

An Unified Biophysical Modelling Library for Early Life Stages Applications in OpenDrift

Adrián Sanjurjo García

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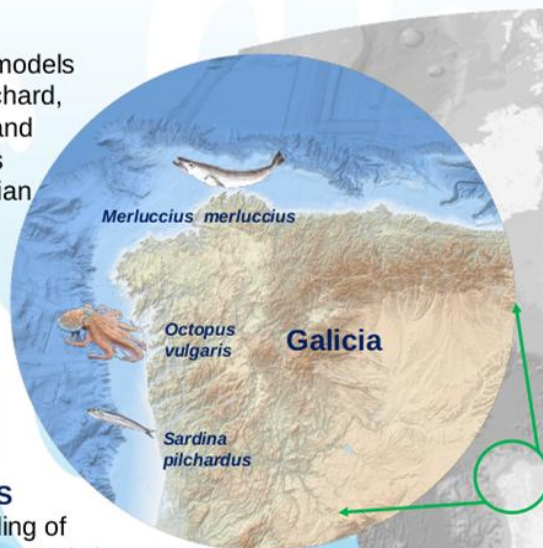
Co-authors: S. González-Pérez, Luz M. García-García, C. García-Fernández, Daniel Rodríguez-Abal, P. Sampedro, J. Otero, Gonzalo González-Nuevo, Manuel Ruiz-Villarreal

Introduction

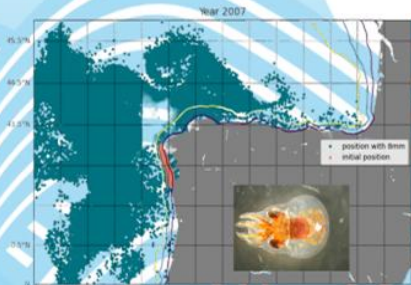
Project PHYSTOFISH (Physics to Fisheries)



Implement E2E models for European pilchard, European hake and common octopus fisheries in Galician waters.



Some RESULTS
Dispersal modeling of *Octopus vulgaris* paralarvae:

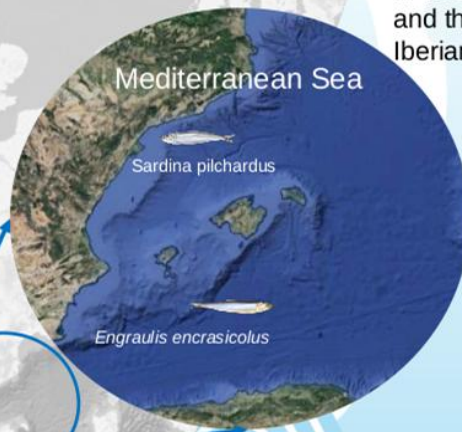


* Galicia Marine Science programme is part of Complementary Science Plans for Marine Science of Ministerio de Ciencia e Innovación included in the Recovery, Transformation and Resilience Plan (PRTR-C17.11). Funded through Xunta de Galicia with NextGenerationEU and the European Maritime Fisheries and Aquaculture Funds.

Project DEMON (Dissipation of Energy in Ocean Models and Connectivity)



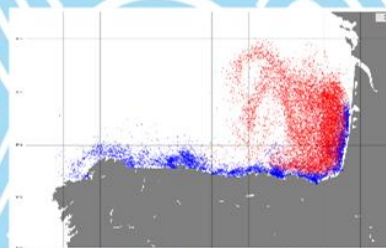
Improve the hydrodynamic models and the Lagrangian ELS models in two regions: the Mediterranean and the North and North-Western Iberian Peninsula.



Study the larval dispersal and connectivity of European pilchard and anchovy.



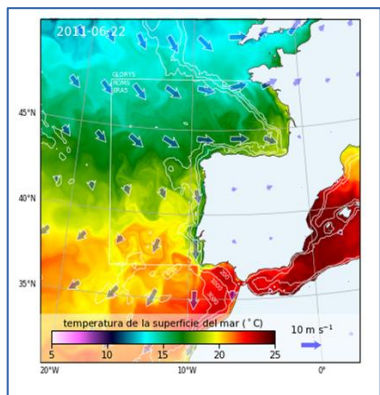
Some RESULTS
Distribution of sardine and anchovy larvae simulated by the model in the Bay of Biscay



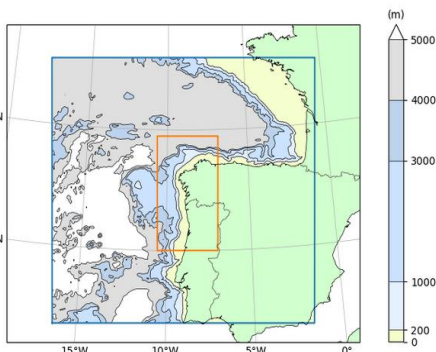
Introduction

Hydrodynamic model (3D)

