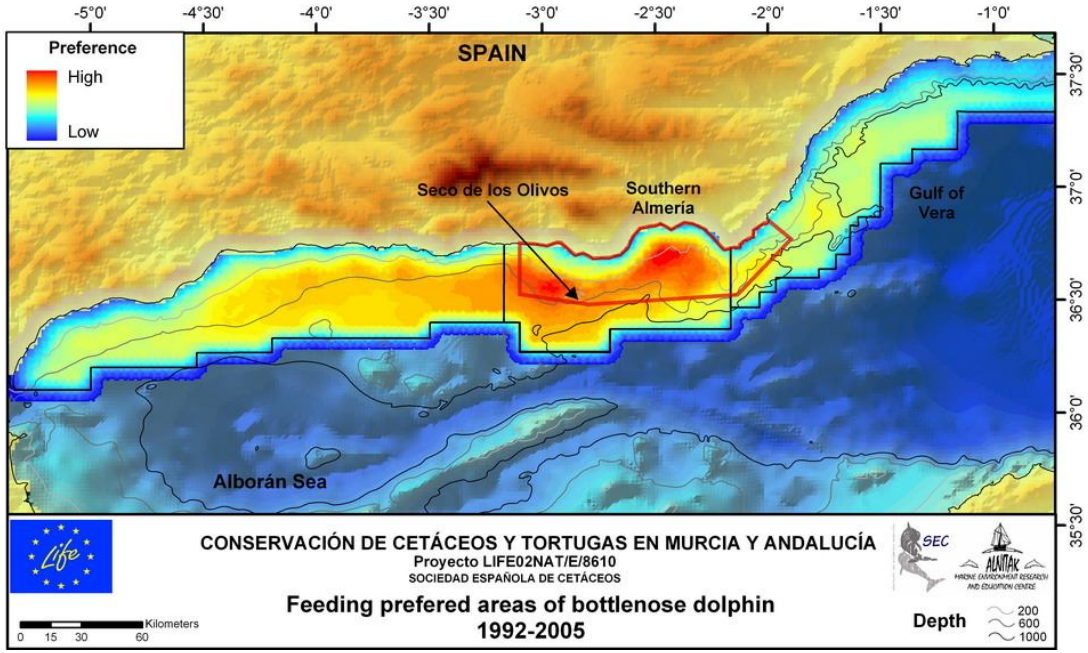
Model-based abundance estimates and their implications for conservation and management



