A modified hyperbolic equation to determine equilibrium plan shape of headland bay beaches

Jon Kemp

Benoit Vandeputte (Ghent University)
Thomas Ecleshaw (UCL)
Richard Simons (UCL)
Peter Troch (Ghent University)

IMDC
International Marine & Dredging Consultants

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Introduction – coastal developments

- For coastal development projects, artificial beaches are an attractive feature
- **Static equilibrium bay theory**
- **Empirical equations** of natural headland bay beaches

Main empirical equations

Limitation

- log spiral equation: does not represent the straight section of the beach

Limitation

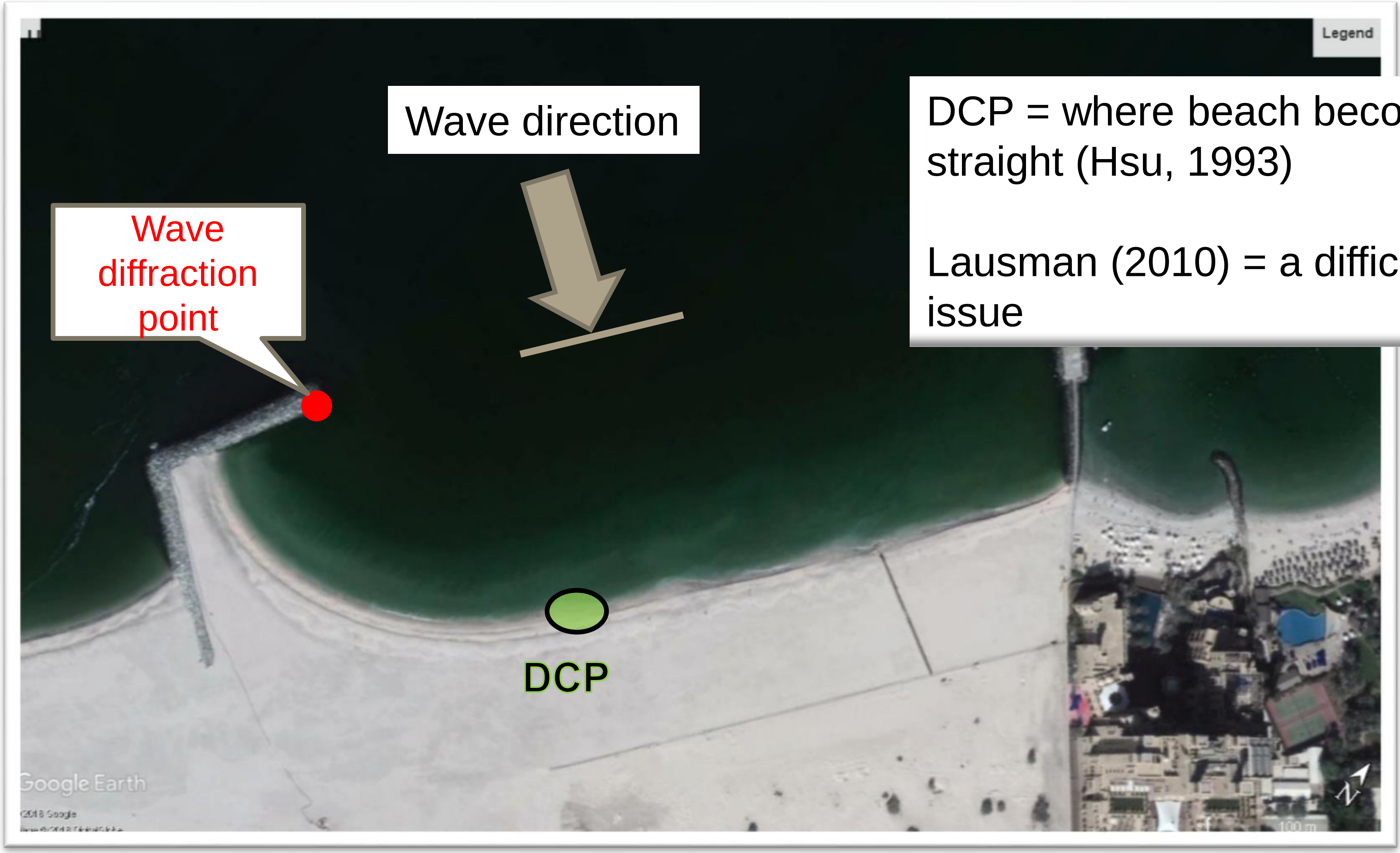
- Hyperbolic equation: lack of a tangible wave diffraction point

Limitation

- Parabolic equation: locating the downcoast control point

- Log spiral: 1965 Yasso
- Parabolic: 1989 Hsu & Evans (27 beaches)
- Hyperbolic: 1999 Moreno & Kraus (42 beaches)

Identifying the downcoast control point



DCP = where beach becomes straight (Hsu, 1993)