- ROMS Rutgers
- 30 vertical levels
- 3.5 km horizontal resolution
- Meteorological forcing
- Tides
- Rivers



Velocities
Turbulence
Temperature
Salinity
Density



Biogeochemical model N2PZD2 (nutrient sources)

- Fennel et al, 2006

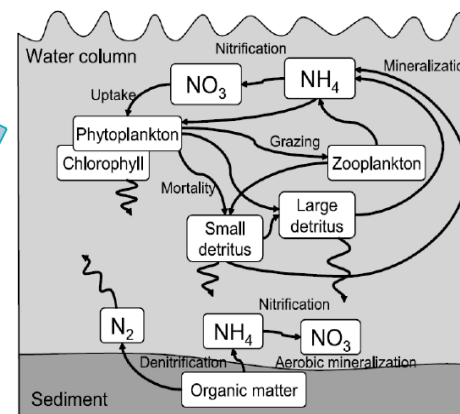


Figure 1. Biological model schematic.

Phyto
Zoo

Lagrangian IBM model

- Offline, Ichthyop or OpenDrift
- Physical processes (advection and dispersion)
- Biological behaviour of Early Life Stages (growth, buoyancy, vertical migration, etc.)

Transport
Survival
Connectivity



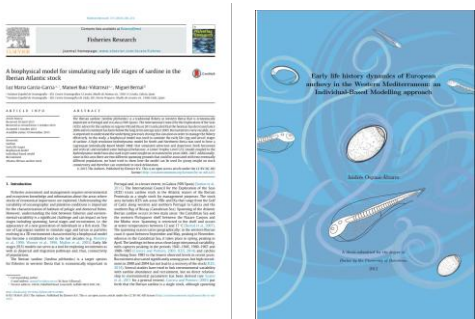
Introduction

Project background



Ichthyop

- Java
- 1 base module for eggs and larvae
- Encapsulation



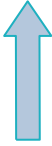
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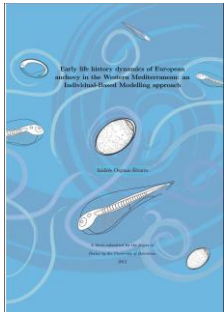
Different modules:

- OceanDrift
- Leeway
- OpenOil
- PlasticDrift
- Larvalfish



Python

- Easy to learn
- 1 module = one script
- Experience in the team



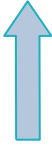
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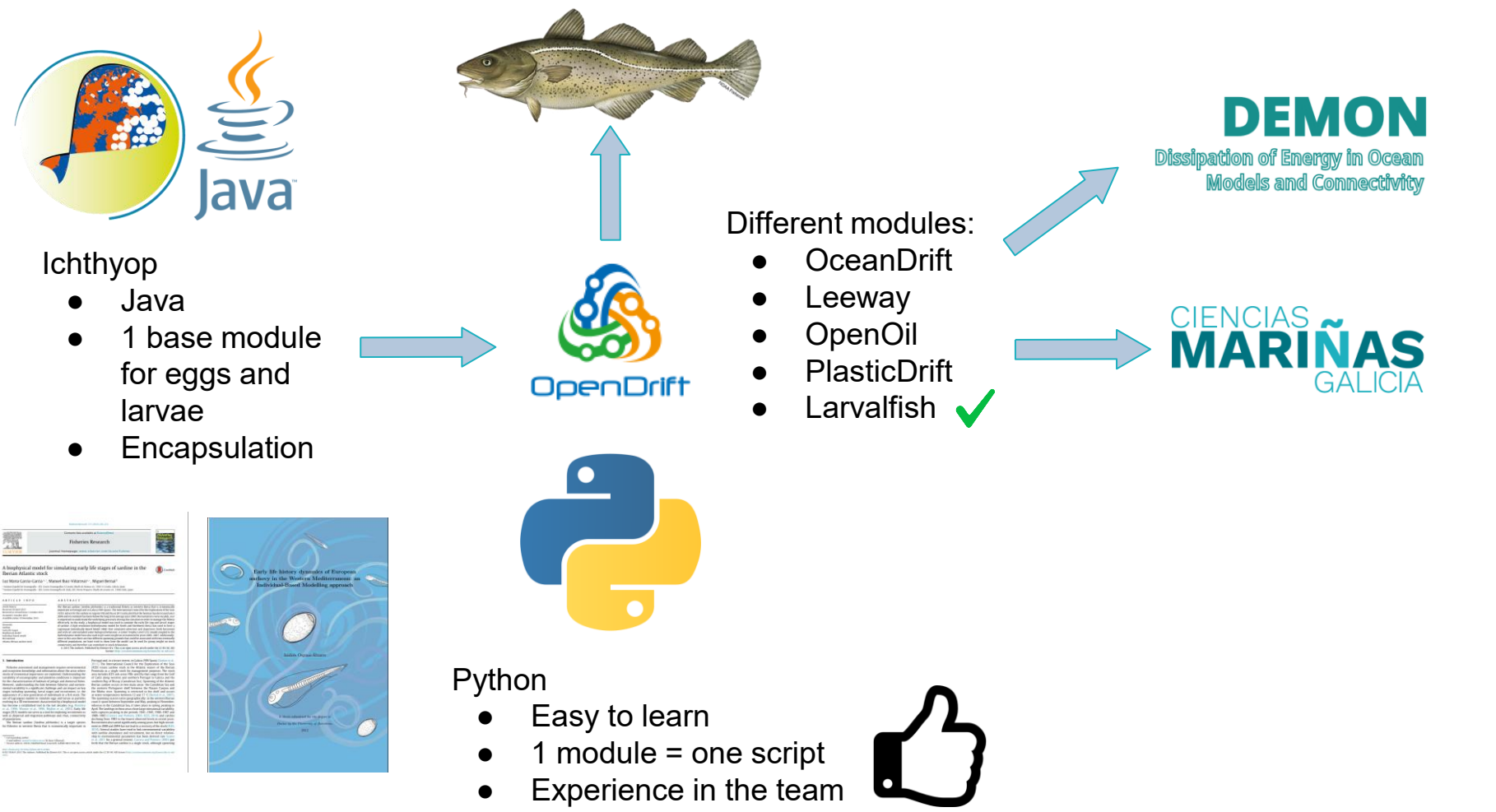
