

Hidrodinámica en las Bahía

Caso de estudio: Bahía de Cádiz

Ingeniería de Costas 2015-2016

Carmen Zarzuelo Romero
zarzueloc@ugr.es

- **Características Generales**
 - Bahía
 - Comportamiento hidrodinámico
- **Caso de estudio: Bahía de Cádiz**
 - Situación
 - Futuras actuaciones
 - Comportamiento hidrodinámico
 - Estudio analítico
 - Estudio numérico
 - Campañas de campo

Bahía

- Una bahía es una entrada a un mar, océano o lago rodeada por tierra excepto por una apertura, que suele ser más ancha que el resto de la penetración en tierra adentro. *(Wikipedia)*
- Entrada de mar en la costa, de extensión considerable, que puede servir de abrigo a las embarcaciones. *(RAE)*
- Entrada de mar en la costa, ancha y de extensión considerable, pero menor que la del golfo. *(Wordreference)*

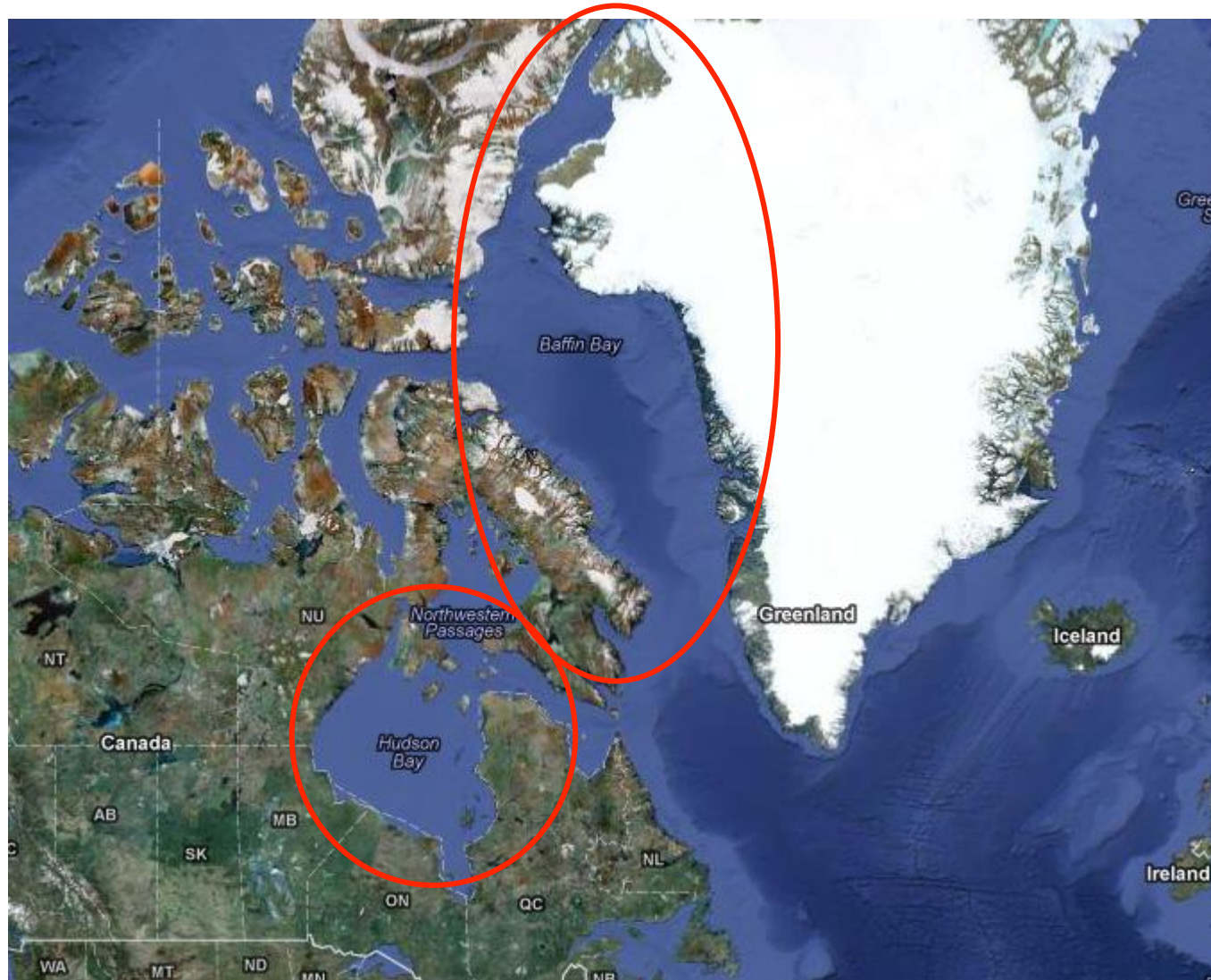
Bahía

- Formada por los movimientos del mar o del lago.
- Gran importancia económica y estratégica para las zonas colindantes.

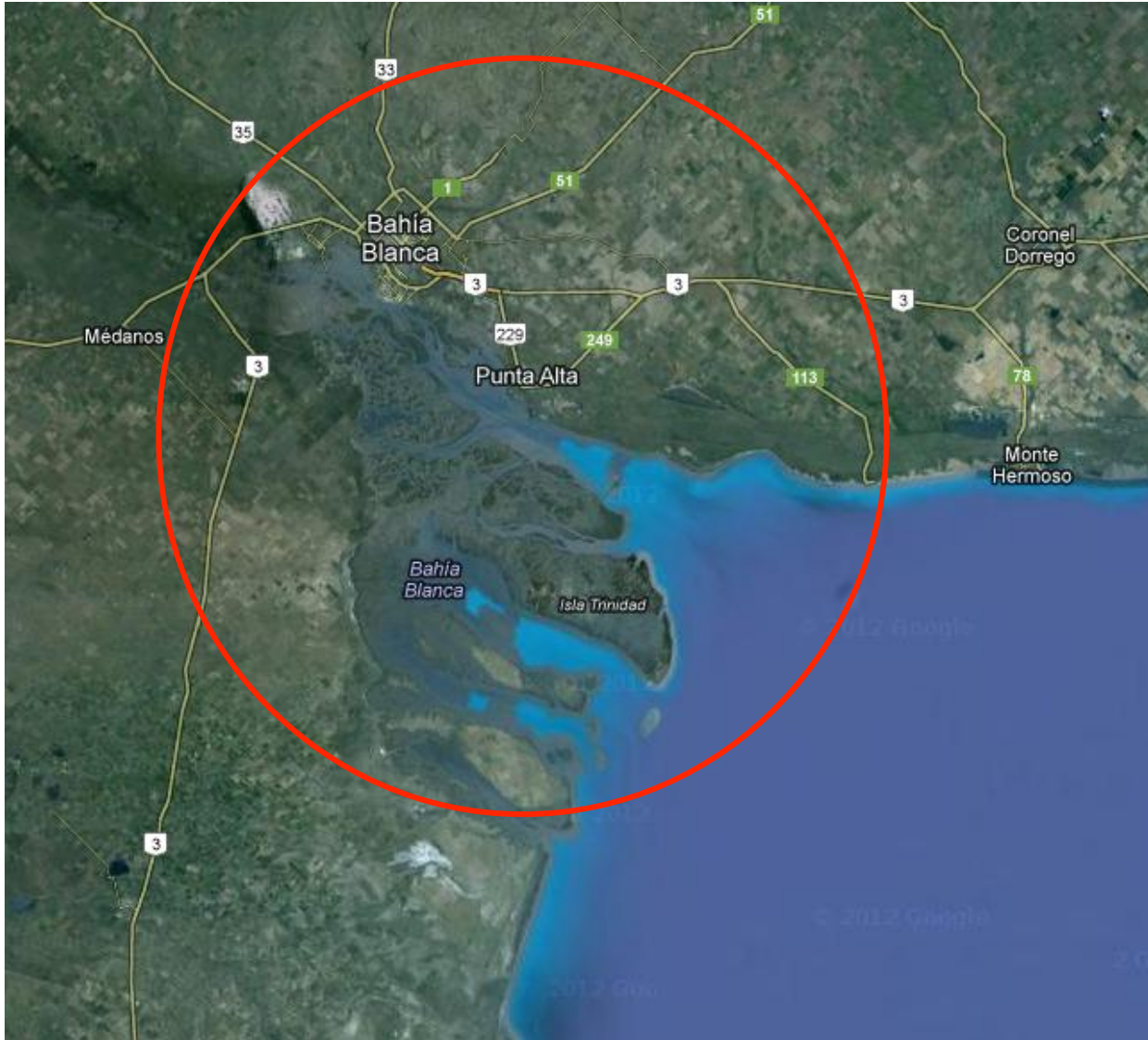
Bahía

- Formada por los movimientos del mar o del lago.
- Gran importancia económica y estratégica para las zonas colindantes.
 - Puertos
 - Comercio
 - Industria
 - Núcleos urbanos

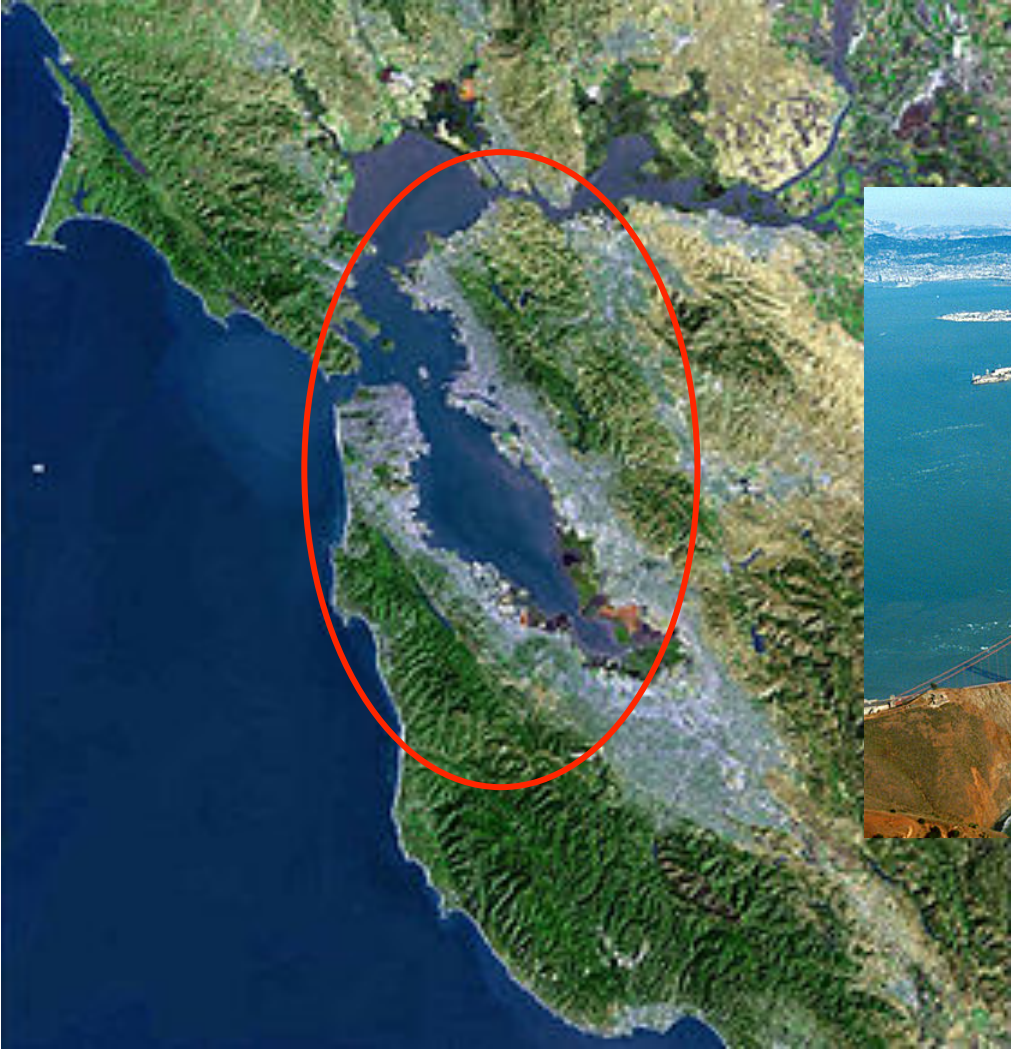
Bahía Hudson y Baffin (Canadá)



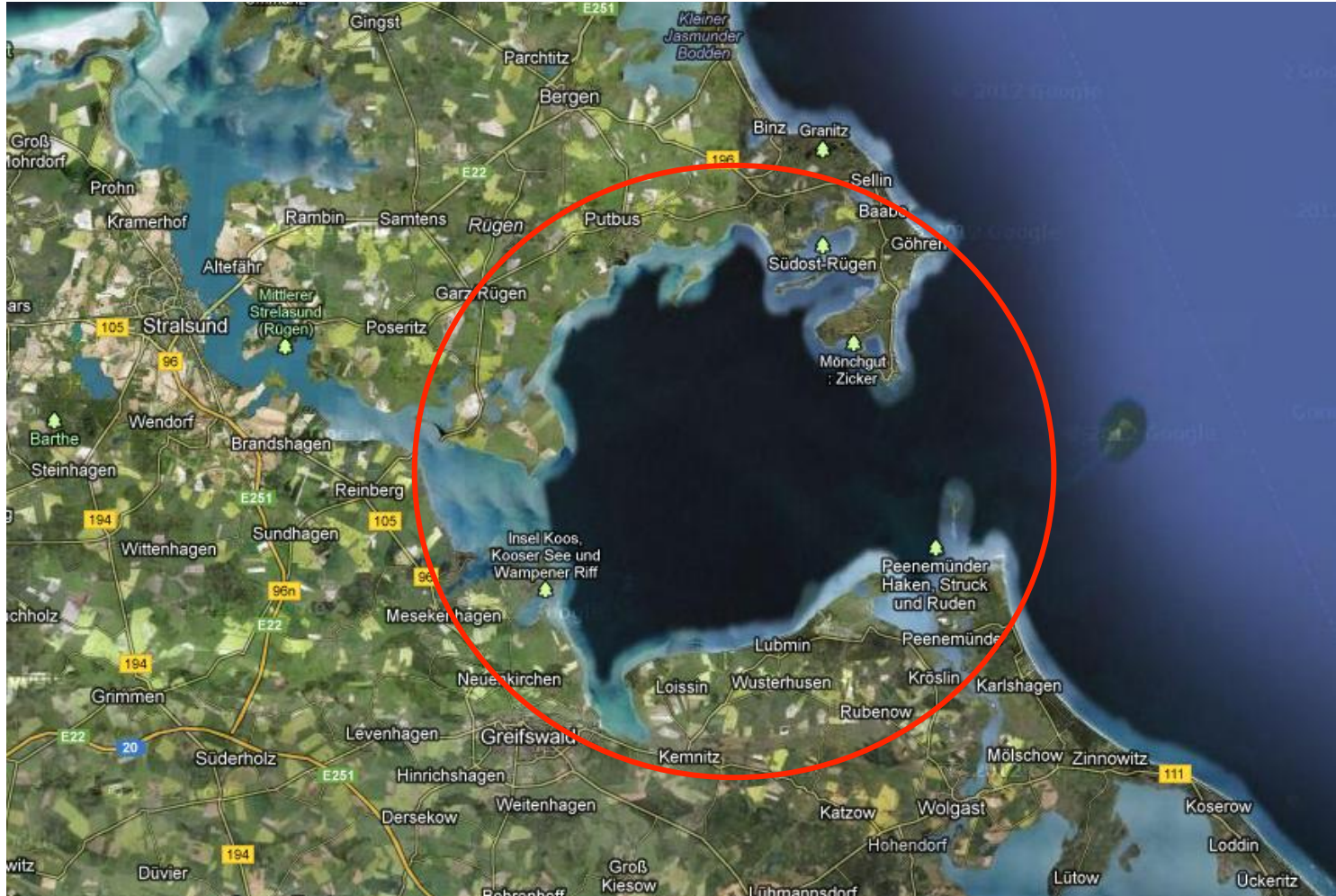
Bahía Blanca (Argentina)



Bahía San Francisco (EEUU)



Bahía Greifswald (Alemania)



Bahía La Concha (España)



Bahía Cádiz (España)

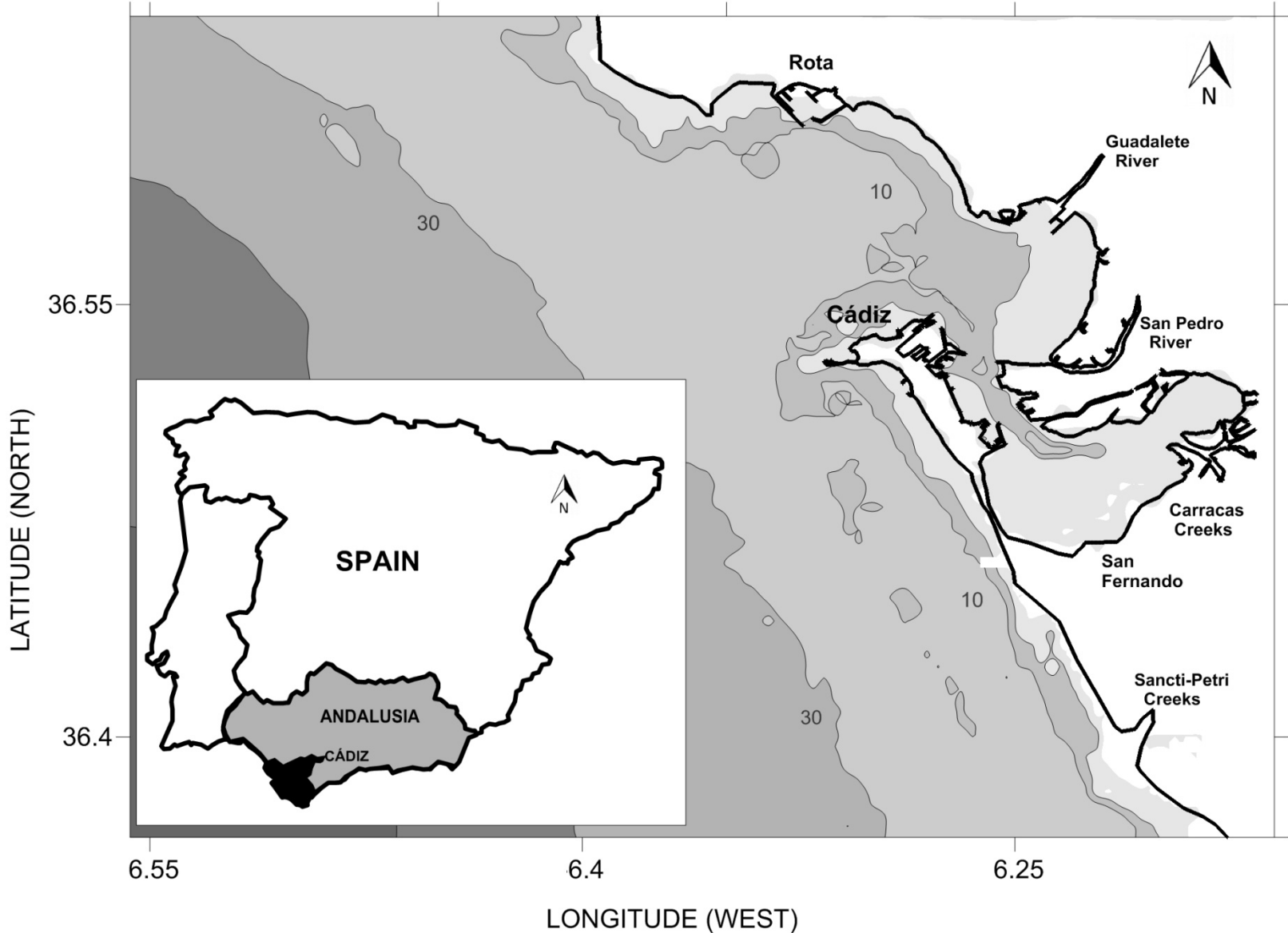


Comportamiento hidrodinámico

(Dividir en 6 ppt)

- Tres partes: Externa, Interna y Conexión
- Intercambio de flujos y sedimentos
- Pérdidas de carga
- Caracterizar de la marea y las corrientes
- Interacción del viento y oleaje
- Forzamientos atmosféricos y fluviales

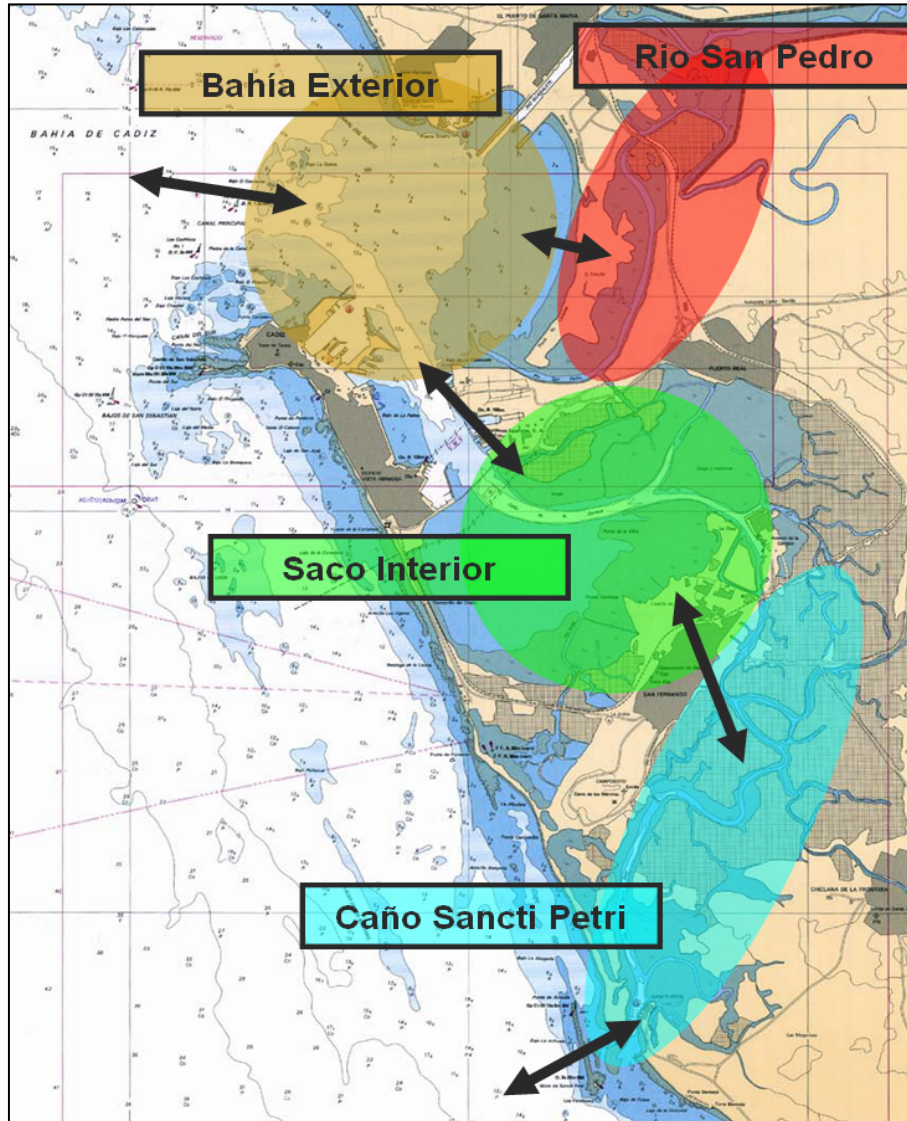
Caso de Estudio: Bahía de Cádiz



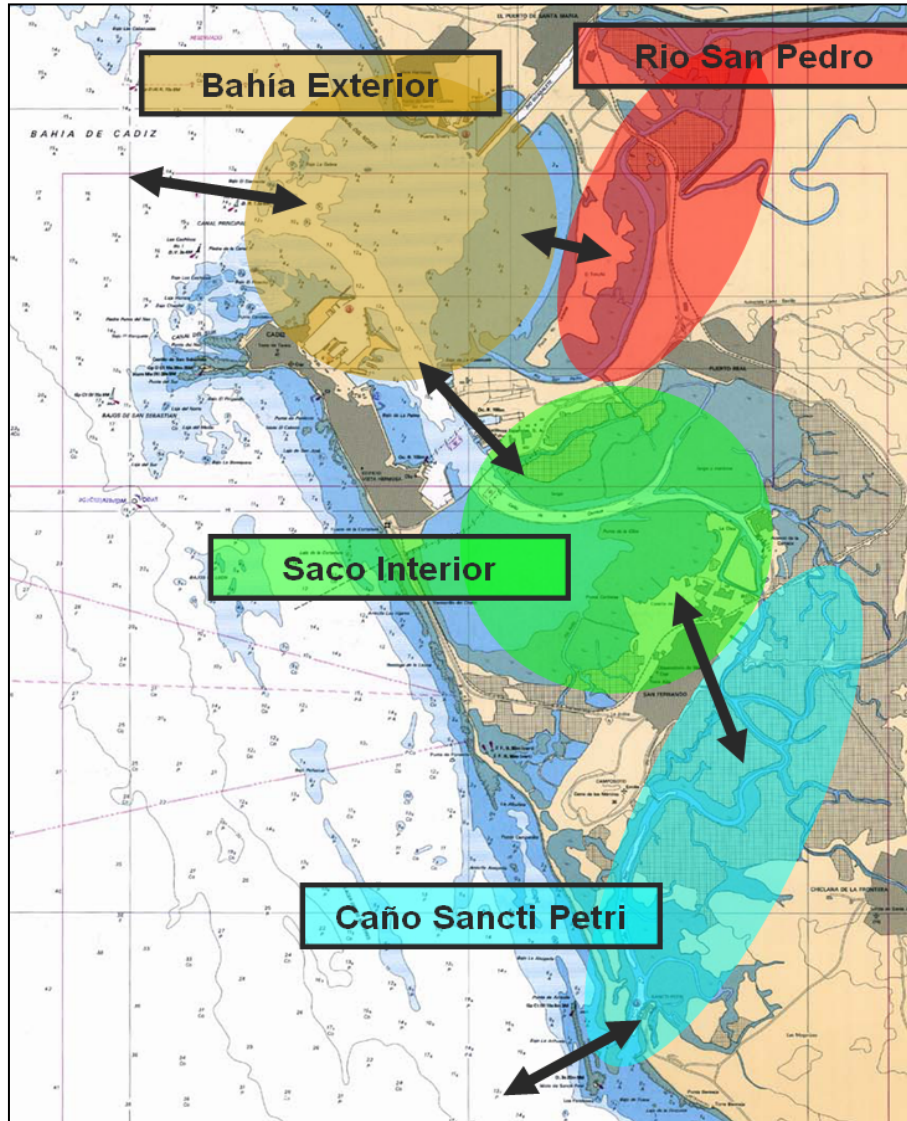
Caso de Estudio: Bahía de Cádiz

- Situación
- Futuras actuaciones
- Comportamiento hidrodinámico
 - Estudio analítico
 - Estudio numérico
 - Campañas de campo