Lausman (2010) = a difficult issue

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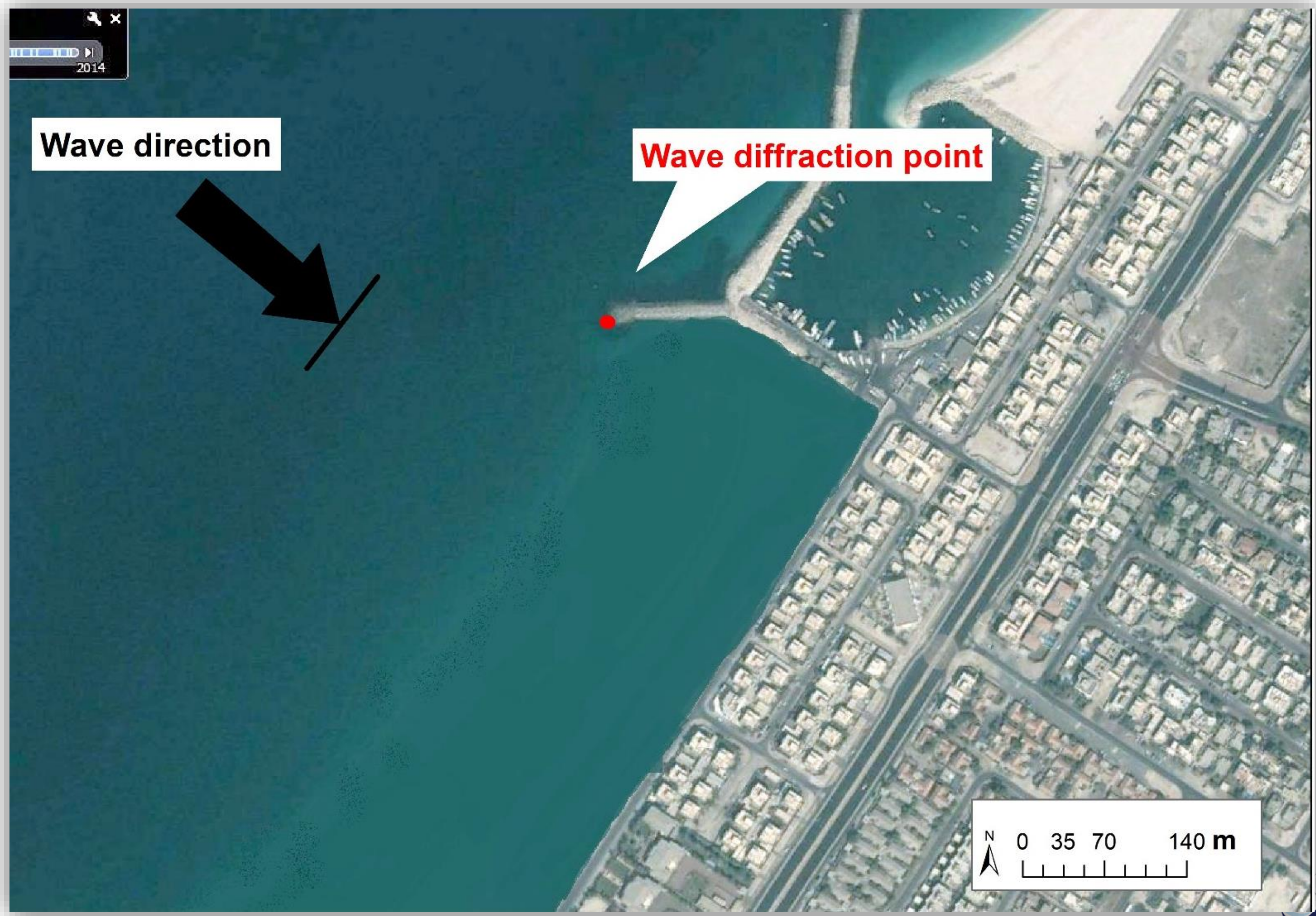
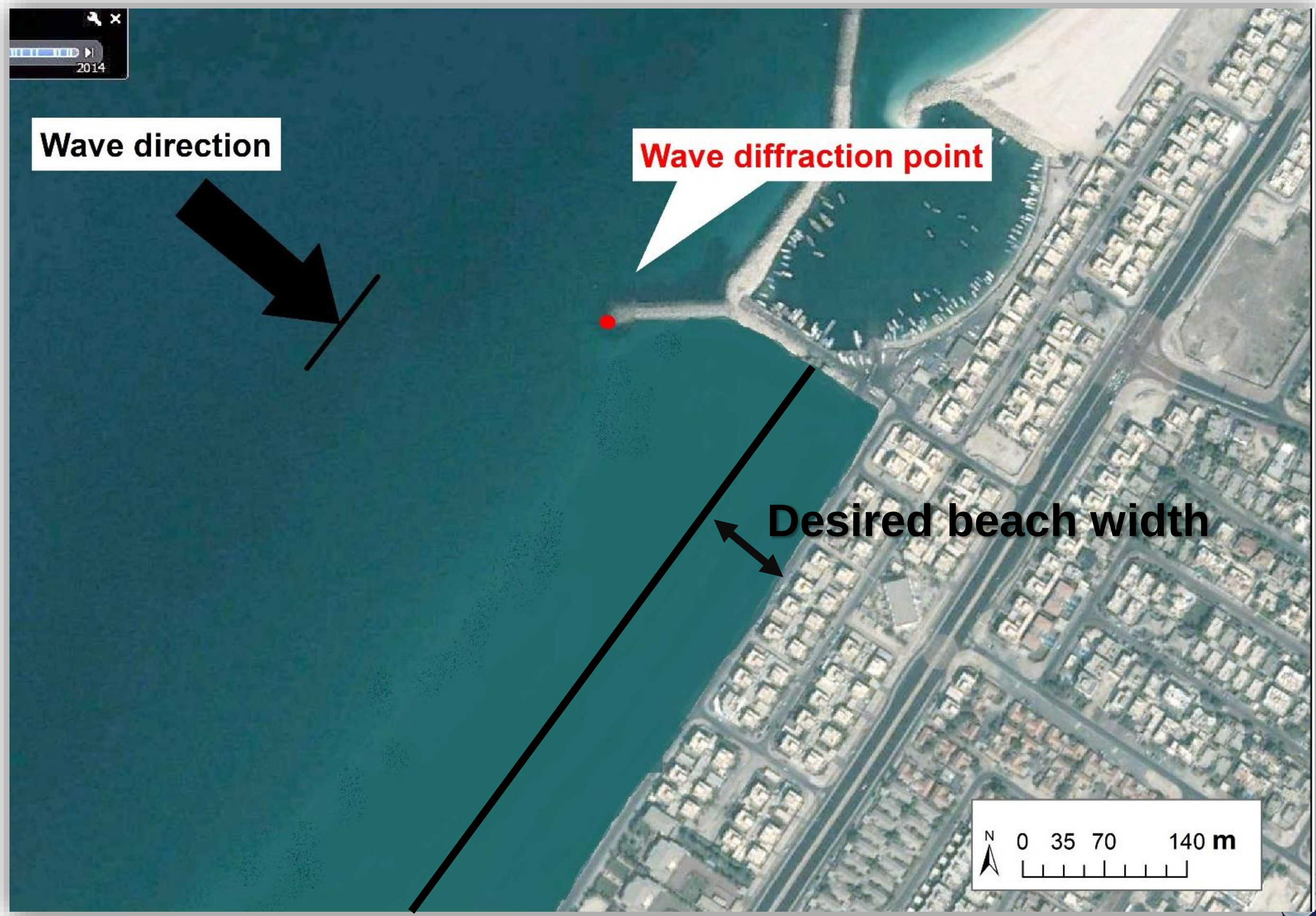
The problem