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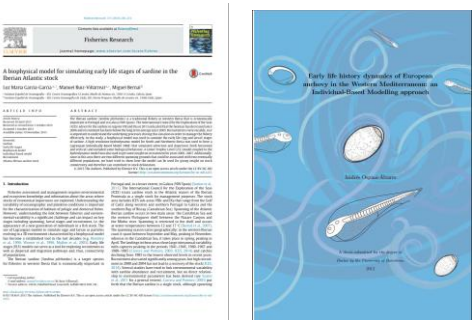


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Project background



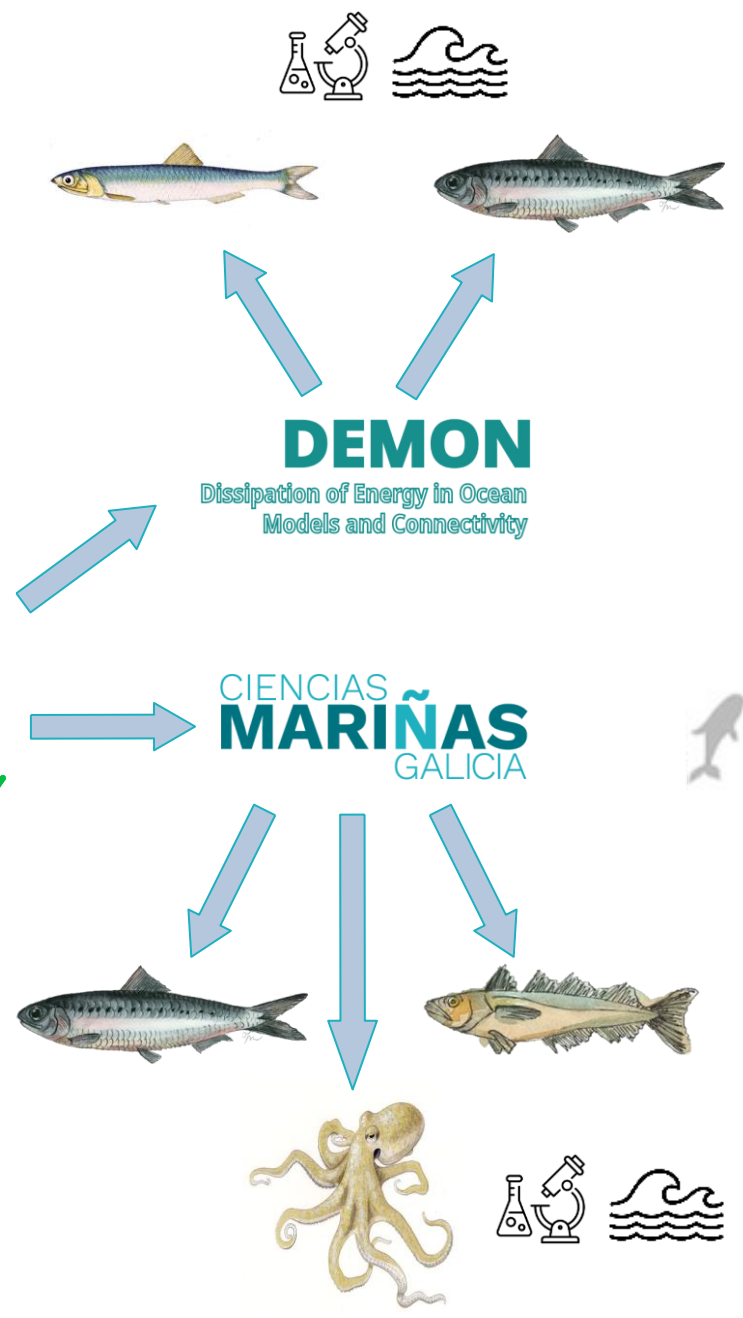
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- Java
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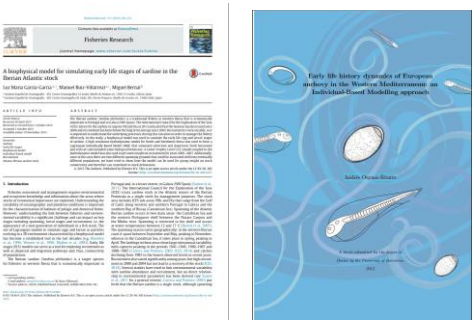


