MareFrame

Granger-causality analysis of Gadget model outputs and environmental drivers.

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 613571

Hello!

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CSIC Consejo Superior de Investigaciones Científicas

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THE GENERAL PROBLEM FOR FISHERIES MODELLERS

Models for ecosystem-based fisheries management

2.

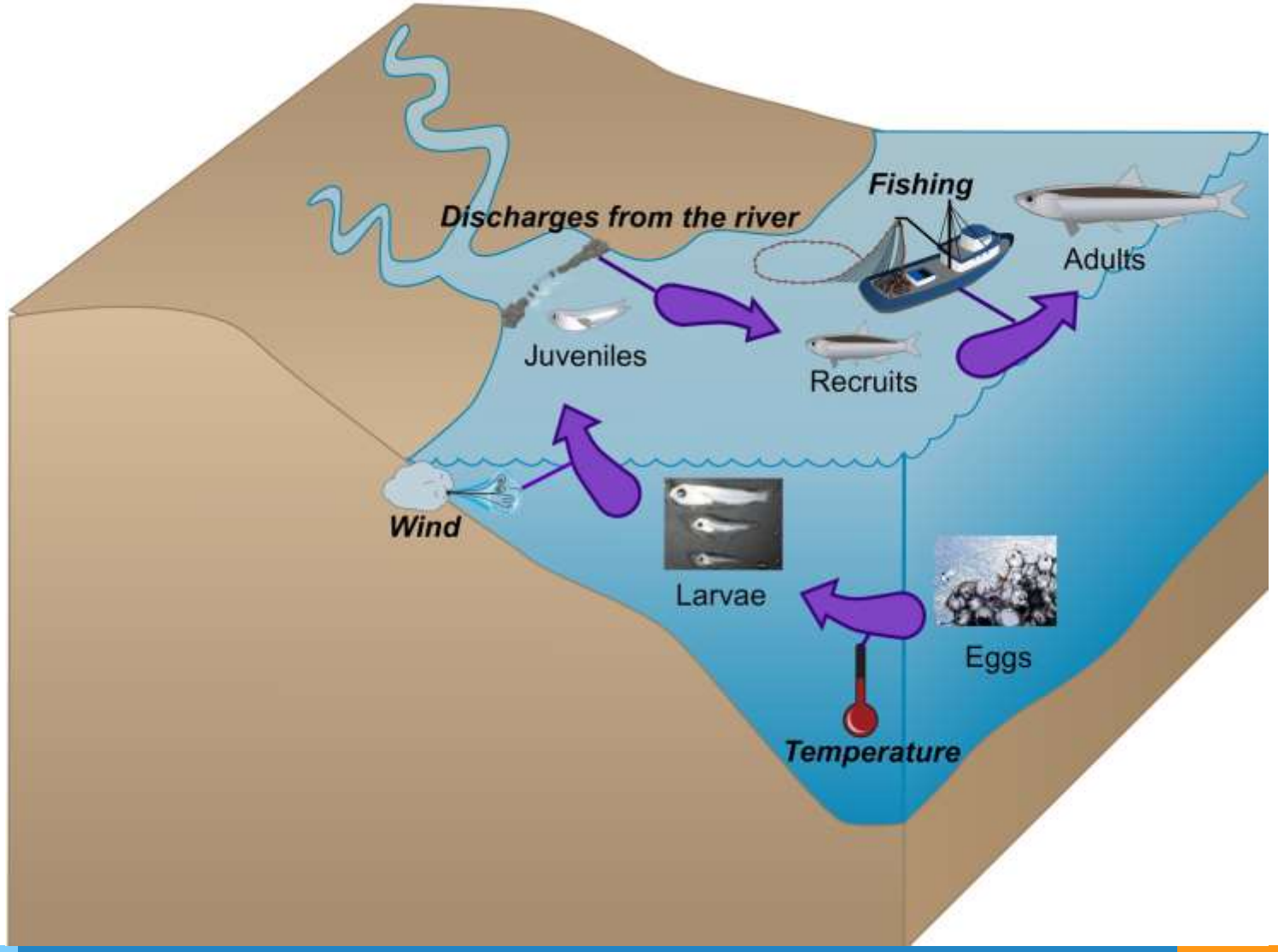
A SOLUTION PROPOSAL FOR ANCHOVY FISHERY IN THE GULF OF CADIZ

Anchovy in the Gulf of Cádiz

Engraulis encrasicolus

3.646.276,35 EUR in the first quarter of 2016, is the most important fishery in the region representing 10% of the Andalucian commercial landings