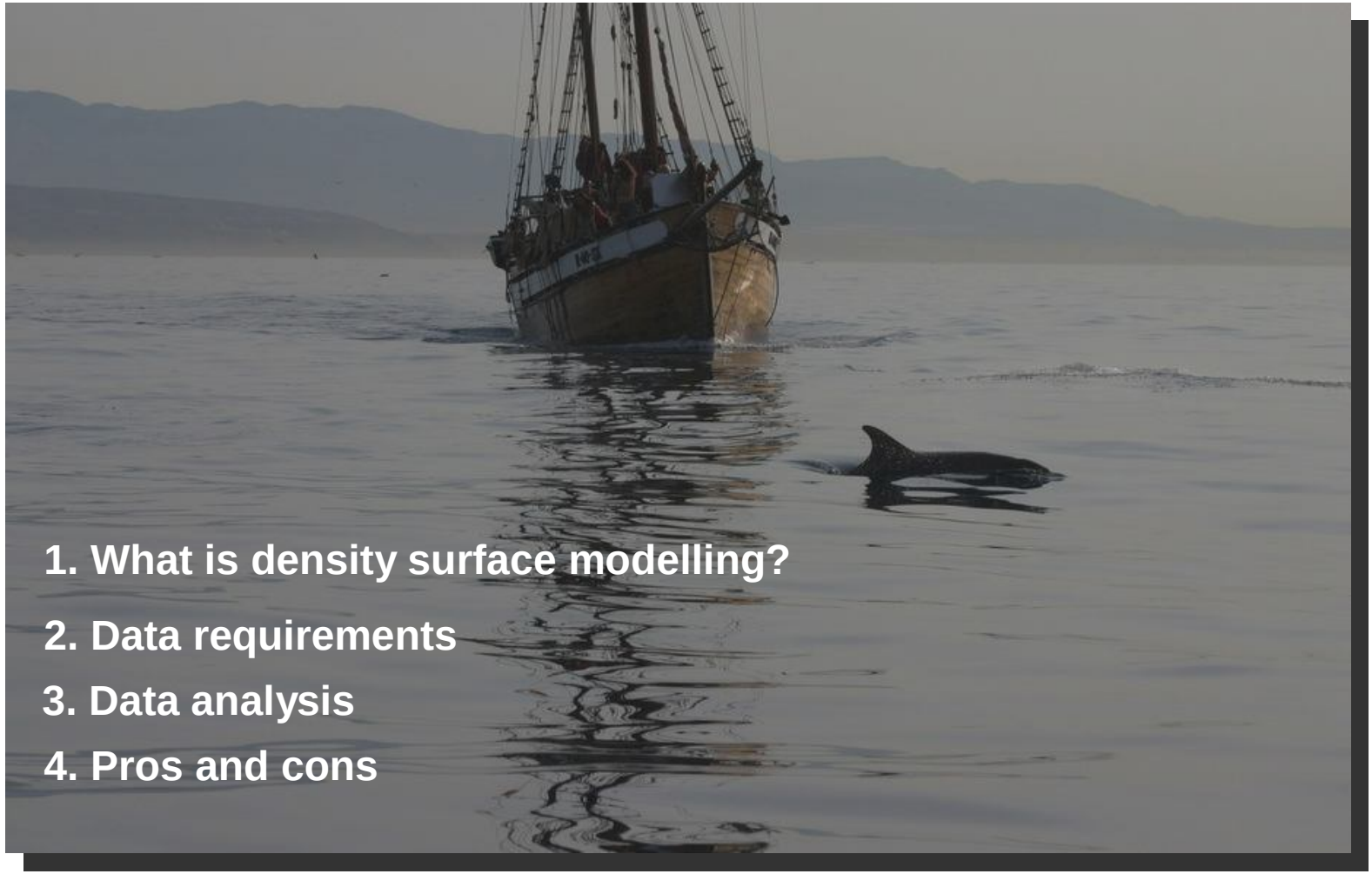
Ana Cañadas

ALNITAK

Challenging cetacean conservation

Cetaceans are typically highly mobile and wide-ranging species

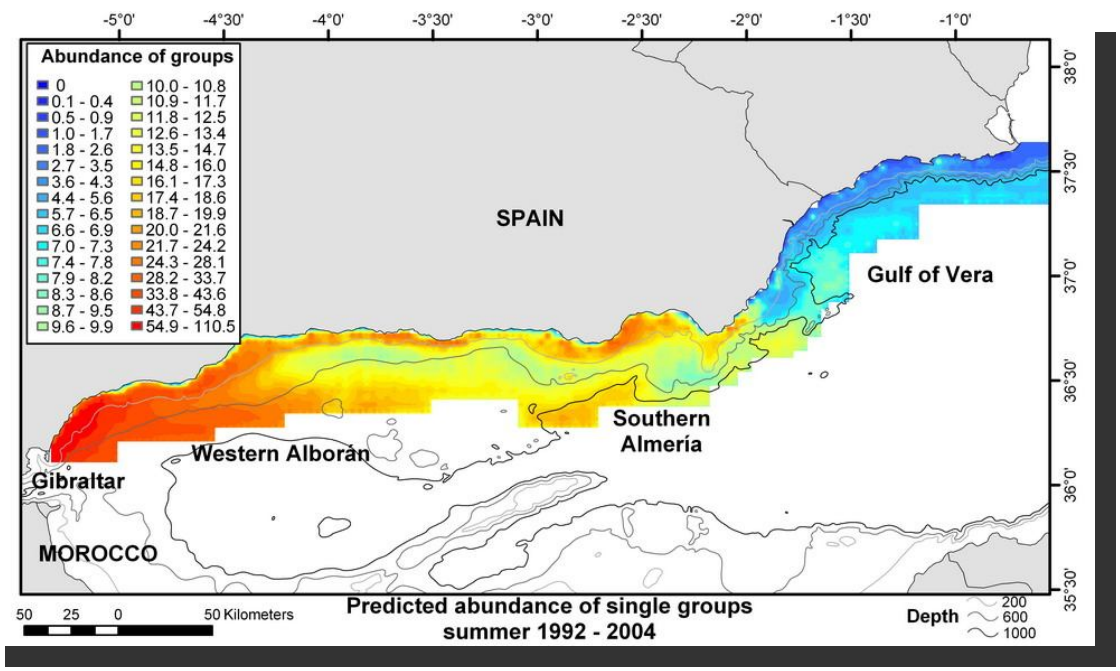
Model-based abundance estimates: Density Surface Modelling



1. What is density surface modelling?
2. Data requirements
3. Data analysis
4. Pros and cons

What is Density Surface Modelling?
The concept

Density Surface Modelling incorporates data on the environment to generate a spatial prediction of relative or absolute density based on the preference for habitats defined by combinations of environmental covariates.



Provides the best description of distribution available, as informed by features of the environment shown to be important

Represents a great improvement over using simple measures of occurrence – e.g. distribution maps, encounter rates