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Project background



- Ichthyop
- Java
 - 1 base module for eggs and larvae
 - Encapsulation



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DEMON
Dissipation of Energy in Ocean Models and Connectivity

CIENCIAS **MARIÑAS** GALICIA



Multiple codes for multiple species

High percentage of shared functions

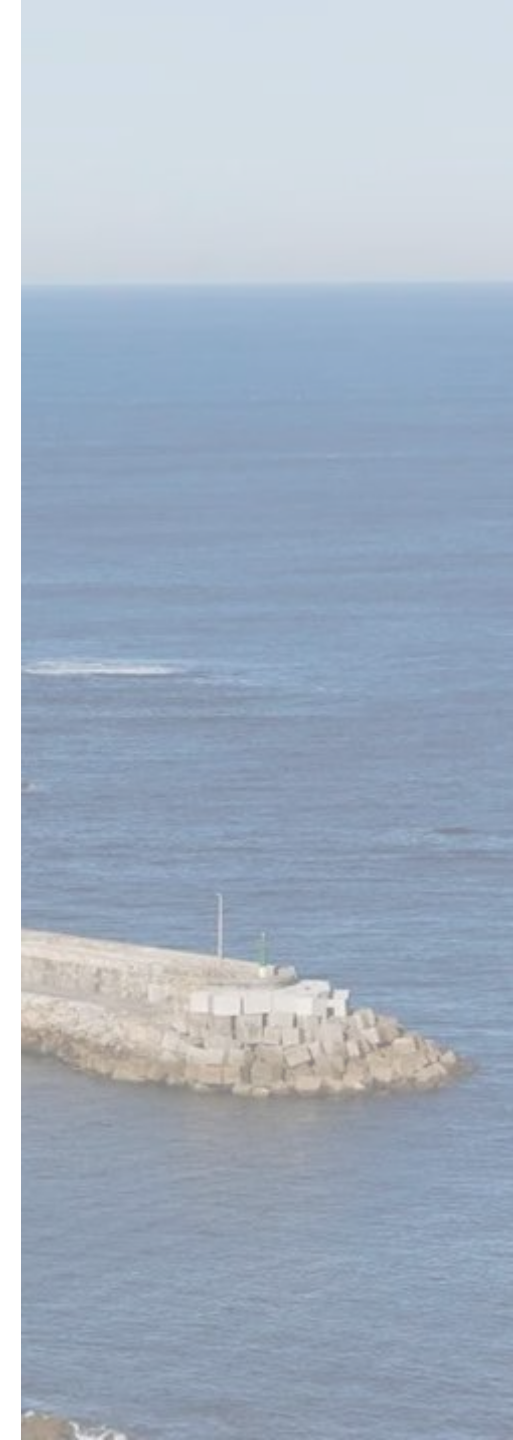
Larvalfish generic



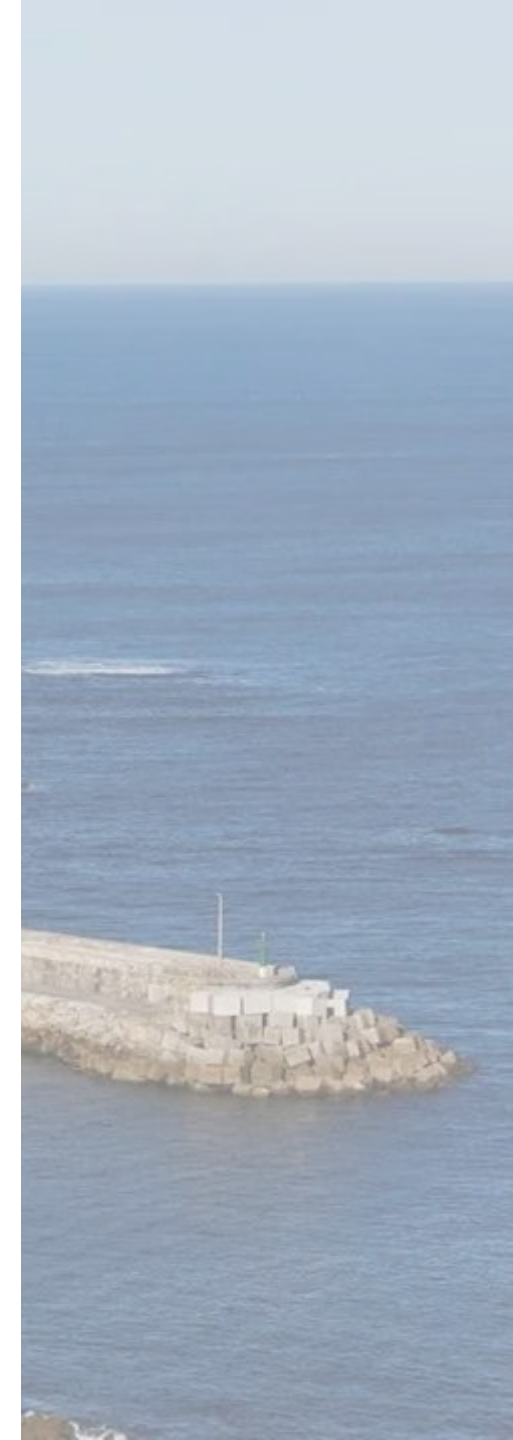
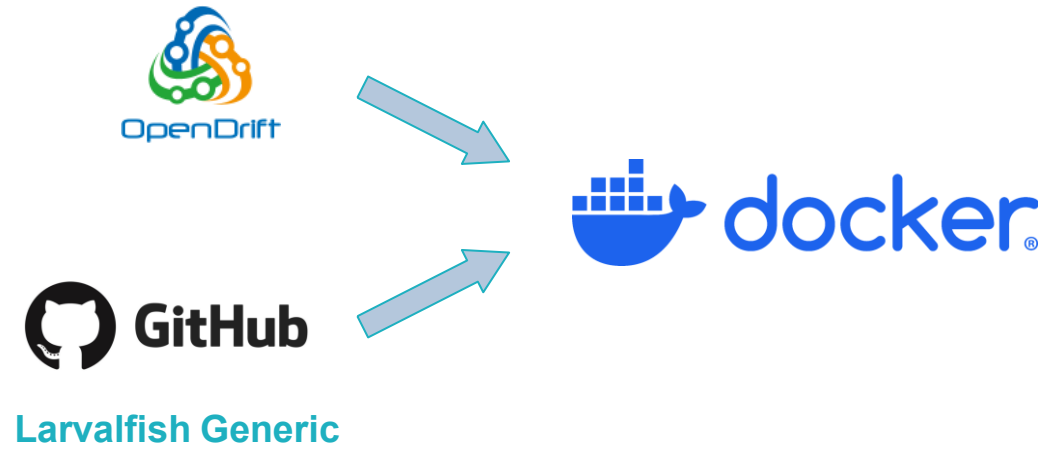
Project development (WIP!!!)