Environmentally-based recruitment

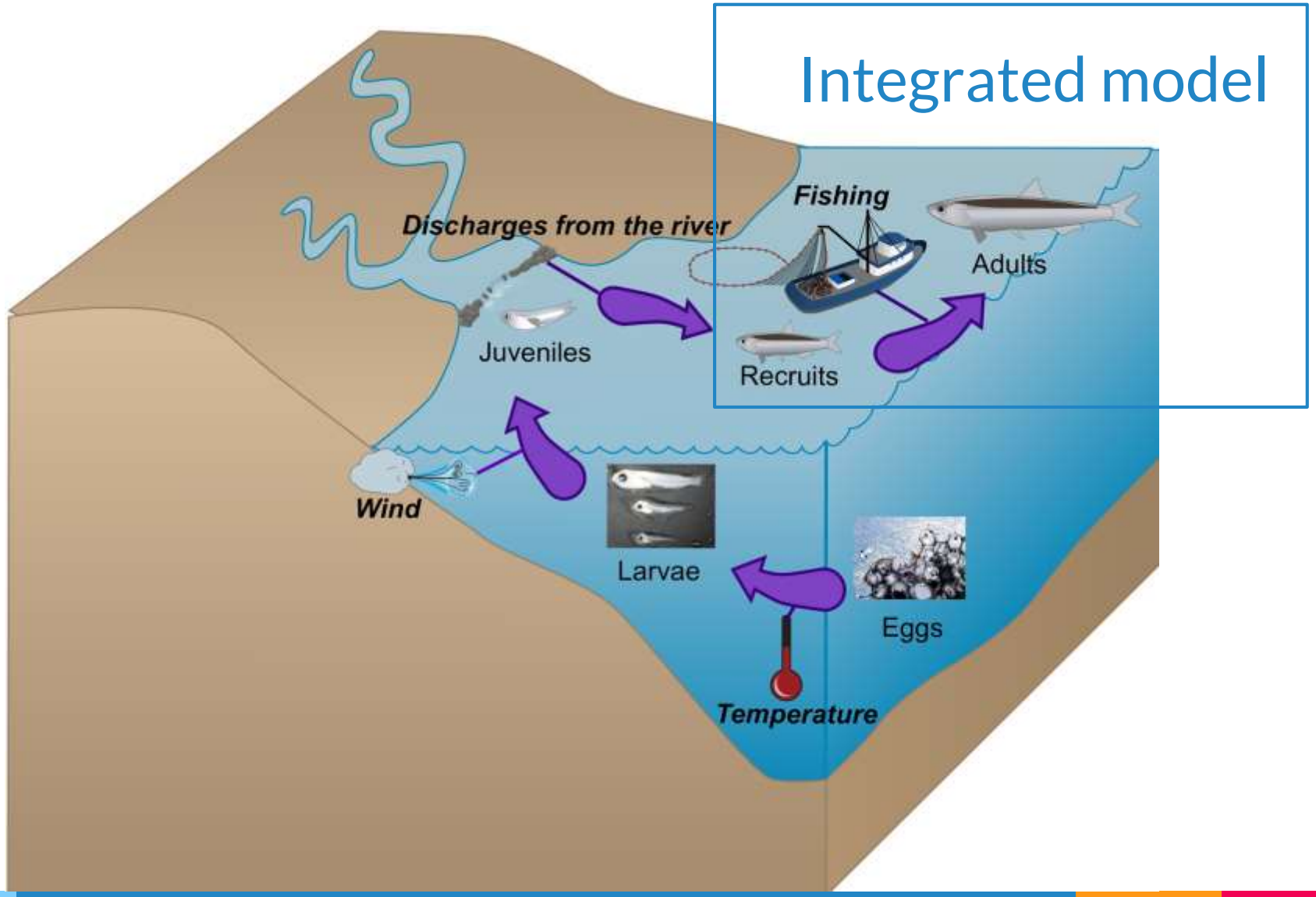


Ecosystem approach to fisheries EAF

The approach

Expand an integrated model to incorporate the ecosystem approach

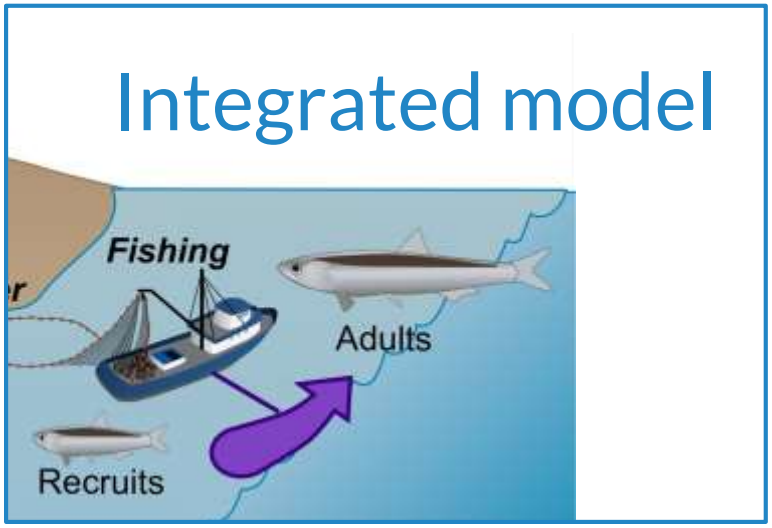
Model implementation



Model implementation

Integrated model
A model that includes a lot of information, i.e:

- Survey abundance, age-length composition
- Spawner-recruit relationships
- CPUE and effort
- Direct estimates of abundance from mark-recapture or line transect methods.



GREAT ADVANTAGE: Consistency
"The inclusion of auxiliary information along with catch-age data allows for unbiased estimation" (Quinn 2003)

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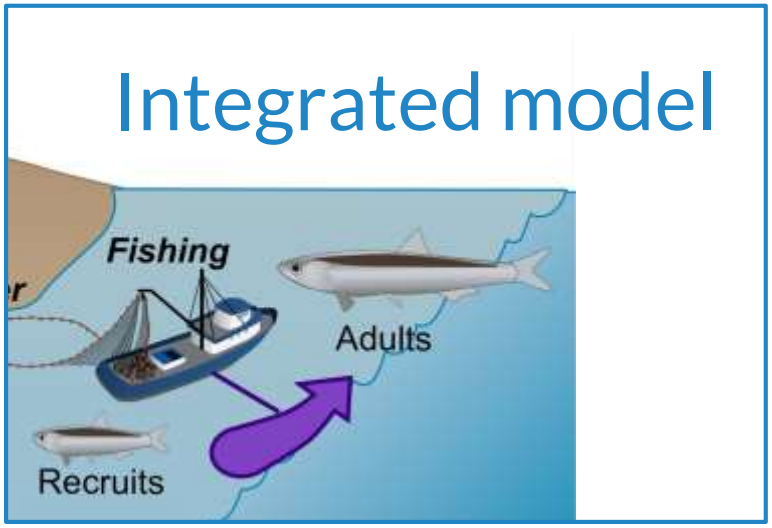

Examples:

- SS3
- Gadget

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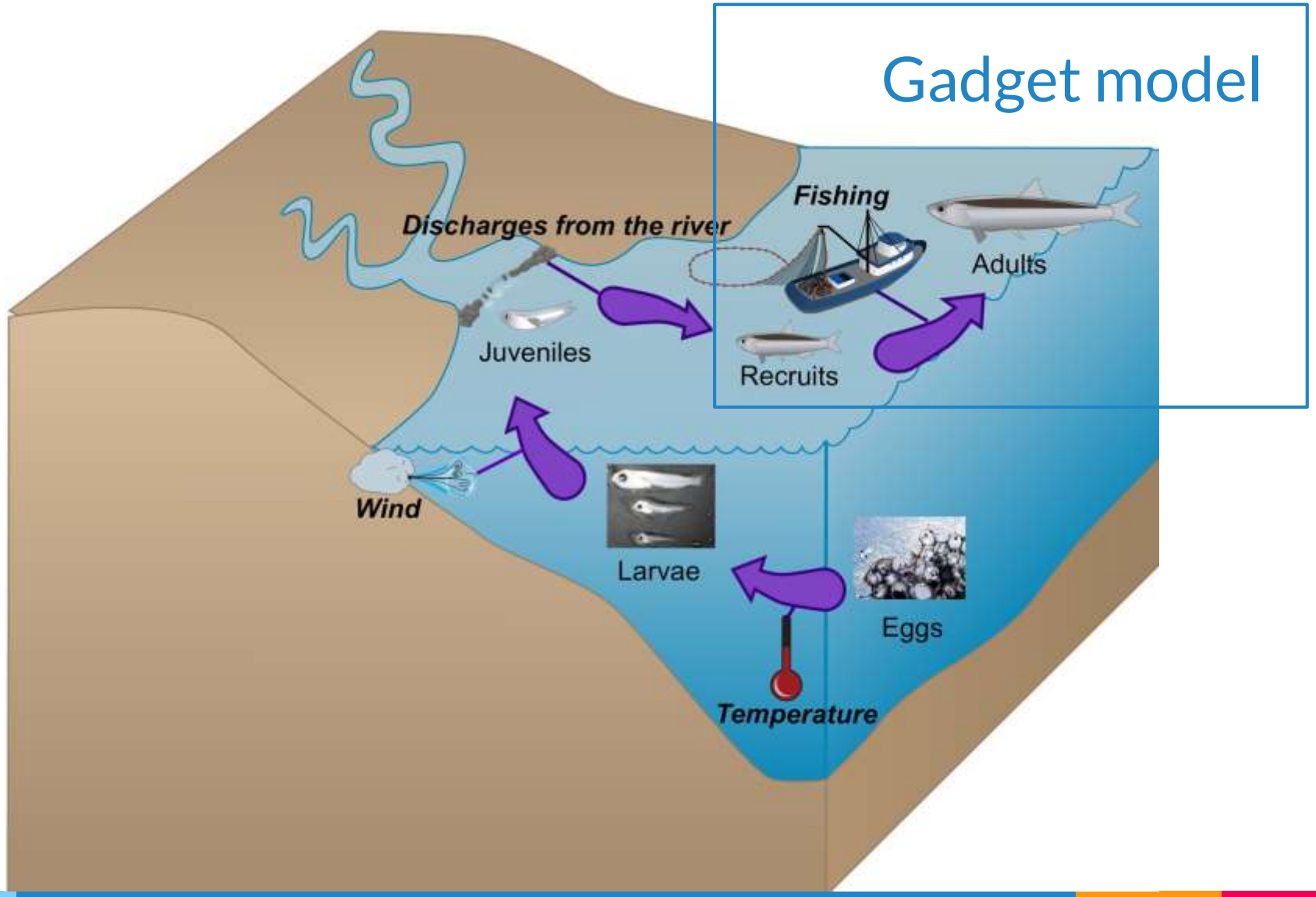
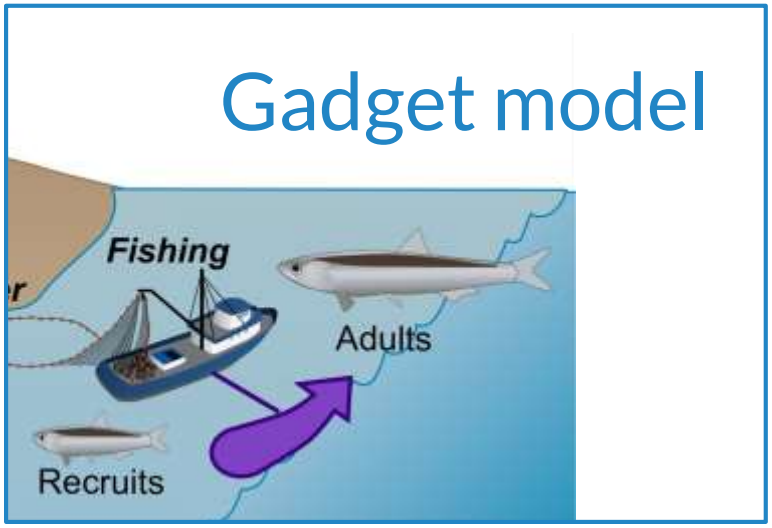
Model implementation



Model implementation

Gadget
A parametric, age-length-structured model. For this implementation we used:

- Landings 1988-2015 (Numbers, Age and length distributions)
- 3 Acoustic Surveys (Numbers, Age and length distributions)



ADVANTAGES:

- It is used in assessment (Cod, ling, hake)
- Data input and data output automated in R (data.frames, mfdb and Rgadget packages)
- Multiarea and multispecies