- Identifying the downcoast point



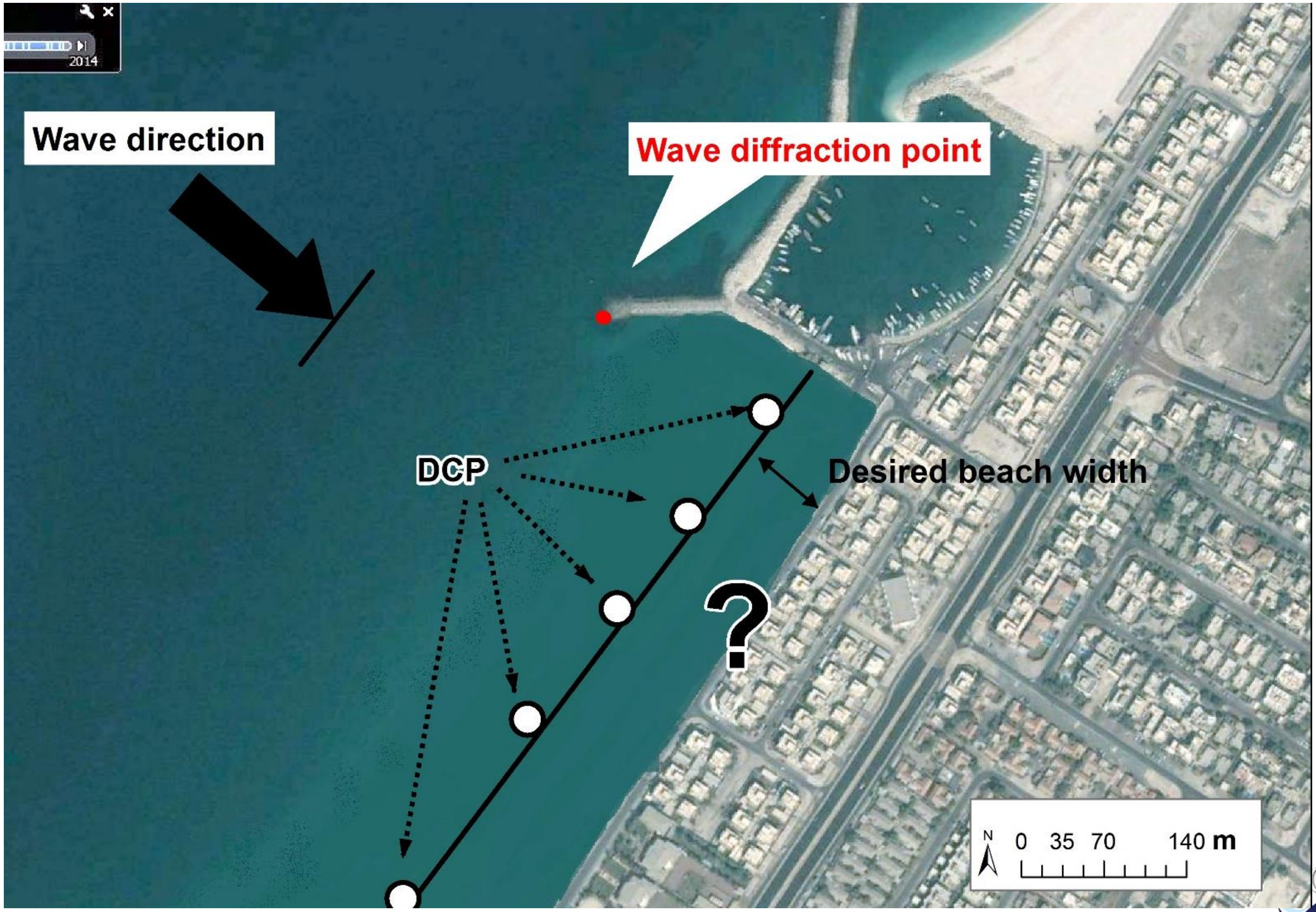
The problem

- Identifying the downcoast point



The problem

- Identifying the downcoast point