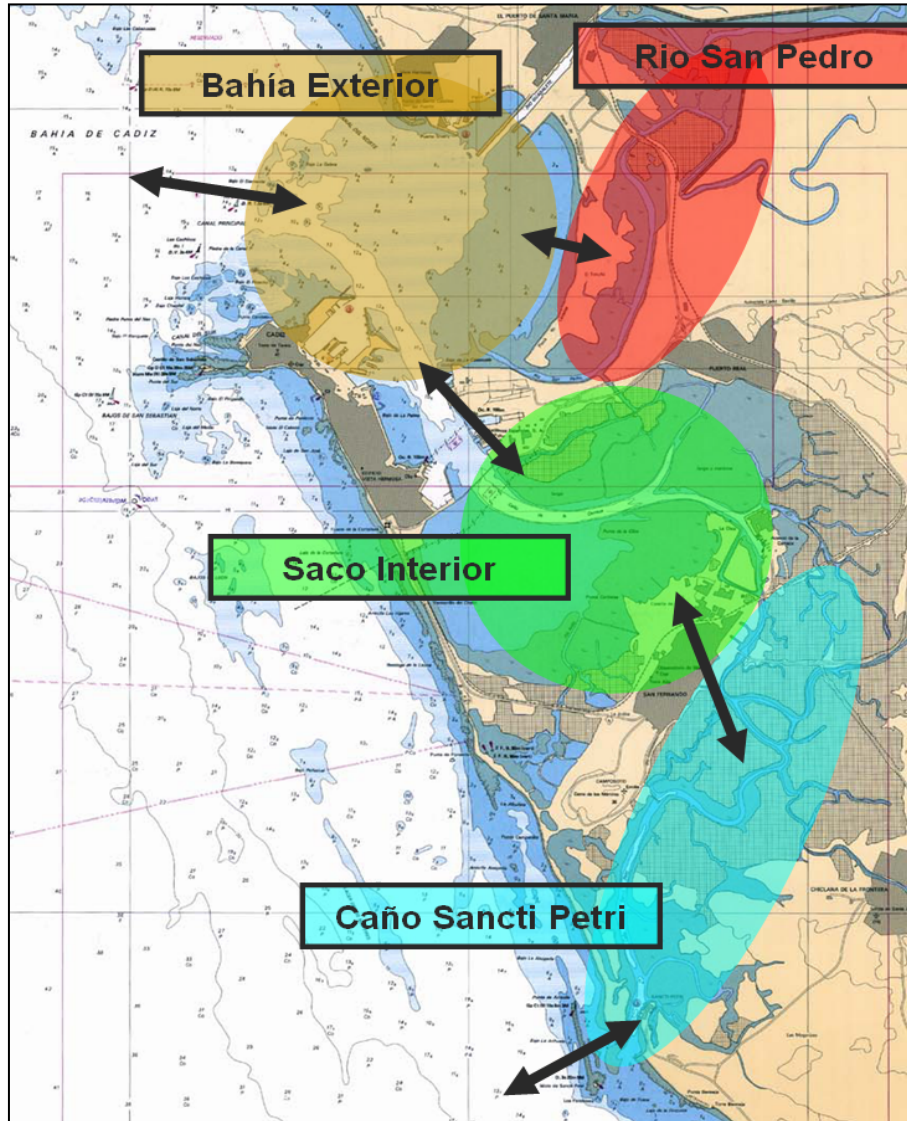
Situación



Situación

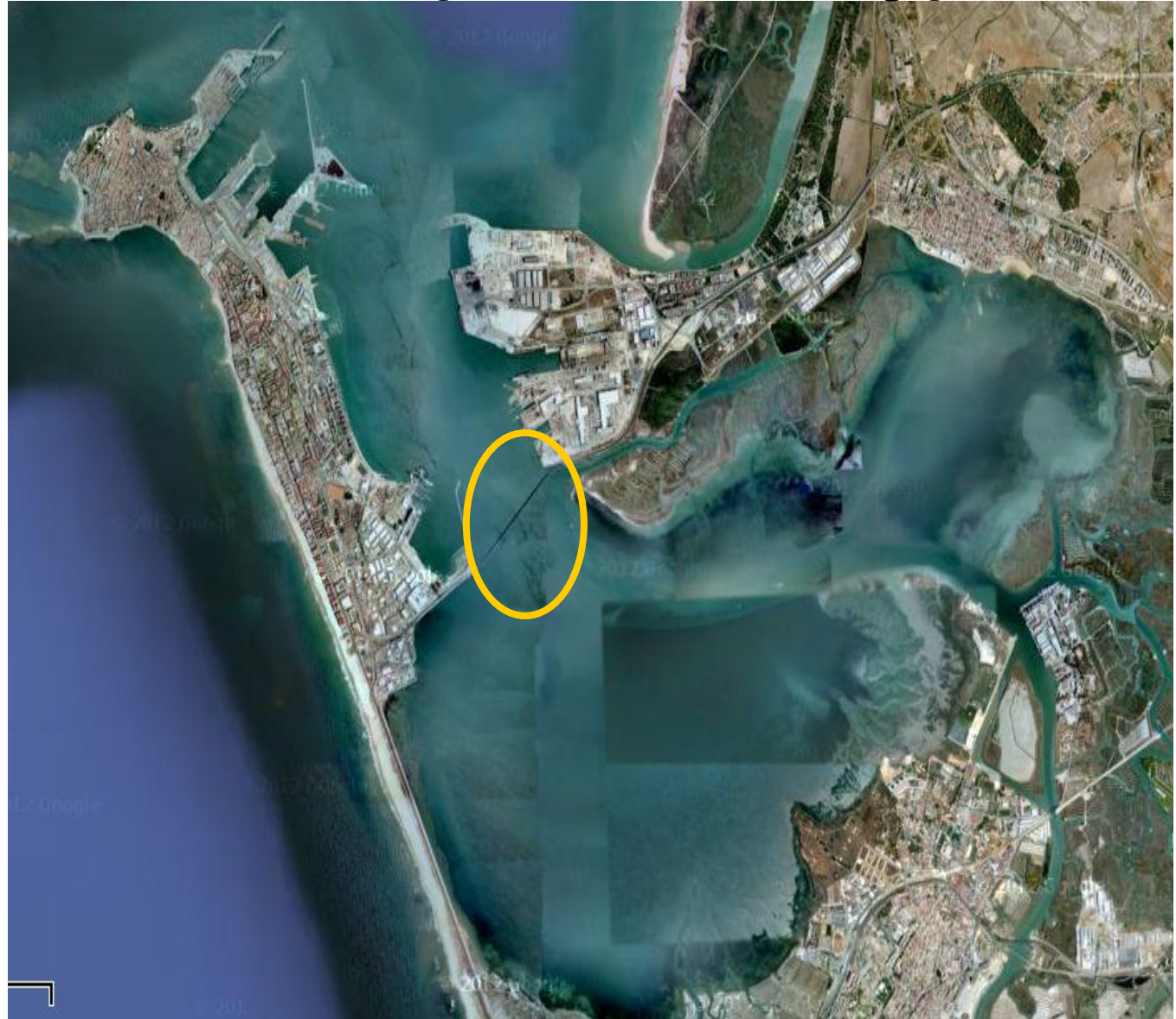


Situación



Actividad humana (Hasta Hoy)

- Puente de Carranza



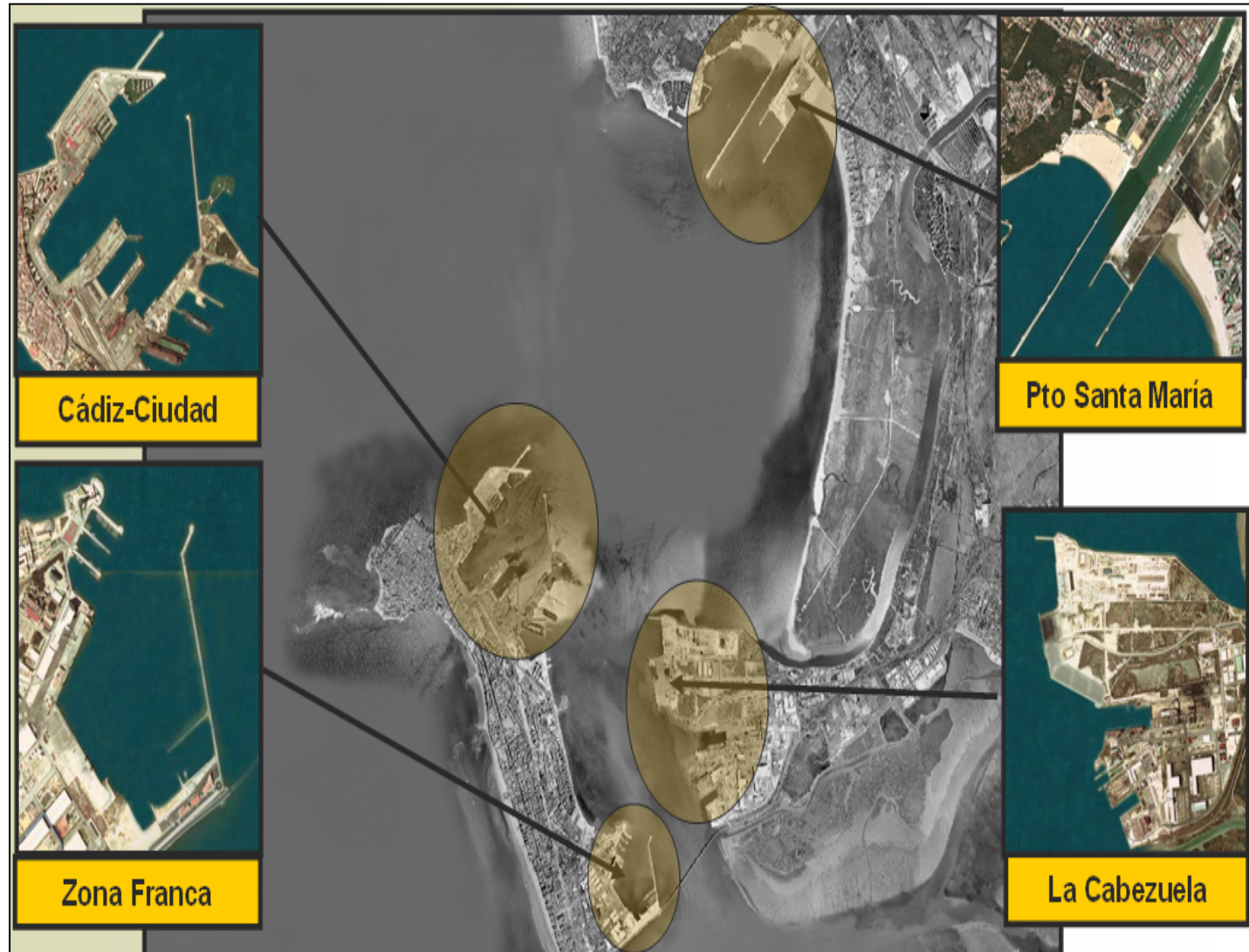
Actividad humana (Hasta Hoy)

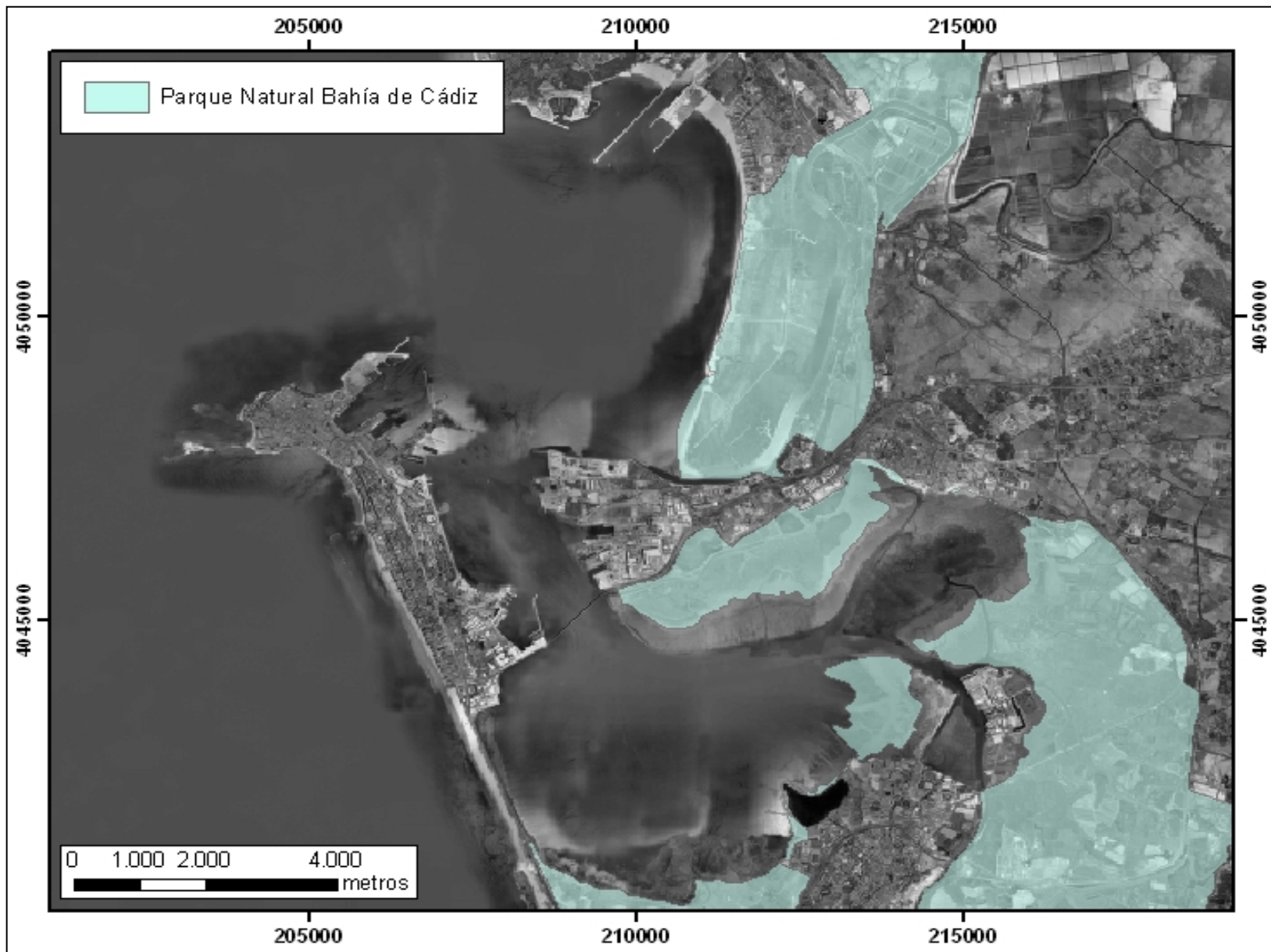
- Puente de Carranza



Actividad humana (Hasta Hoy)

- Puertos
- Espigones
- Muelles





Animalitos

Actividad humana (Futura)

- “La Pepa”



Actividad humana

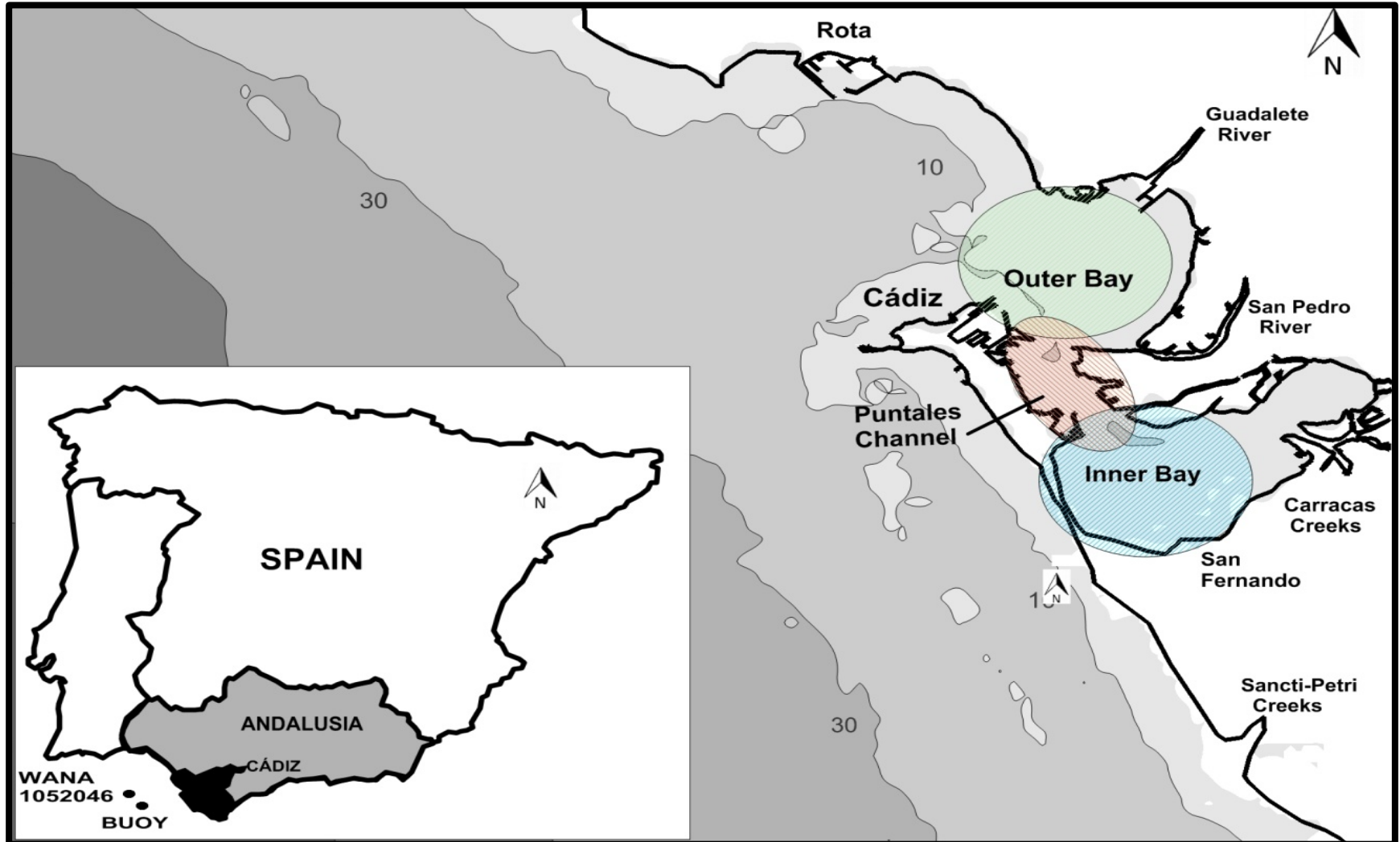
- Disminución de la tasa de renovación de aguas entre la Bahía externa y el Saco Interior
- Disminución de la biodiversidad
- Problemas de calidad de aguas
- Aterramientos del saco interior de la Bahía

Actividad humana

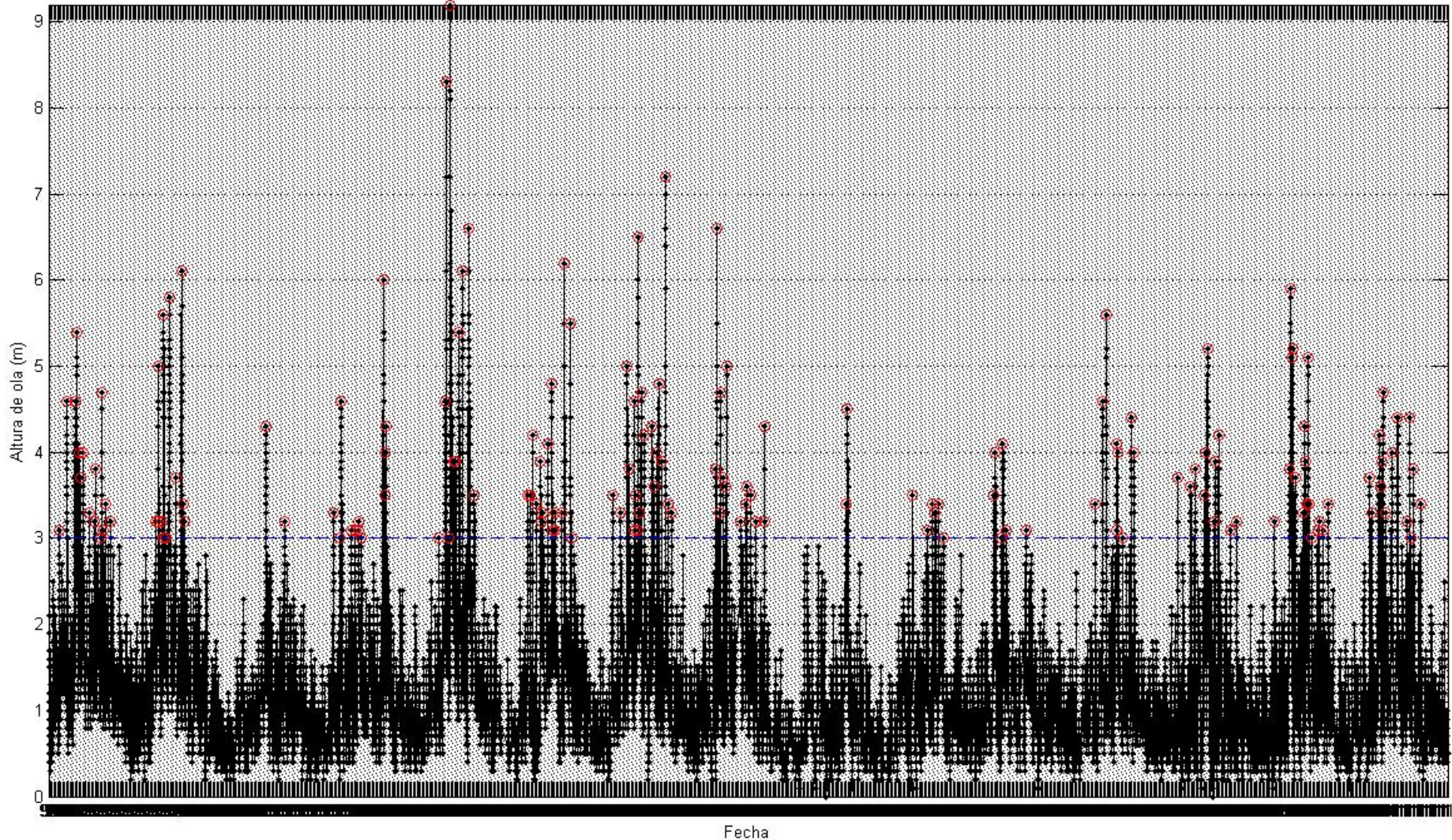
- Disminución de la tasa de renovación de aguas entre la Bahía externa y el Saco Interior
- Disminución de la biodiversidad
- Problemas de calidad de aguas
- Aterramientos del saco interior de la Bahía

