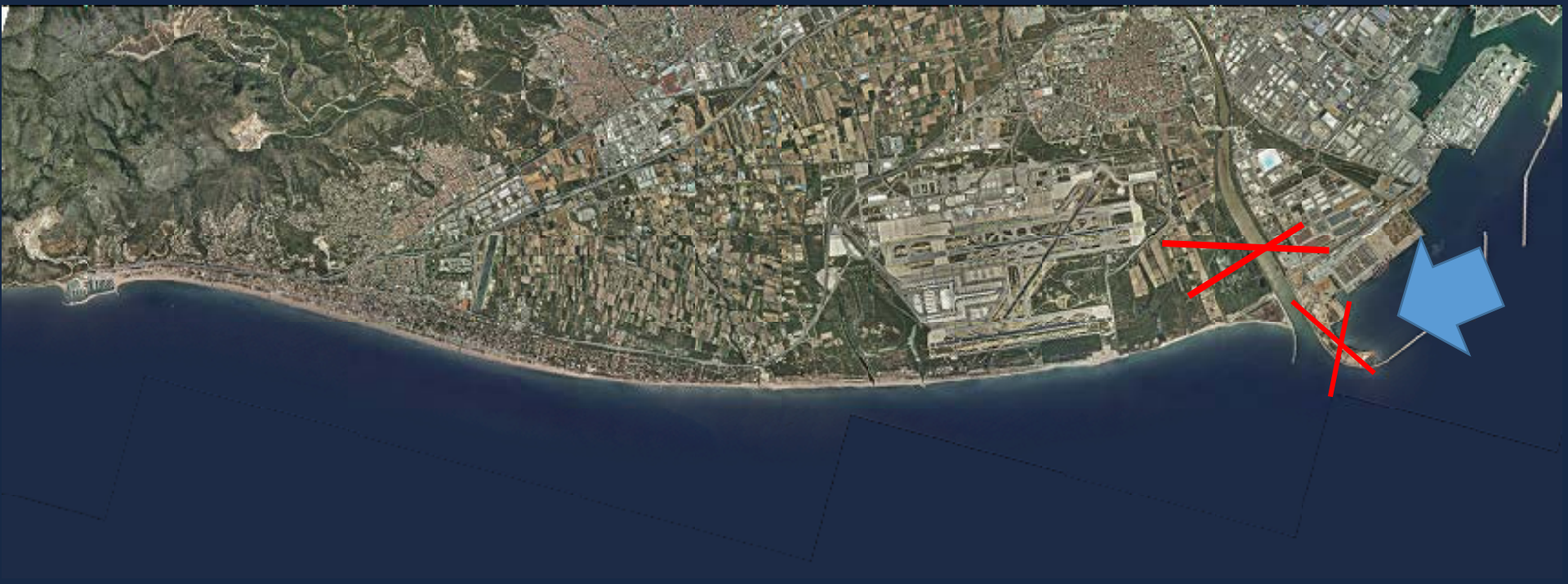
SIZE MATTERS

The 15,5 km of public beaches at the Llobregat delta amount only 2.370.000 m^3 of backshore and dunes, less than the 12% of the replenishment of the Sand Engine experiment at the Netherlands.



SIZE MATTERS

Very few sand, with no sand inflow after the construction of the new port dyke entering into the sea 1,8 km. No more sand arriving from the river. No sand cleaning by the sea, as it is a micro tidal environment.



SIZE MATTERS

Very few sand but:

- Delivering huge amounts of ES.
- The most visited landscape of Catalonia.
- Densities arriving to 500 sun-bathers/100m.
- The “brandscape” of the Metropolitan Area of Barcelona.

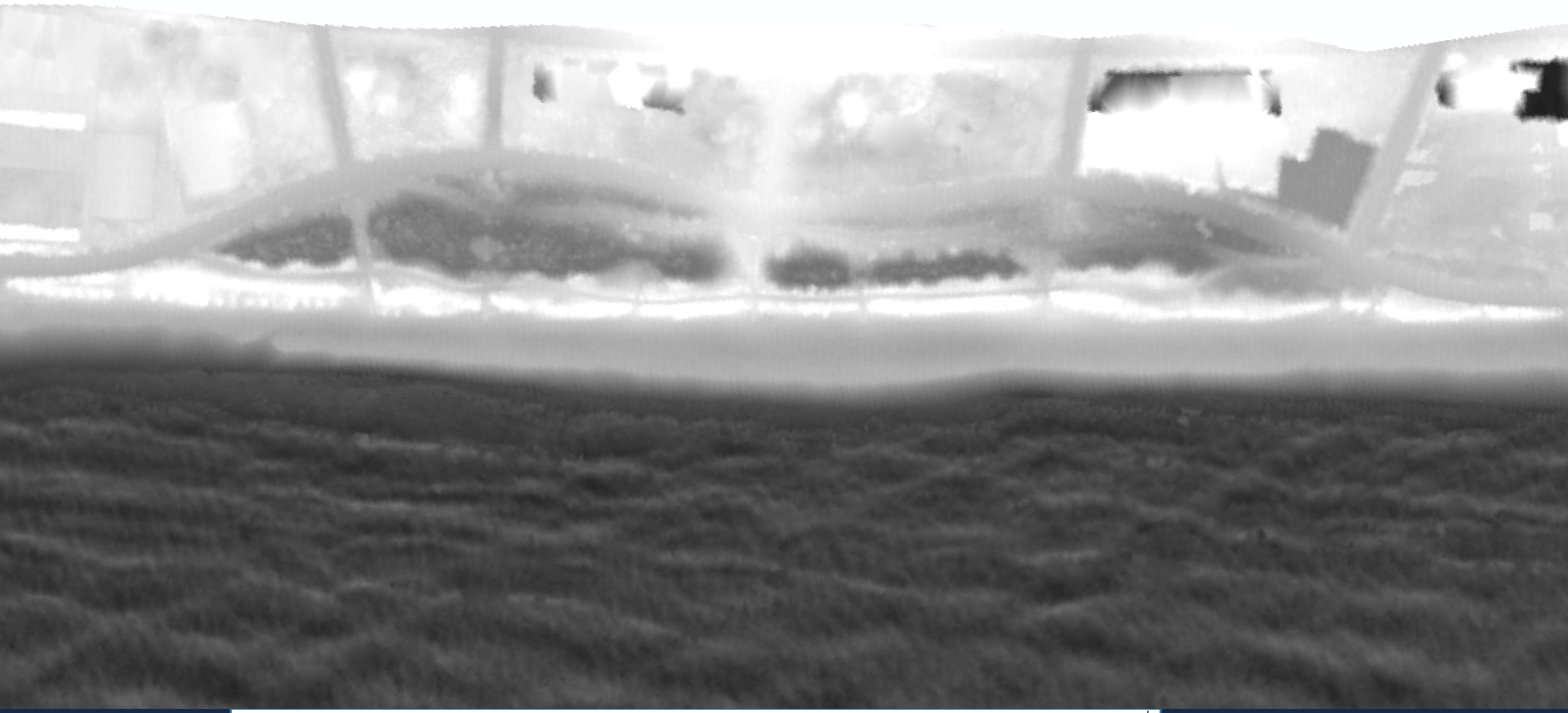
PURPOSE:

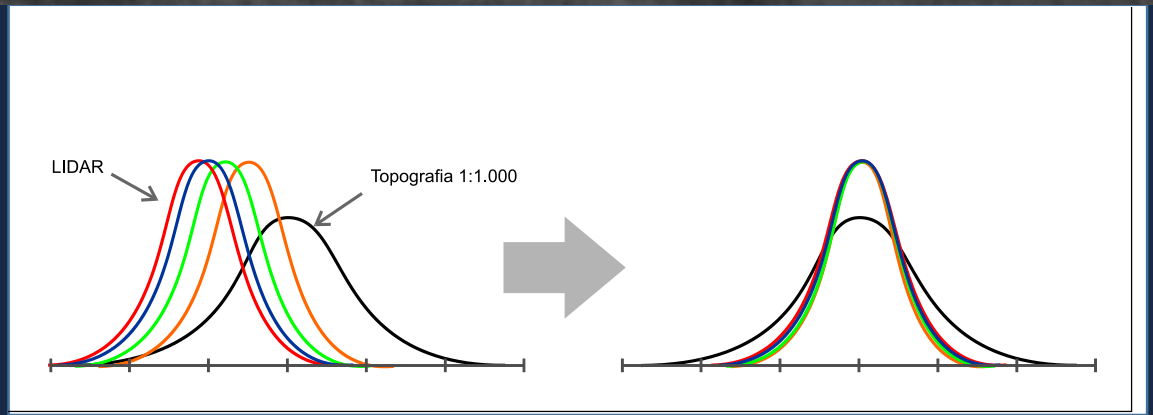
- Can an ES-based management plan aim to achieve a resilient beach in front of climatic change?
- Explore the limits of the dune construction as a NBS.

SCOPE:

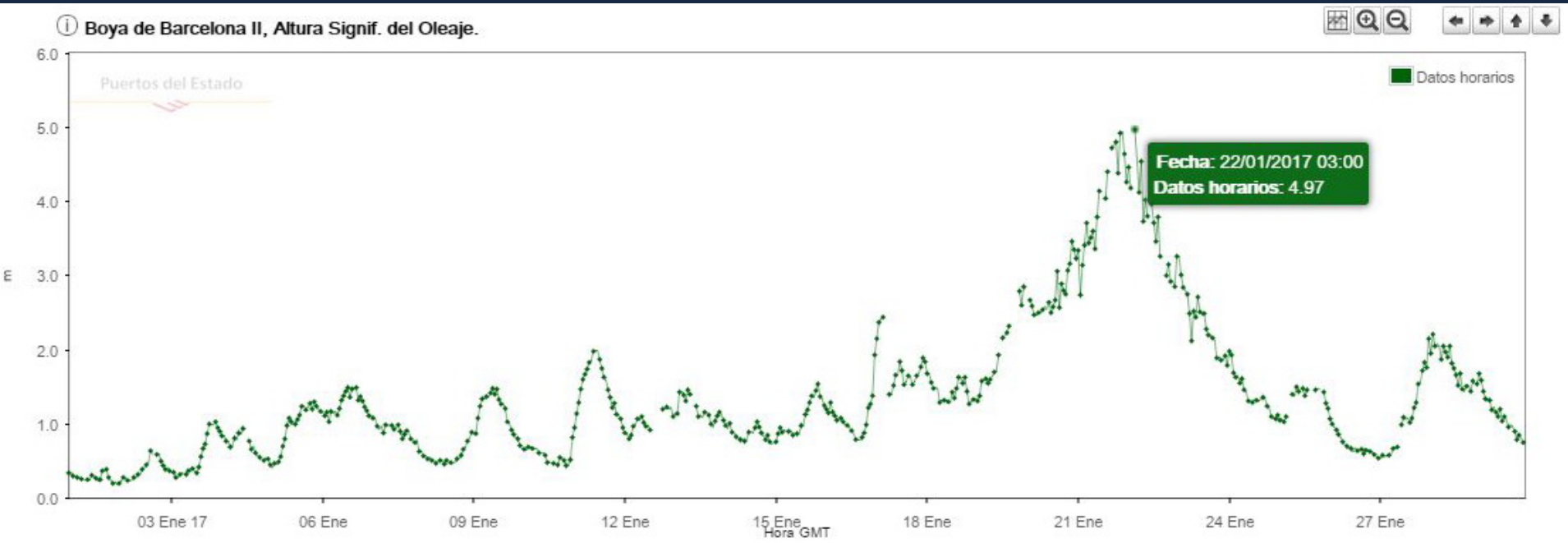
- Information sources
- What kind of sand needed?
- How much dry sand needed?