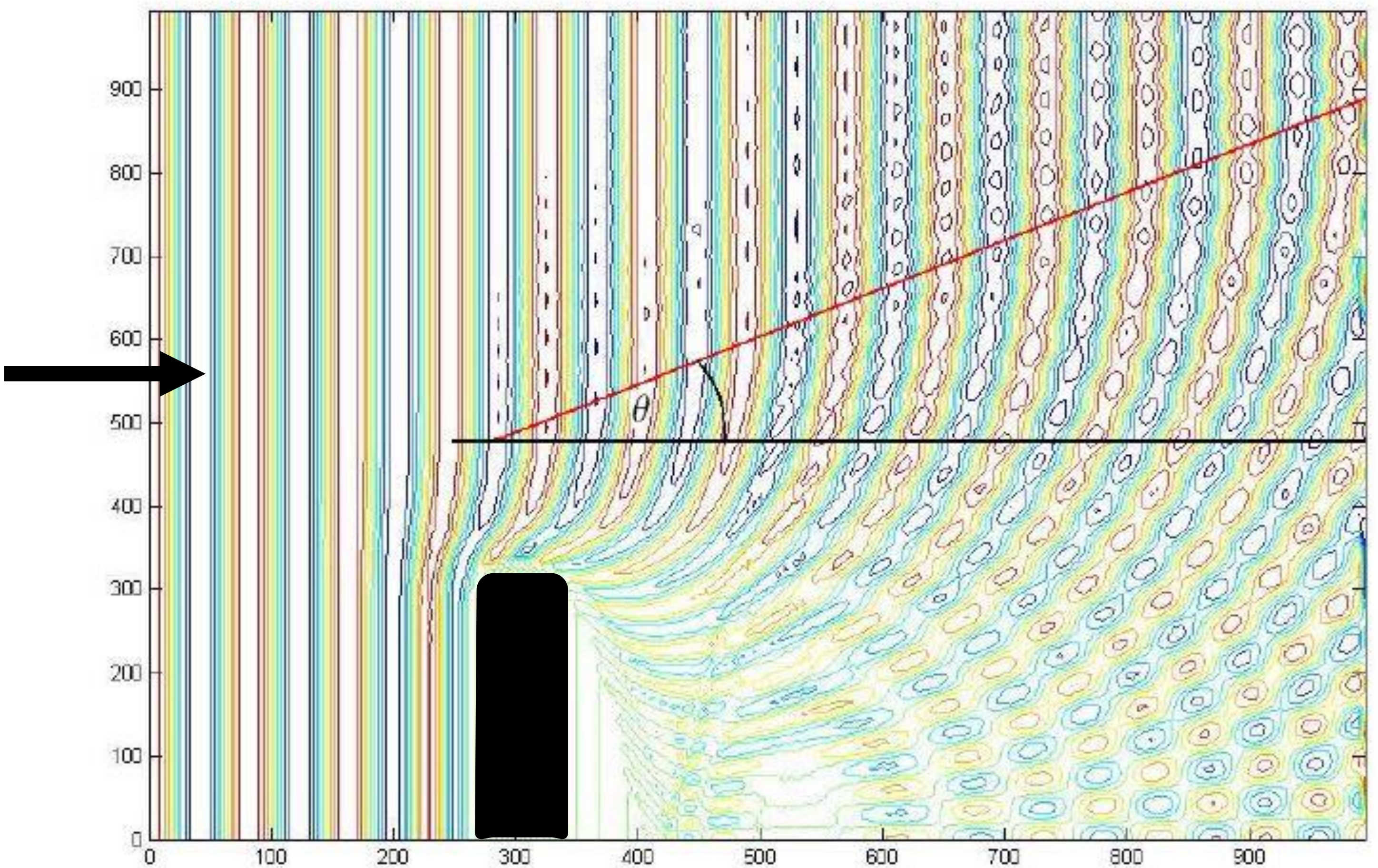


The solution - Experiment 1

- Assessment of existing beaches

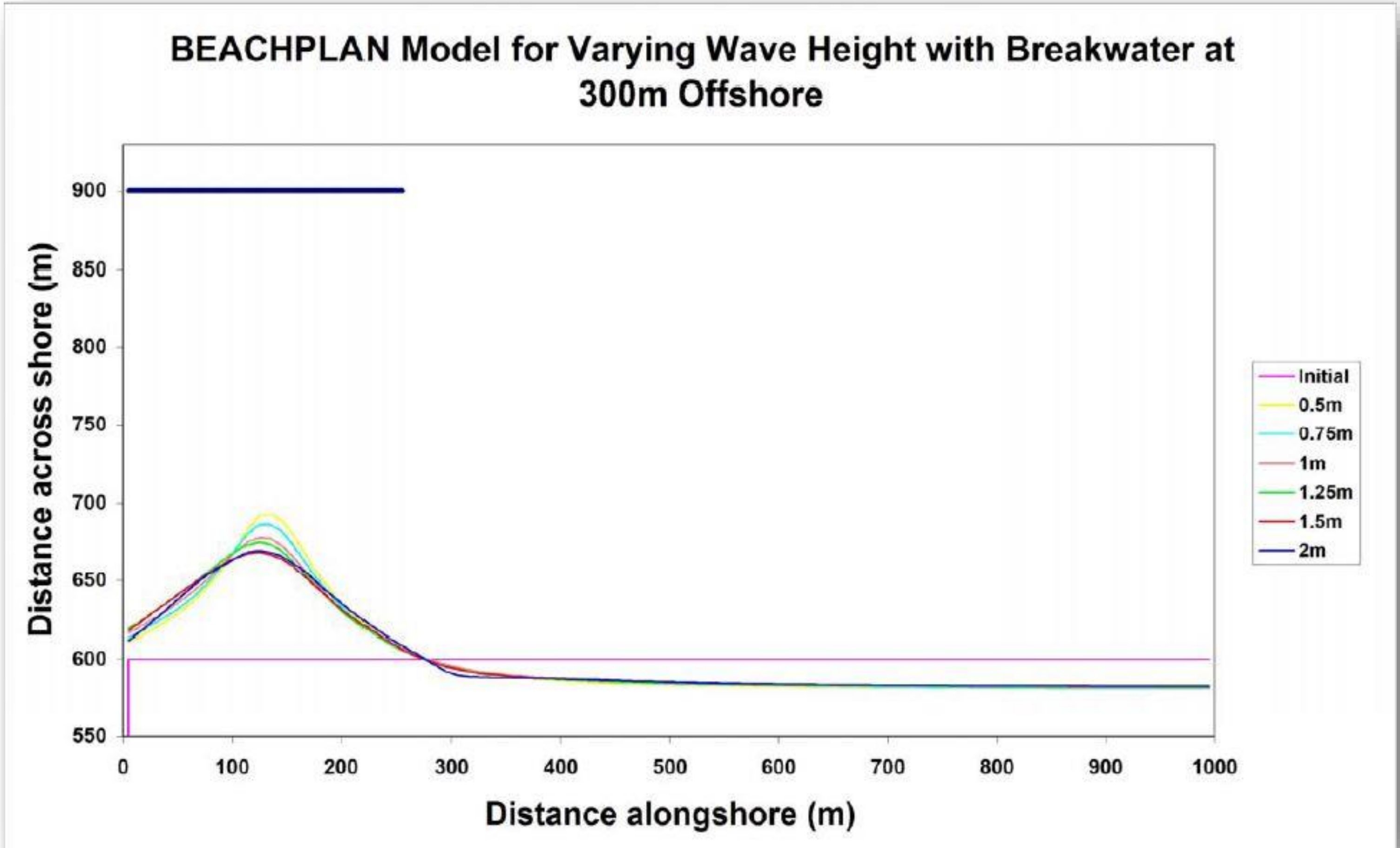
The solution - Experiment 2

- Wave modelling: REF/DIF