What is Density Surface Modelling?
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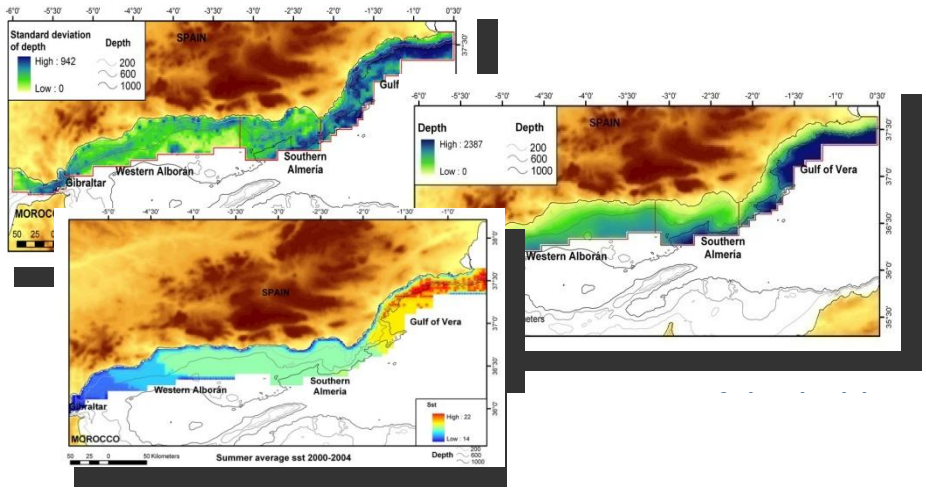
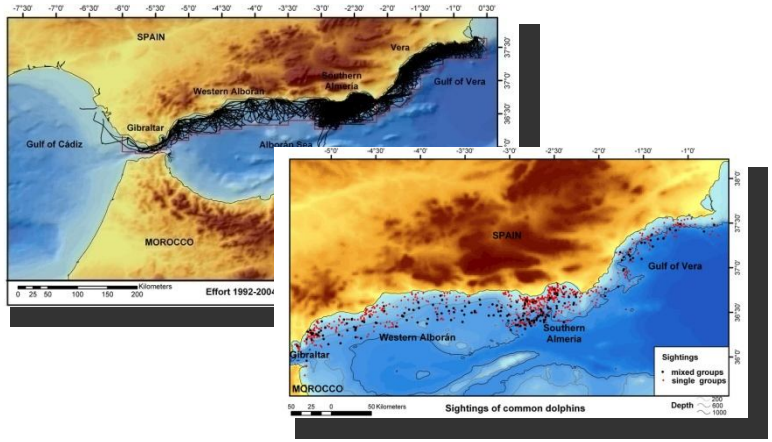
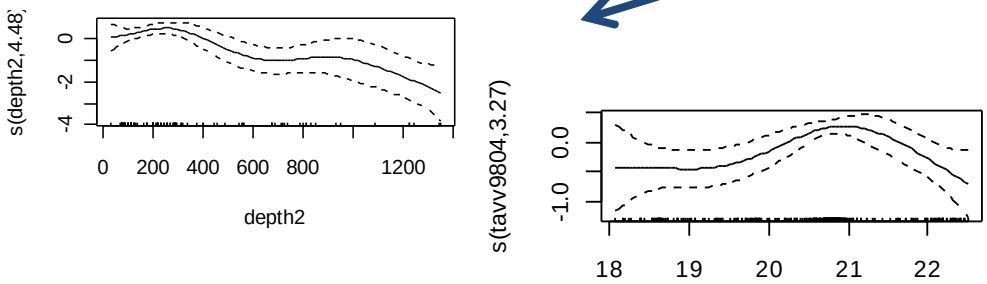
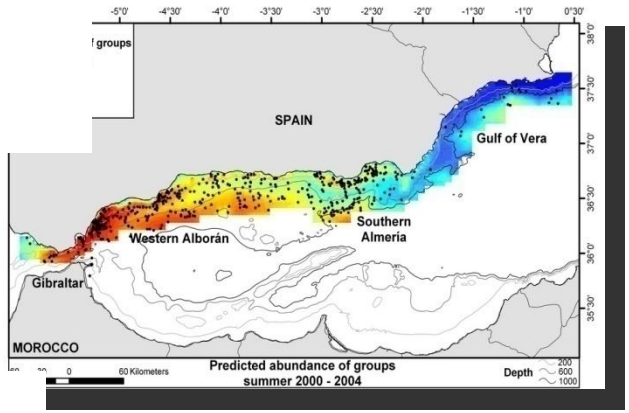




Effort and sightings data



Species - habitat relationships

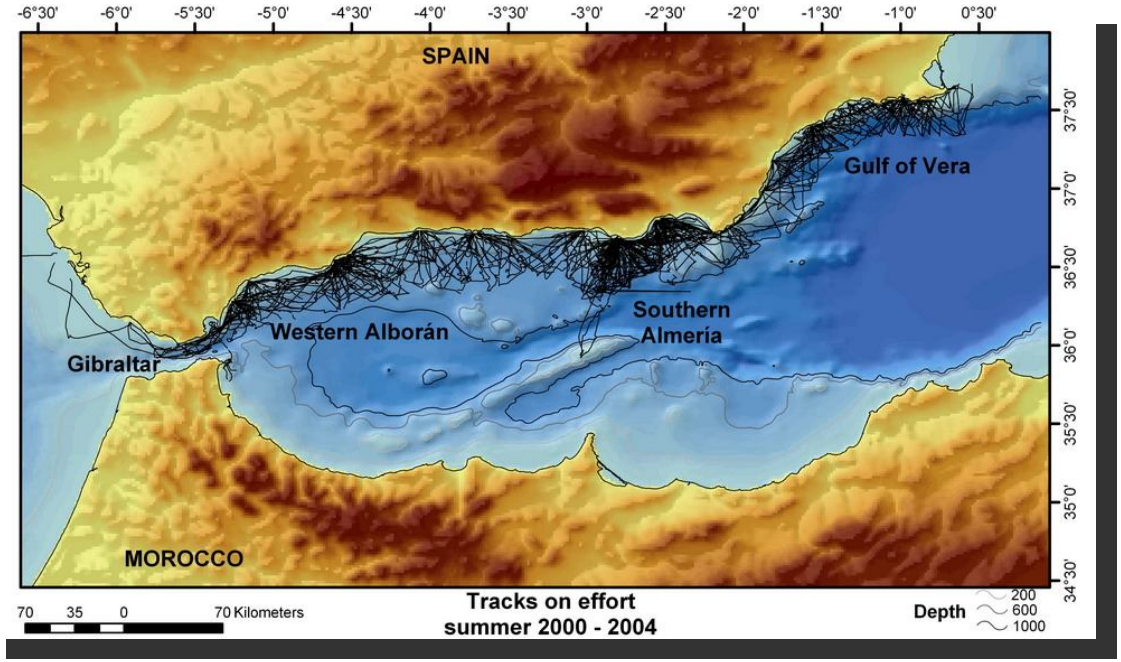


Spatial prediction of density

What is Density Surface Modelling?
The concept

When surface modelling is combined with line transect sampling (**model-based method**)

alternative technique to conventional line transect sampling (**design-based method**) for abundance estimation