**Modifica → Comportamiento
hidrodinámico**

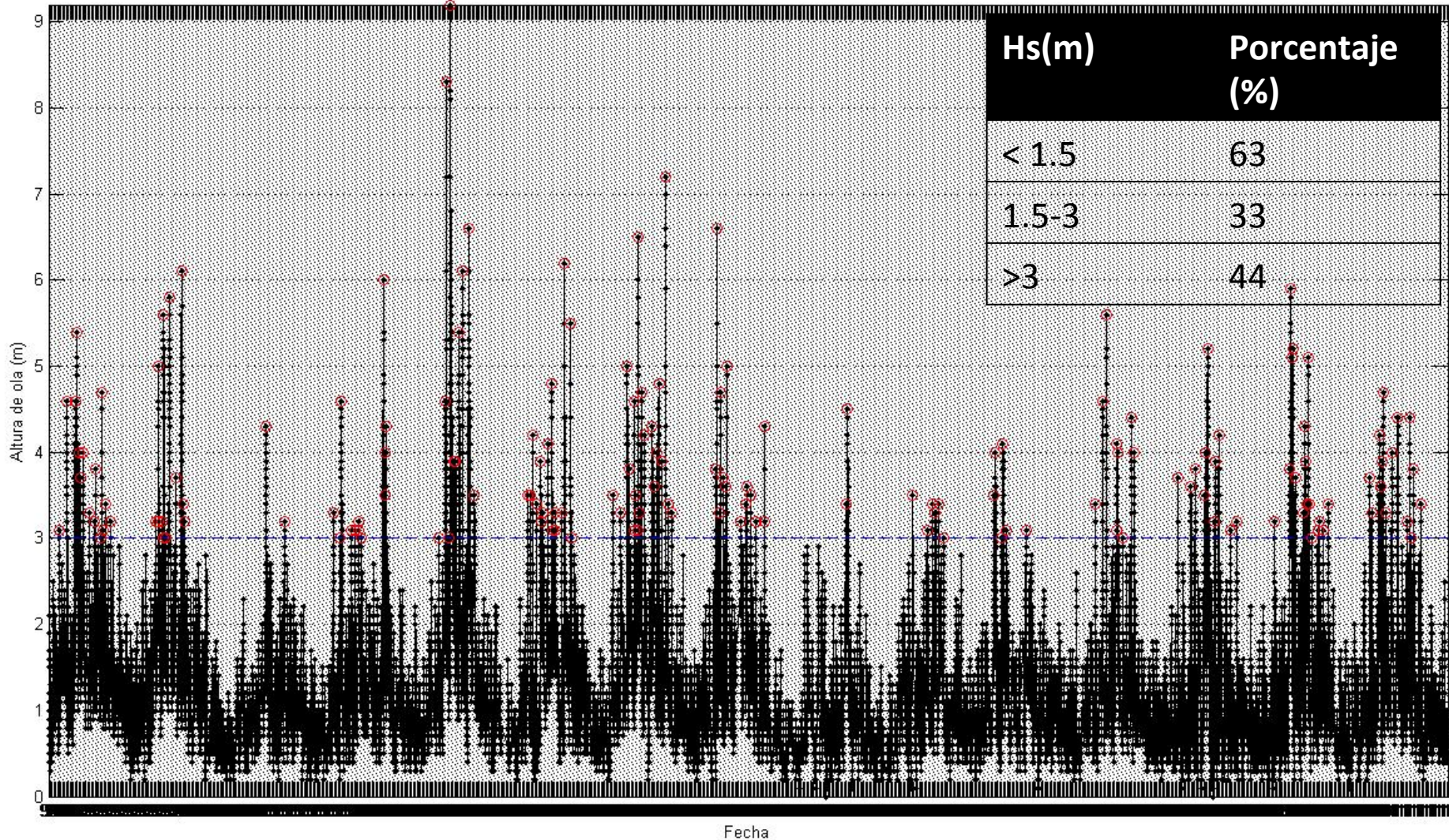
Caracterización de la zona



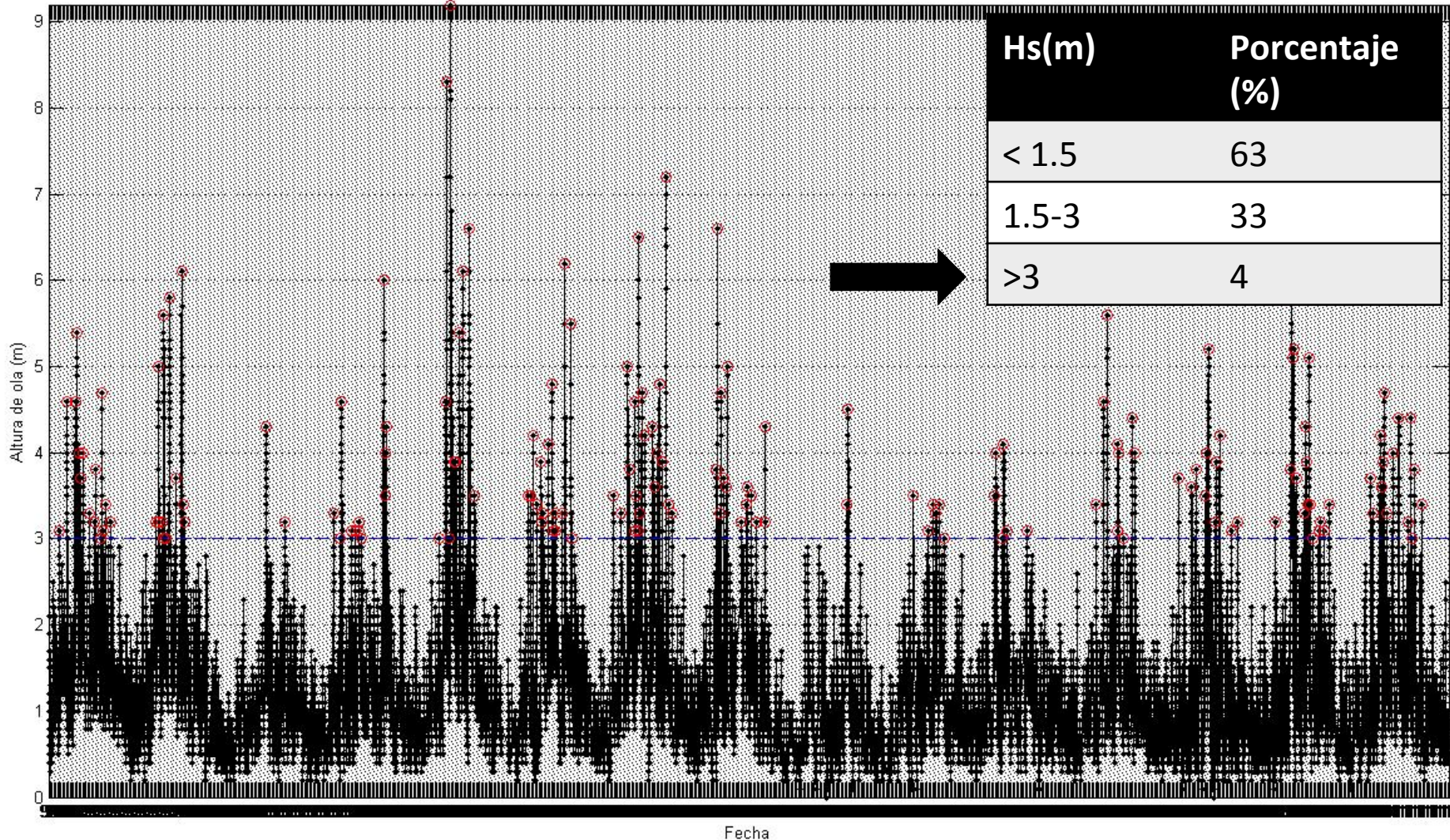
Caracterización de la zona: Oleaje



Caracterización de la zona: Oleaje

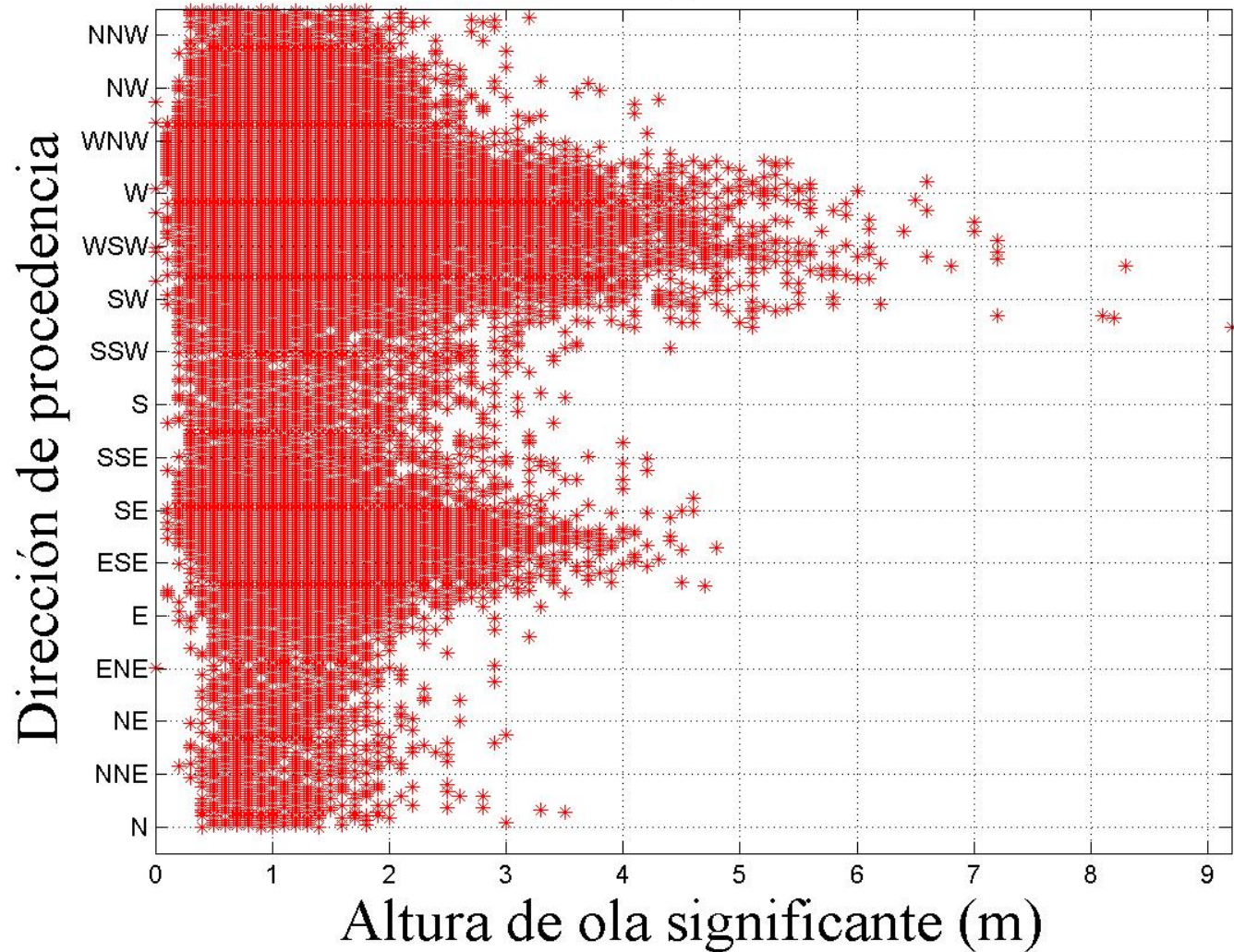


Caracterización de la zona: Oleaje



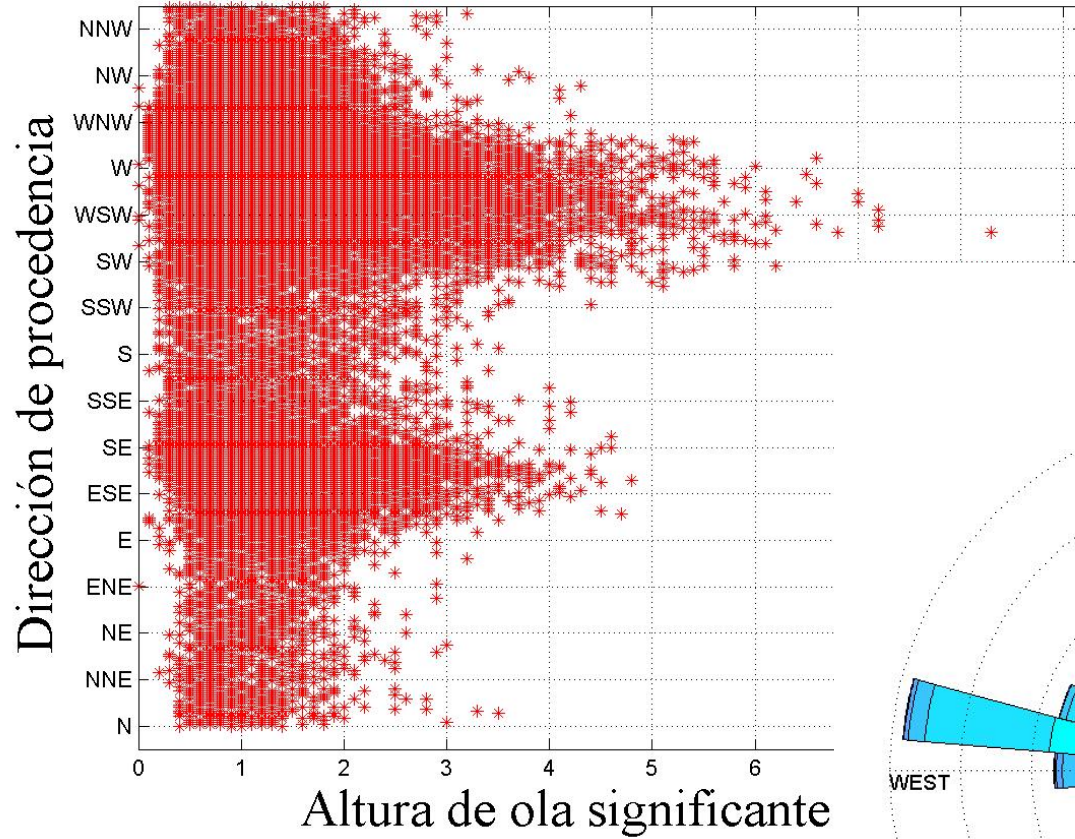
Caracterización de la zona: Oleaje

Gráfico de dispersión, Hs-Dir

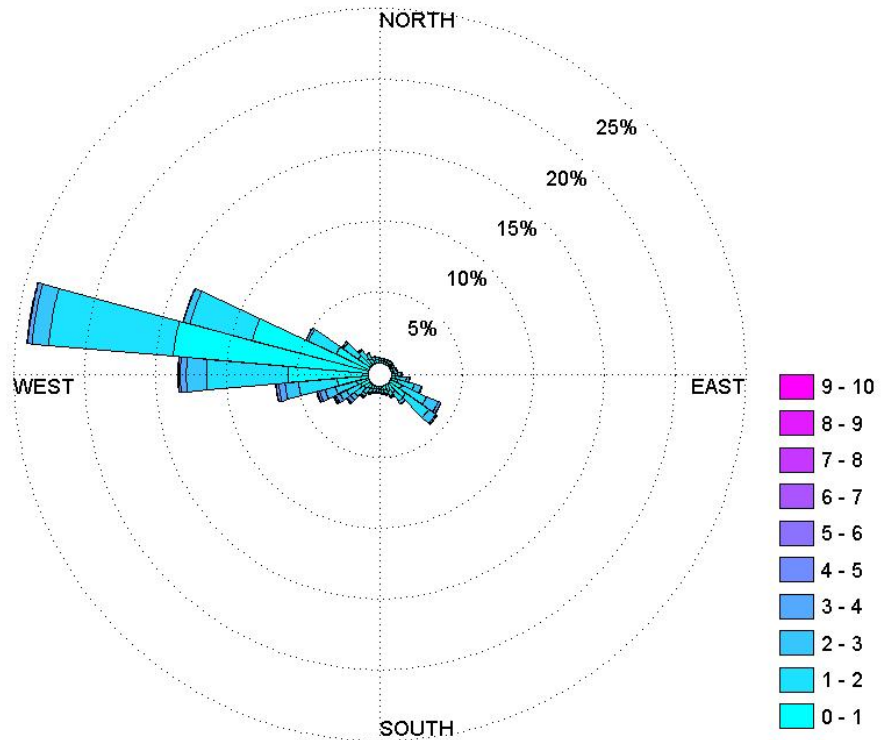


Caracterización de la zona: Oleaje

Gráfico de dispersión, Hs-Dir

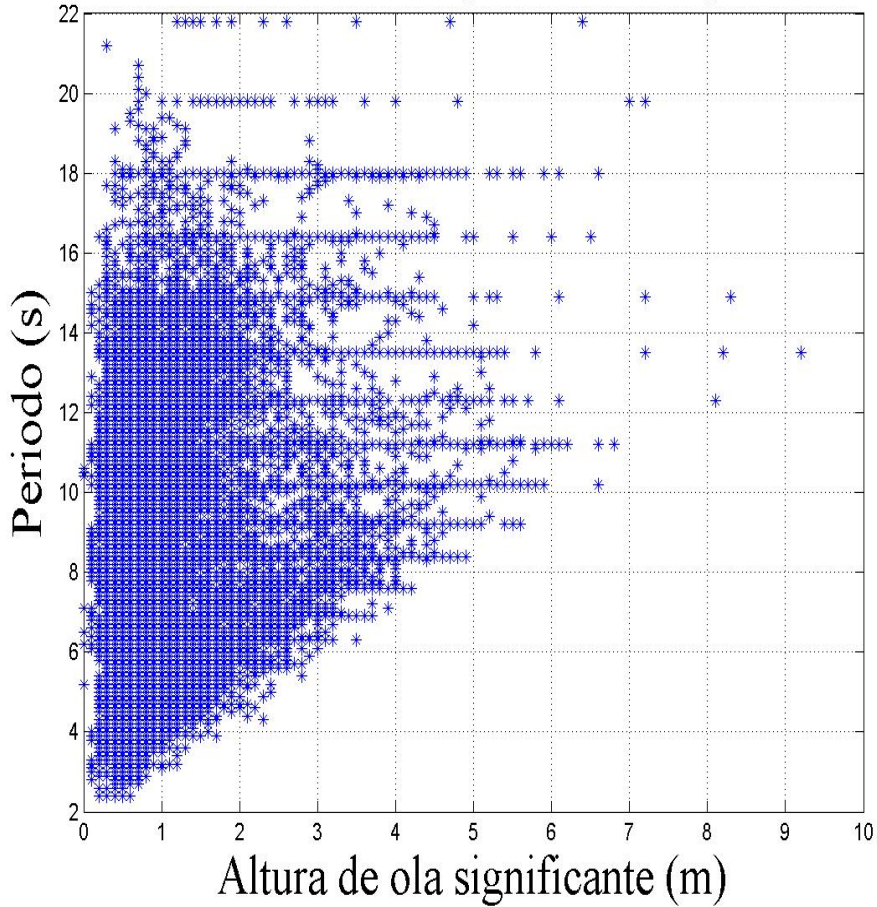


Rosa de Oleaje



Caracterización de la zona: Oleaje

Gráfico de dispersión, Hs-Tp



Caracterización de la zona: Oleaje

Gráfico de dispersión, Hs-Tp

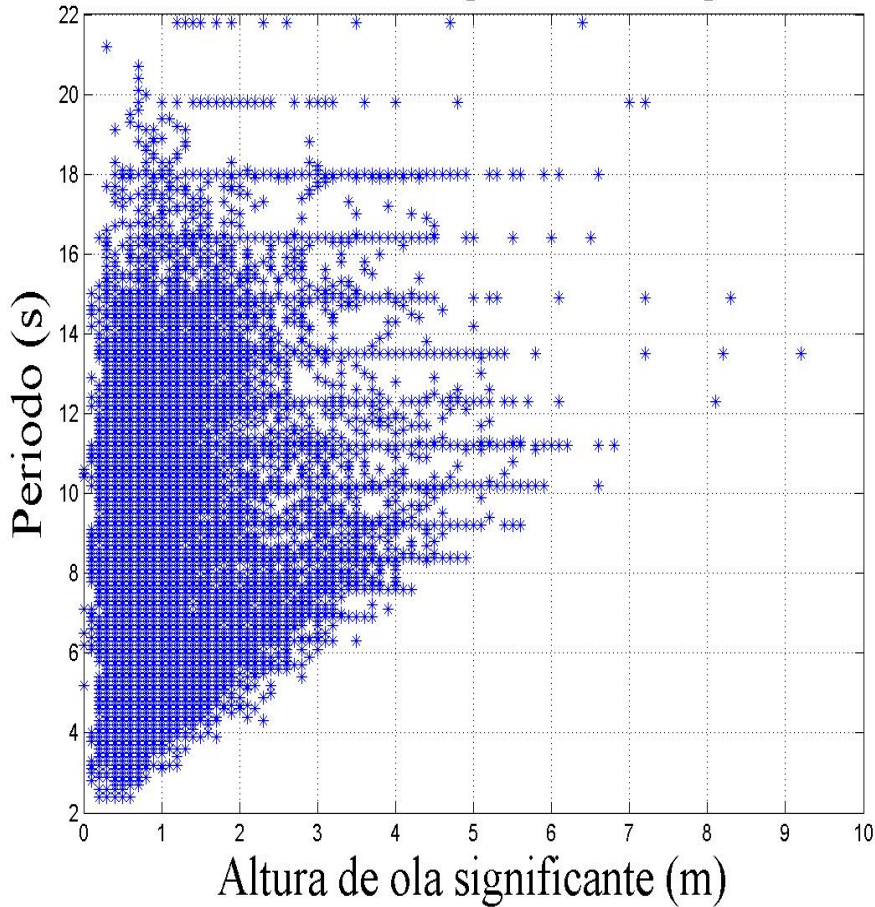
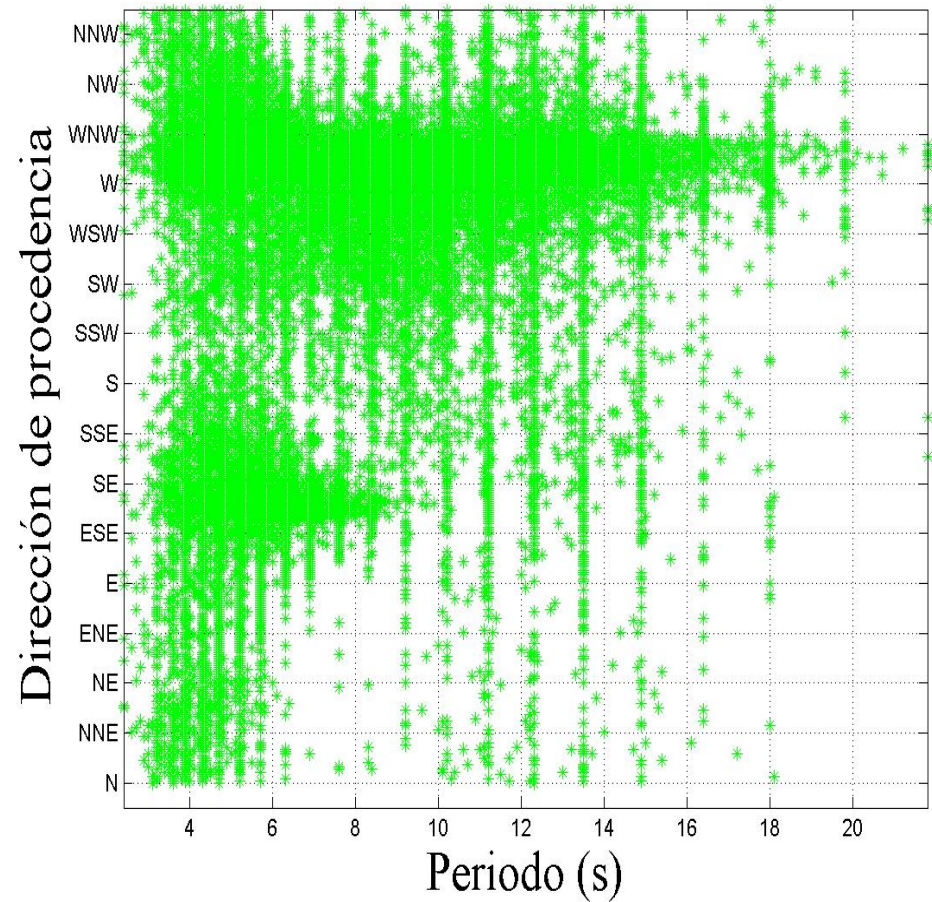
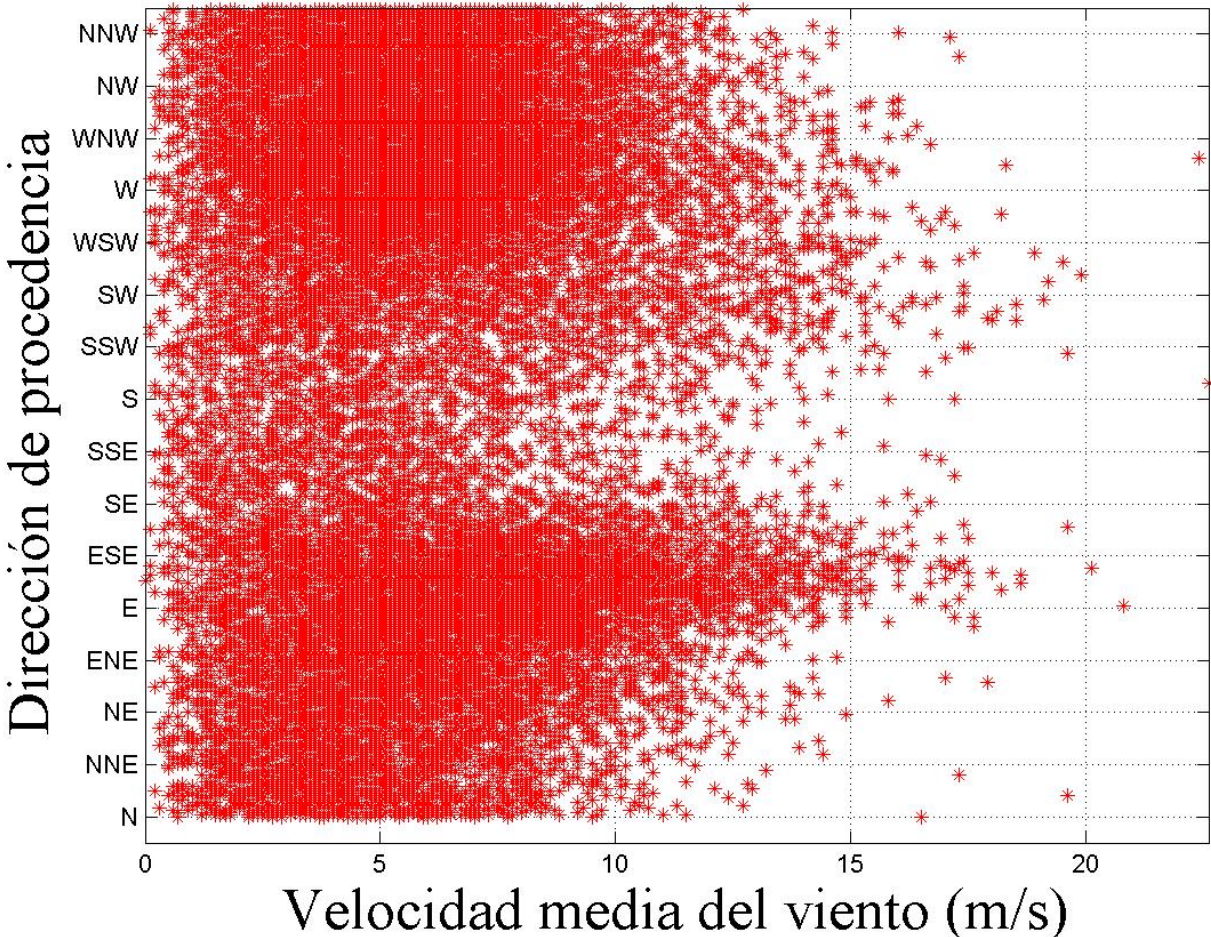