  - Tp: 6-15s, Hs:0.5-2.0m, Dir ±40°



The solution - Experiment 3

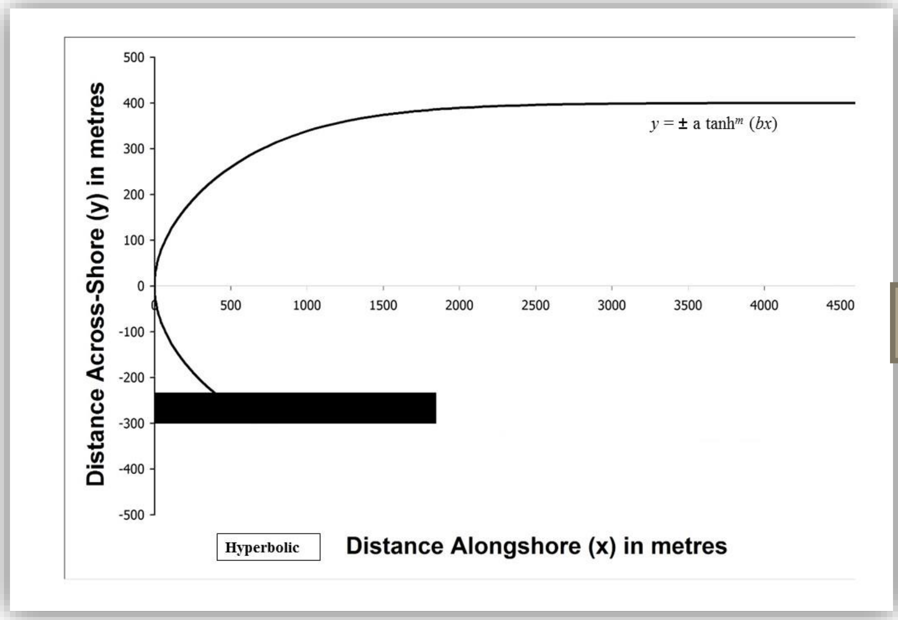
- Beach modelling: Beachplan
  - 10 year timeseries of waves