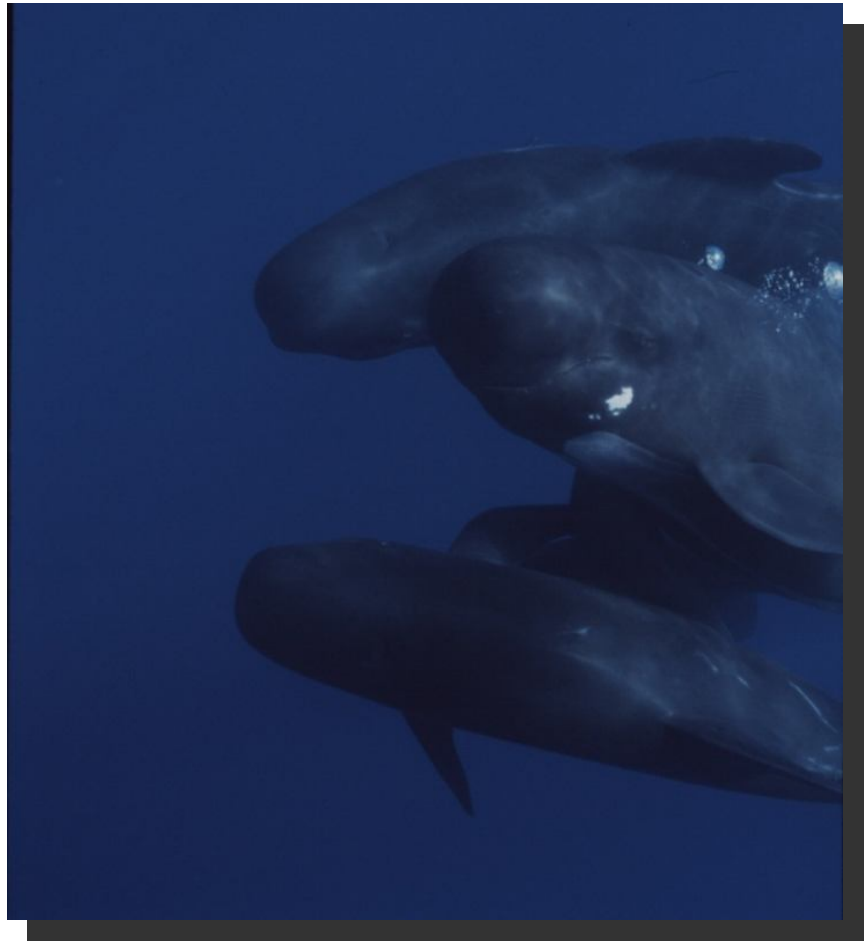


What is Density Surface Modelling?
The concept

It can be used to achieve two main objectives:

a) To obtain information on distribution and habitat use of a given species

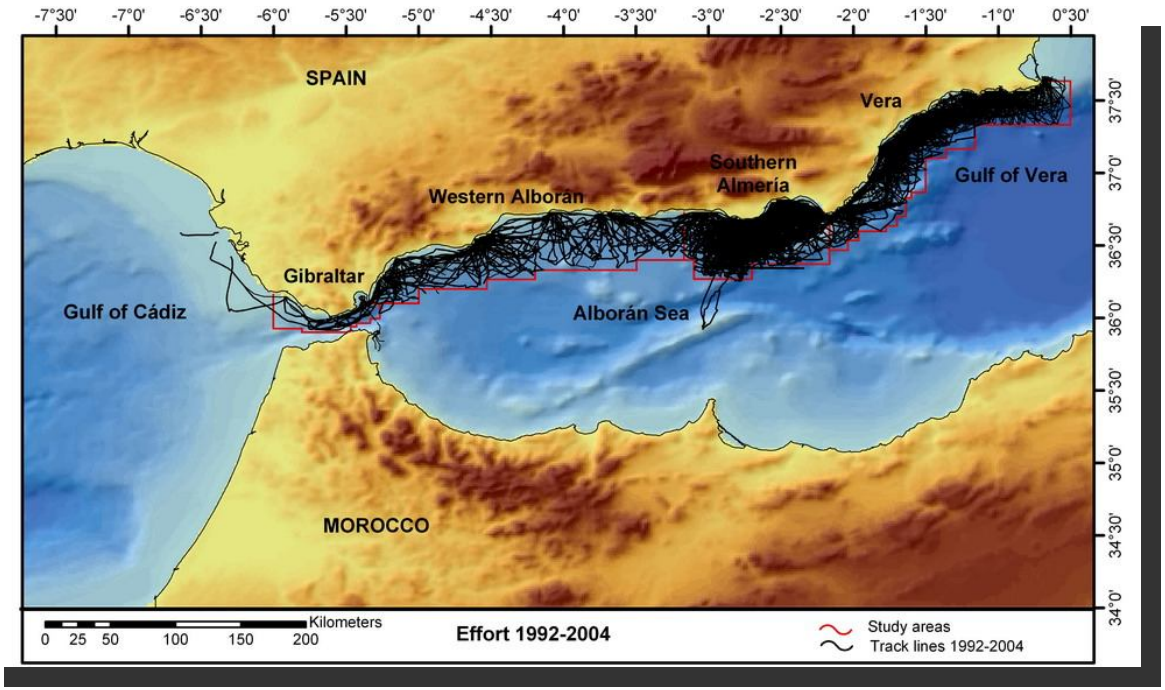
b) To obtain, in addition to a) abundance estimates



Data requirements
Effort

Data recorded during the track lines:

- Date
- Time
- Position (lat-lon)
- Effort (on/off)
- Searching conditions (e.g. sea state, position of observer, etc.)