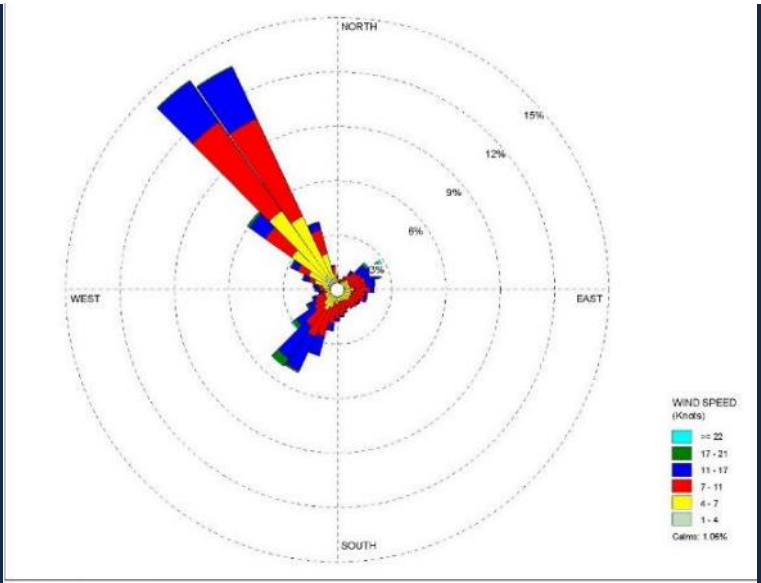
High resolution LIDAR (1 point/m^2)





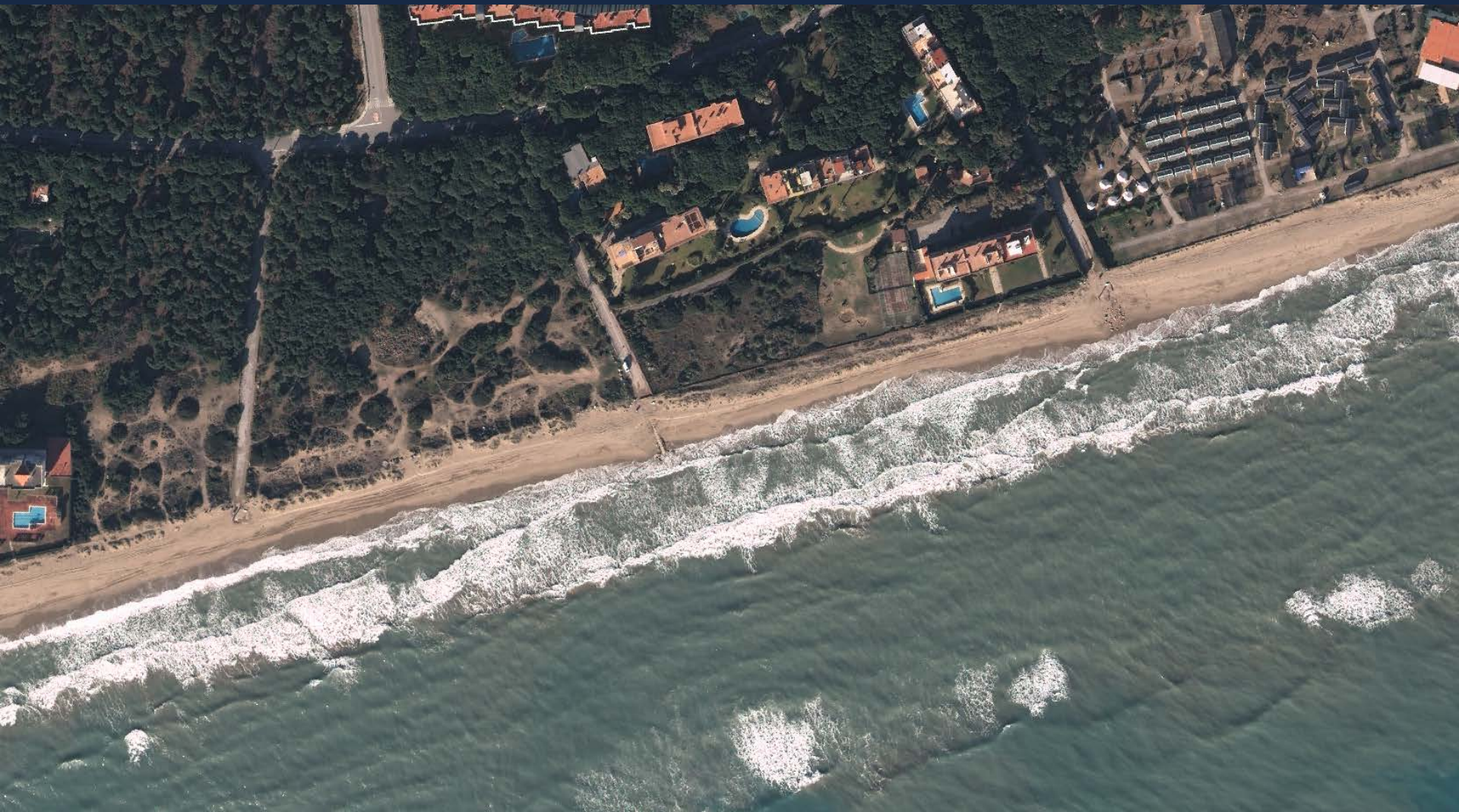
Wave environment & wind direction



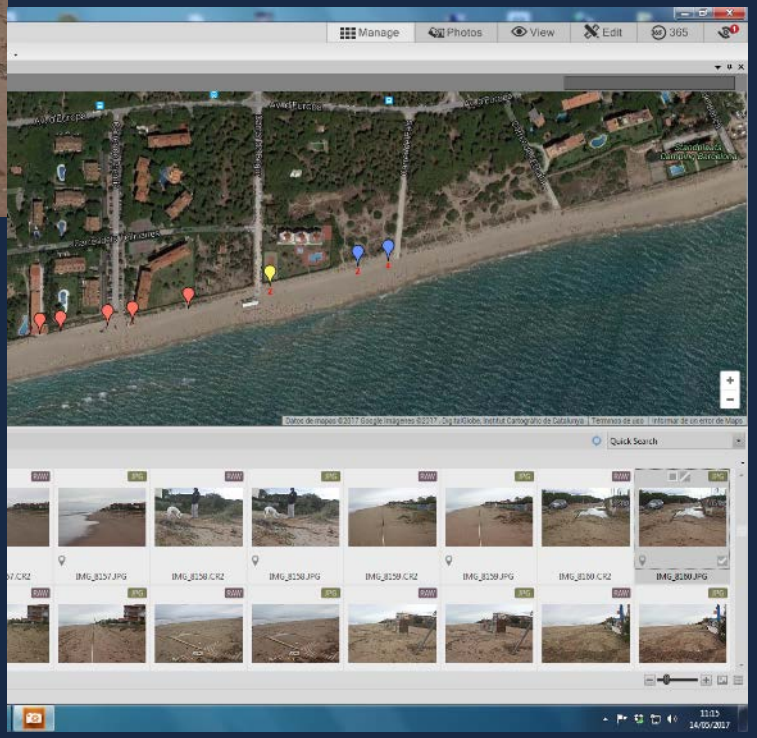


Wind intensity, direction and seasonality

Satellite imaginery and flights, one of them only 4 days after the biggest storm in 15 years.