Gráfico de dispersión, Dir-Tp



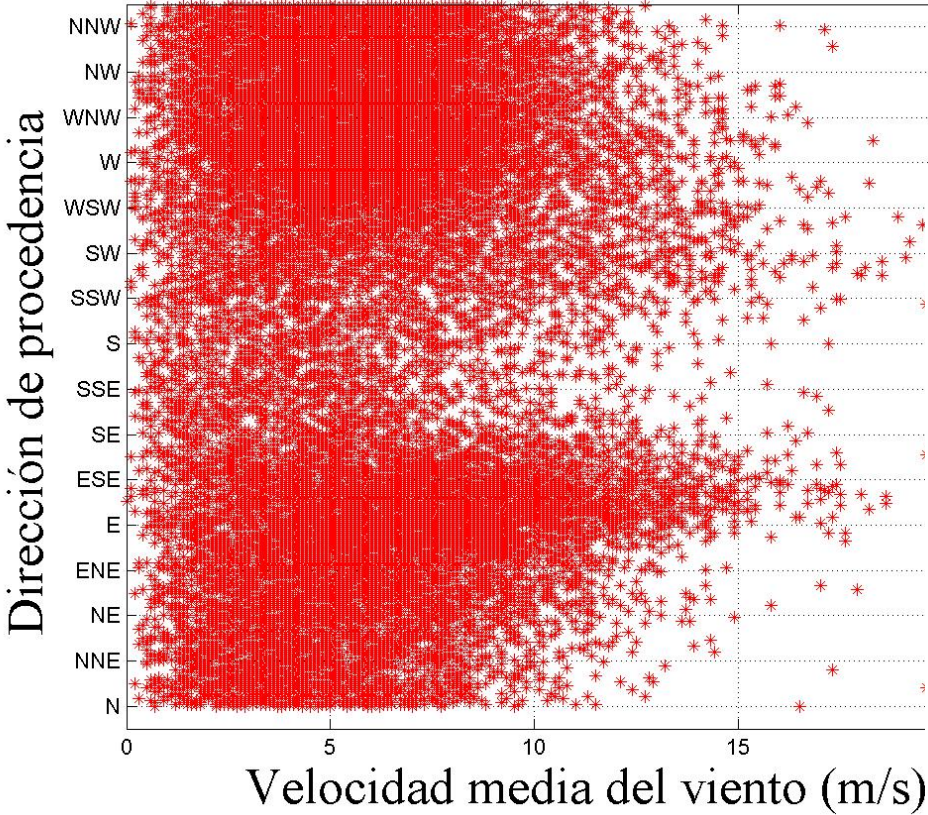
Caracterización de la zona: Viento

Gráfico de dispersión, VelV-DirV

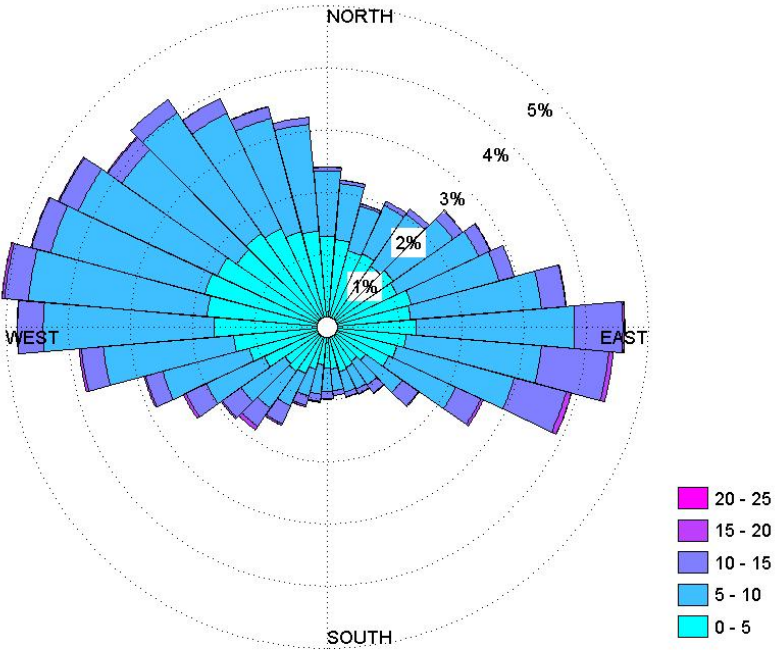


Caracterización de la zona: Viento

Gráfico de dispersión, VelV-DirV



Rosa de viento



Comportamiento hidrodinámico

- Estudio analítico
- Estudio numérico
- Campañas de campo

Comportamiento hidrodinámico

- Estudio analítico

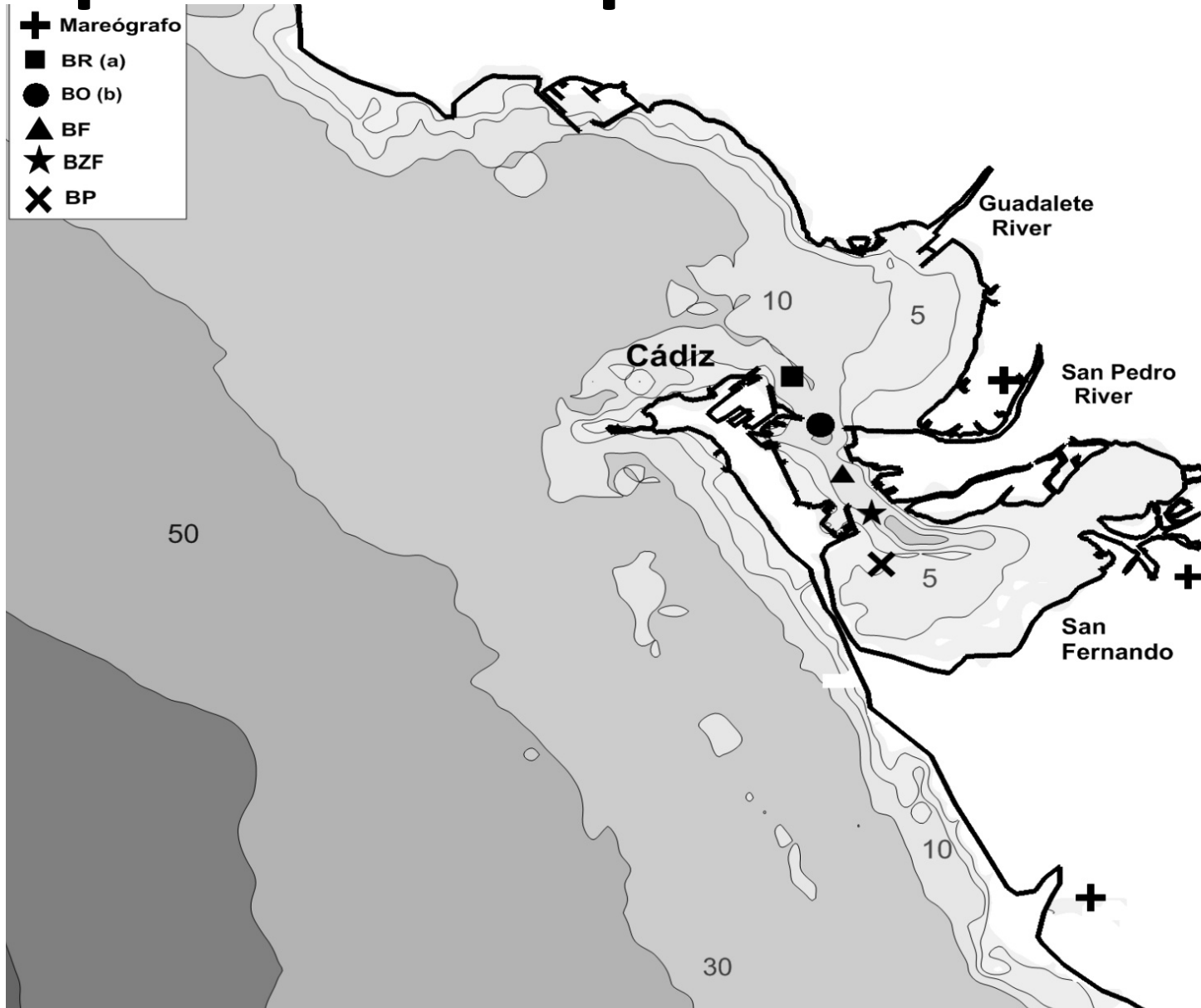
- **Estudio numérico**

- **Campañas de campo**

Campaña de Campo

- Superficie libre
- Presión
- Velocidades (ENU)
- Temperatura
- Salinidad
- Turbidez

Campaña de Campo



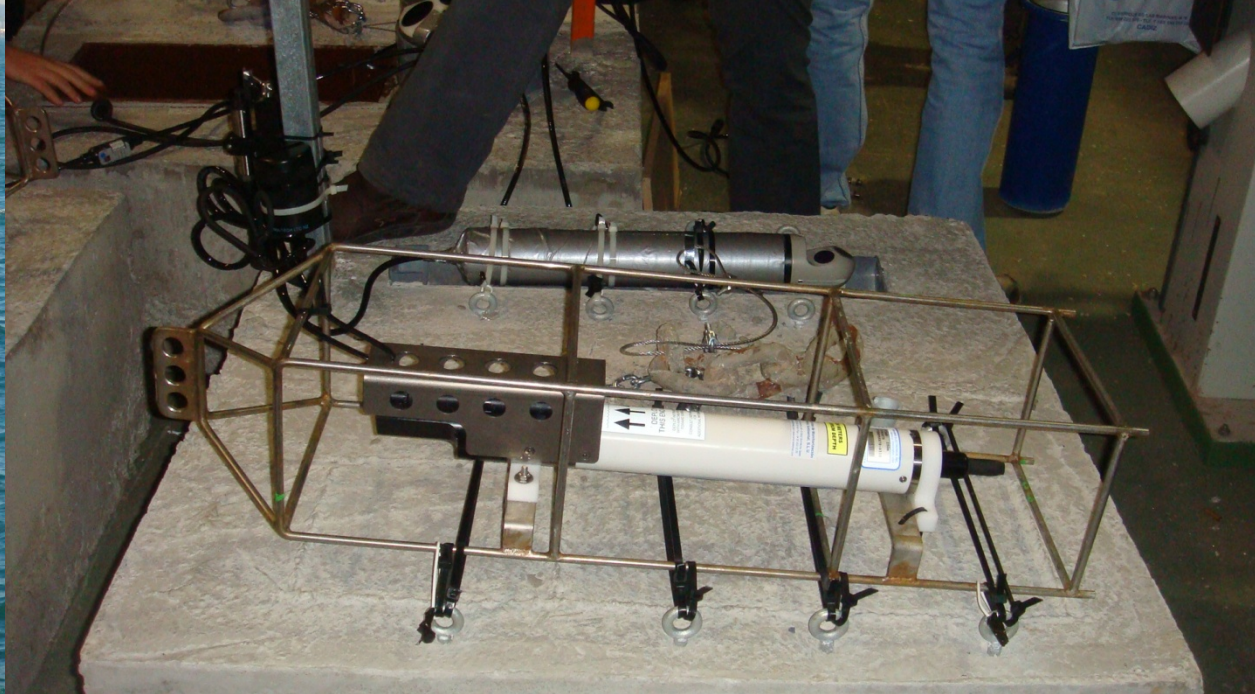
Campaña de Campo (Diciembre)



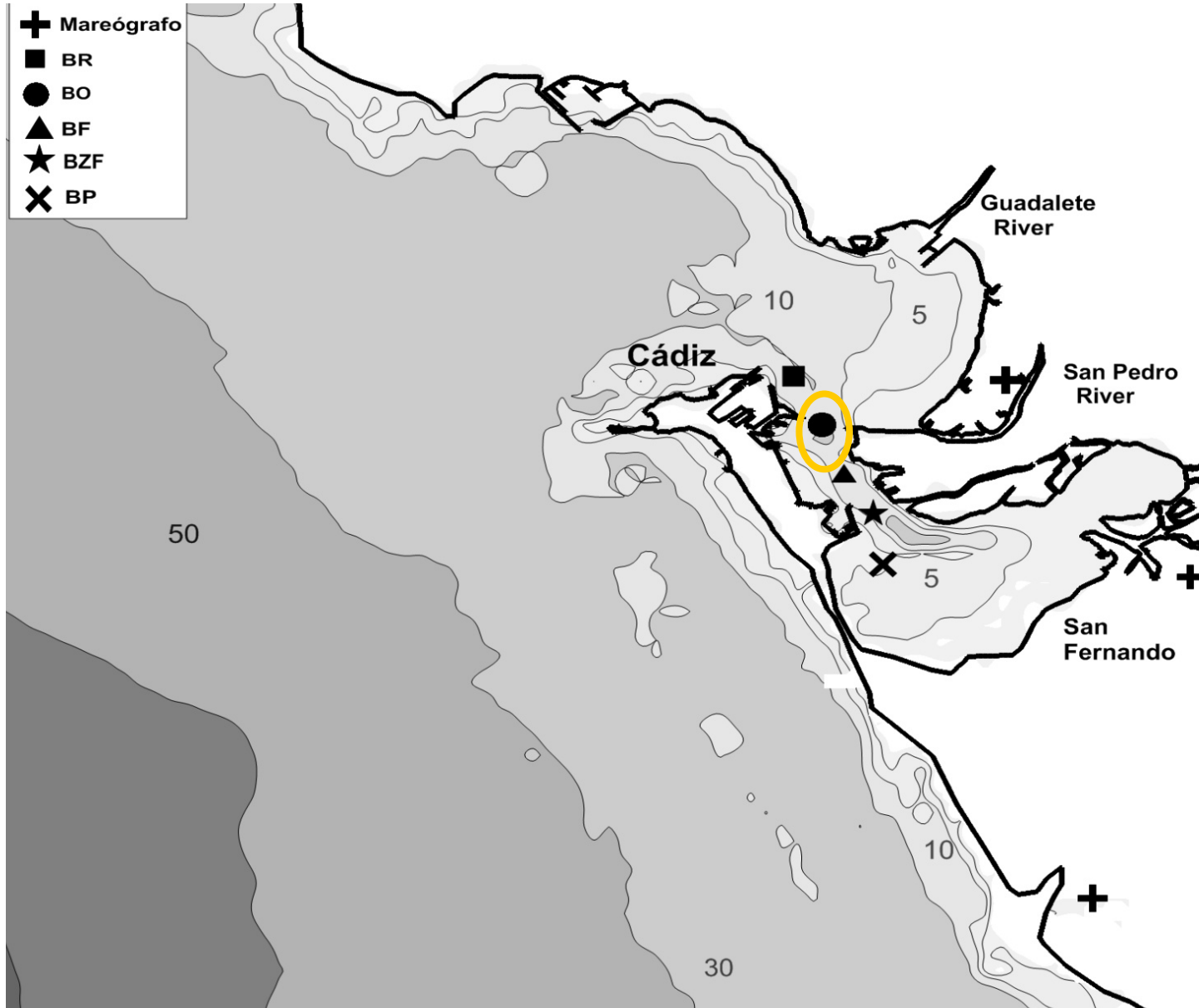
Campaña de Campo (Diciembre)



- Presión y velocidades
- Turbidez
- Temperatura y Salinidad



Campaña de Campo (Diciembre)



Campaña de Campo (Diciembre)

- Presión, velocidades y superficie libre
- Turbidez
- Temperatura y Salinidad



Campaña de Campo (Diciembre)



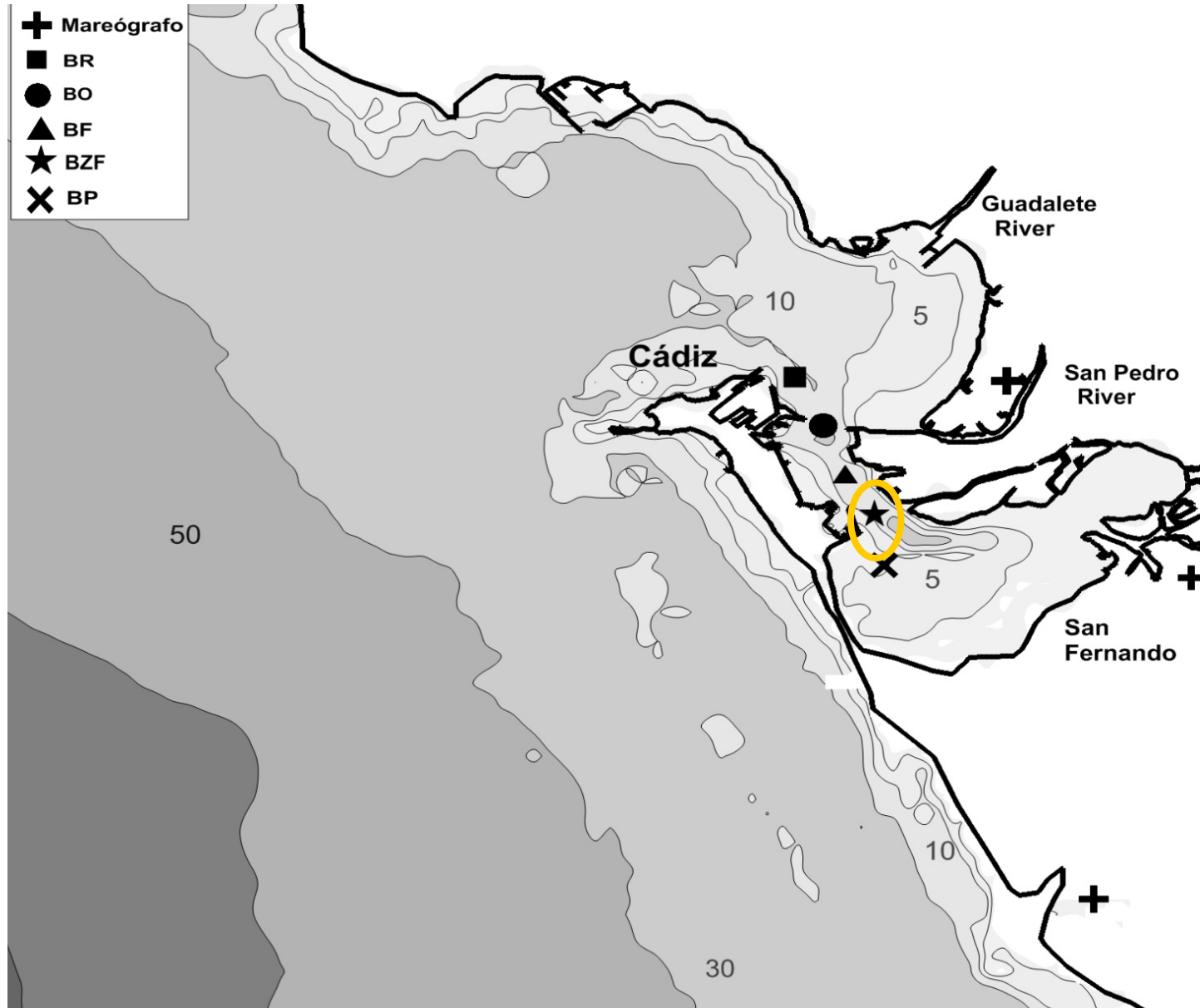
Campaña de Campo (Diciembre)



- Presión y velocidades
- Temperatura y Salinidad

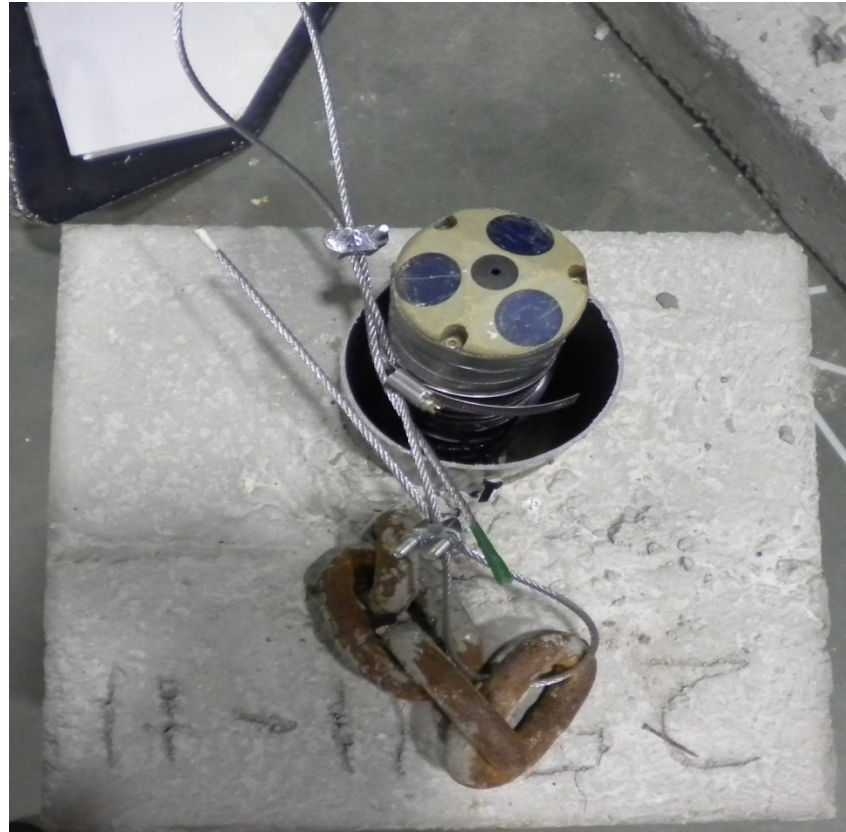


Campaña de Campo (Febrero)