Blue: required for habitat preferences and for abundance estimates

Red: required for abundance estimates

Data requirements
Sightings

Data recorded during the sightings:

Minimum:

- Date
- Time
- Position at first sighting (lat-lon)
- Species
- Group size
- Searching conditions (e.g. sea state, position of observer, etc.)
- Angle and distance
- Heading of the animals when spotted
- Initial cue

Desirible:

- Behaviour
- Presence of calves

Blue: required for habitat preferences and for abundance estimates

Red: required for abundance estimates (for the detection function)

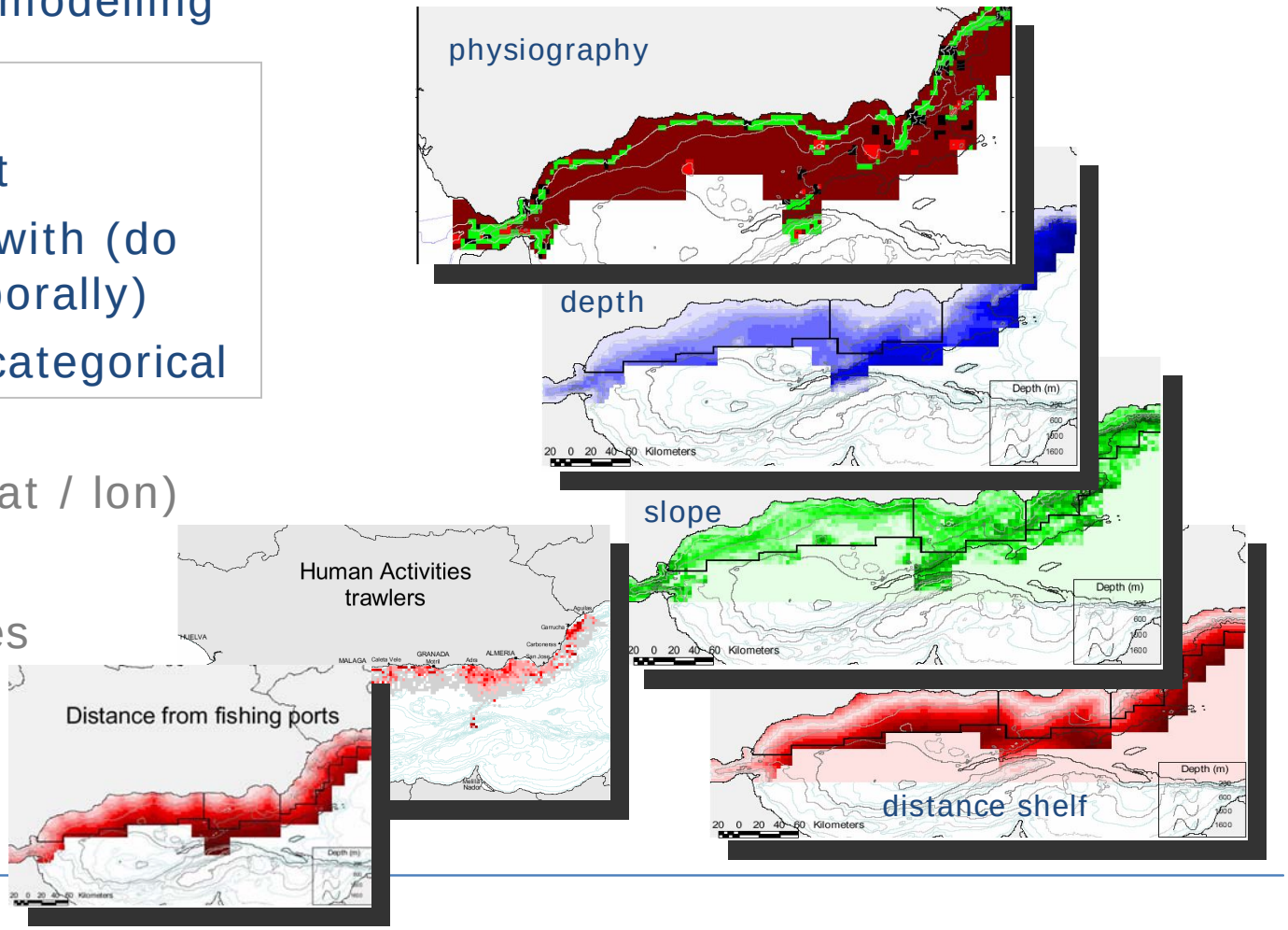
Data requirements
Environmental covariates

Covariates: explanatory/predictive variables that could be used for the surface modelling

Fixed

- Easier to collect
- Easier to work with (do not change temporally)
- Continuous or categorical

- Geographical (lat / lon)
- Environmental
- Human activities



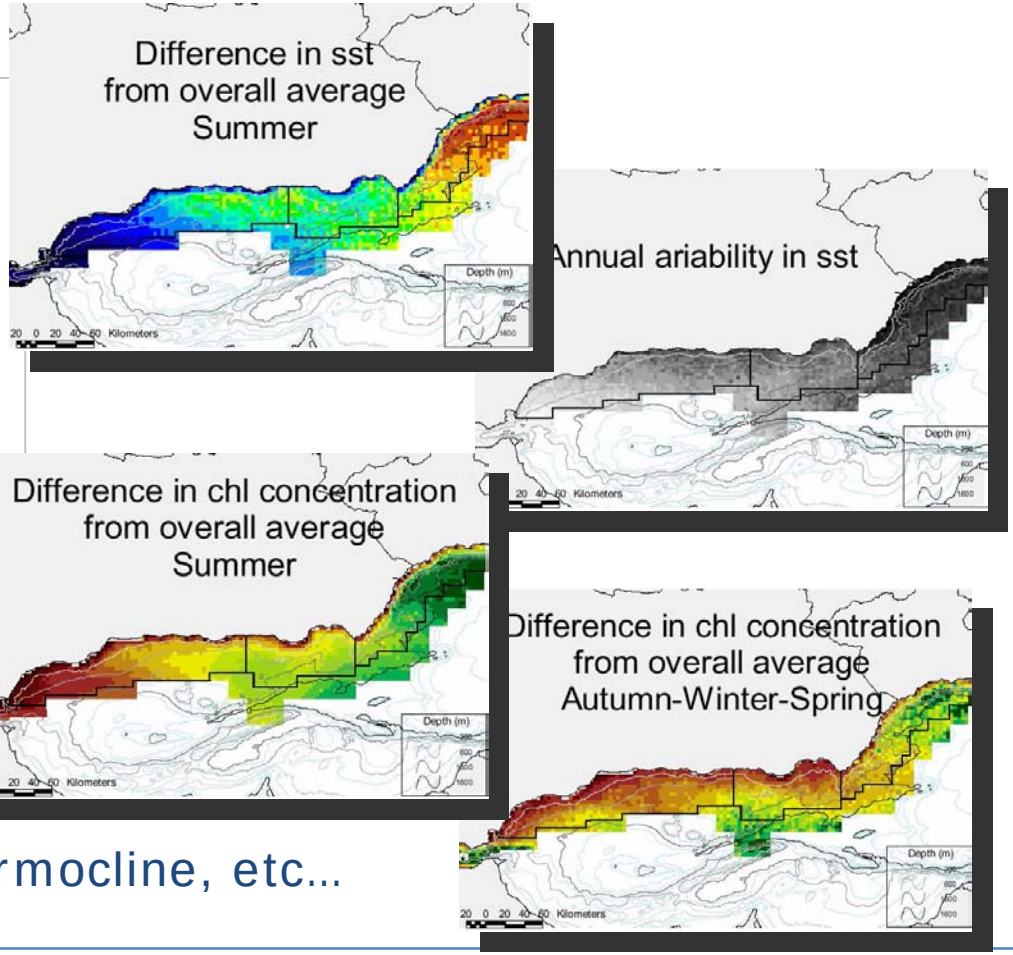
Data requirements
Environmental covariates