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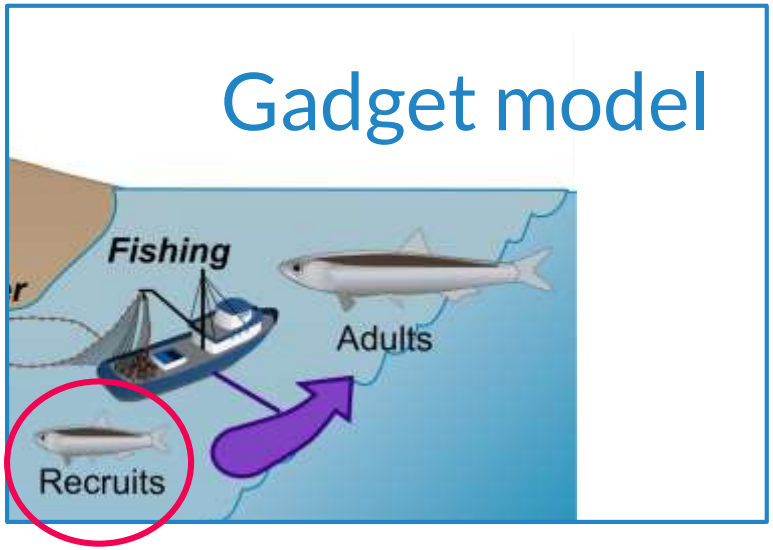
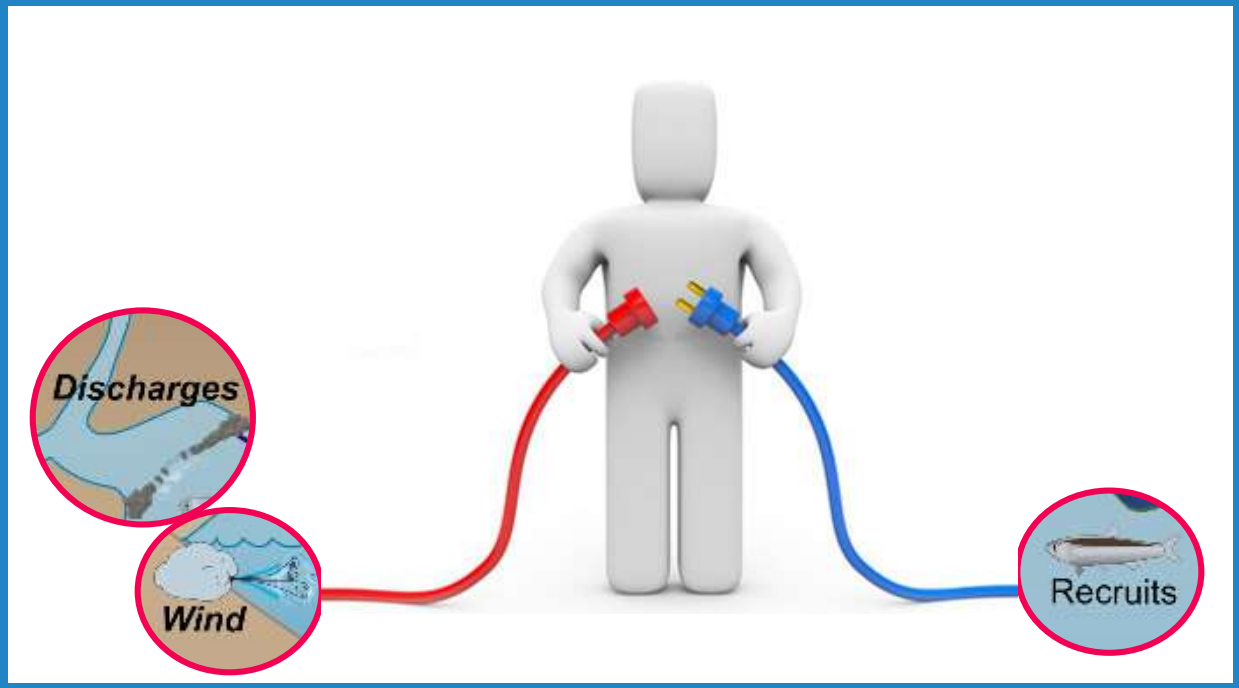
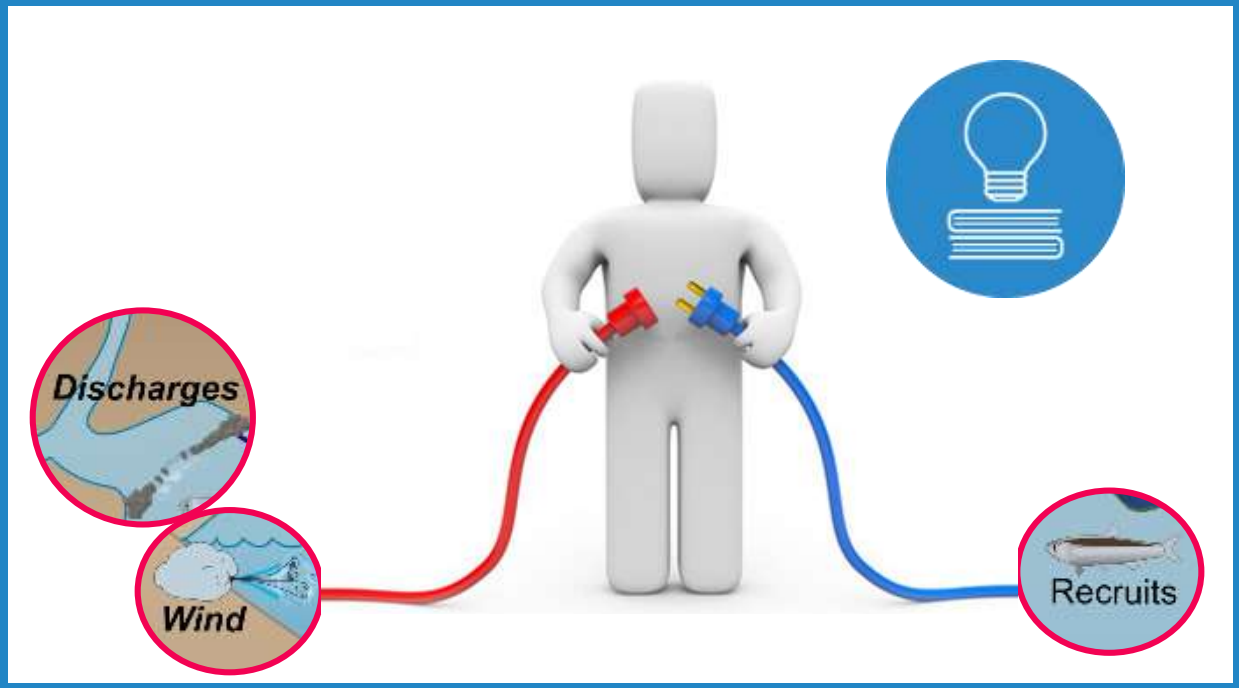


Simulation and log-likelihood optimization


Discharges
Wind
Recruits



Granger-causality

Provides a framework that uses predictability to identify causation between time-series variables

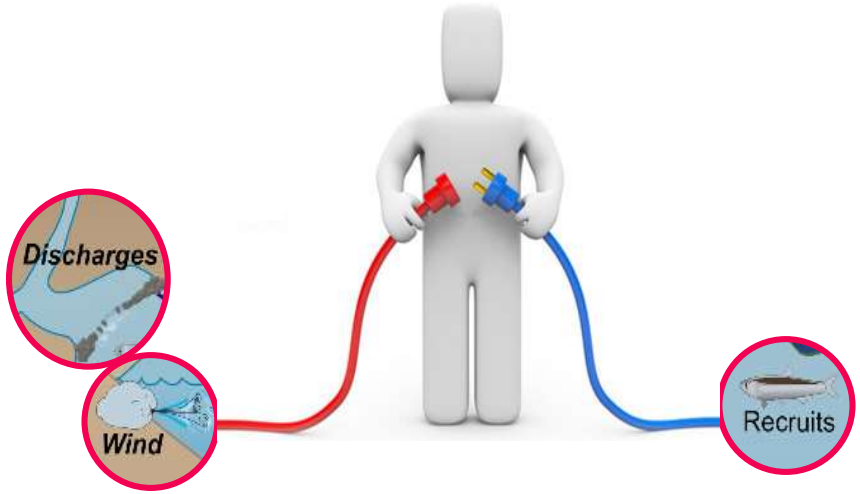
Granger-causality

Granger-causality concept says that an stationary time-series variable X is said to "Granger-cause" (Granger, 1969) the stationary time-series variable Y, if past values of X help to predict the current value of Y better than just the past values of Y do.