Campaña de Campo (Febrero)

- Presión y velocidades



Campaña de Campo (Febrero)



Campaña de Campo (Febrero)

- Presión y velocidades



Campaña de Campo (Configuración)

Deployment Planning

Standard **Advanced**

Instrument _____

Frequency: 2 MHz

Mounting _____

Moving buoy

Mooring line

Fixed structure

Current profile _____

Profile interval (s): 900

Number of cells: 20

Cell size (m): 0.5

Environment _____

Coastal water

River

Deep water (>300 m)

Open ocean

Use Advanced Settings

Deployment planning

Battery pack: Lithium

Battery capacity (Wh): 165

Assumed duration (days): 60

Battery utilization (% of capacity): 70

Memory required (MB): 35

Vertical vel. prec. (cm/s): 0.6

Horizont. vel. prec. (cm/s): 1.9

Z-cell vel. prec. (cm/s): 1.1

Compass update rate (s): 900

Power level: HIGH

Update Aceptar Cancelar Aplicar Ayuda

Campaña de Campo (Configuración)

Deployment Planning

Standard Advanced

Current profile

Average interval (s): 120

Blanking distance (m): 0.2

Compass upd. rate (s): 900

Measurement load (%): 9 Auto

Coordinate system: ENU File wrapping

Power level

Low High

Speed of sound

Measured

Salinity (ppt): 35

Fixed (m/s): 1525

Wave bursts

Cell size (m): 1

Number of samples: 1024

Sampling rate: 1 Hz

Interval (s): 3600

Update from Standard

Deployment planning

Assumed duration (days): 60

Battery utilization (% of capacity): 70

Memory required (MB): 35

Vertical vel. prec. (cm/s): 0.6

Horizont. vel. prec. (cm/s): 1.9

Z-cell vel. prec. (cm/s): 1.1

Analog inputs

Input 1: NONE

Input 2: NONE

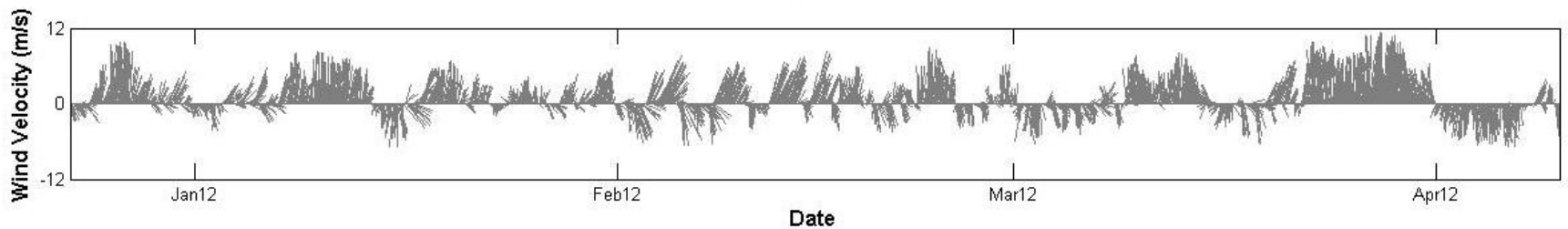
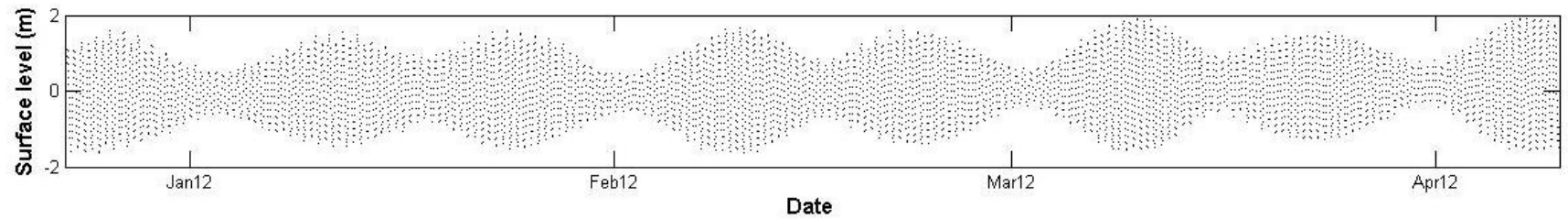
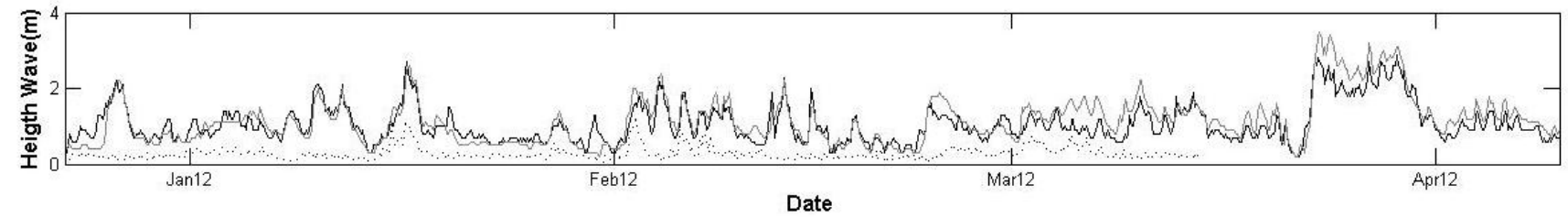
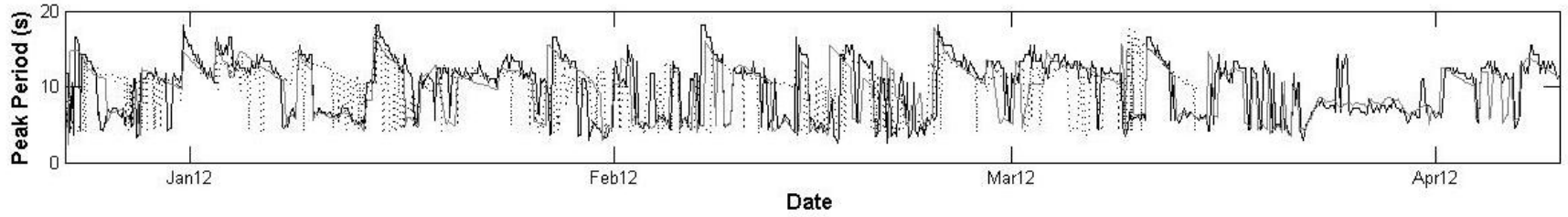
Output power

Update Aceptar Cancelar Aplicar Ayuda

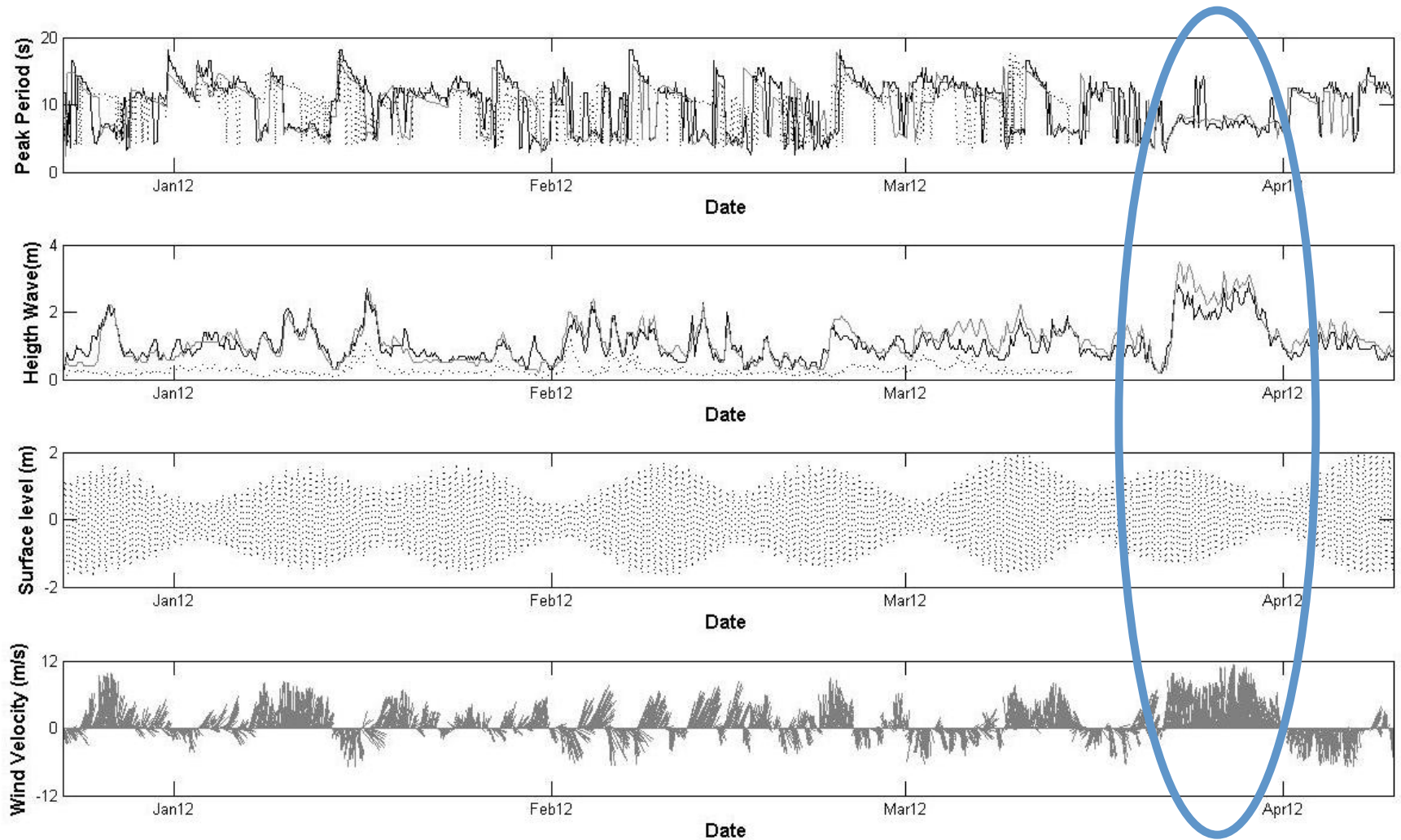
Campaña de Campo (Resultados)

- Extracción de datos
- Post-procesado
- Análisis de los datos

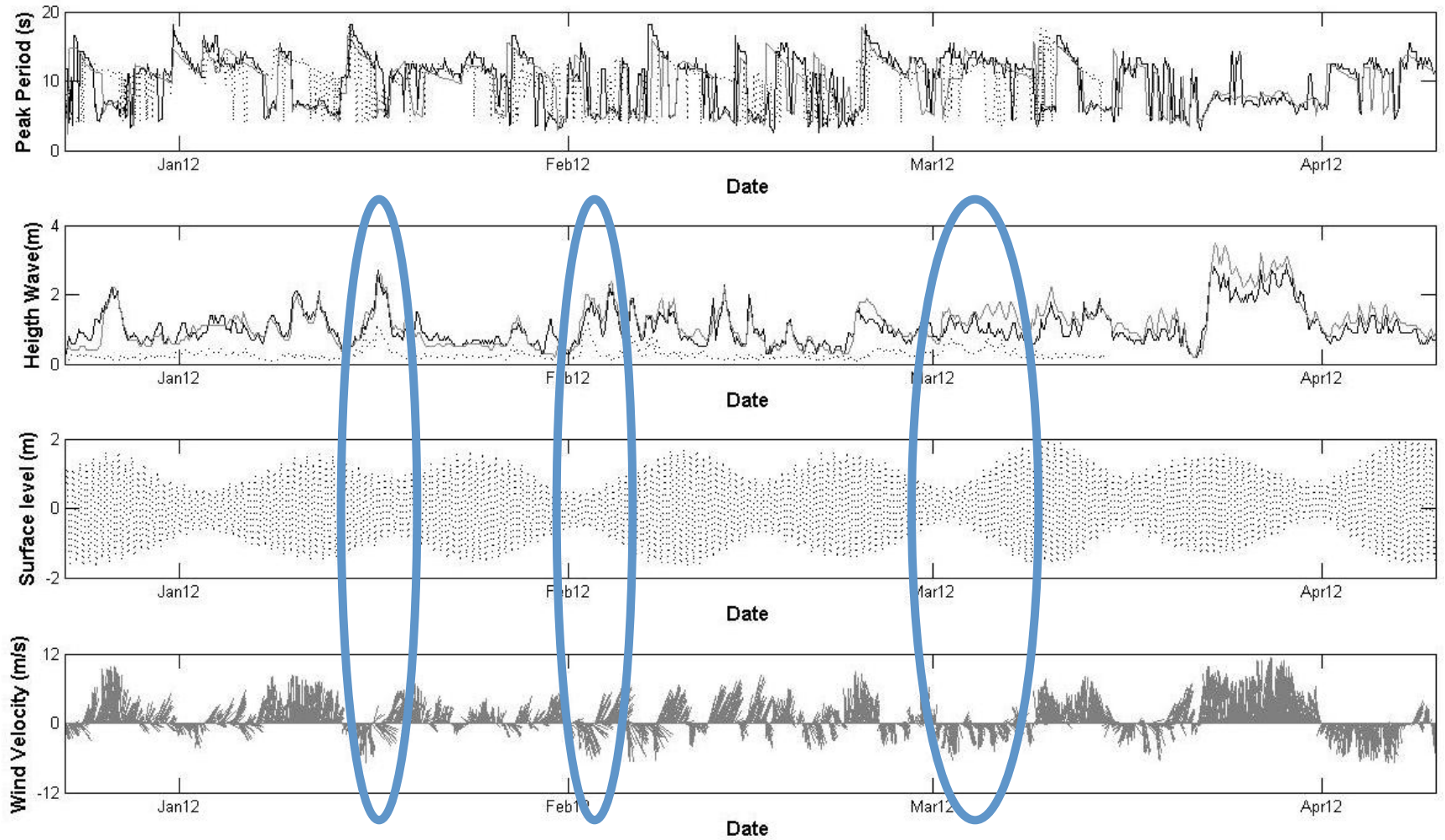
Campaña de Campo (Resultados)



Campaña de Campo (Resultados)

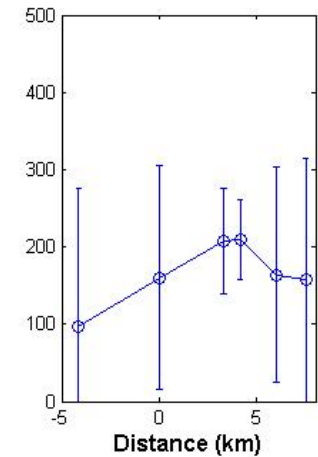
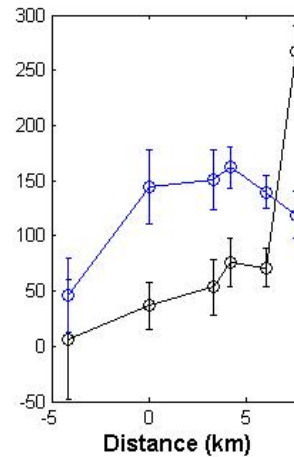
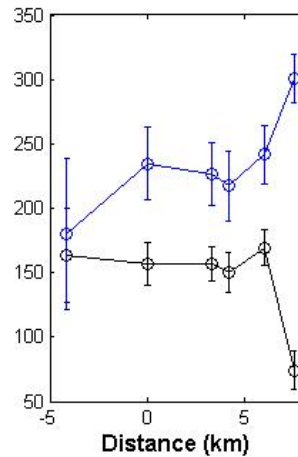
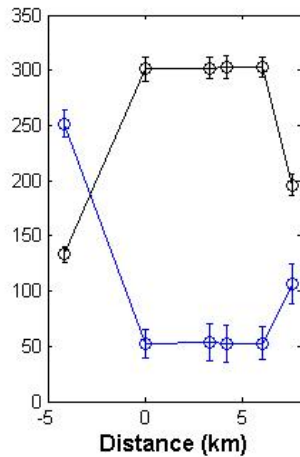
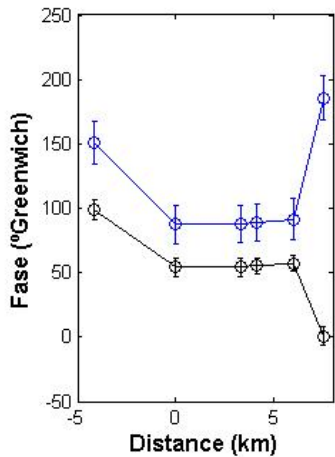
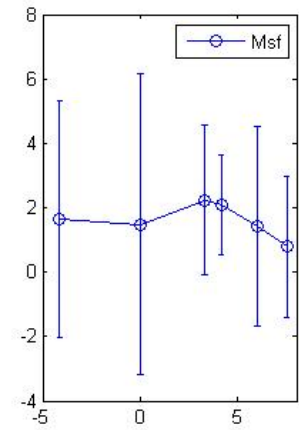
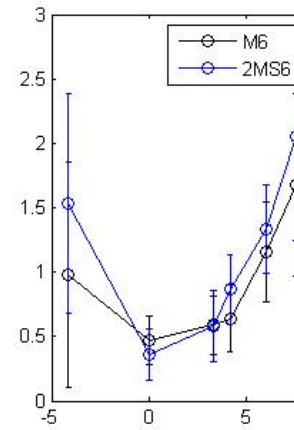
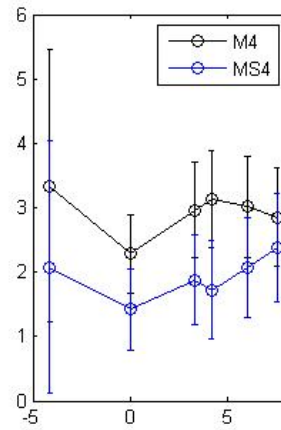
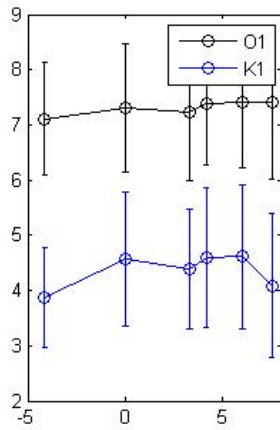
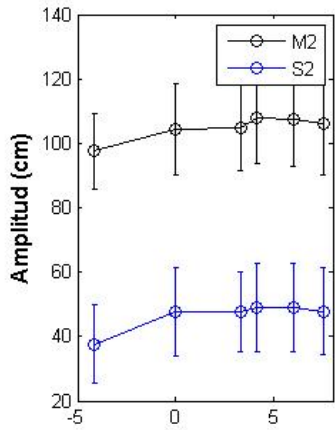


Campaña de Campo (Resultados)



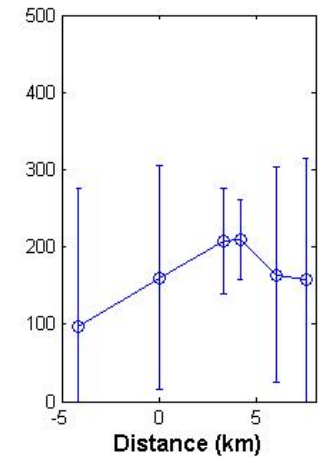
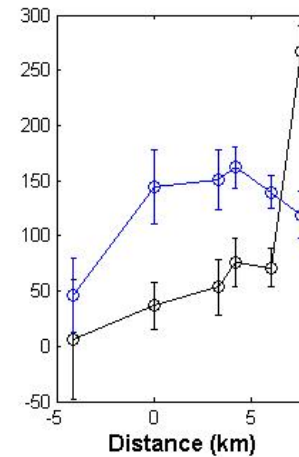
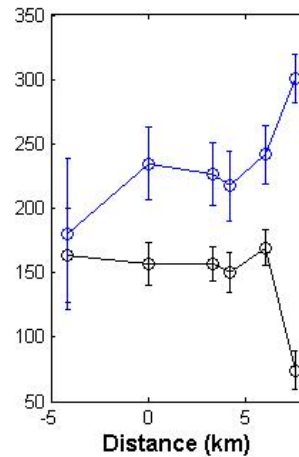
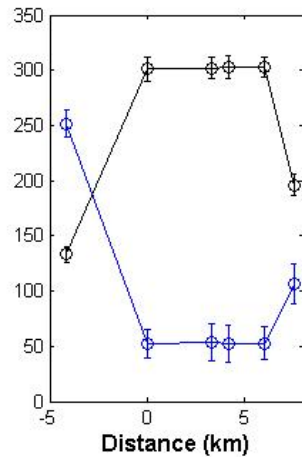
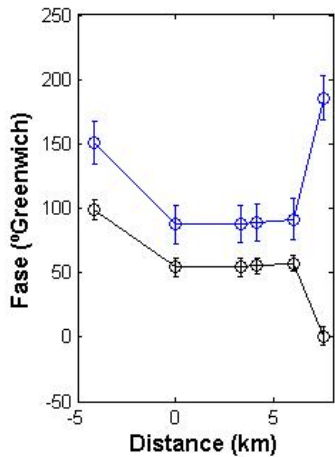
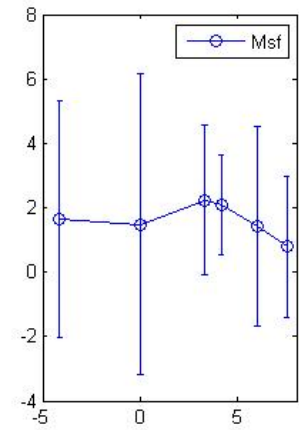
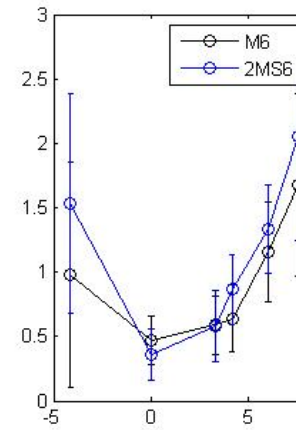
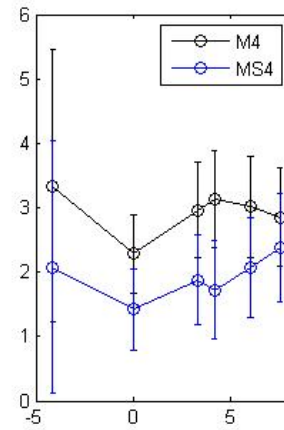
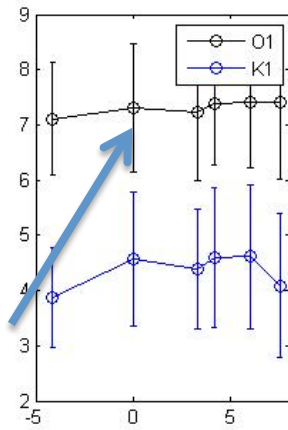
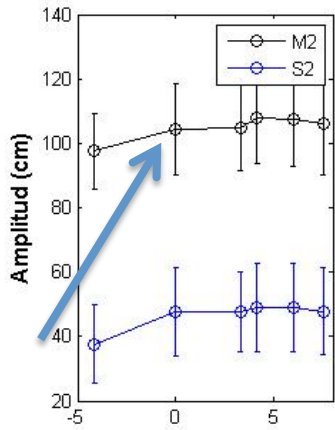
Campaña de Campo (Resultados)