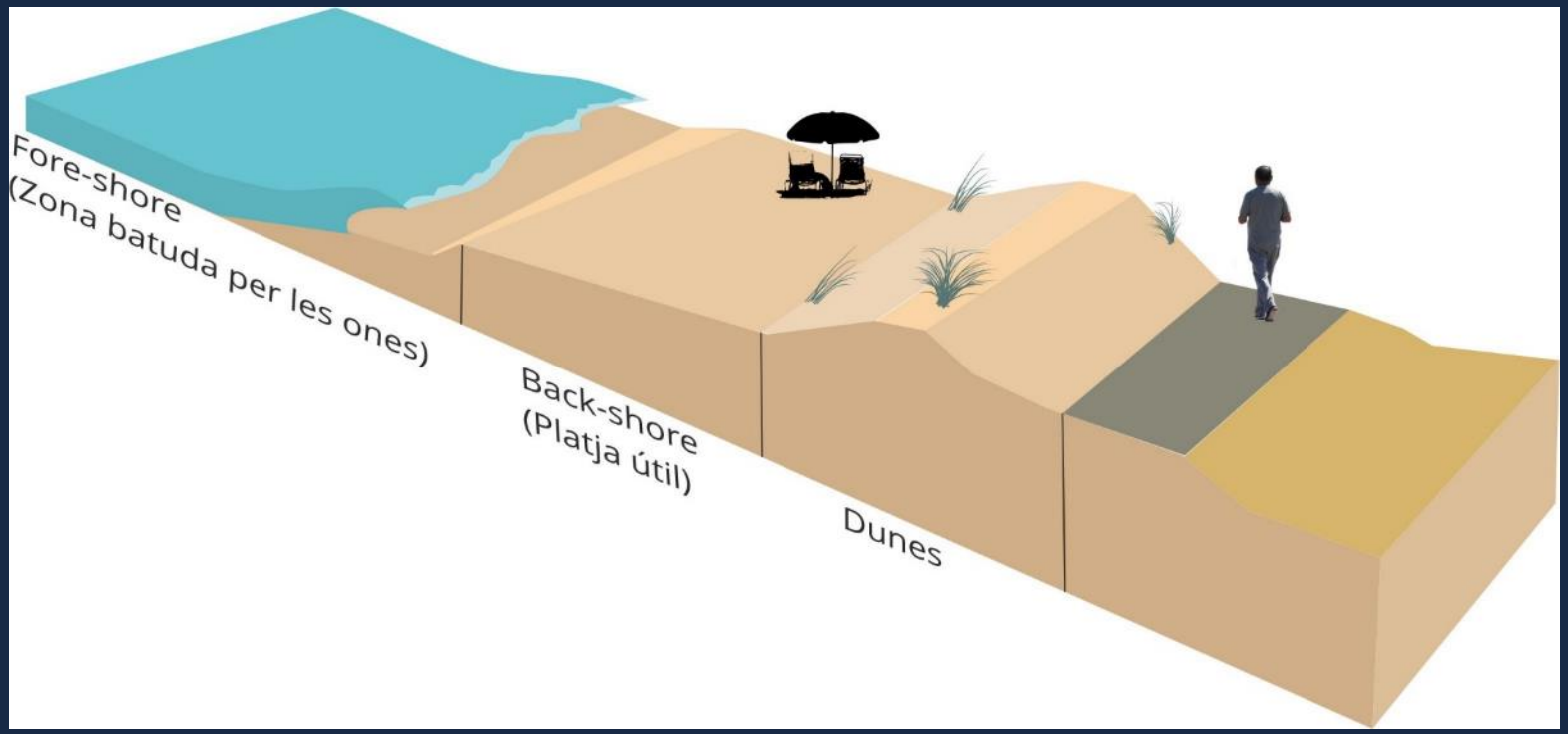


Geotagged photos



And citizen science opportunity

Basic elements of a beach

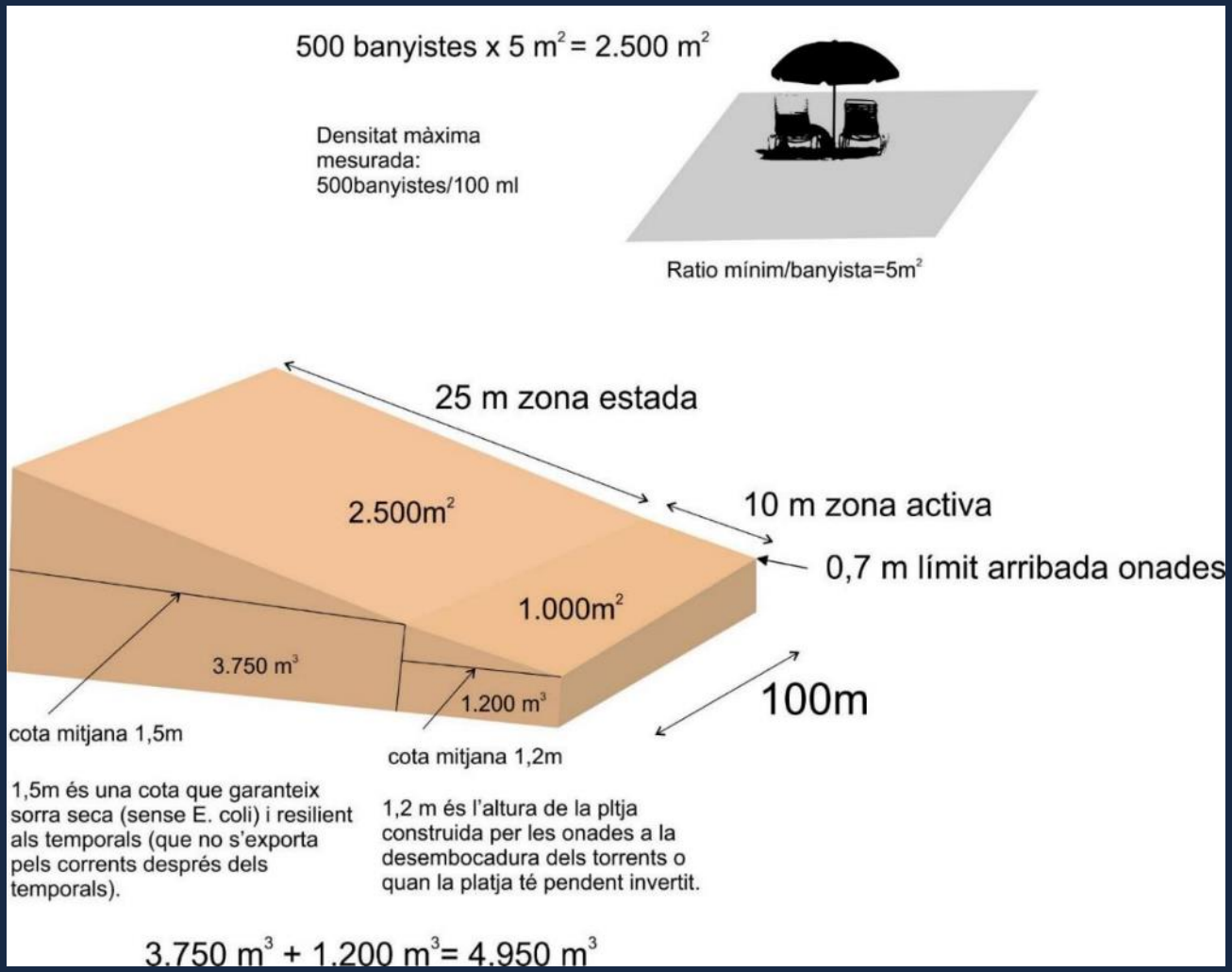


Basic elements of a beach

Size needs for intensive use


1,2 m
Low energy wave limit
1,0 m
Limit of wind scouring
Washover flooding
Sewage discharge
Dry sand anywhere over 1,2 m height.

Minimum volume needed to cope with the highest density of sunbathers found on fieldwork: 4.950 m^3 /100 m beach stretch (if slope optimized!).



Urbanized areas with less than 5.000m^3 of sand, and without dunes

Relevant drivers:

Dyke south-west

Port Ginesta

La retenció de sediments fa ampliar les platges de Les Botigues i Castelldefels.

Pets

Gossos i gats

Cada gos aboca diàriament 0,3 kg d'excrements i 0,75 litres d'orina. Les colònies de gats es concentren a les zones de major interès ambiental.

Intensive social use-Mechanical sand screening

Ús social intensiu

Per proveir platges netes per a més de 7.000.000 de visitants anuals, la sorra es neteja contínuament amb mitjans mecànics.

Coastal regression

Regressió deltaica

La manca d'arribada de sediment va iniciar un procés de regressió que el 2004 s'estava estabilitzant.

Climatic change

El canvi climàtic

A més temperatura del mar, major energia disponible pels temporals.

Augment del nivell del mar.

Sand inflow interruption

El nou dic del port

Finalitzat el 2004, s'endinsa 1,8 km al mar. Interrupció del transport de sediments.

Afecta el balanç sedimentari de totes les platges del delta.

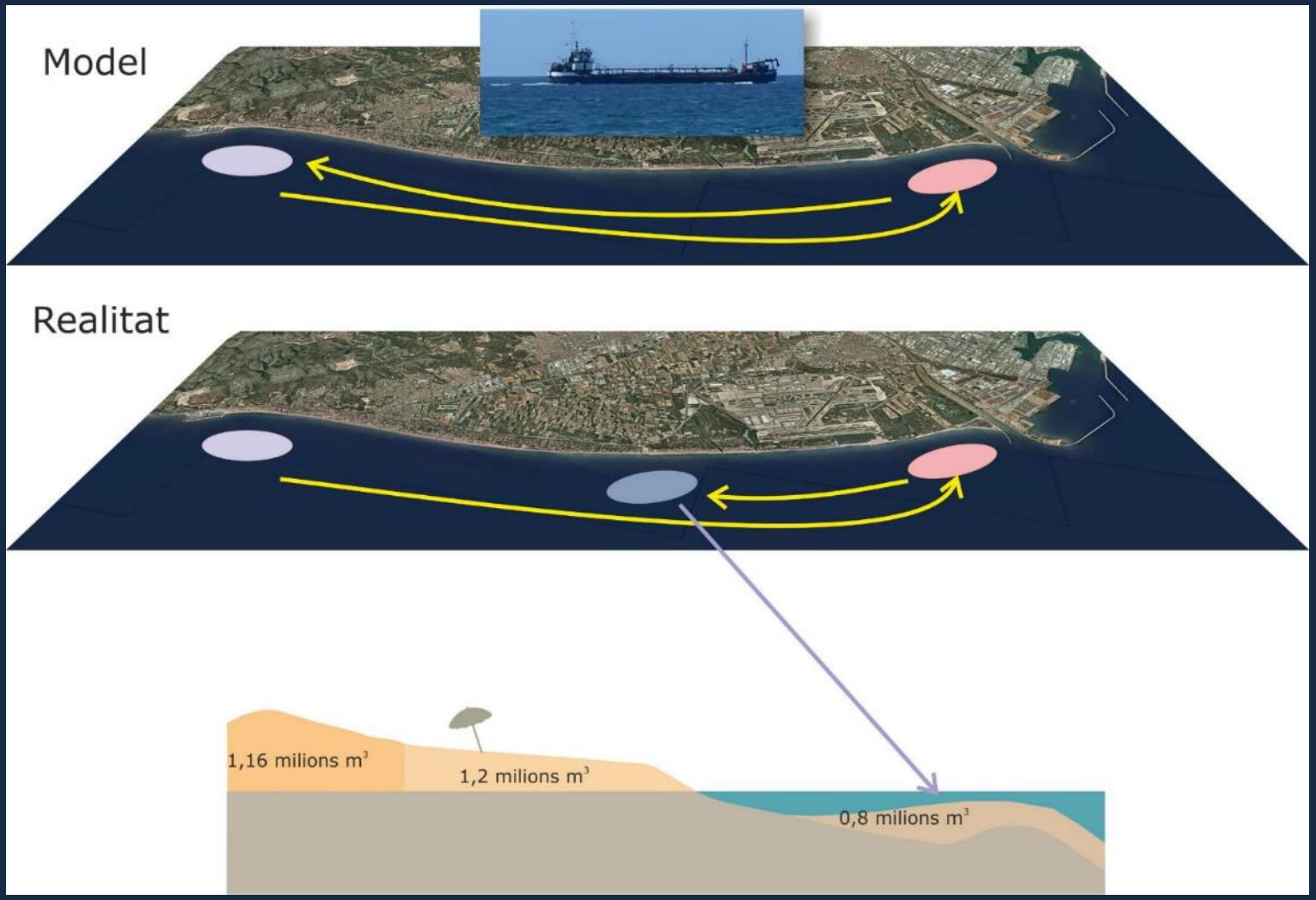
100.000 m^3 of beach nourishment each year

Recàrrega de sorra

Cada any s'extreuen uns 100.000 m^3 de sorra de l'entorn de Port Ginesta i es dipositen a les platges del Prat de Llobregat.

La sorra no retorna al punt d'origen.

The expected sand transport model within the sand nourishment project did not work.

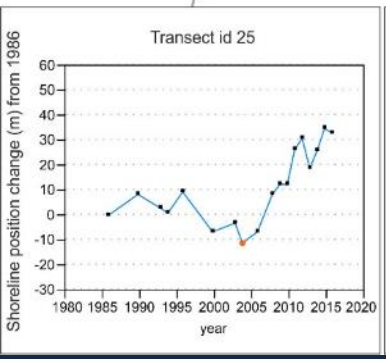


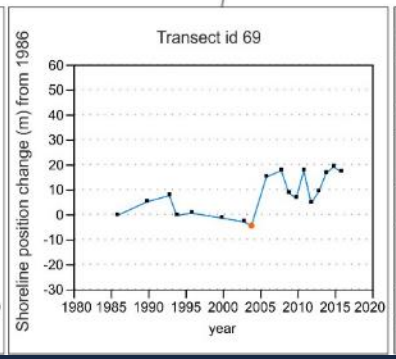
Analysis:

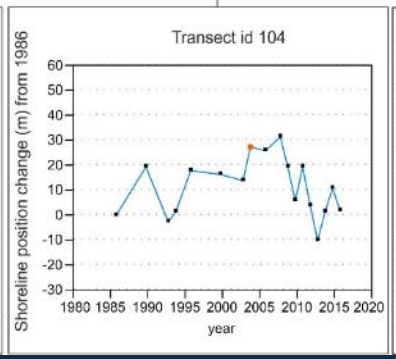
Processes triggered by the most determinant drivers:

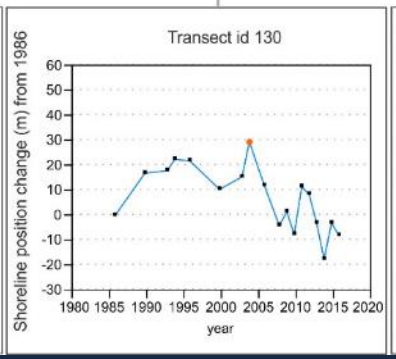
- Concave beaches.
- Beaches losing natural recovering capacity.
- Beach regression.
- Limits on dune formation and management.