Covariates: explanatory/predictive variables that could be used for the surface modelling

Dynamic

- Satellite images / *in situ* data
- Difficult to incorporate in models (change temporally)
  - Aggregation/Stratification at different temporal scales
  - Can show relatively fixed structures

- Sea surface temperature
- Chlorophyll concentration
- Sea level, prey, currents, thermocline, etc…



Data requirements
Implications for survey procedures

- Reasonable coverage across the range of variables

  Extrapolation is dangerous! – potential for first exploration…
- Coverage in different seasons desirable

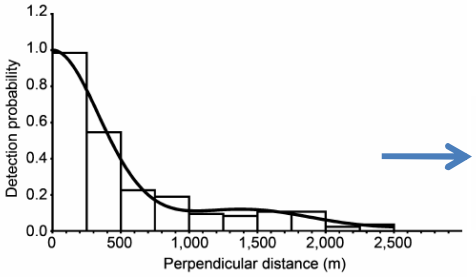
- Enough sample size
  - To allow the use of enough variables
  - Minimum sample size partially depends on distribution patterns
  - Effort required larger than for conventional line transect

- Otherwise, same requirements for survey procedure as conventional like transect but less strict in design

Data analysis

Steps:

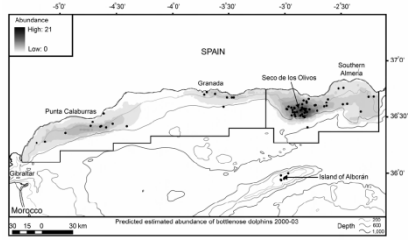
1. Estimation of detection function and *p* for each group
2. Estimation of number of groups (HT)
3. Modelling the abundance of groups (e.g. GLM, GAM) & prediction
4. Modelling the group sizes (e.g. GLM, GAM) & prediction
5. Estimation of abundance (3*4) & surface prediction
6. Estimation of CV and 95% CI (bootstrap)



$$\hat{N}_i = \sum_{j=1}^{n_i} \frac{1}{\hat{p}_{ij}}$$

$$\hat{N}_i = \exp\left[\ln(a_i) + \theta_0 + \sum_k f_k(z_{ik})\right]$$

$$E(s_j) = \exp\left[\hat{g}_j(y,v) + \theta_0 + \sum_k f_k(z_{jk})\right]$$

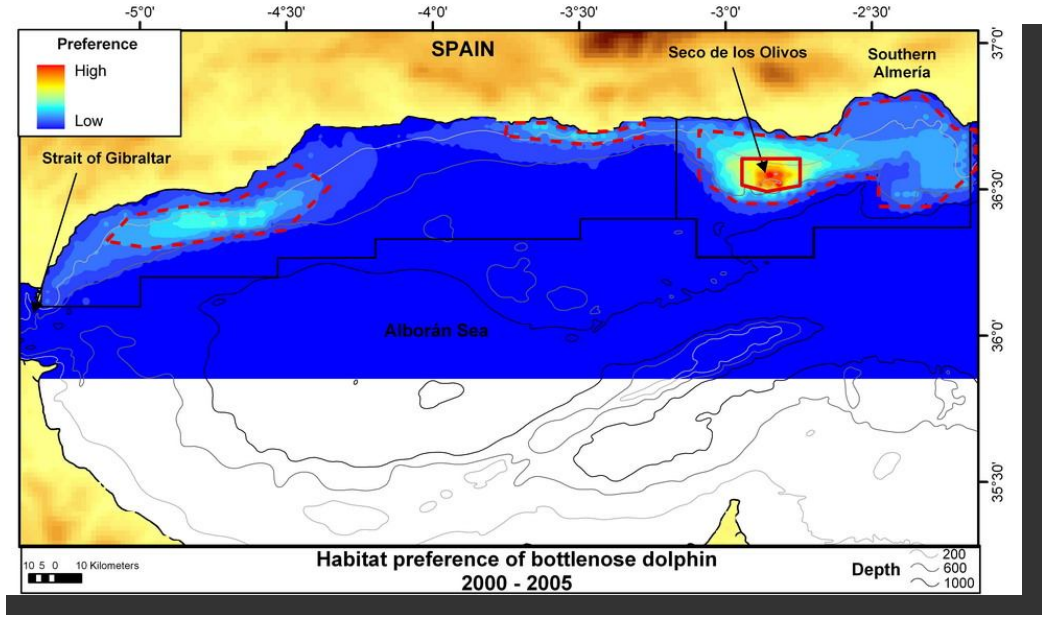


Limitations

- Data hungry
- Predictive, not explanatory: limited number of covariates
- Only allows covariates known for the whole study area
- Difficult use of dynamic covariates
- Should not be extrapolated outside study area
- Caution with the conclusions: spatial and temporal scales