16/02/12-14/03/12



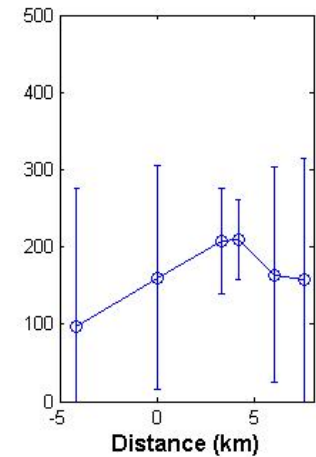
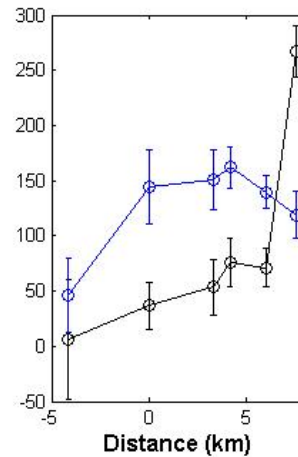
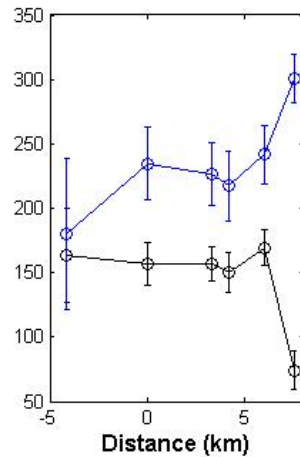
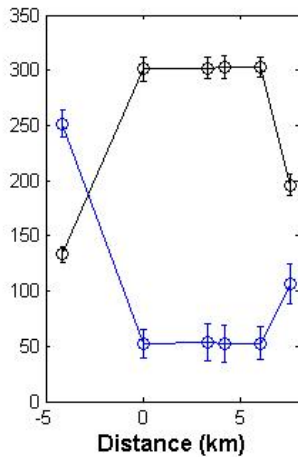
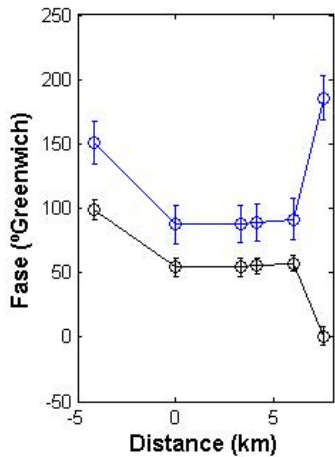
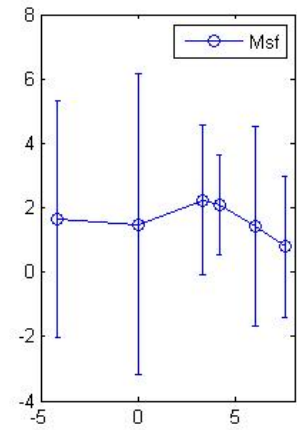
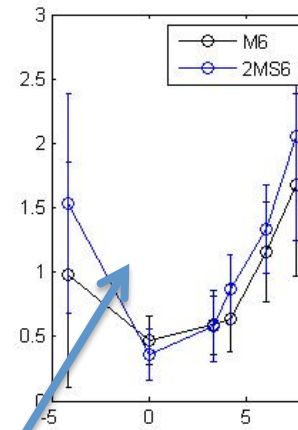
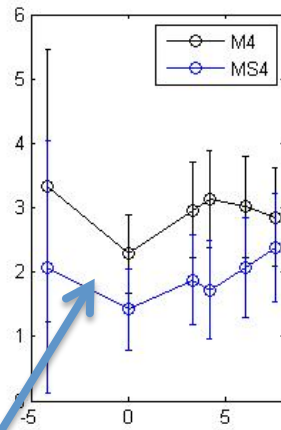
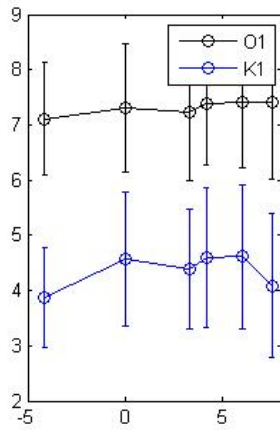
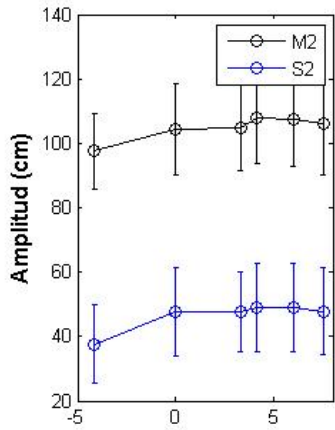
Campaña de Campo (Resultados)

16/02/12-14/03/12



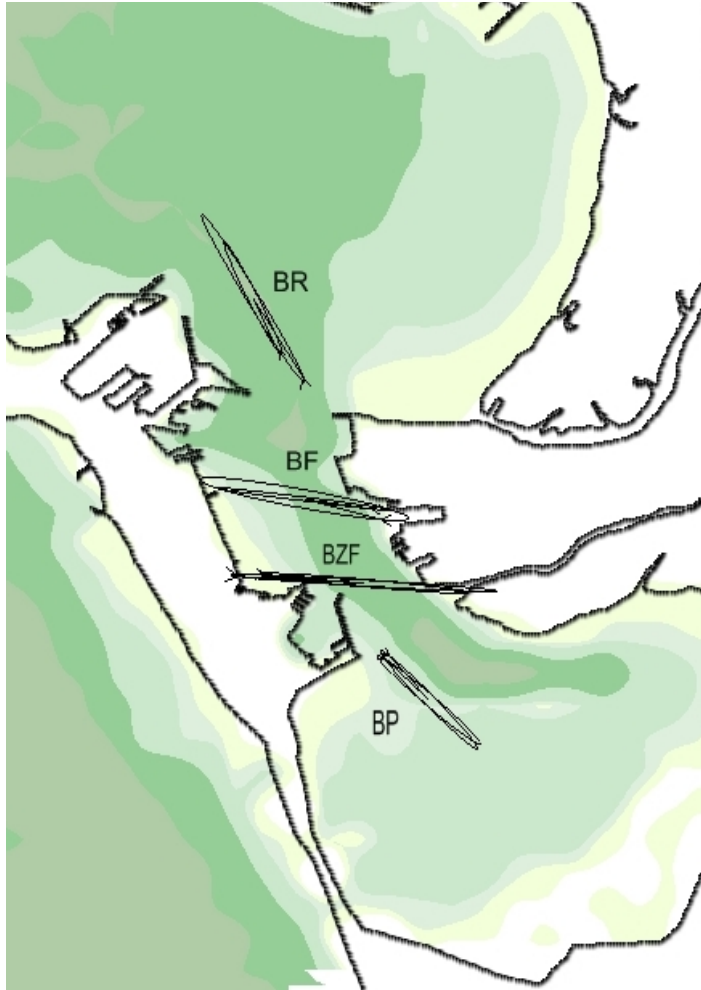
Campaña de Campo (Resultados)

16/02/12-14/03/12

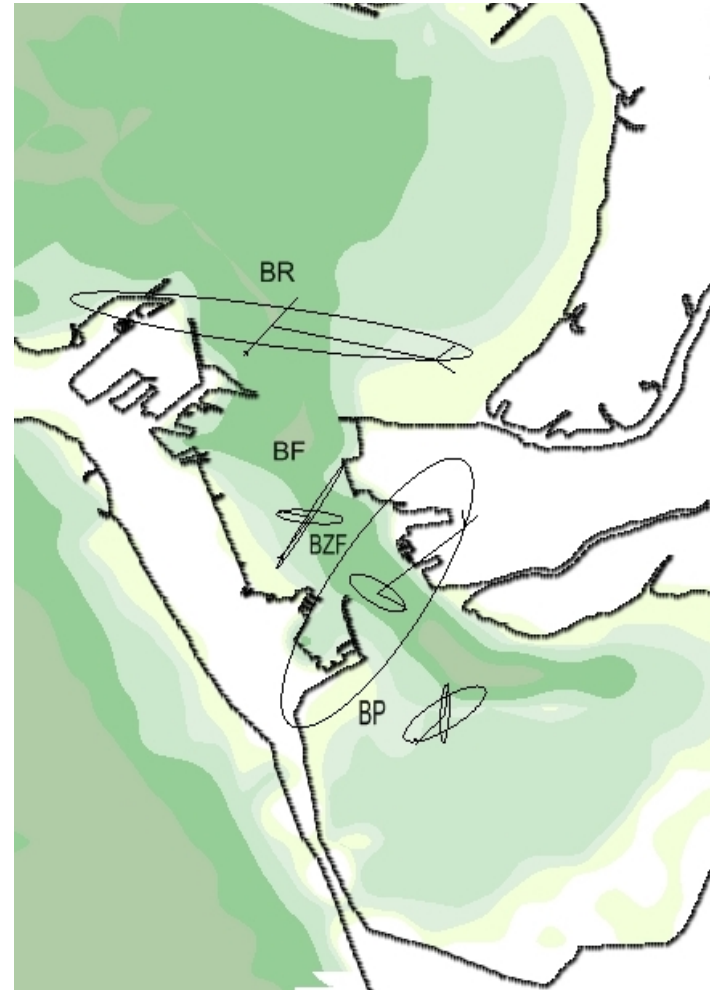


Campaña de Campo (Resultados)

~dm

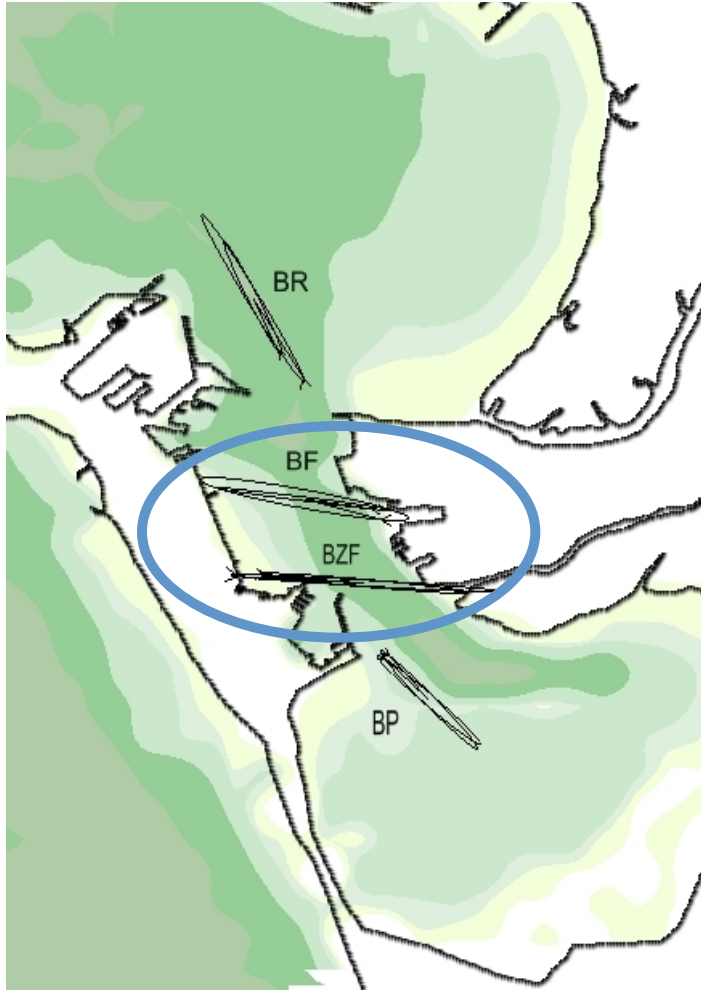


~cm

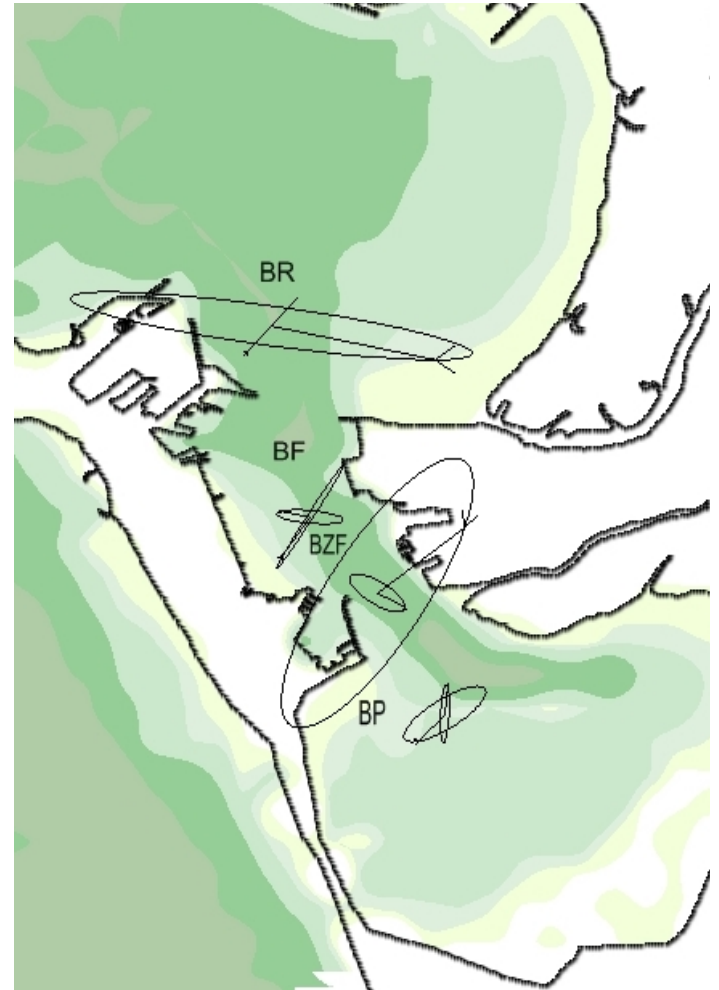


Campaña de Campo (Resultados)

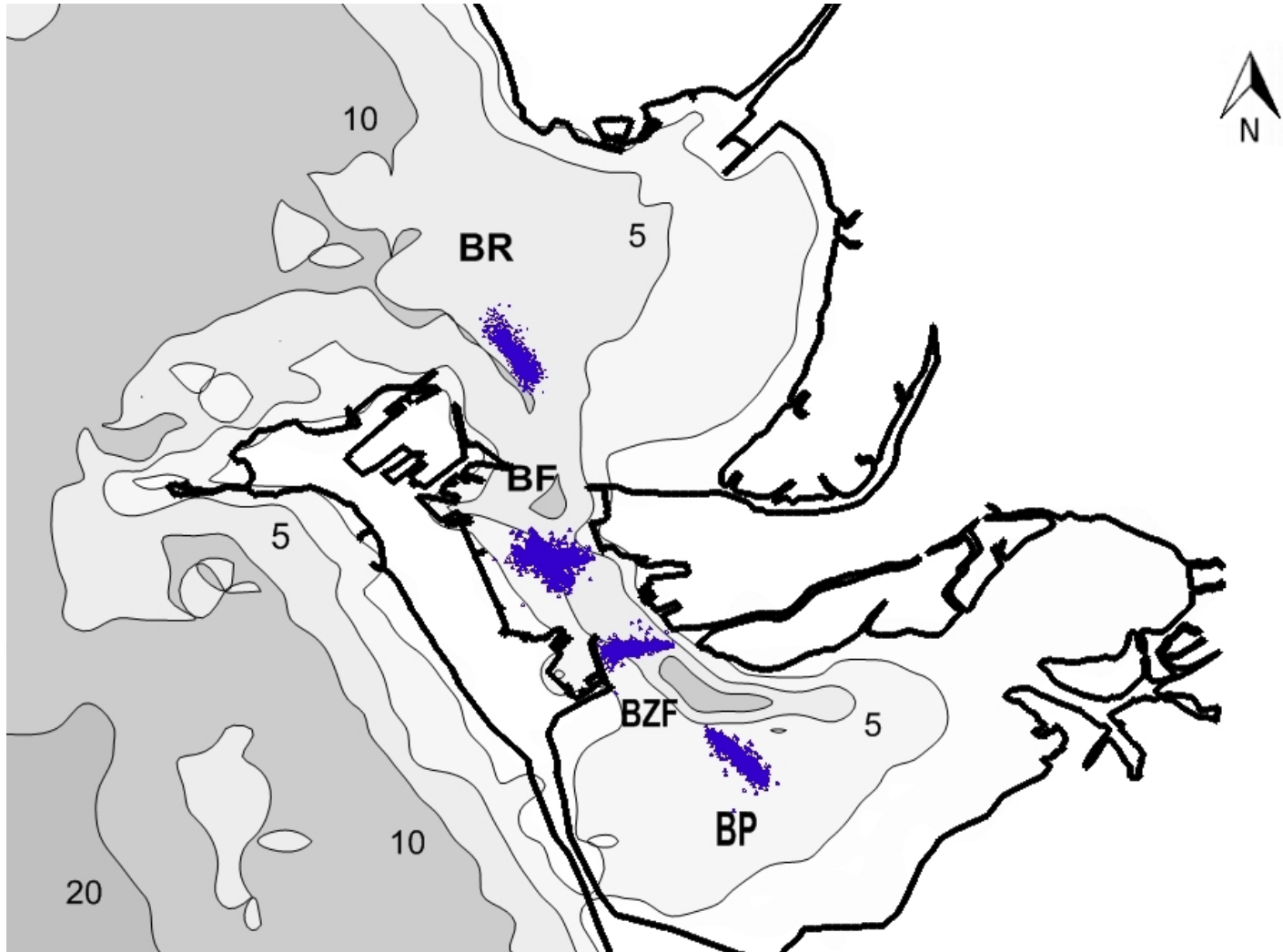
~dm



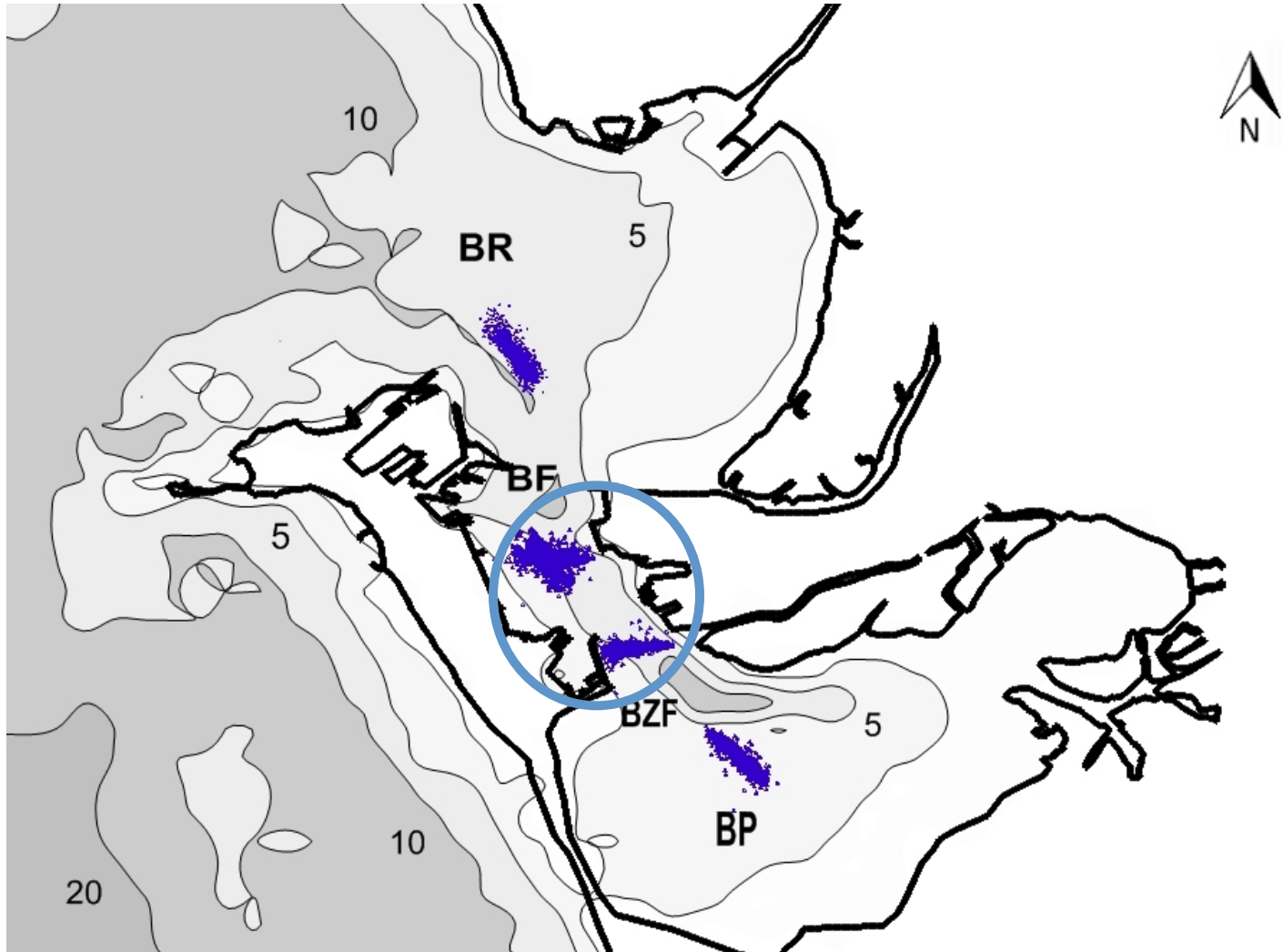
~cm



Campaña de Campo (Resultados)



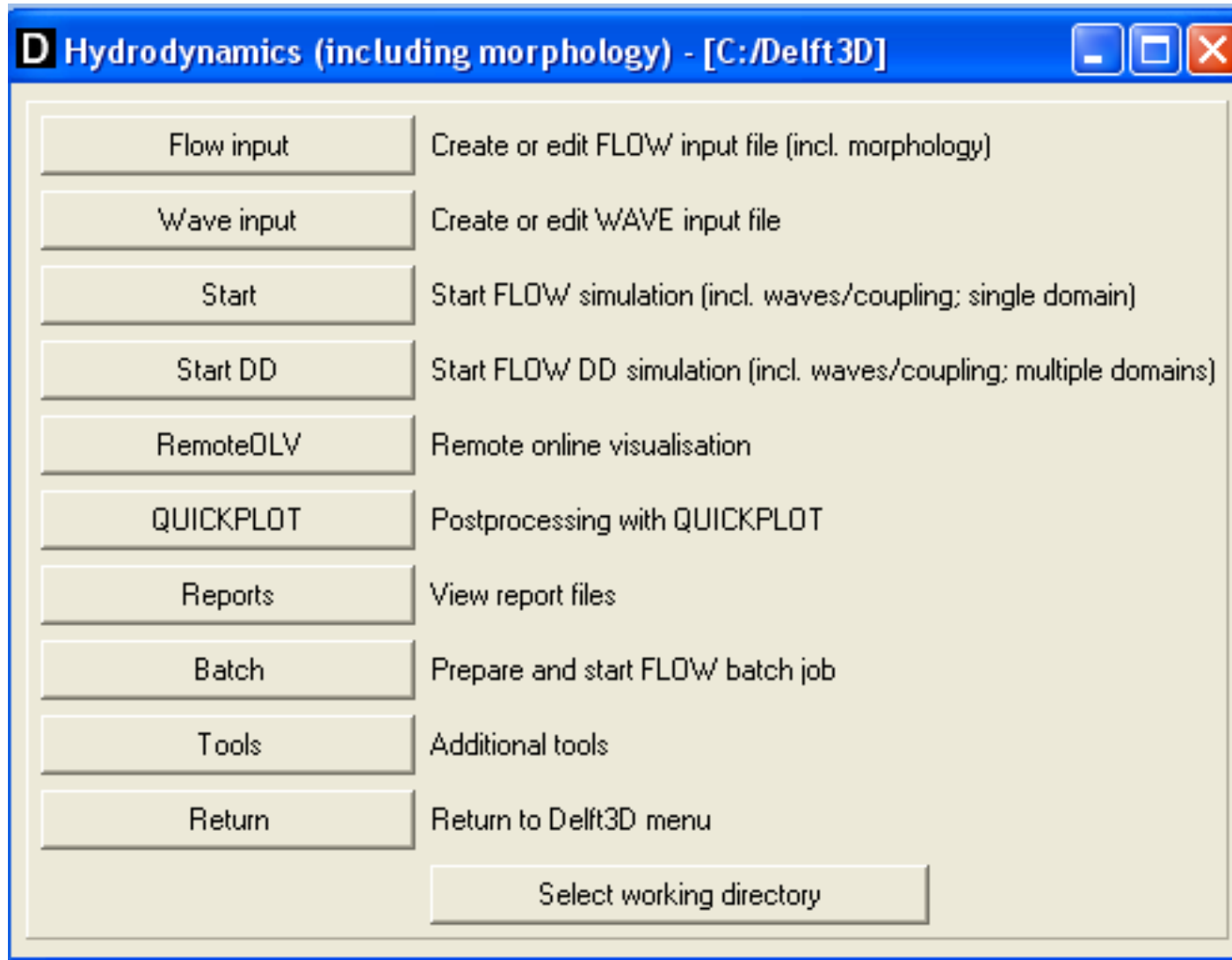
Campaña de Campo (Resultados)