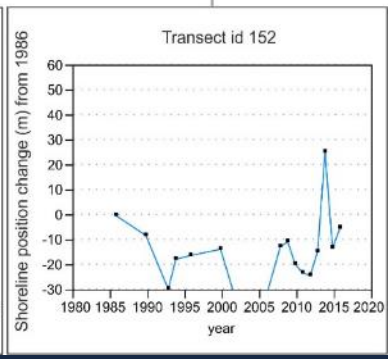
Digital Shoreline Analysis System (DSAS) shows how the construction of the Dyke has affected the whole beach System.







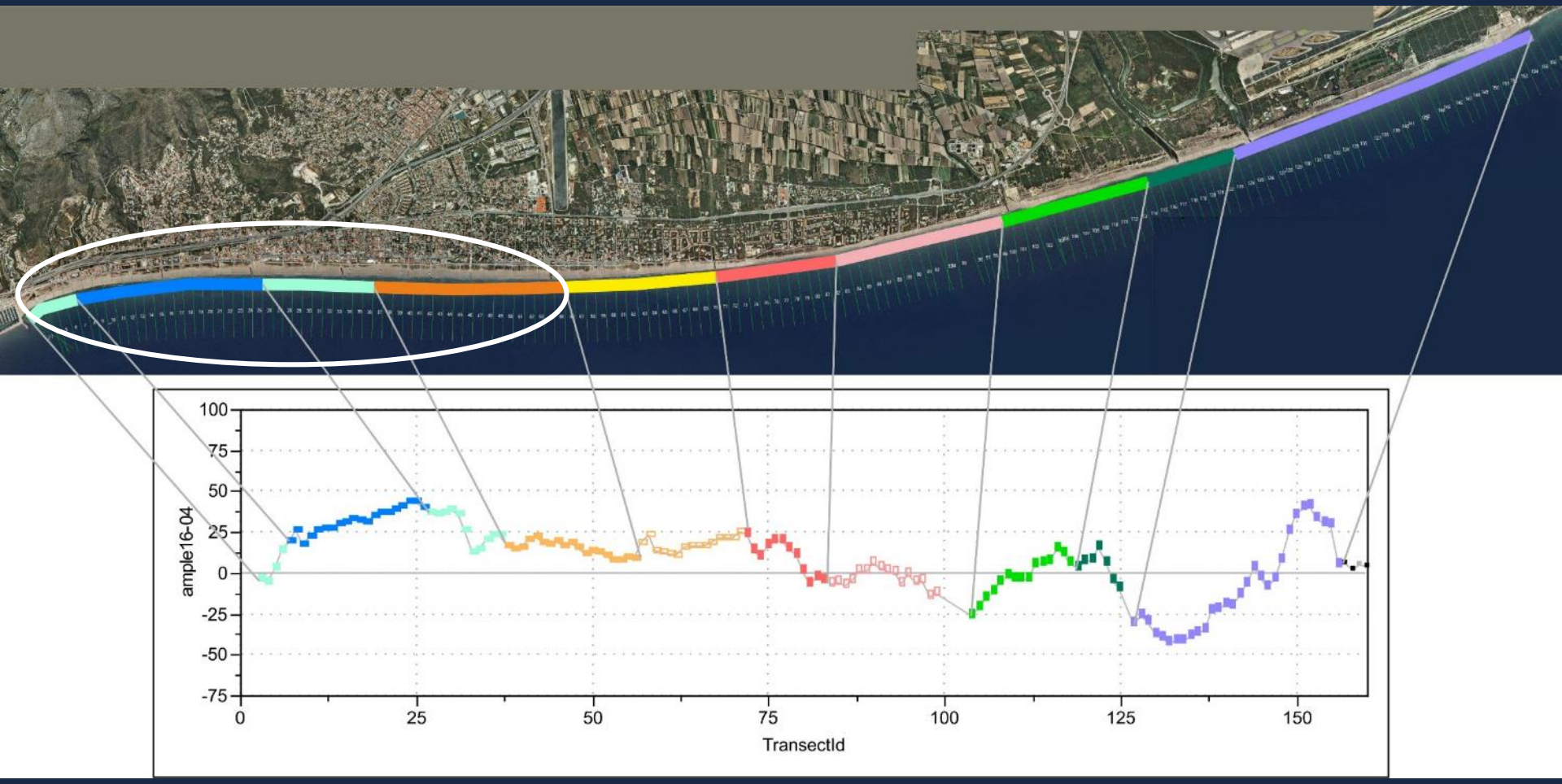




Extensive beach widening

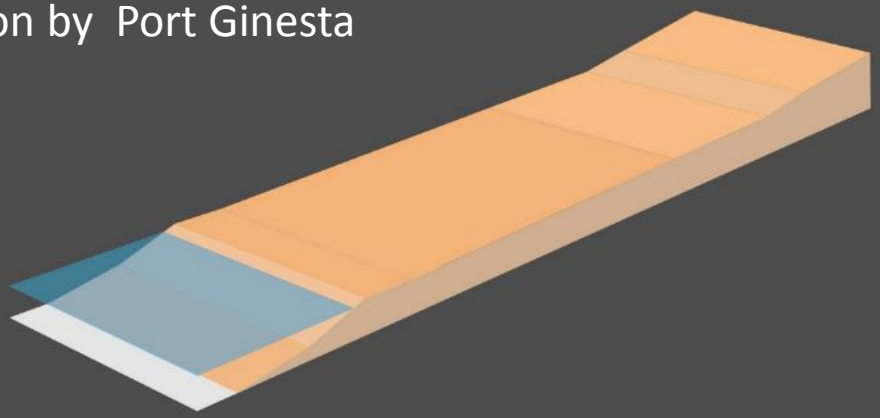
Coastal regression

DSAS analysis show how 69% of the beaches have widened from 2004, when the construction of the dyke ends.

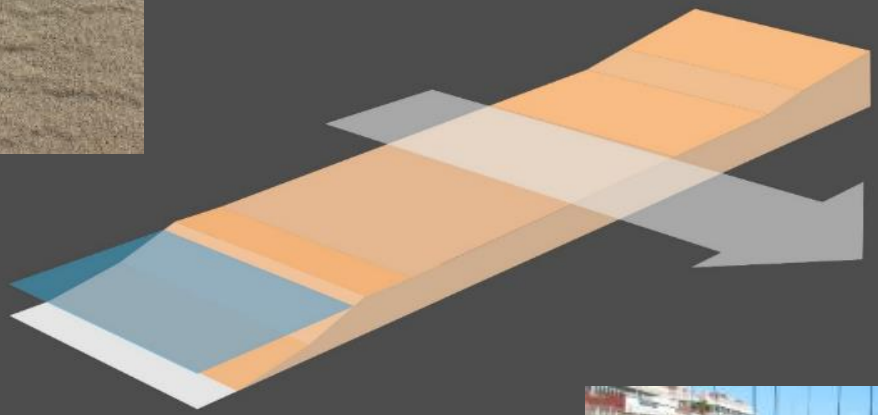


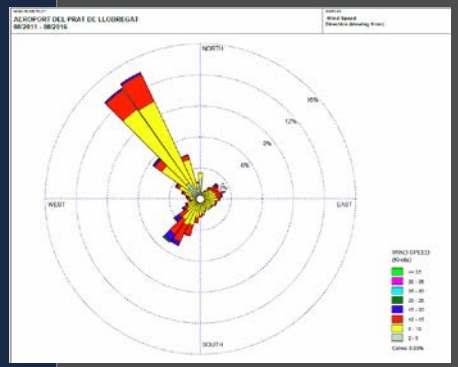
Pressures:

At the SW half of the beaches, significant widening due to sediment accumulation by Port Ginesta