$$Y_t = a + \alpha_1 Y_{t-1} + \cdots + \alpha_L Y_{t-L} + \beta_1 X_{t-1} + \cdots + \beta_L X_{t-L} + \epsilon_t$$

Test

$$H_A : \beta_i \neq 0$$



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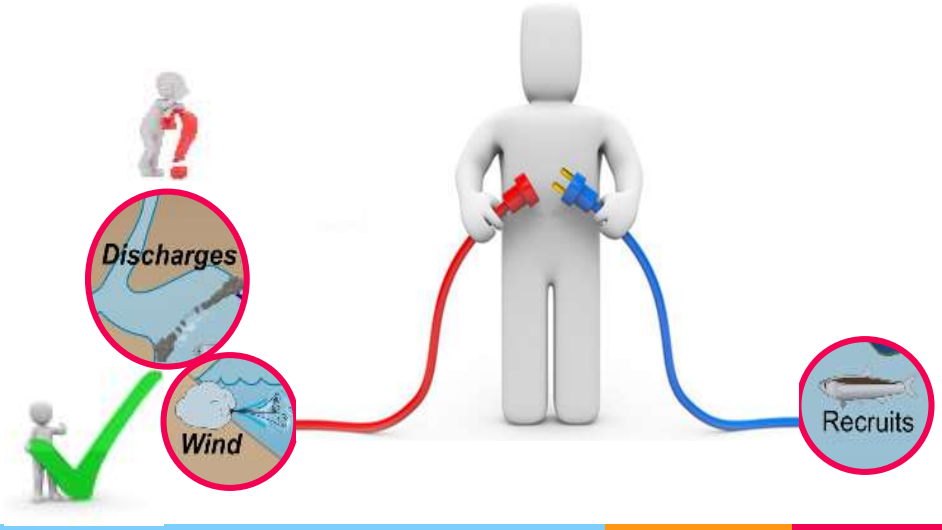
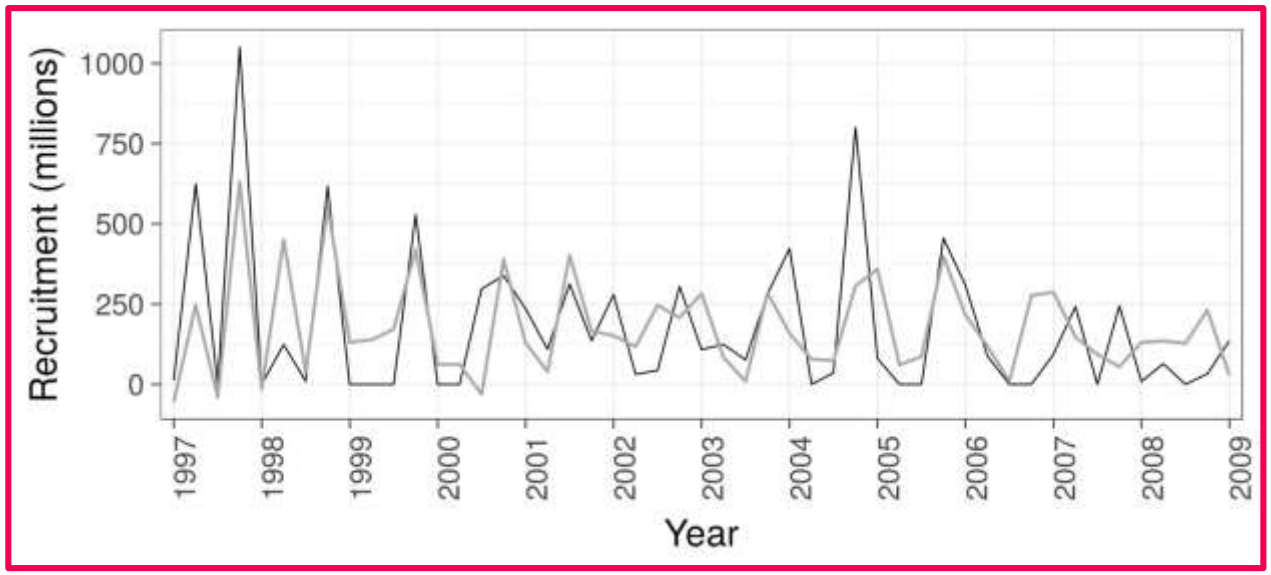


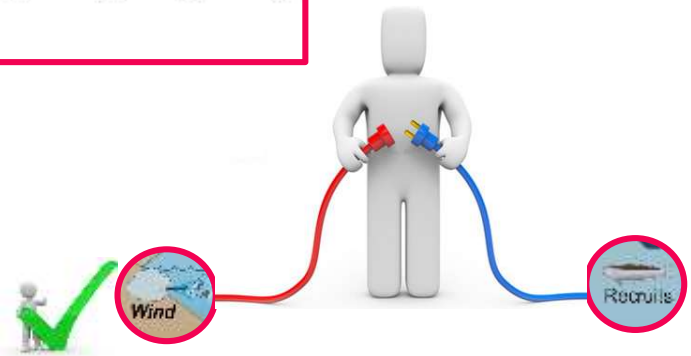
WARNING: A well specified model is needed: No serial autocorrelation, no roots outside the unit circle