Modelo numérico: DELFT 3D

- Procesos 3D
- Sólidos en suspensión, temperatura y salinidad
- Cambios de batimetría
- **Flow+Wave**
- Gratuito

Modelo numérico: DELFT 3D



Modelo numérico: DELFT 3D

Navigation menu:

- Description
- Domain**
- Time frame
- Processes
- Initial conditions
- Boundaries
- Physical parameters
- Numerical parameters
- Operations
- Monitoring
- Additional parameters
- Output

Domain

Grid parameters Bathymetry Dry points Thin dams

Grid parameters

Open grid File : ...\\delft3d_bueno\040912\9712.grd

Open grid enclosure File : ...\\delft3d_bueno\040912\9712.enc

Co-ordinate system: Cartesian

Grid points in M-direction: 245

Grid points in N-direction: 245

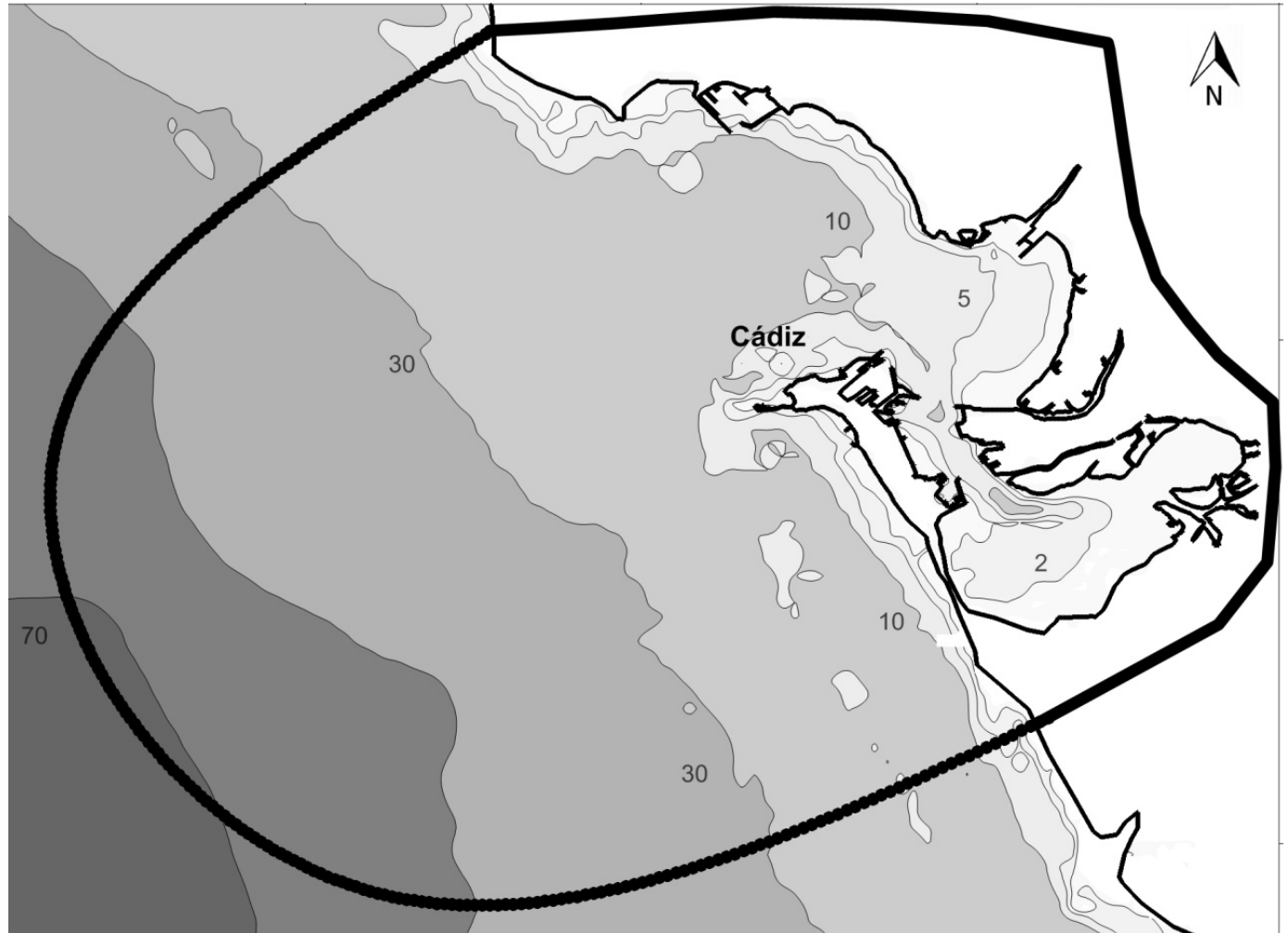
Latitude: [dec. deg]

Orientation: [dec. deg]

Number of layers:

Modelo numérico: DELFT 3D

- Description
- Domain**
- Time frame
- Processes
- Initial conditions
- Boundaries
- Physical parameters
- Numerical parameters
- Operations
- Monitoring
- Additional parameters
- Output



Modelo numérico: DELFT 3D

Description

Domain

Time frame

Processes

Initial conditions

Boundaries

Physical parameters

Numerical parameters

Operations

Monitoring

Additional parameters

Output

Time frame

Reference date [dd mm yyyy]

Simulation start time [dd mm yyyy hh mm ss]

Simulation stop time [dd mm yyyy hh mm ss]

Time step [min]

Local time zone (LTZ) +GMT

GMT = Local time - LTZ

Modelo numérico: DELFT 3D

Navigation menu:

- Description
- Domain
- Time frame
- Processes**
- Initial conditions
- Boundaries
- Physical parameters
- Numerical parameters
- Operations
- Monitoring
- Additional parameters
- Output

Configuration panel:

Constituents

- Salinity
- Temperature
- Pollutants and tracers
- Sediments

Physical

- Wind Secondary flow
- Wave
- Online Delft3D-WAVE

Man-made

- Dredging and dumping

Modelo numérico: DELFT 3D

- Description
- Domain
- Time frame
- Processes
- Initial conditions**
- Boundaries
- Physical parameters
- Numerical parameters
- Operations
- Monitoring
- Additional parameters
- Output

Initial conditions

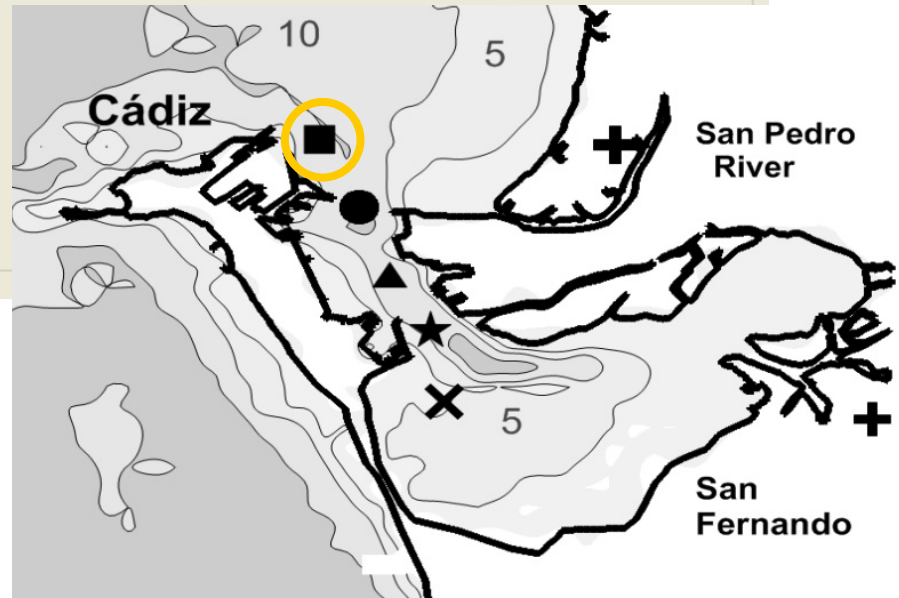
Uniform values

File :

Water level [m]

Salinity [ppt]

Temperature [°C]



Modelo numérico: DELFT 3D

- Description
- Domain
- Time frame
- Processes
- Initial conditions
- Boundaries**
- Physical parameters
- Numerical parameters
- Operations
- Monitoring
- Additional parameters
- Output

Boundaries

Oeste

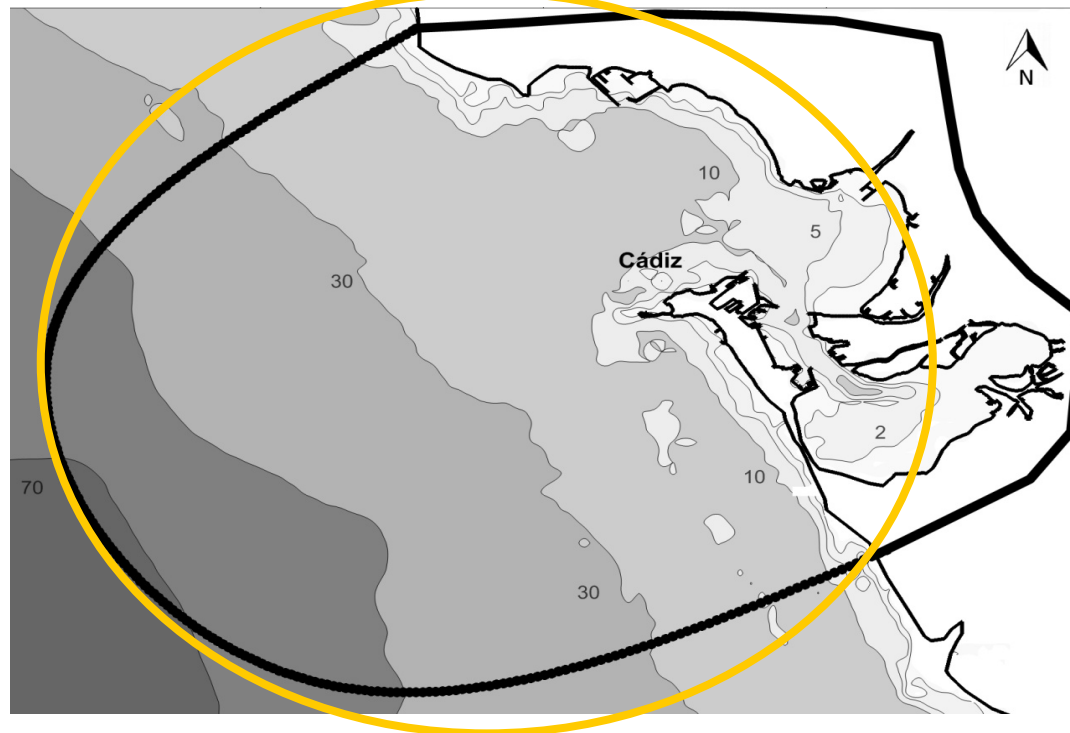
Add Open / Save

Delete

Section name

Oeste

M1	2	N1	1
M2	244	N2	1



Modelo numérico: DELFT 3D

Navigation menu:

- Description
- Domain
- Time frame
- Processes
- Initial conditions
- Boundaries**
- Physical parameters
- Numerical parameters
- Operations
- Monitoring
- Additional parameters
- Output

Boundaries

Oeste

Add Open / Save

Delete

Section name

Oeste

M1 2 N1 1

M2 244 N2 1

Flow conditions

Type of open boundary (quantity): Water level

Reflection parameter alpha: 0 [s²]

Forcing type: Astronomic

Edit flow conditions

Transport conditions

Thatcher-Harleman time lag: 0 [min]

Edit transport conditions

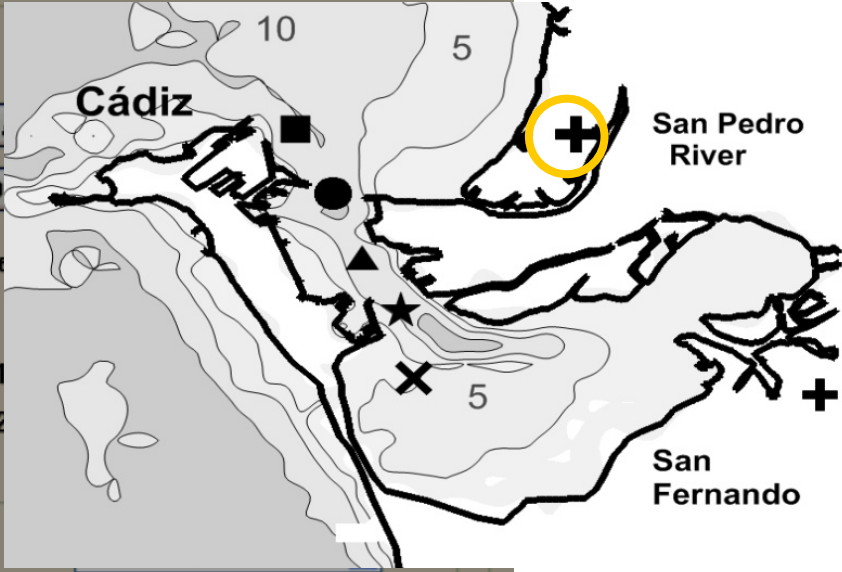
Modelo numérico: DELFT 3D

Navigation menu:

- Description
- Domain
- Time frame
- Processes
- Initial conditions
- Boundaries**
- Physical parameters
- Numerical parameters
- Operations
- Monitoring
- Additional parameters
- Output

Boundaries

Oeste



Flow conditions

Type of open boundary (quantity):

Reflection parameter alpha:

Forcing type:

Edit flow conditions

Transport conditions

Thatcher-Harleman time lag:

Edit transport conditions

Astronomical data for set -Unnamed- Conditions

Name	Amplitude [m]	Phase [deg]	Correction
M2	1.0246	57.63	<input type="checkbox"/>
S2	0.3702	83.907	<input type="checkbox"/>
SA	0.061373	229.87	<input type="checkbox"/>
Q1	0.022629	251.15	<input type="checkbox"/>
O1	0.067	302.79	<input type="checkbox"/>
P1	0.021226	35.55	<input type="checkbox"/>
K1	0.067093	42.66	<input type="checkbox"/>
2N2	0.034361	31.75	<input type="checkbox"/>

Modelo numérico: DELFT 3D

Navigation menu:

- Description
- Domain
- Time frame
- Processes
- Initial conditions
- Boundaries**
- Physical parameters
- Numerical parameters
- Operations
- Monitoring
- Additional parameters
- Output

Boundaries

Oeste

Section name

M1	<input type="text" value="2"/>	N1	<input type="text" value="1"/>
M2	<input type="text" value="244"/>	N2	<input type="text" value="1"/>

Flow conditions

Type of open boundary (quantity):

Reflection parameter alpha: [s²]

Forcing type:

Transport conditions

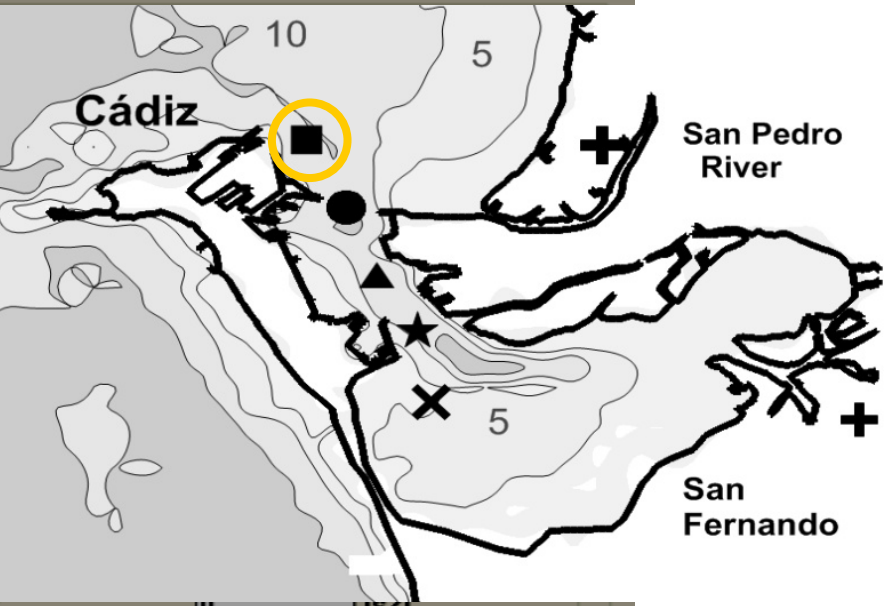
Thatcher-Harleman time lag: [min]

Modelo numérico: DELFT 3D

- Description
- Domain
- Time frame
- Processes
- Initial conditions
- Boundaries**
- Physical parameters
- Numerical parameters
- Operations
- Monitoring
- Additional parameters
- Output

Boundaries

Oeste



Flow conditions

Type of open boundary (qua
Reflection parameter alpha: [0] [S2]

Boundary Oeste

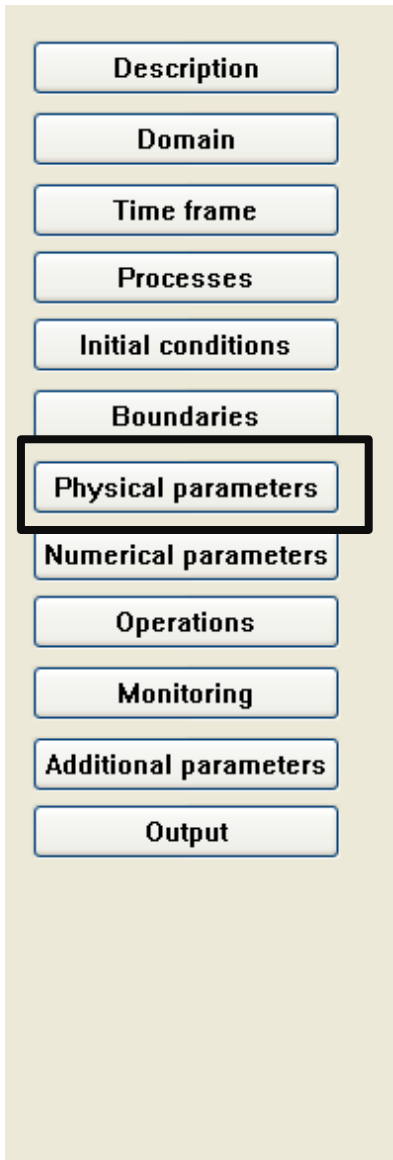
Flow conditions

Quantity: Water level
Forcing type: Astronomic

Constituent: Salinity

Time						Begin	End
dd	mm	yyyy	hh	mm	ss	[ppt]	[ppt]
18	02	2012	00	00	00	37	37
02	03	2012	00	00	00	37	37

Modelo numérico: DELFT 3D



- Rugosidad: Chézy (U:80 v:60)
- Coeficiente de arrastre:
0.005
- Viscosidad: 15
- Viento: Boya Golfo de Cádiz

Modelo numérico: DELFT 3D

Navigation menu:

- Description
- Domain
- Time frame
- Processes
- Initial conditions
- Boundaries
- Physical parameters
- Numerical parameters
- Operations
- Monitoring
- Additional parameters
- Output**

Output

Storage Print Details

Output storage

Start time of simulation : 18 02 2012 00 00 00
Stop time of simulation : 02 03 2012 00 00 00
Time Step [min]: 1

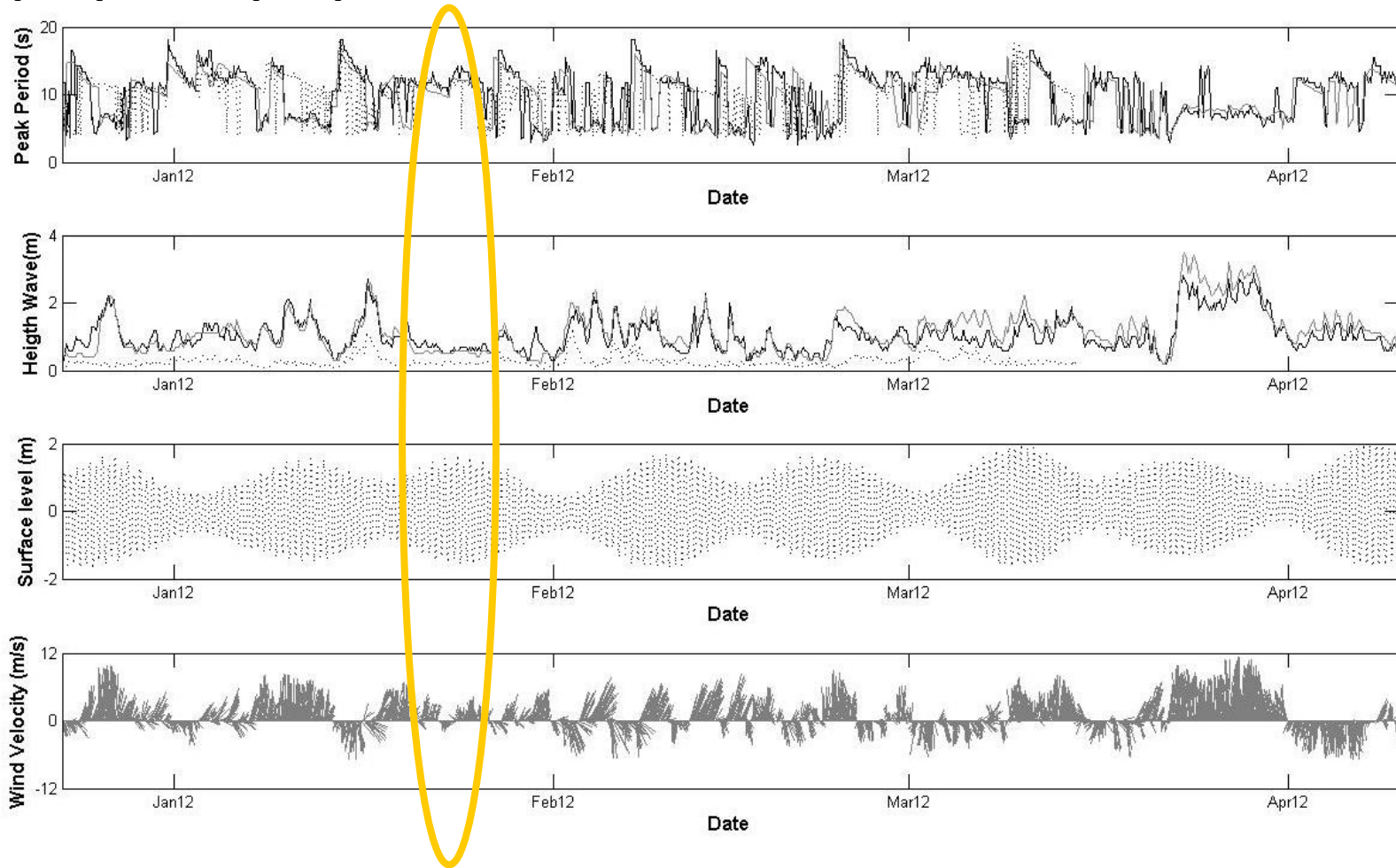
Store map results		Store communication file :	
	dd mm yyyy hh mm ss		dd mm yyyy hh mm ss
Start time	<input type="text" value="18 02 2012 00 00 00"/>	Start time	<input type="text" value="04 09 2012 00 00 00"/>
Stop time	<input type="text" value="02 03 2012 00 00 00"/>	Stop time	<input type="text" value="04 09 2012 00 00 00"/>
Interval	<input type="text" value="15"/> [min]	Interval	<input type="text" value="0"/> [min]
History interval	<input type="text" value="15"/> [min]	Restart int.	<input type="text" value="1440"/> [min]