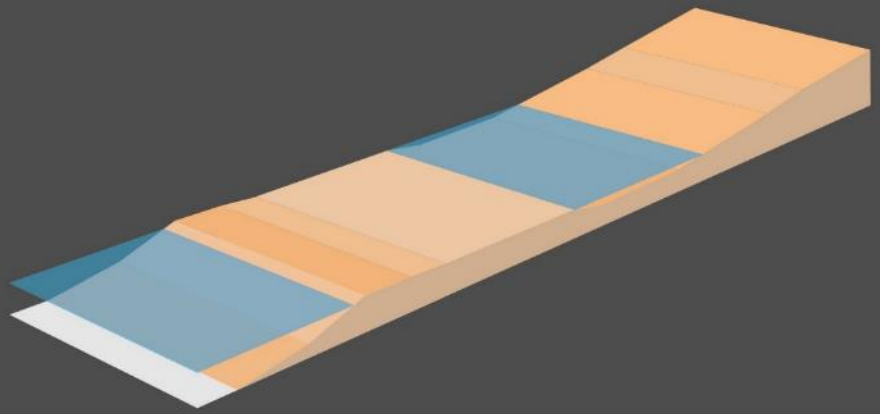


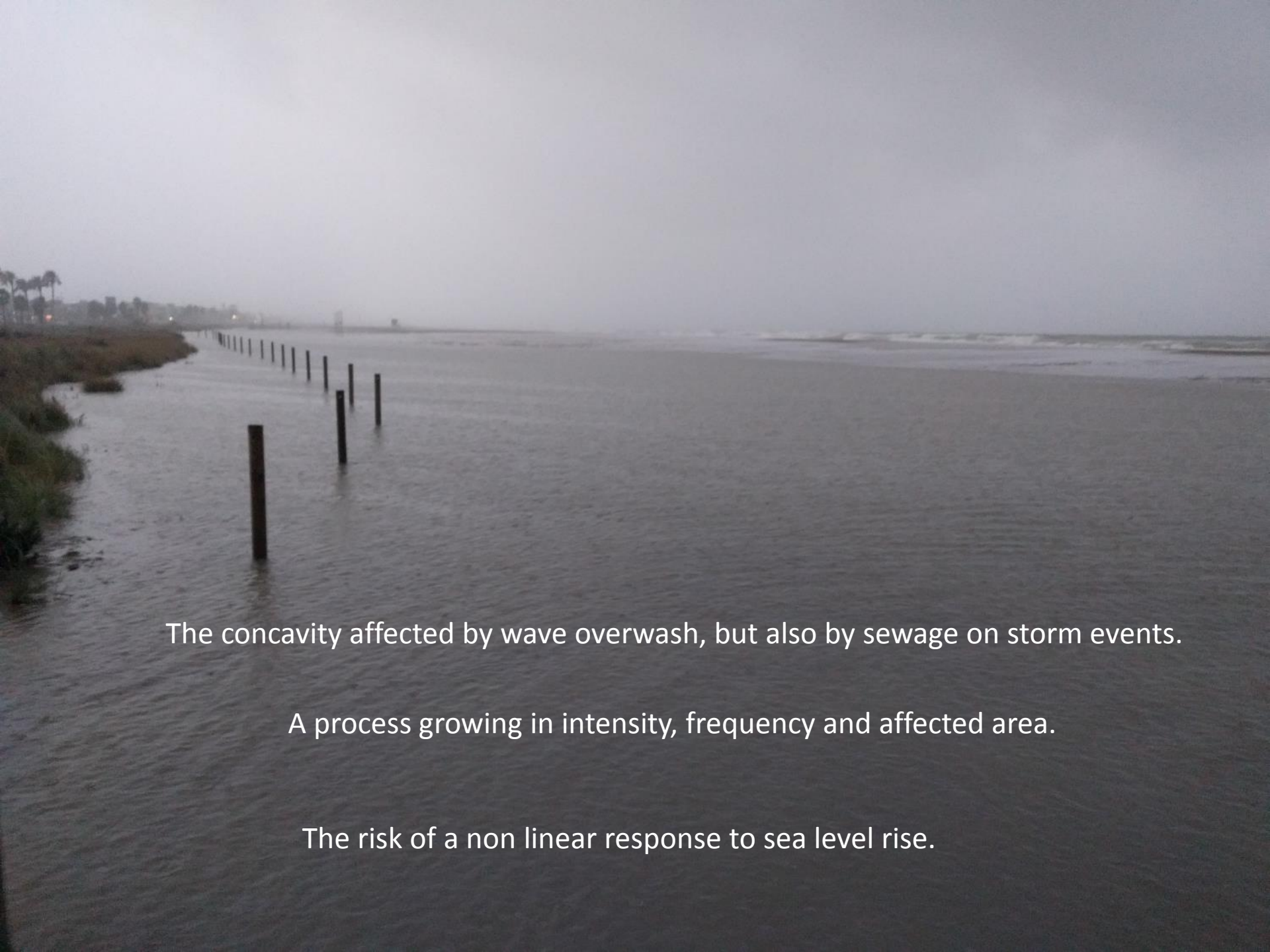
Mechanical sieving impedes vegetation growth.
Strong winter winds scour the beach till arriving to the saturated level.





This process has lead to the loss of more than 42.000 m3 of sand in just the 6 year period (2008-14).





The concavity affected by wave overwash, but also by sewage on storm events.

A process growing in intensity, frequency and affected area.

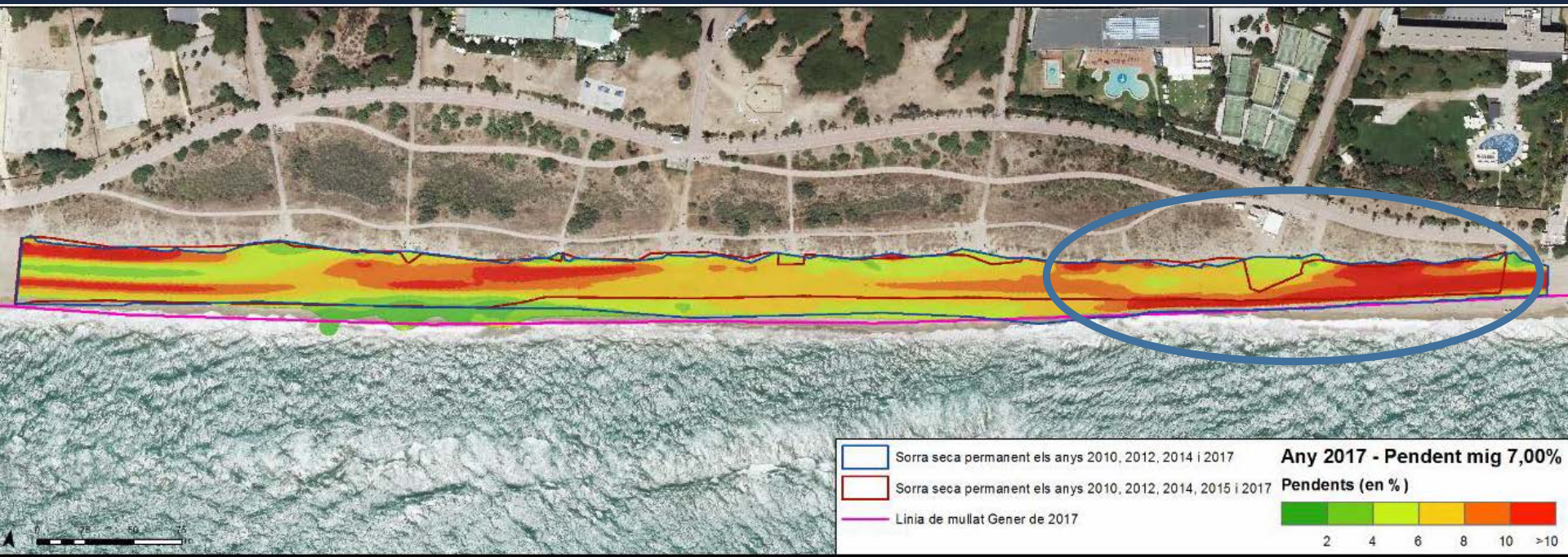
The risk of a non linear response to sea level rise.

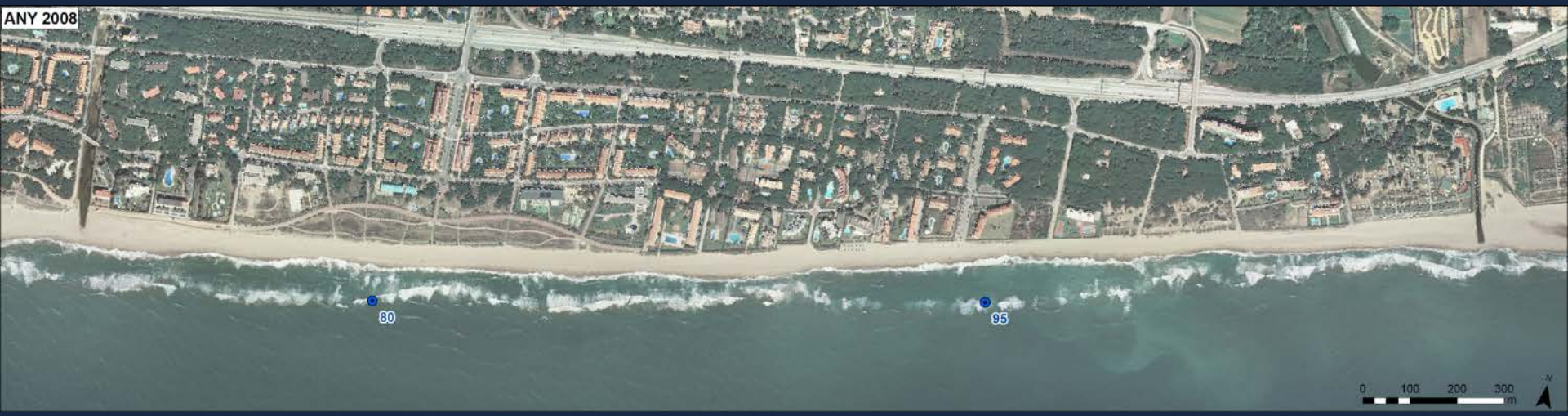
A process leading to other dysfunctions

Pressures:

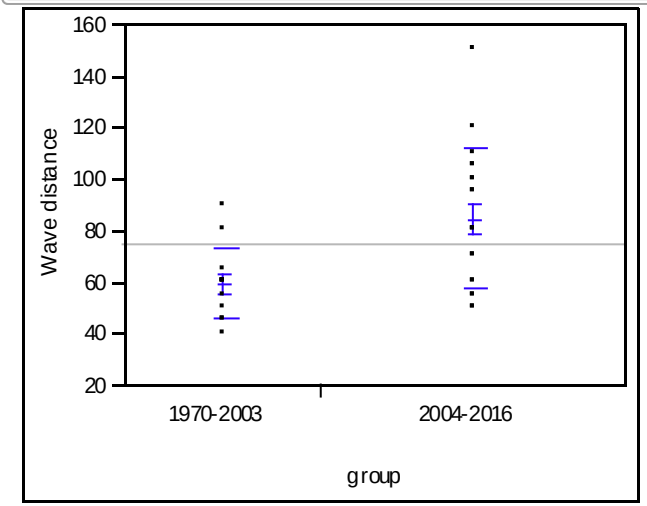
Winter profiles that do not restore spontaneously

We have found that the process of scouring, which leads to higher sand loss, is related to beach slope (> 6%).





Oneway Analysis of Wave distance By group



Excluded Rows 3

Means and Std Deviations

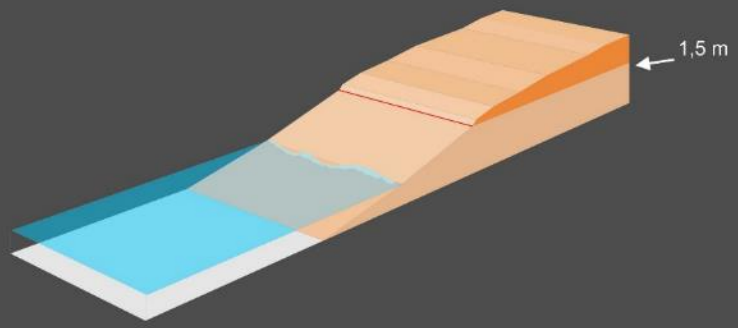
Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1970-2003	13	59,2308	13,8212	3,8333	50,879	67,583
2004-2016	20	84,5000	26,7001	5,9703	72,004	96,996

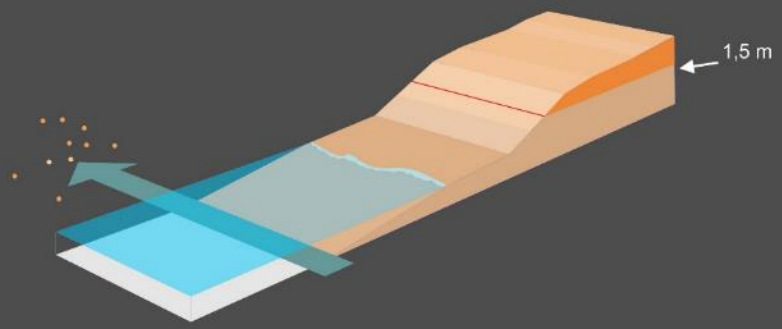
Probably sand nourishment operations increases the volume of sandbars and its distance to the shoreline, thus creating lower wave energy environments.