Recruitment-environmental factor relationship

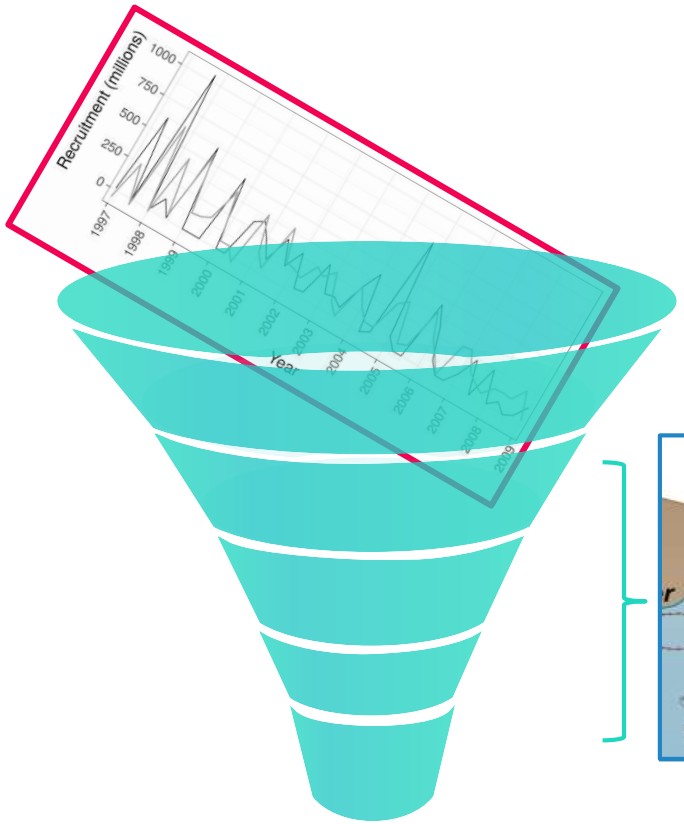
$$R_t = a + \alpha_1 R_{t-1} + \cdots + \alpha_L R_{t-4} + \beta_1 W_{t-1} + \cdots + \beta_L W_{t-4} + \epsilon_t$$

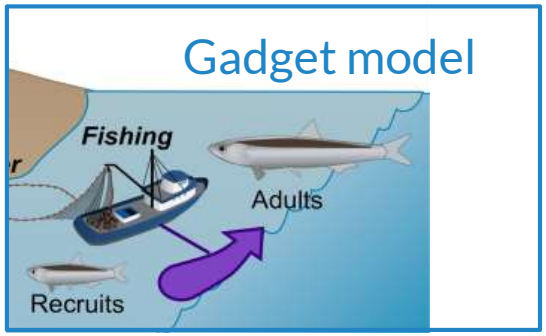


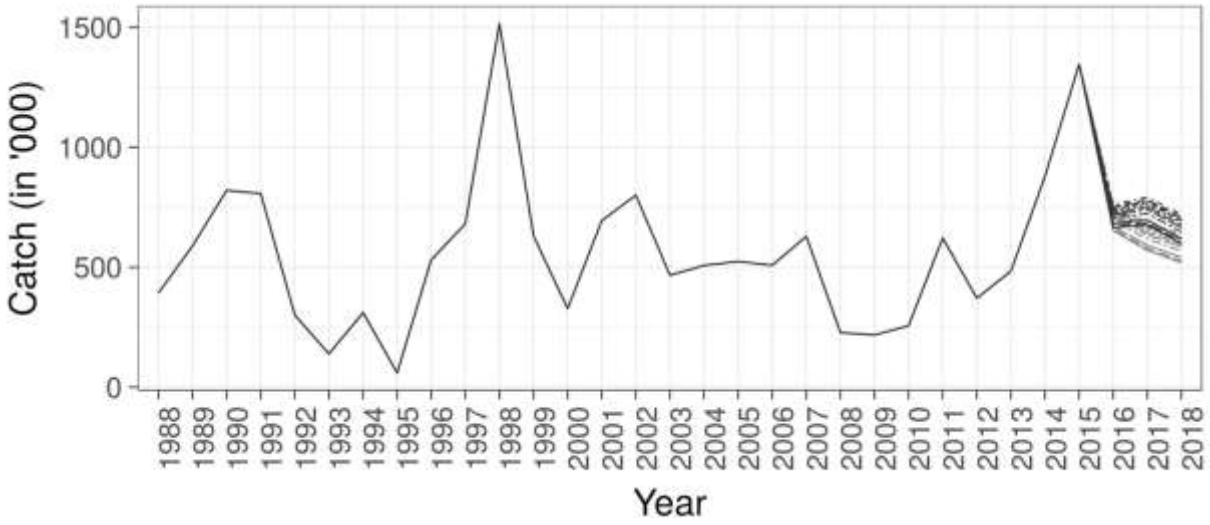
Comparison between Gadget recruitment output time series (black line) and fitted values (grey line).



Forecast







Three years forward projection with a Gadget simulation in two different wind scenarios: Good wind conditions (dark grey) and bad wind conditions (light grey).

3.
SUMMARY

The process

Implement a Gadget model

Test if wind Granger-cause recruitment output

$$R_t = a + \alpha_1 R_{t-1} + \cdots + \alpha_L R_{t-4} + \beta_1 W_{t-1} + \cdots + \beta_L W_{t-4} + \epsilon_t$$

Use wind and recruitment in the last year to forecast recruitment

Concepts and conclusions

Integrated models

Owing to their capacity to consistently combine diverse information, **they should detect the variability induced by external drivers (e.g. environment) on key components of the stock dynamics (e.g. recruitment)** in cases where these external drivers are relevant but not yet identified or incorporated into the modelling exercise.

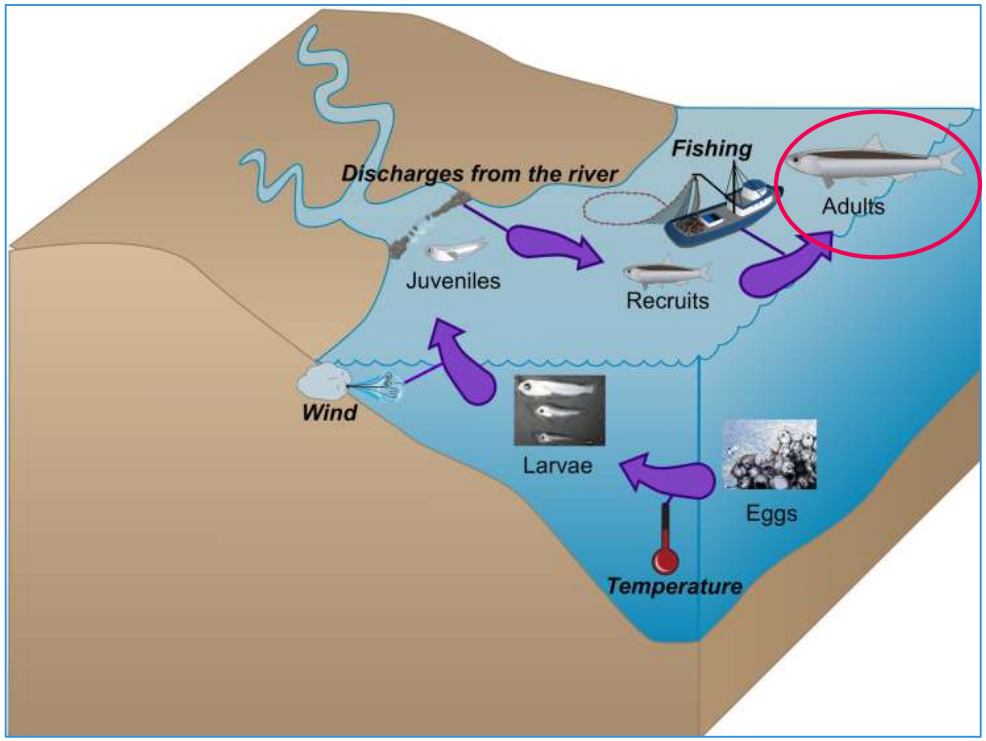
Granger Causality

Is a great tool to test "causality" and provides a functional form of the "cause" over the "effect".