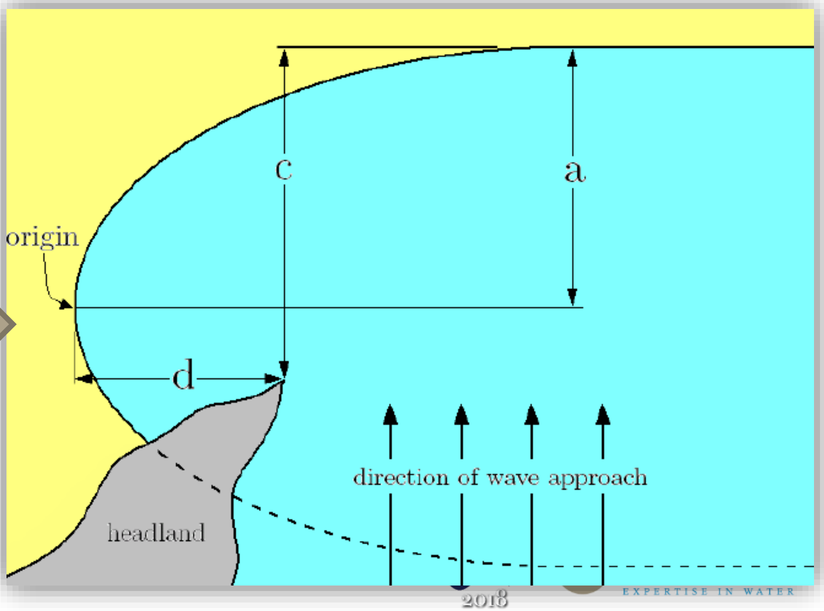


The Solution: Experiment 4

- Remove need of DCP
- Revisit Hyperbolic Tangent Bay Shape Equation

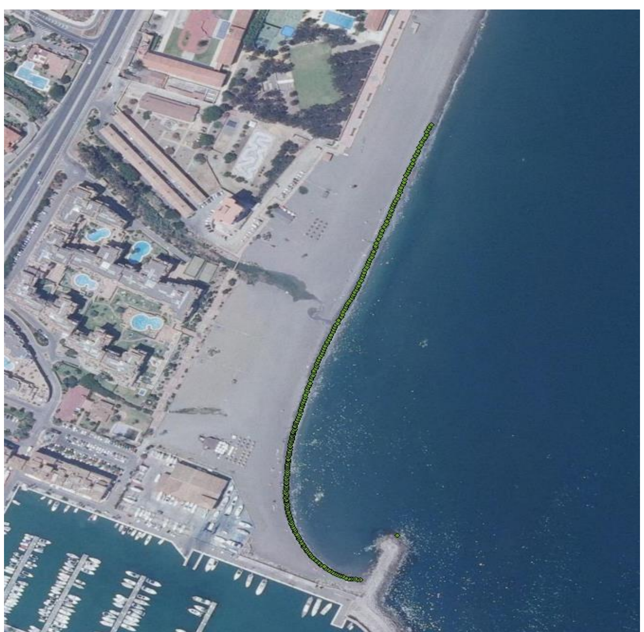
1. **Determining the wave diffraction point in the <u>hyperbolic</u> equation**