Advantages and usefulness

- Allows a description of distribution and abundance in relation with environmental variables
- Allows the creation of contiguous areas of highest predicted relative densities



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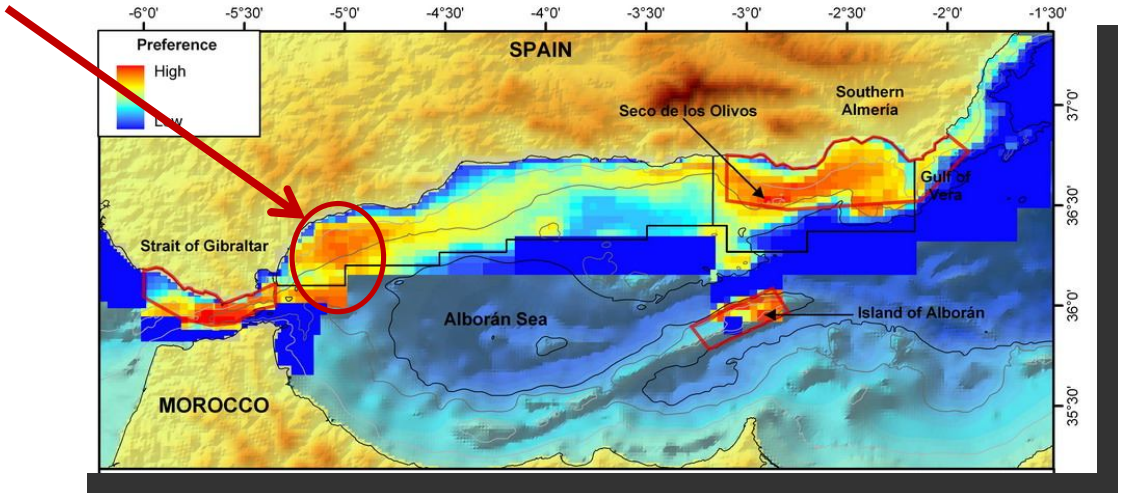

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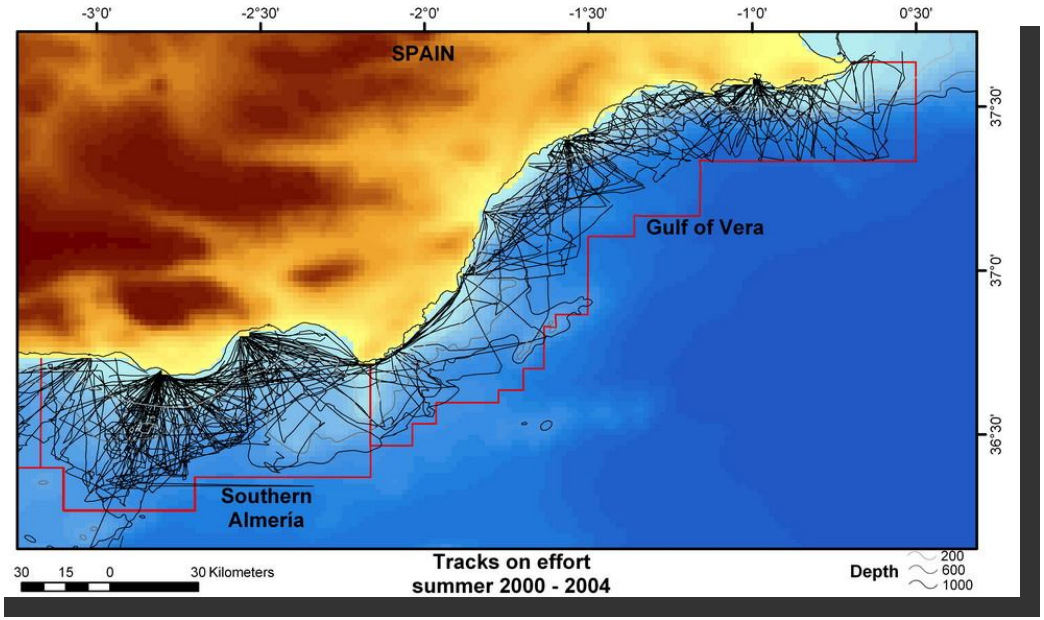
- May achieve increased abundance estimator precision



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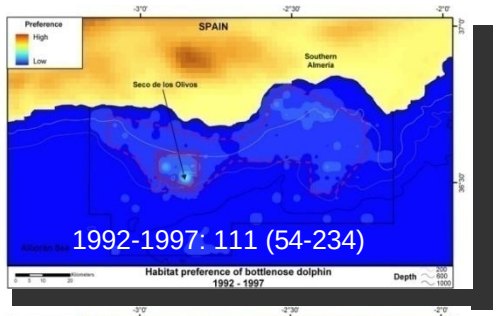