Wind and anchovy recruitment in Gulf of Cadiz

- We have confirmed the relationship between wind and recruitment
- We have proved that wind "Granger-cause" recruitment.
- We have incorporated wind in the integrated model (Gadget) for forecasting
- We have presented a form of ecosystem-based fisheries model

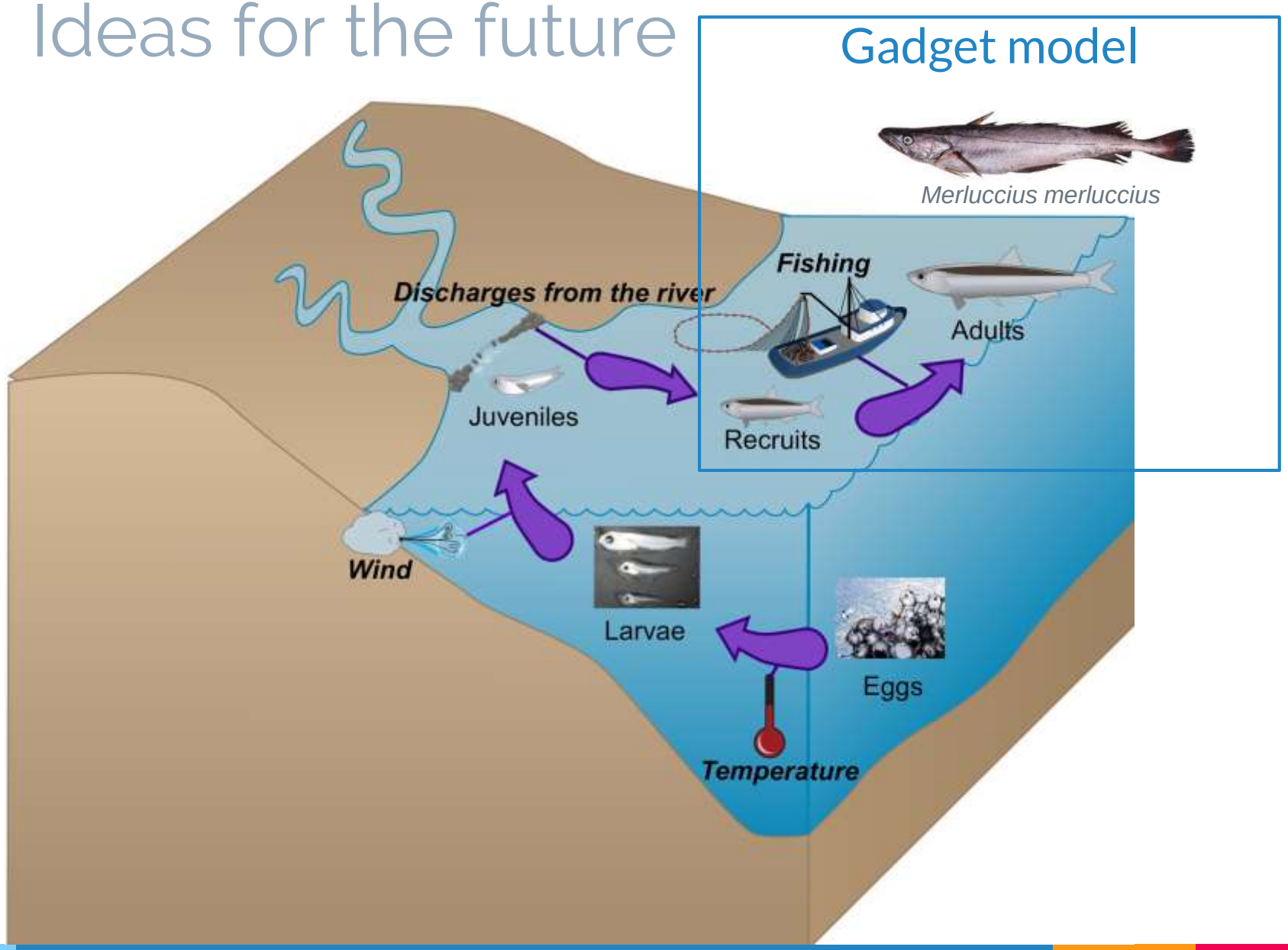