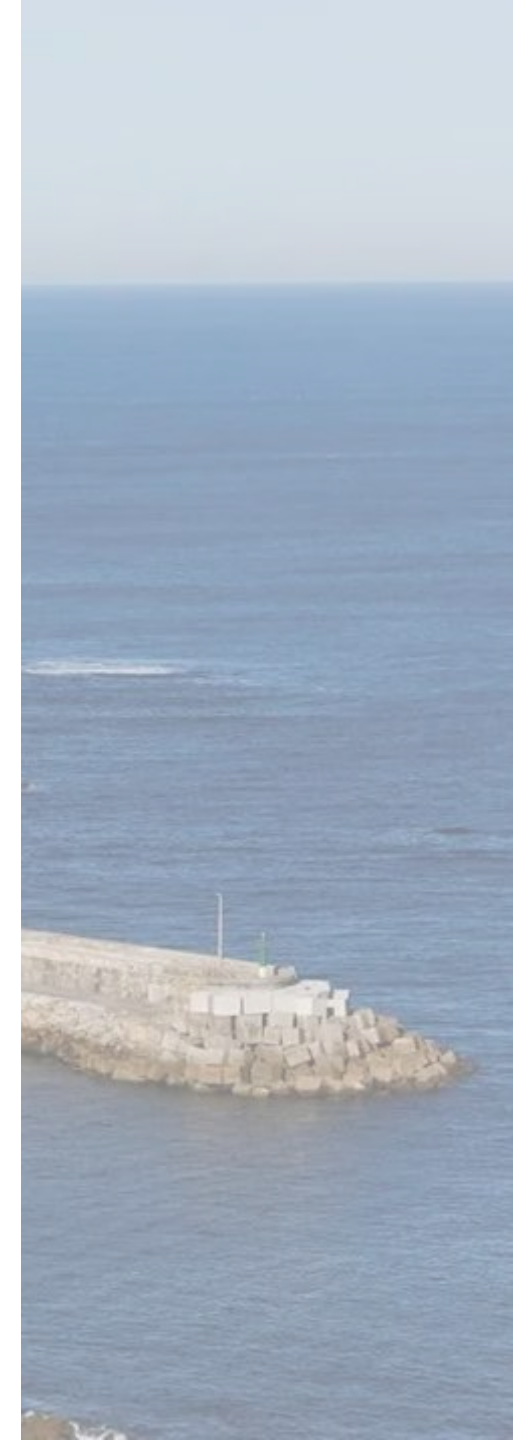
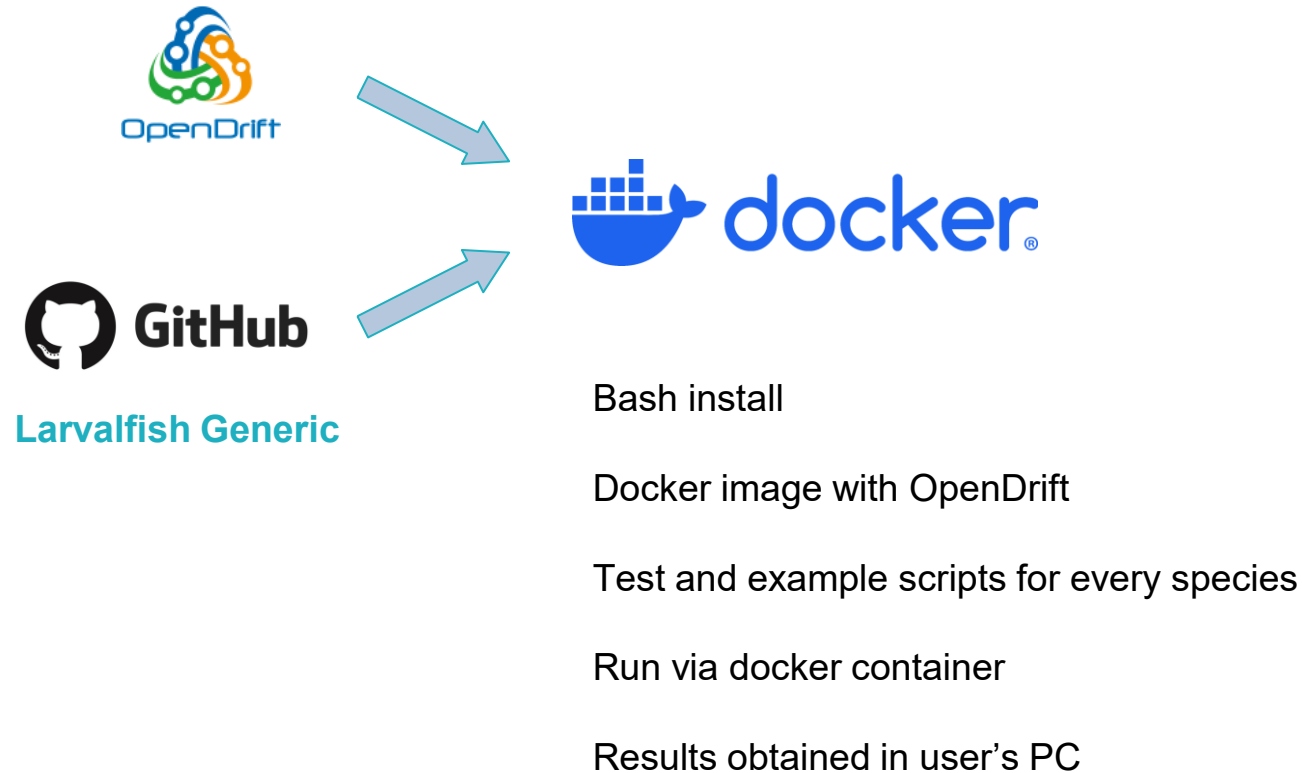
Larvalfish Generic