Fourier analysis Online visualisation
 Online coupling

File : Filename unknown

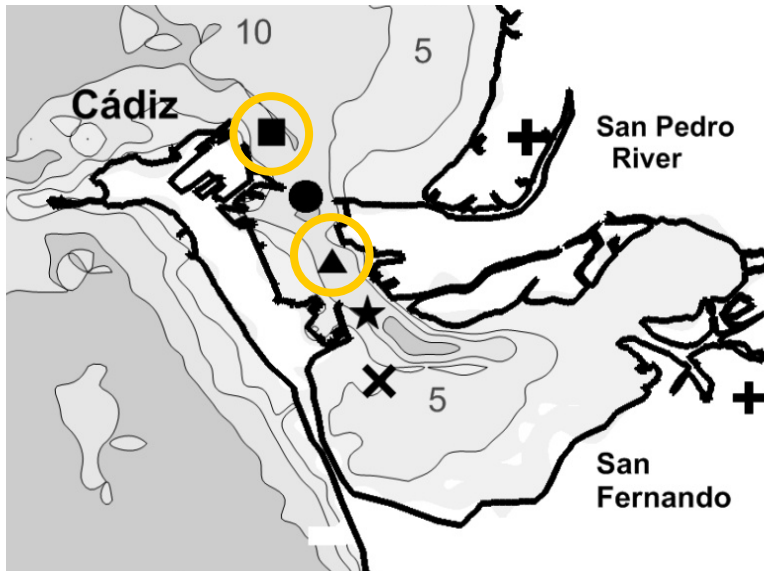
Aplicación del modelo → Validación

• 17/01/12-30/01/12



Aplicación del modelo → Validación

•17/01/12-30/01/12



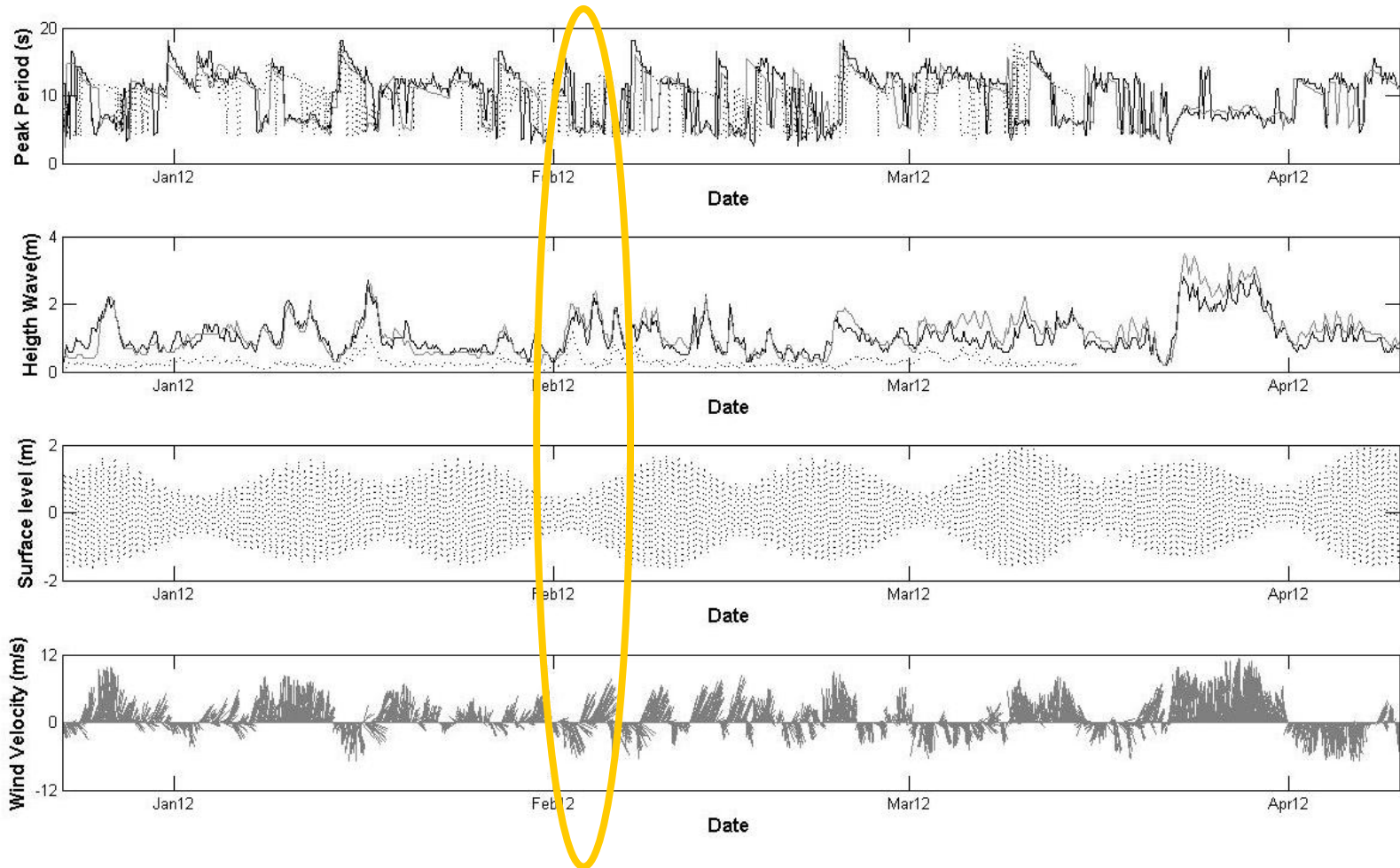
Niveles: $R \sim 0.99$

Velocidad Este: $R \sim 0.8$

Velocidad Norte: $R \sim 0.94$

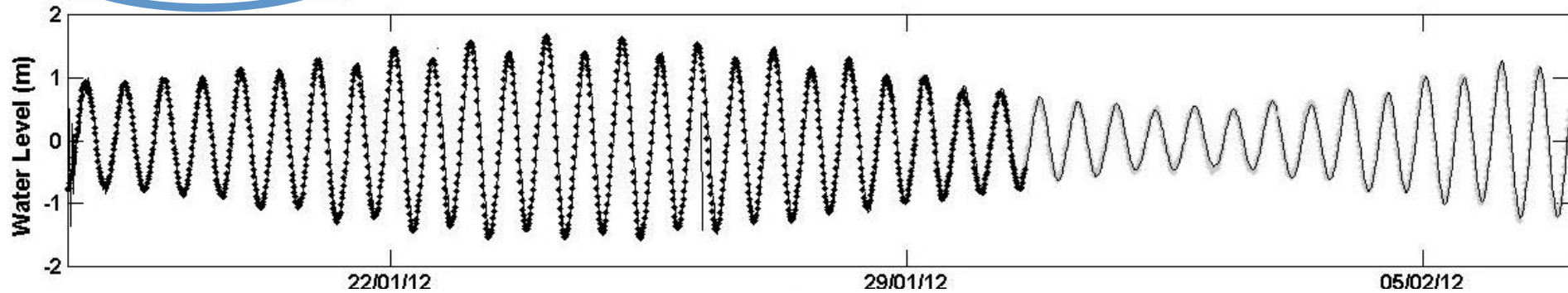
Aplicación del modelo → Validación

• 29/01/12-10/02/12

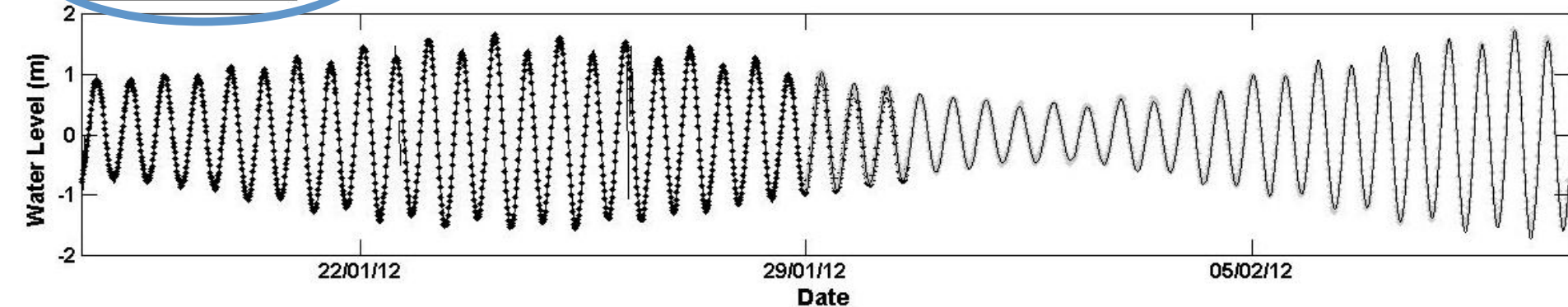


Aplicación del modelo → Validación

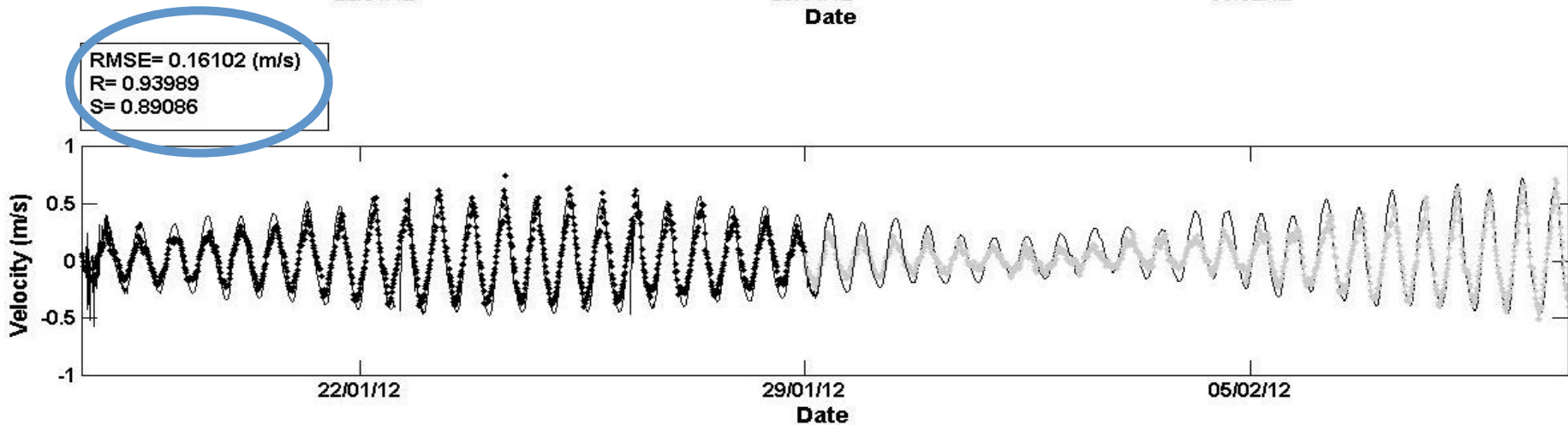
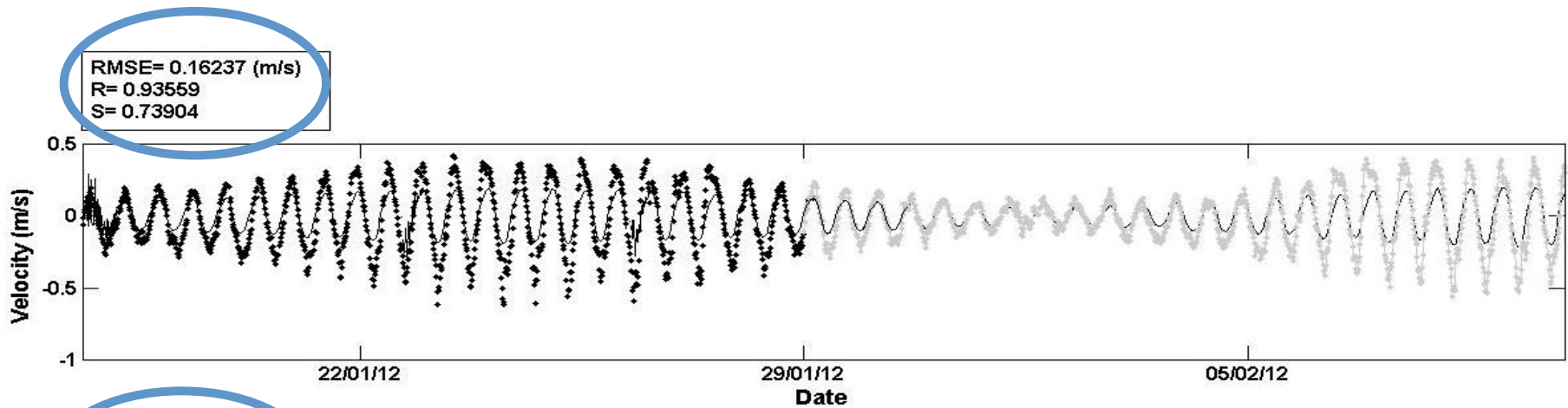
RMSE= 0.10337 (m)
R= 0.98973
S= 0.98958



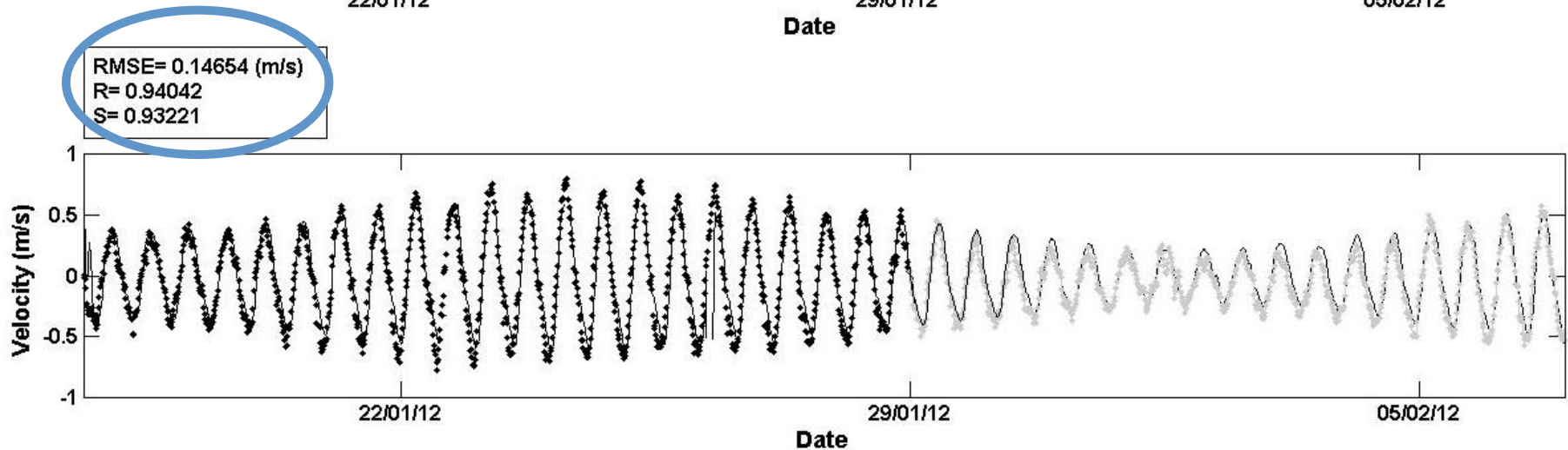
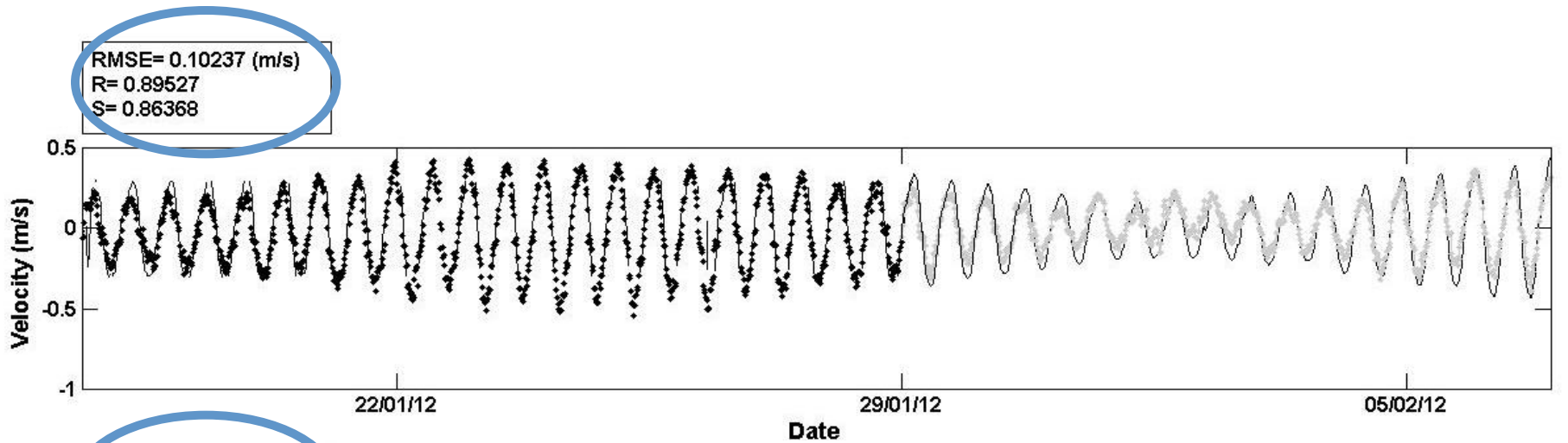
RMSE= 0.12645 (m)
R= 0.98517
S= 0.98495



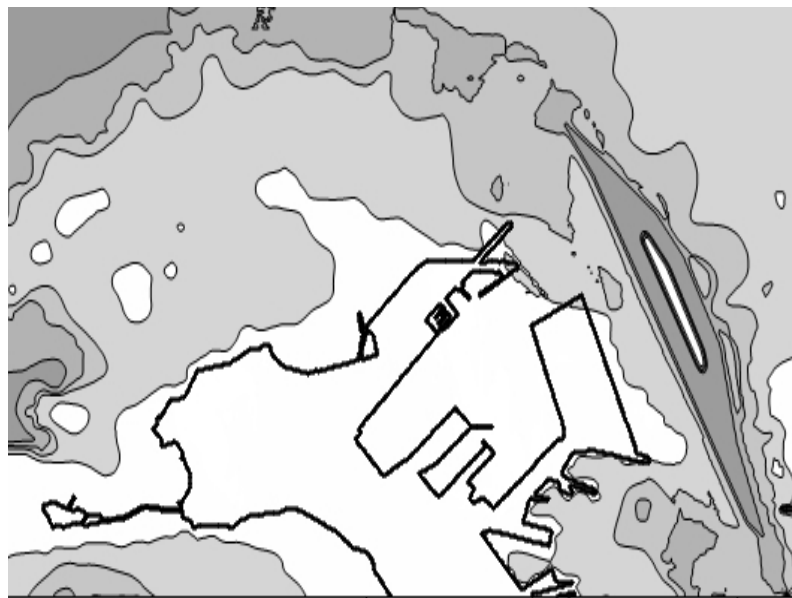
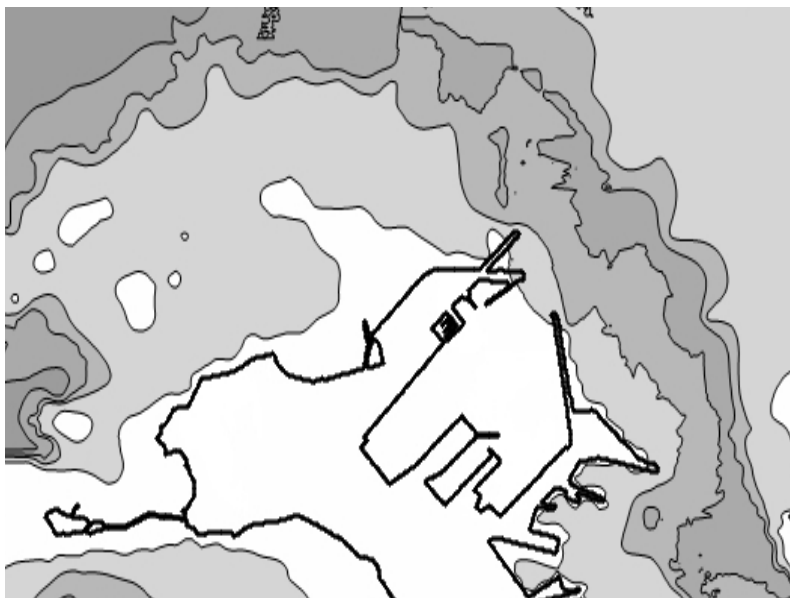
Aplicación del modelo → Validación



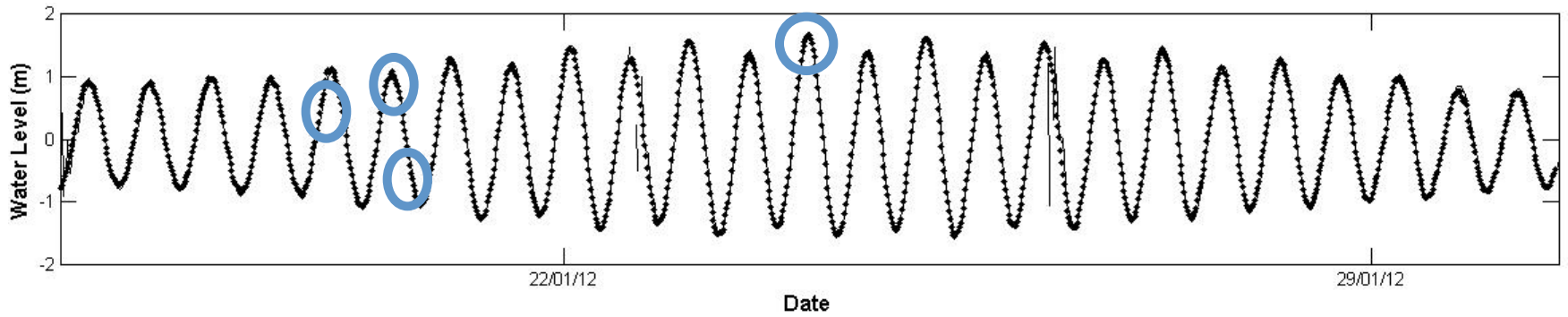
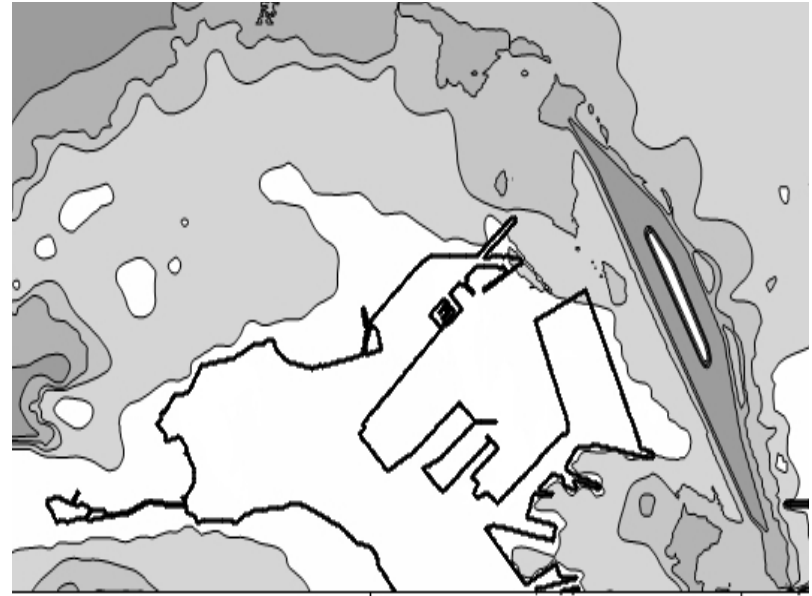
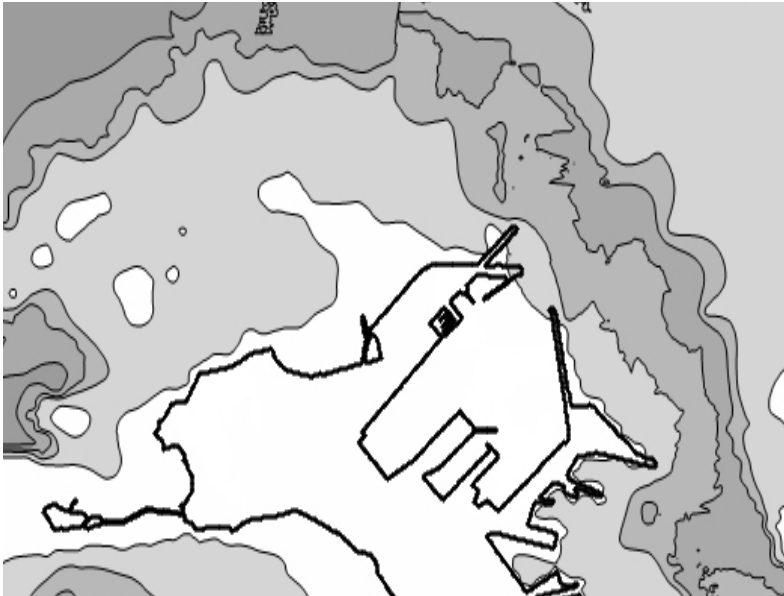
Aplicación del modelo → Validación



Dragado



Dragado



Dragado