More spectacular sand bars related to sand nourishment works from 2004 .

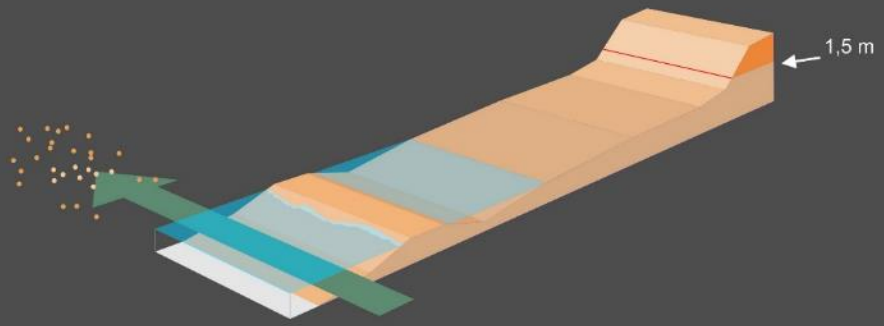
Not enough space for a ratio of $5m^2$/person and 500 visitors/100 m

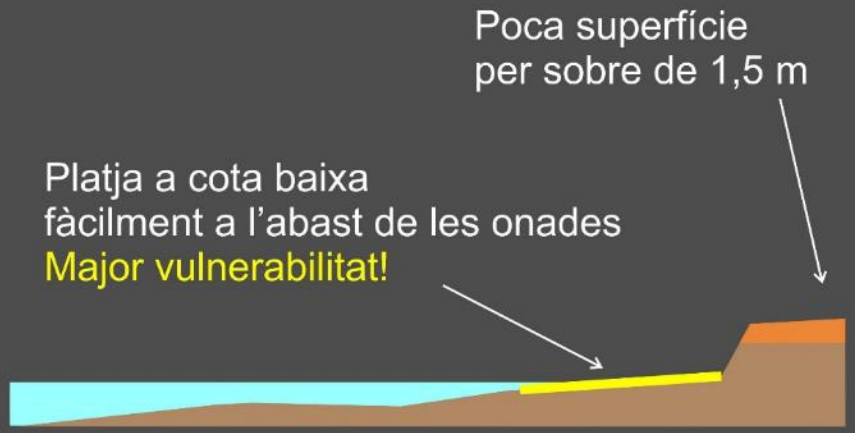
Slope determines vulnerability





When higher than 5%





A second storm, even of a much lower intensity, can scour a much bigger amount of sand. Leaving flat beaches with much less sand volume and increased vulnerability.

Pressures:

Finally the most exposed beaches keep enduring a continued erosion process.

Pressures:

Slow but constant

The role of dunes:

Exploring their limits as Nature Based solution.

Dune erosion shows how that the root system of marram grass and other dune plants don’t oppose any resistance to erosion.

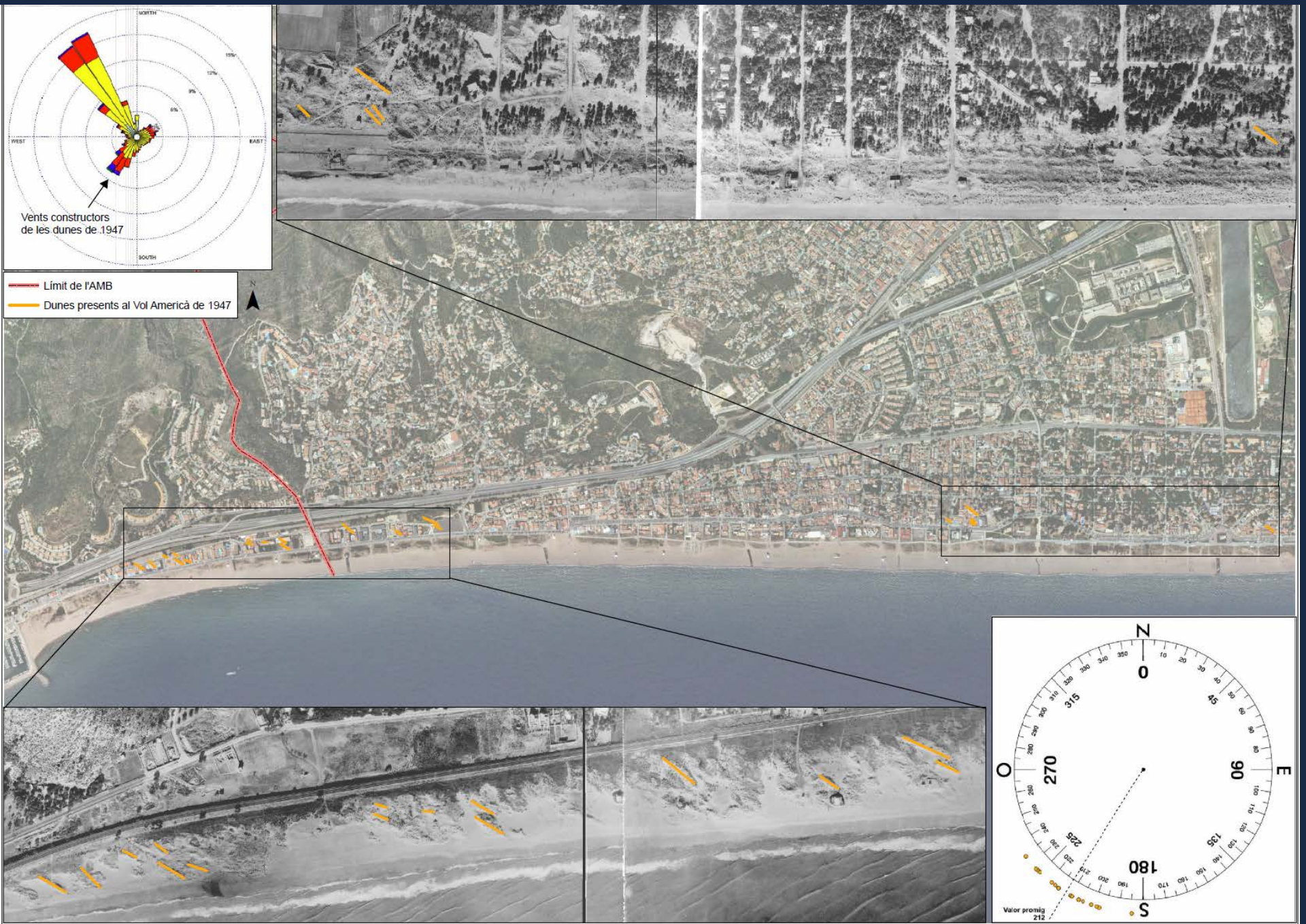
Marram grass (*Ammophila arenaria*) protects the coast by capturing sand

Biotic soil factors affecting the growth and development of *Ammophila arenaria.*

A negative feed back with vegetation cover increase.

The need of mobile and semi-mobile dunes.

Transverse dunes linked to summer winds

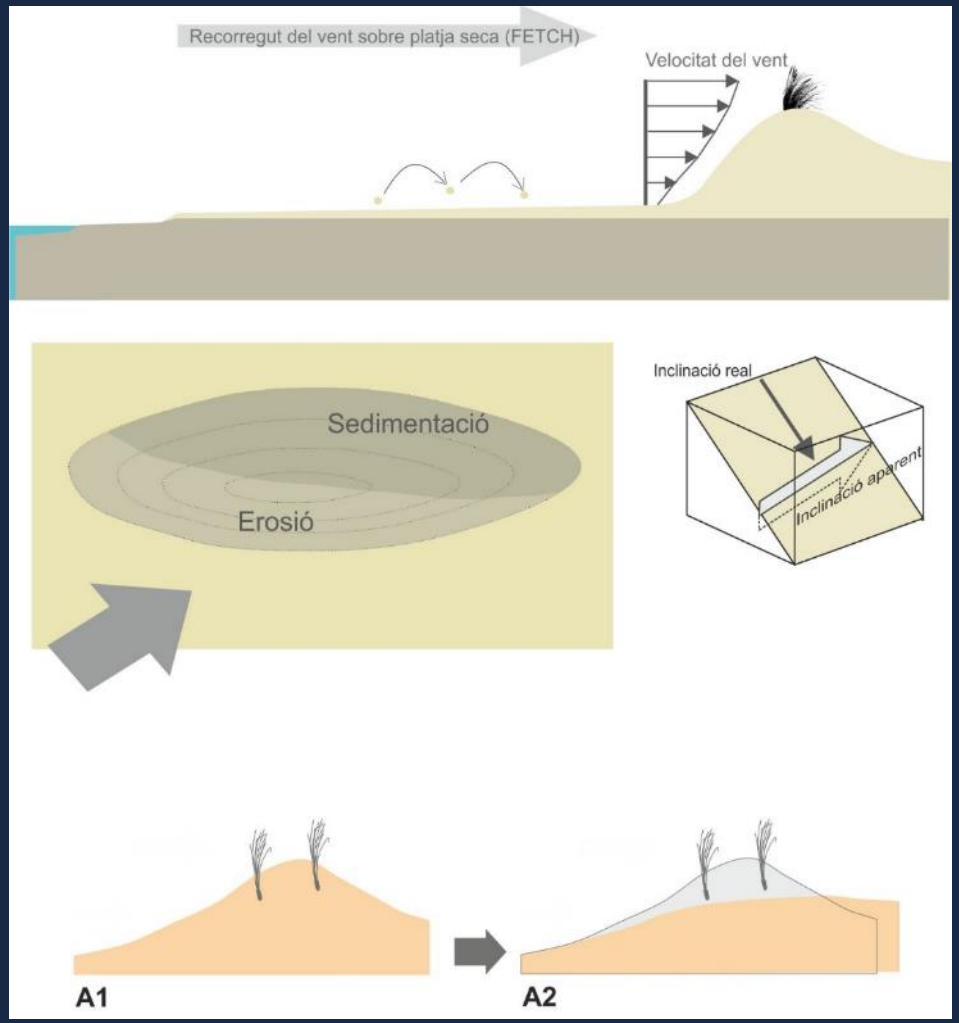


Mechanical sieving and intensive social use impedes the natural sand aeolian transport, but is only one of the relevant factors

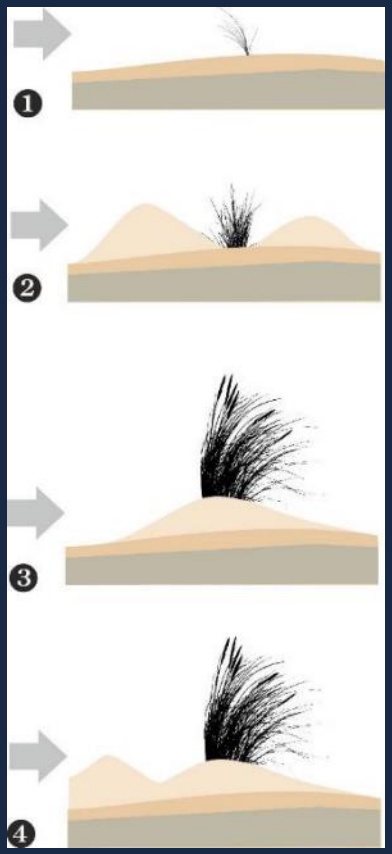
But wind still keeps its ability to erode dunes and uproot marram grass

Wind direction and its angle with the shore leads to different responses

Erosion risk areas can be thus determined. Relative slope is also a relevant factor.