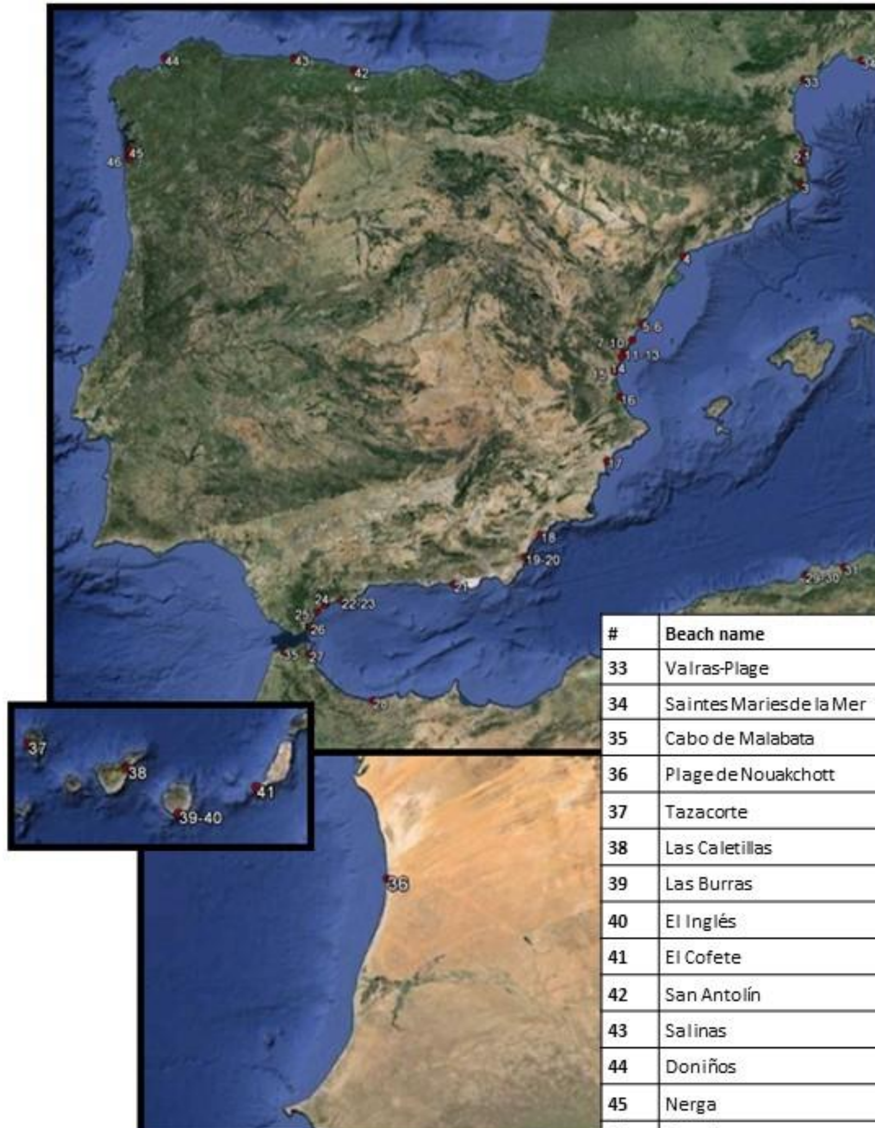




Assessment of beaches

1. **46 beaches**
   a) **1 headland**
   b) **Equilibrium**
   c) **Straight section**
   d) **Digitised shoreline**