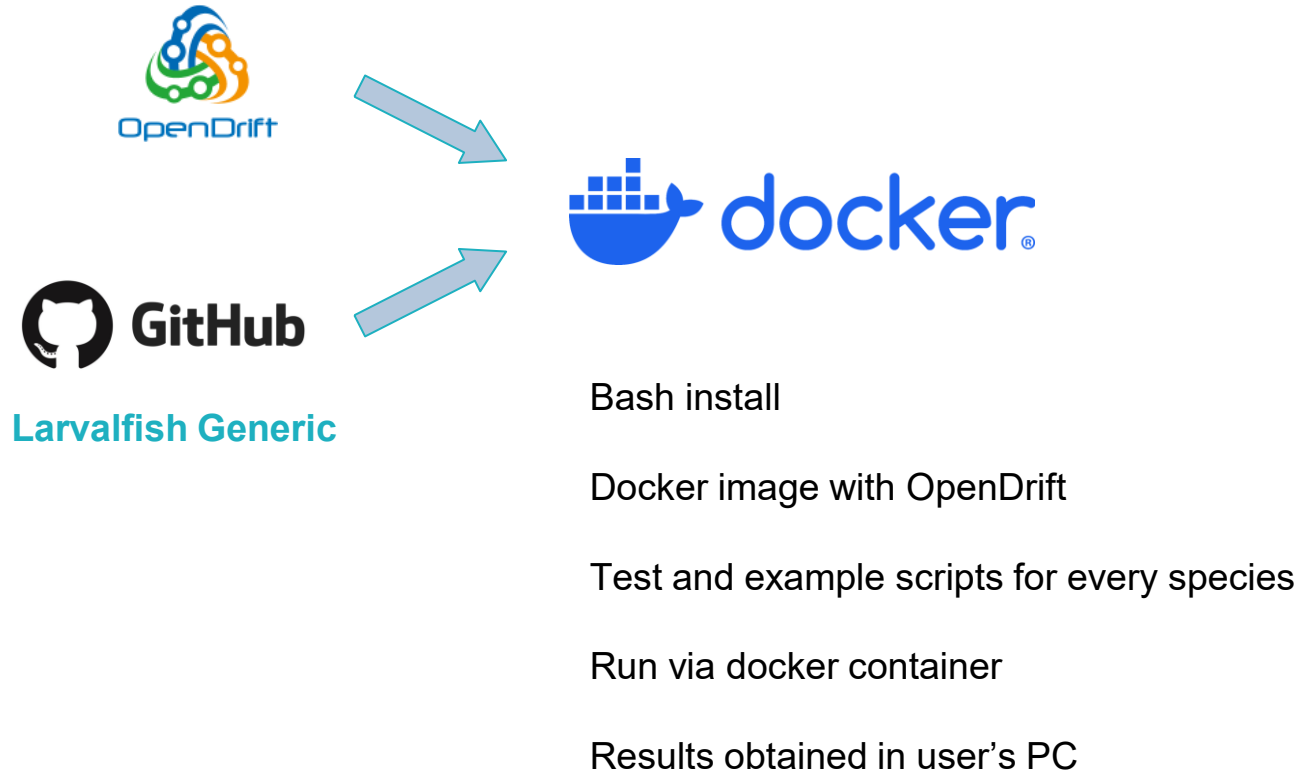
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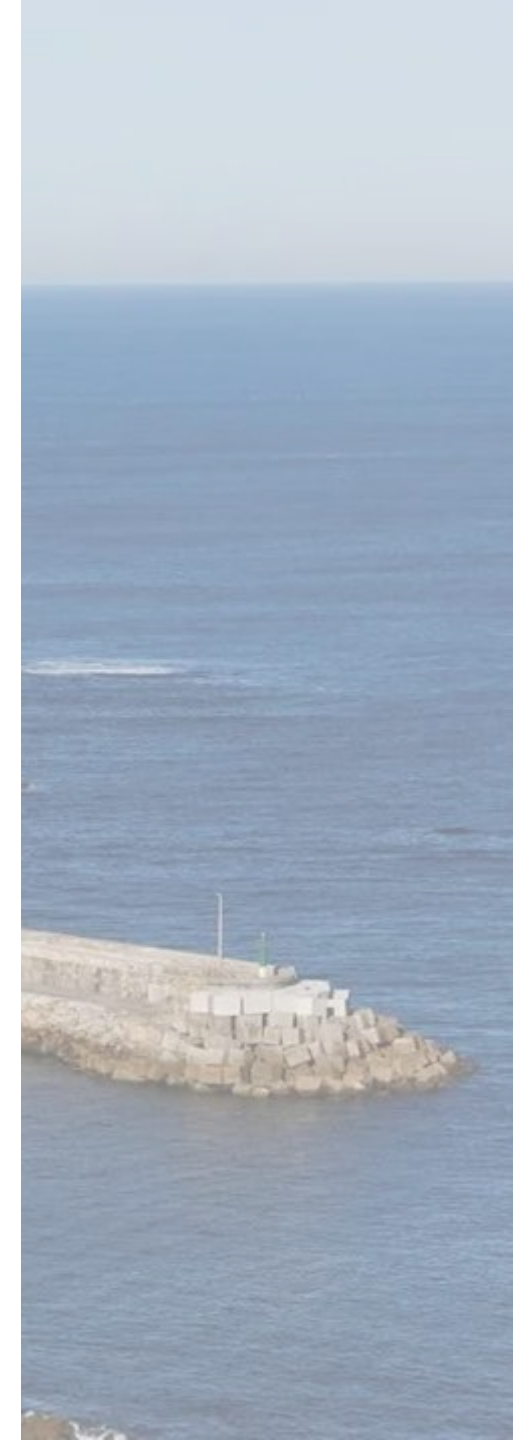