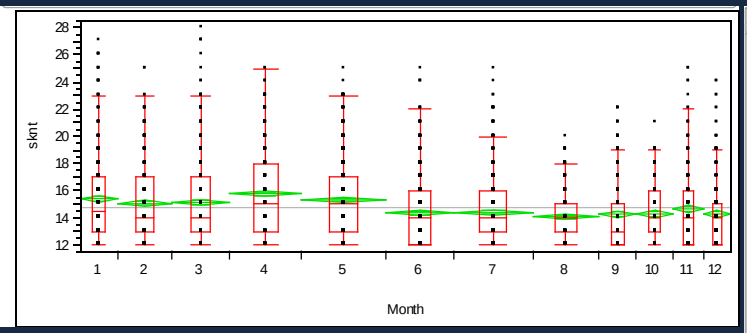


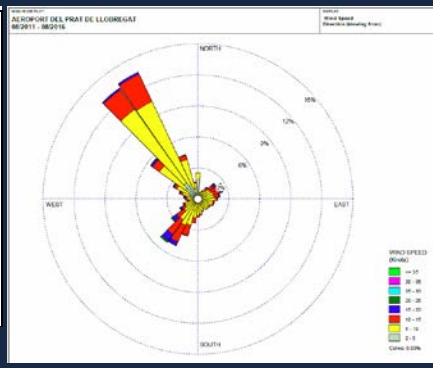
We have developed a new system to transform marram grass plantings in to efficient sand-trapping systems

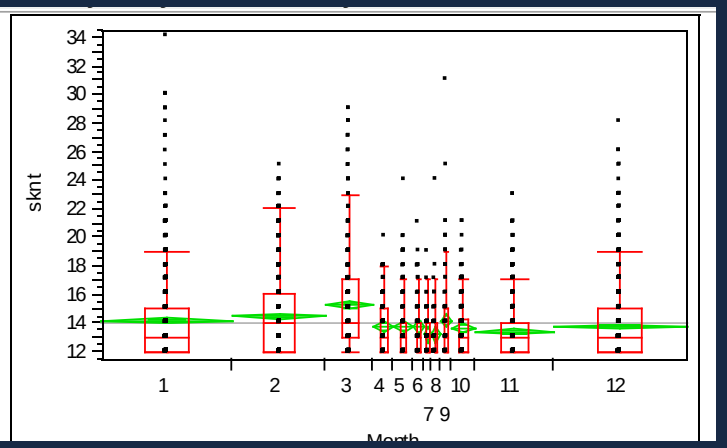


Marram grass as natural capital and core element of a nature based solution

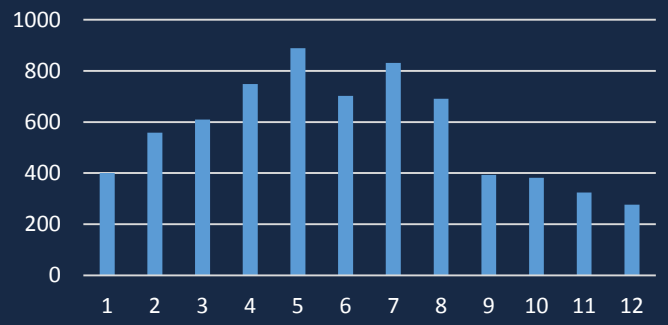
Also by the design of “illegal” dunes (in geomorphologic terms!). Constructed dunes that are perpendicular to shoreline. Thus being able to capture winter sand transport (when a critical size has been achieved).



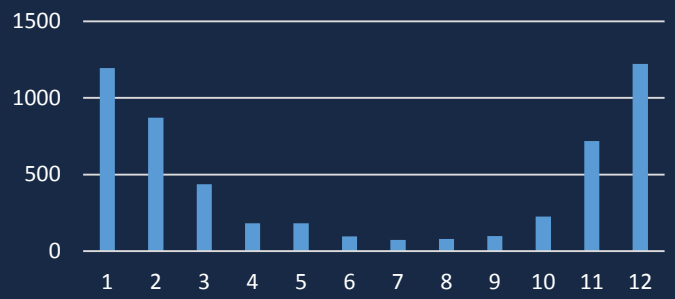




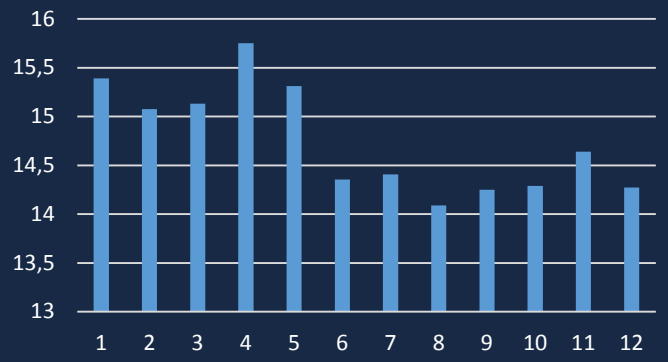
nº ½ h events>11knts 180º-270º



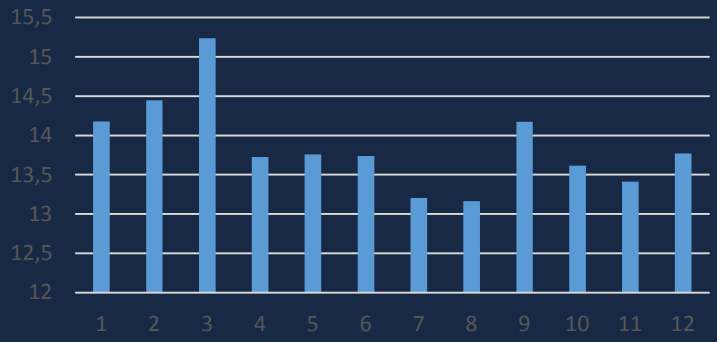
nº 1/2h events >11 knots 270º-360º



Mean velocity knts



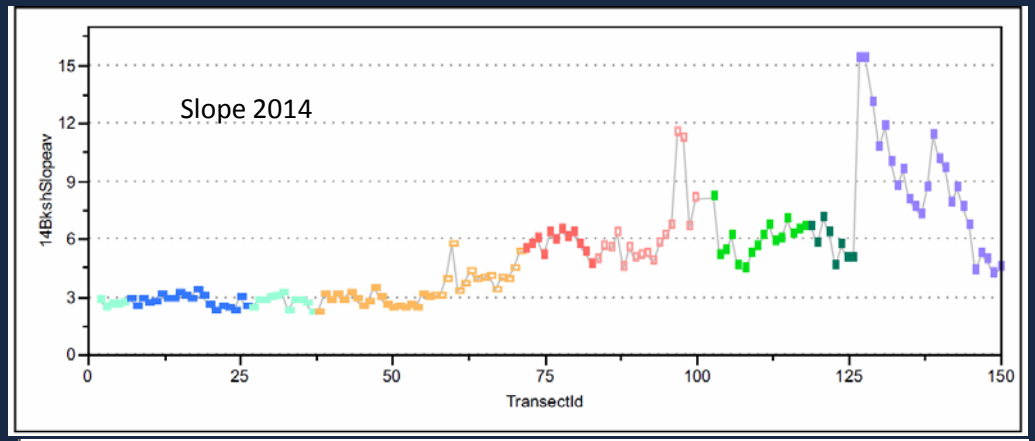
mean velocity knts

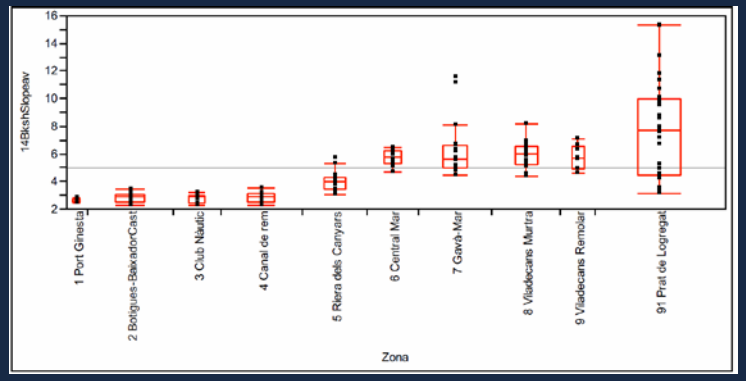


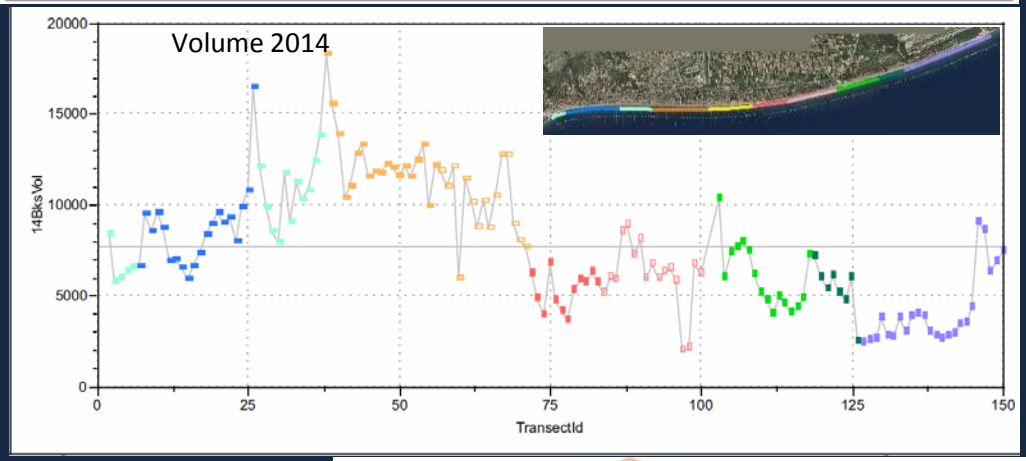
Recommendations and results:

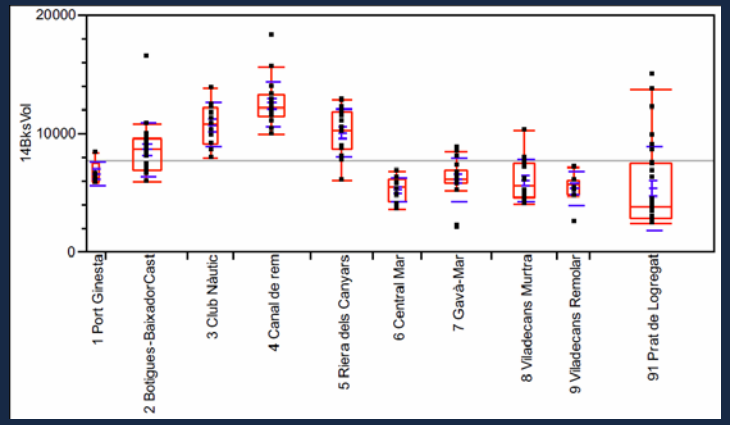
- Data driven adaptive management systems would work quite well.
- 3D beach structure is as relevant as the total emerged sand volume.
- Dune construction can be a core element of the sand budget management, and a very efficient and effective nature based solution.
- Dune construction must be balanced and complemented with other actions like beach profile reconstruction (and beach slope control), and coastal lagoons excavation.
- A sound improvement of the governance system is needed.