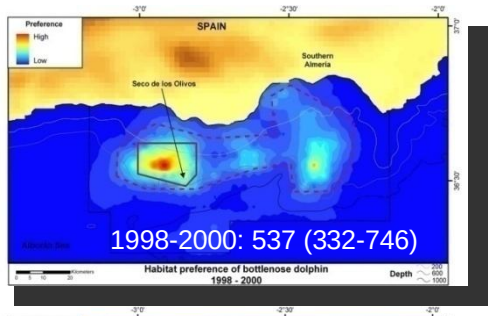

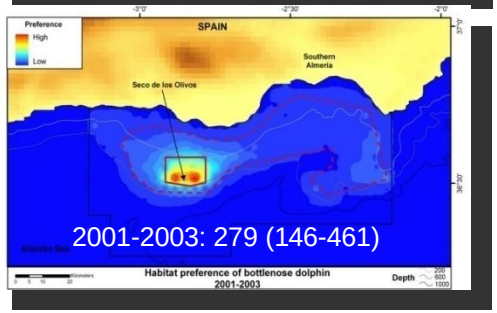

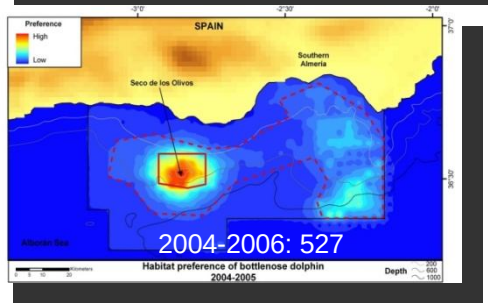

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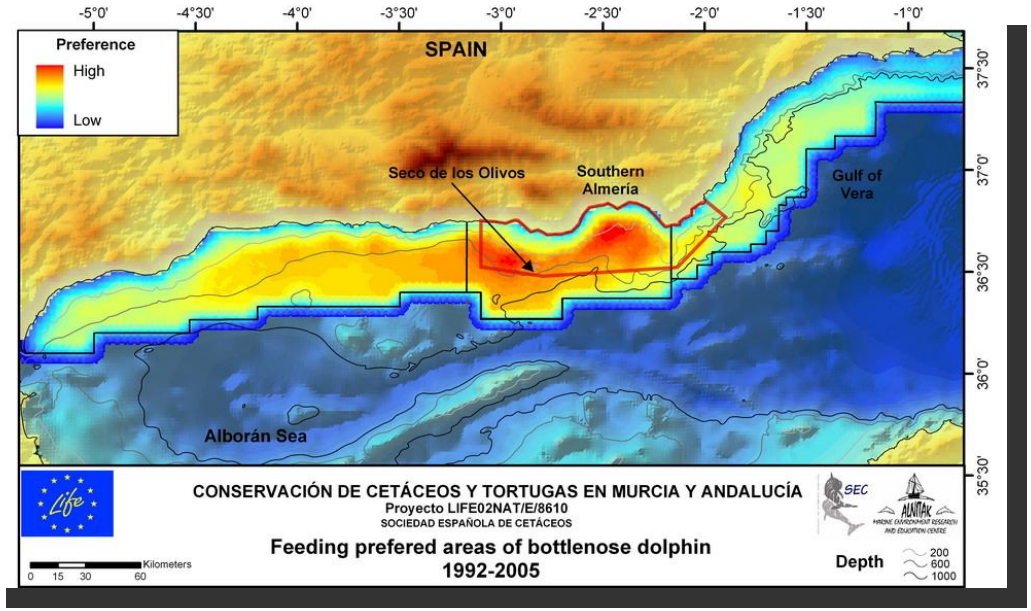
- Predictions may be done to test other areas



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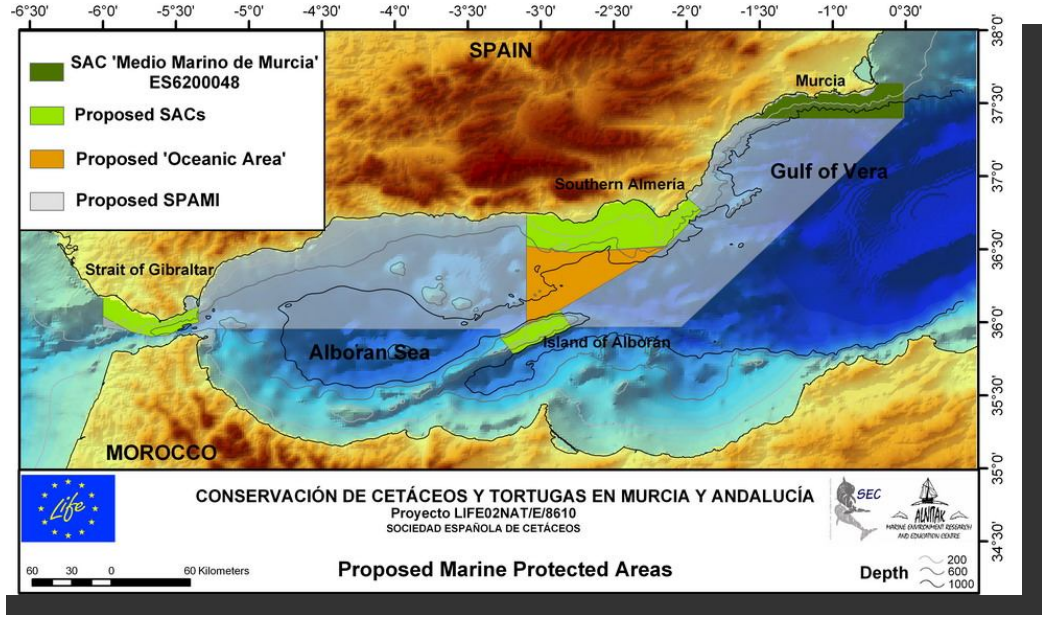
- Predictions may be done to test other areas
- May detect hot spots, useful for long-term small scale monitoring and MPA design
- Allows to make an easy connection between science and policy makers (results presented in a user-friendly format)



Thank you