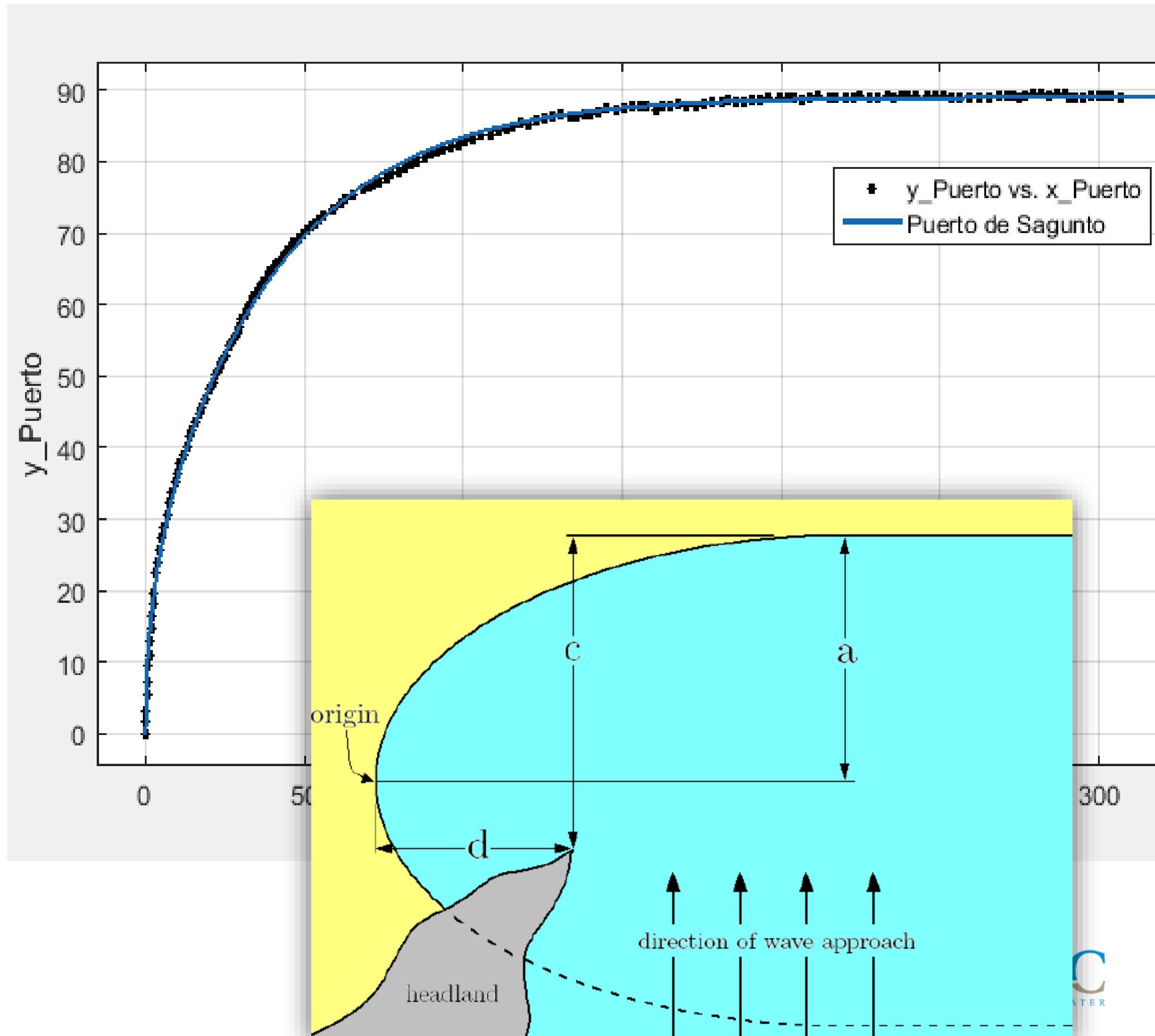


#	Beach name
1	Rastrell
2	Moll Grec
3	Torre Valentina
4	L'Arenal
5	Torre Sant Vicent
6	Els Terrers
7	Benafeli
8	Benafeli
9	Benafeli
10	Benafeli
11	L'Estanyol
12	Les Cases
13	El Cerezo
14	Racó de Mar
15	Port de Sagunt
16	El Racó
17	El Postiguet
18	La Colonia
19	El Cantal
20	Cueva del Lobo
21	Censo
22	Nagüeles
23	Río Verde
24	El Cristo
25	Sabinillas
26	Catalan Bay
27	Plage de Restinga
28	Plage de Torres de Alacala
29	Plage Zéralda_1
30	Plage Zéralda_2
31	Plage de Boumerdès
32	Plage du Rocher Noir
33	Valras-Plage
34	Saintes Maries de la Mer
35	Cabo de Malabata
36	Plage de Nouakchott
37	Tazacorte
38	Las Caletillas
39	Las Burras
40	El Inglés
41	El Cofete
42	San Antolín
43	Salinas
44	Doniños
45	Nerga
46	Panxón

Determine wave diffraction point

- **a)** **Best fit hyperbolic curve in matlab by varying a, b & m coefficients**
  - **i.** **m ≈ 0.5**
  - **ii.** $b = 1.573 \cdot a - 1.07$

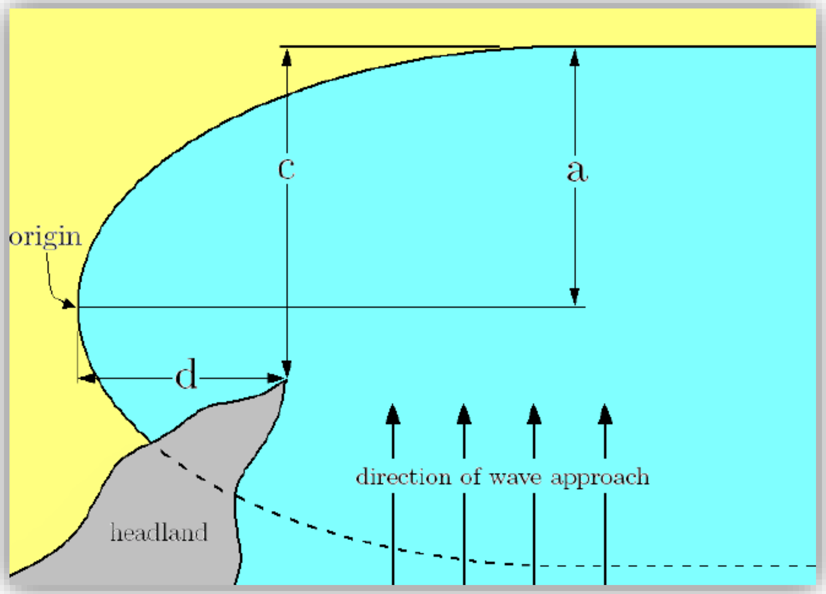
- **b)** **Determine wave diffraction point coordinates and scaling (c,d,a)**
- **c)** **relative to the origin of the hyperbolic tangent equation**
  - **i.** **X coordinate c/a = 1.256**
  - **ii.** **Y coordinate d/a = 0.517**



New hyperbolic equation

1. Create modified hyperbolic tangent equation

$$y = (\pm(0.82c)\, tanh^{0.55}\, ((1.464/c)x + 0.588)) + 0.18c$$



where:

y = Distance cross shore [m]

x = Distance along shore [m]

c = Orthogonal distance between straight section of the beach and the point of wave diffraction [m]

Only C is required input and is related to beach width

Conclusion: Application of modified hyperbolic equation

1. **GIS tool**
   a) Define the diffraction point by the clicking on the headland
   b) Define the wave direction
   c) Defines the beach width by clicking on the appropriate section of the beach
   d) Beach planshape plotted

For more information see the paper or contact me at **Jon.Kemp@imdc.be**