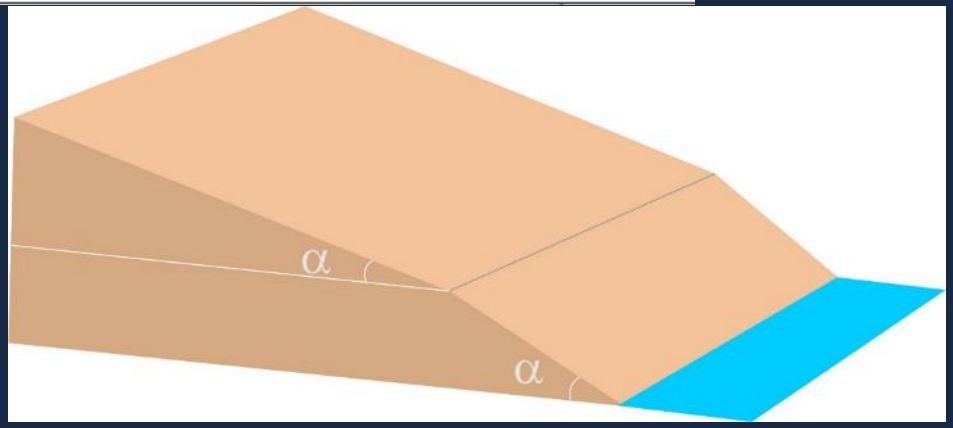
Slope and its relation with vulnerability











Slope and its relation with emerged sand volume

Bivariate Fit of 14BkshSlopeav By 14BksVol

Allows to identify zones that do not follow the correlation trend: areas with permanent sand escarpments, and flood-prone concavities.

Zones que escapen a la lògica de la correlació indiquen processos diferents: escarpaments permanents i cubetes inundables.

14BkshSlopeav

14BksVol

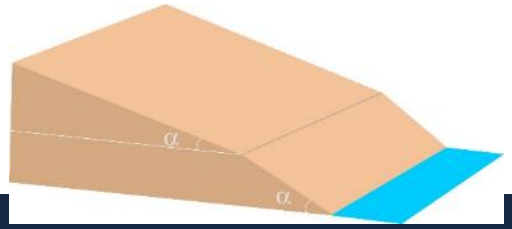
Transformed Fit to Log

Transformed Fit to Log

14BkshSlopeav = 45,354944 - 4,5219197 Log(14BksVol)

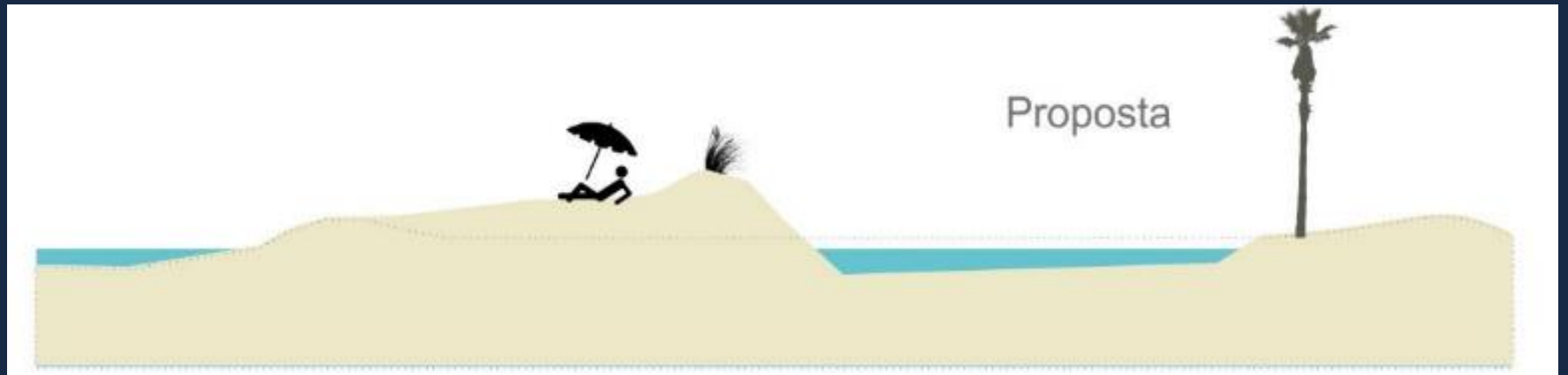
Summary of Fit

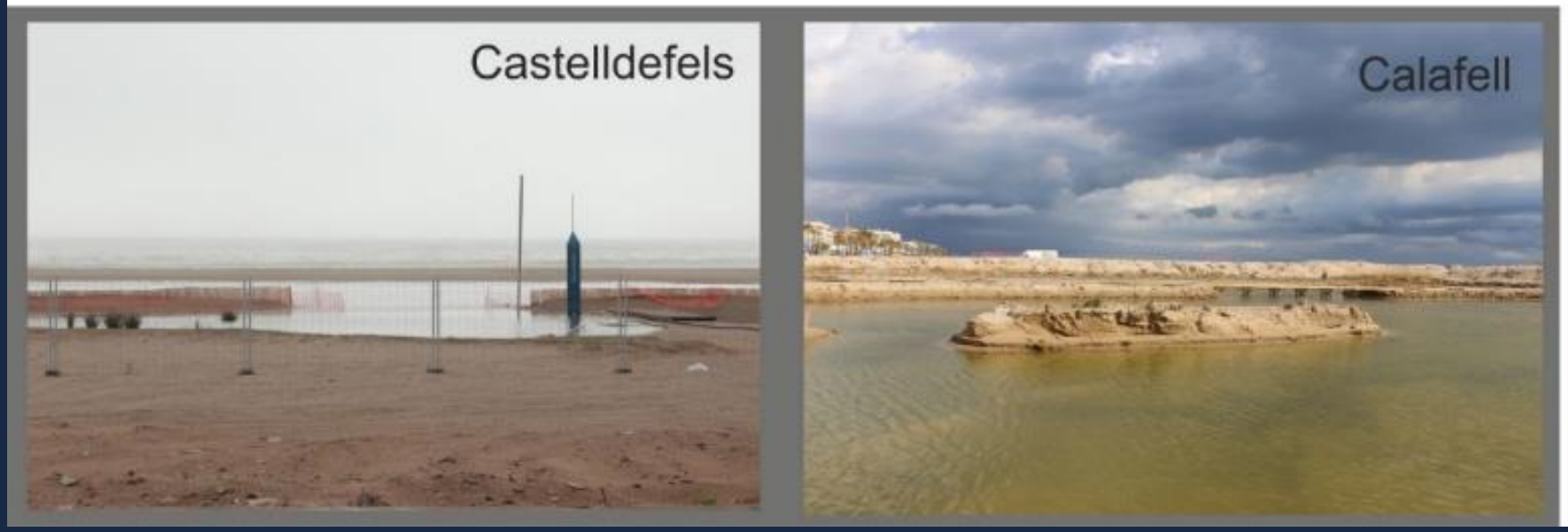
RSquare	0,790633



It is possible to have a global view of pressure trends and its response to management measures

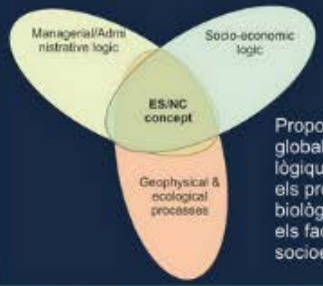
Moving emerged dry sand is very cheap and effective!
A good way to protect coast against storm surges and erosion





Governance needs, transparency, social involvement .

Serveis ecosistèmics, una visió integradora



Proporcionen una visió global que integra les lògiques de la gestió, els processos biològics i geològics, i els factors culturals i socioeconòmics.

Diversitat d'actors

La governança del litoral necessita ampliar la diversitat d'actors. Cal incorporar la complicitat dels milions de visitants anuals, anant més enllà de l'educació ambiental. Projectes de ciència ciutadana i programes de comunicació enfocats a les singularitats dels diferents grups (veïns, visitants, ..).

Economia: el valor dels serveis ecosistèmics

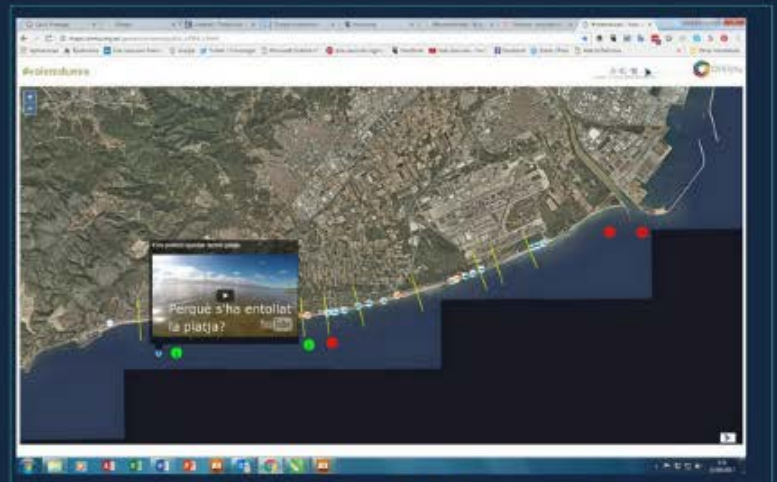
Els serveis ecosistèmics no es valoren solament en termes de serveis recreatius i de salut. Per exemple, la qualitat de la platja comporta més del 30% del preu del sòl construït. I una major diversitat d'agents implicats pot obrir les portes a noves vies de finançament.

Solucions basades en la natura

Entendre el vent i l'ecologia del borró per construir dunes. Sabem perquè la majoria dels borrons plantats anteriorment degeneraven i morien en menys de 10 anys. Hem descobert que el vent ja no pot construir dunes de forma natural, però que manté la seva capacitat d'erosionar-les. I hem après a imitar la natura per construir dunes resilients.

Hem realitzat un projecte pilot a Calafell per demostrar els beneficis de **transformar la sorra humida en llacunes litorals plenes de biodiversitat**. Un nou paisatge de gran qualitat visual.

La tecnologia LIDAR permet identificar les zones amb major vulnerabilitat i les zones que poden cedir sorra. Així es poden optimitzar els procediments de **reconstrucció dels perfils de platja amb dunes**.



Un sistema de gestió adaptatiu, transparent i obert. Les dades i els resultats de les accions es mostren en un mapa interactiu, obert a projectes de ciència ciutadana i a la transferència de coneixement per centres educatius i de recerca.

Thank you very much

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