Ideas for the future



Test Granger-causality

Merluccius merluccius

Ideas for the future



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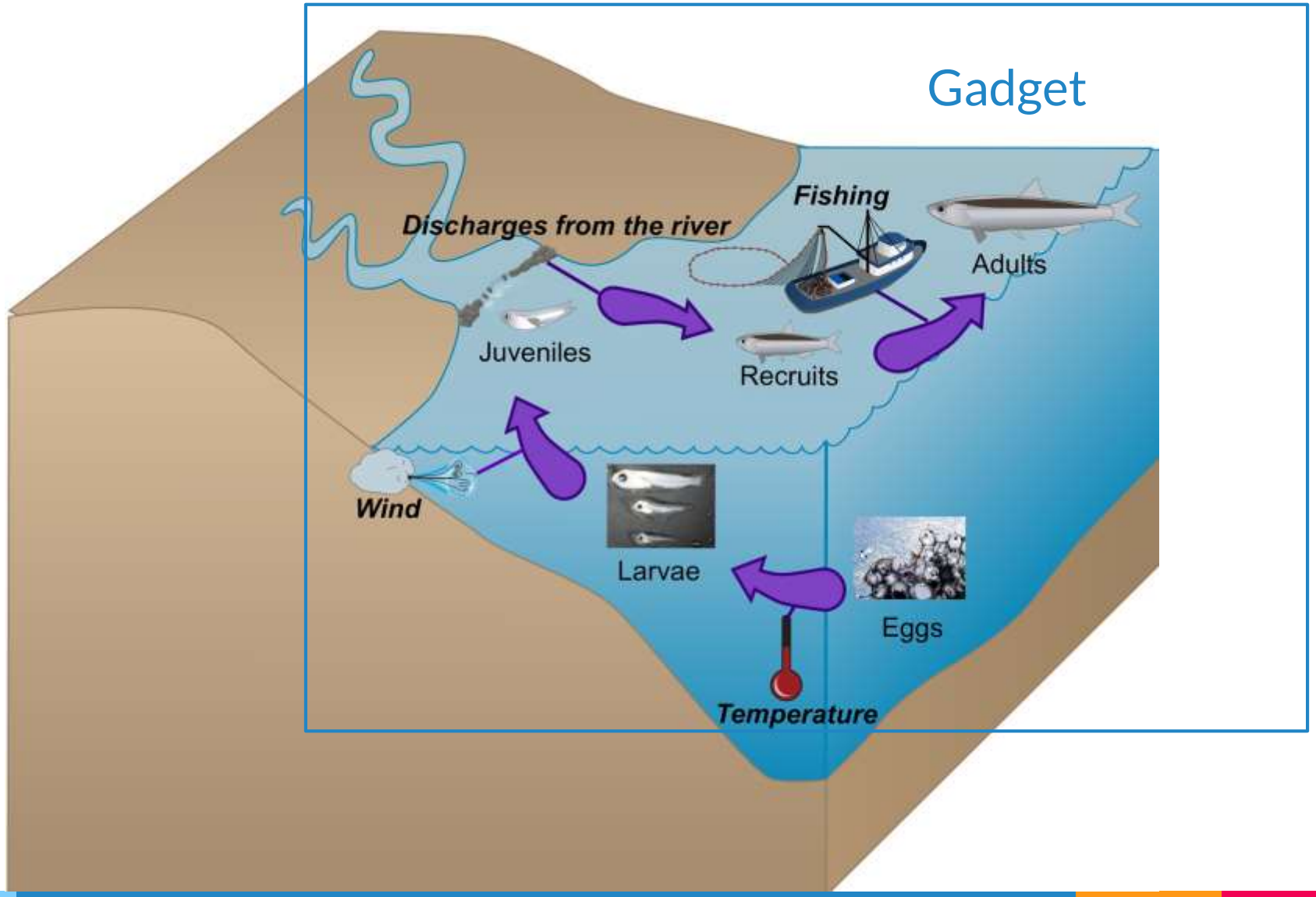

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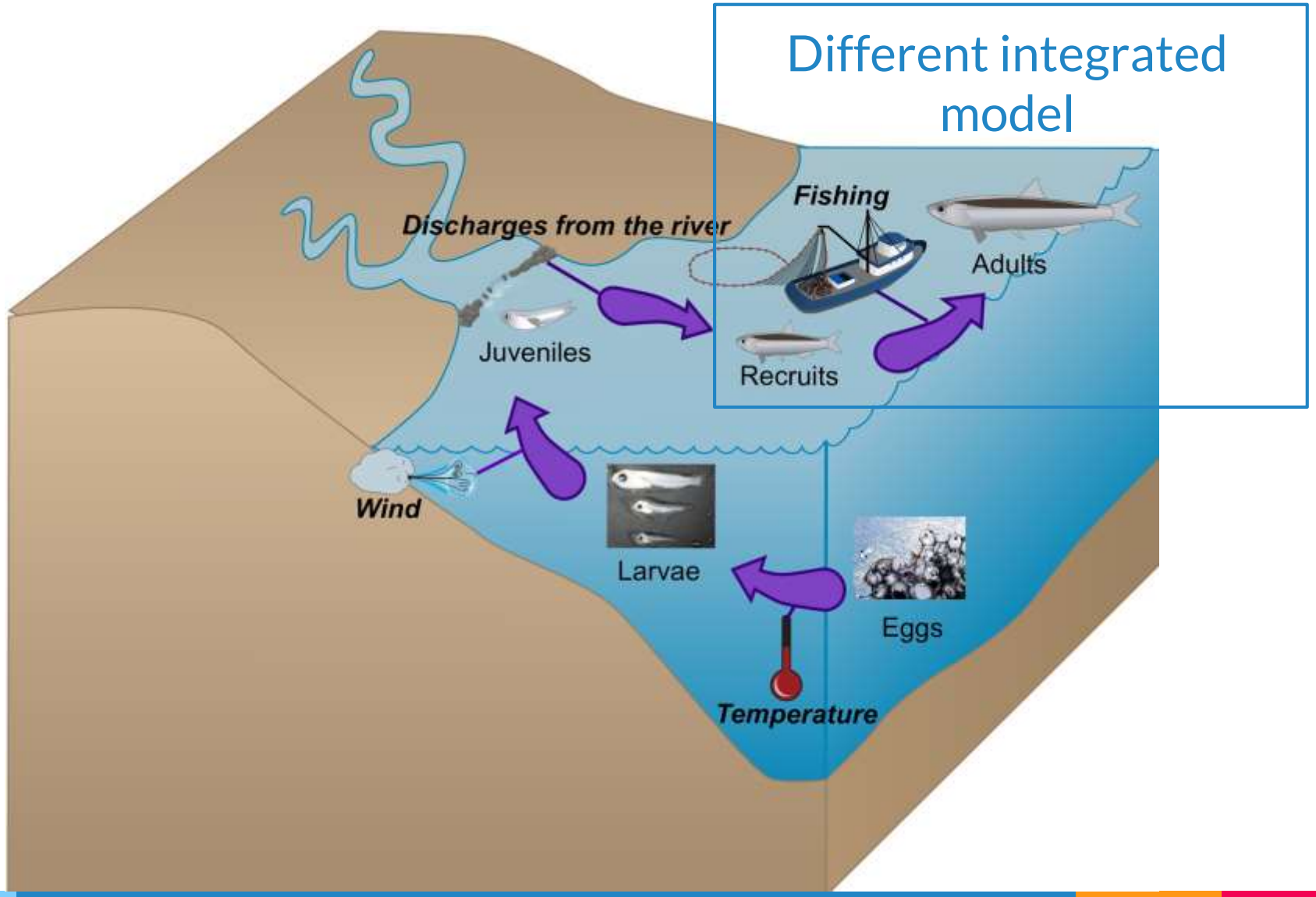

Thank you!

Any questions?

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