Project development (WIP!!!)

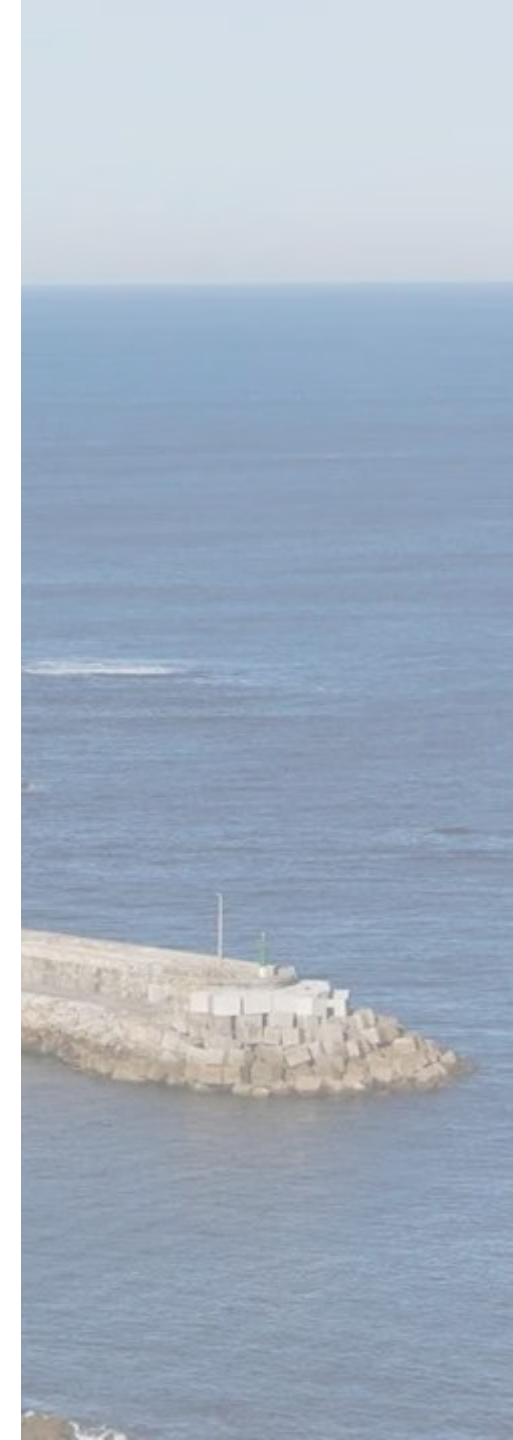
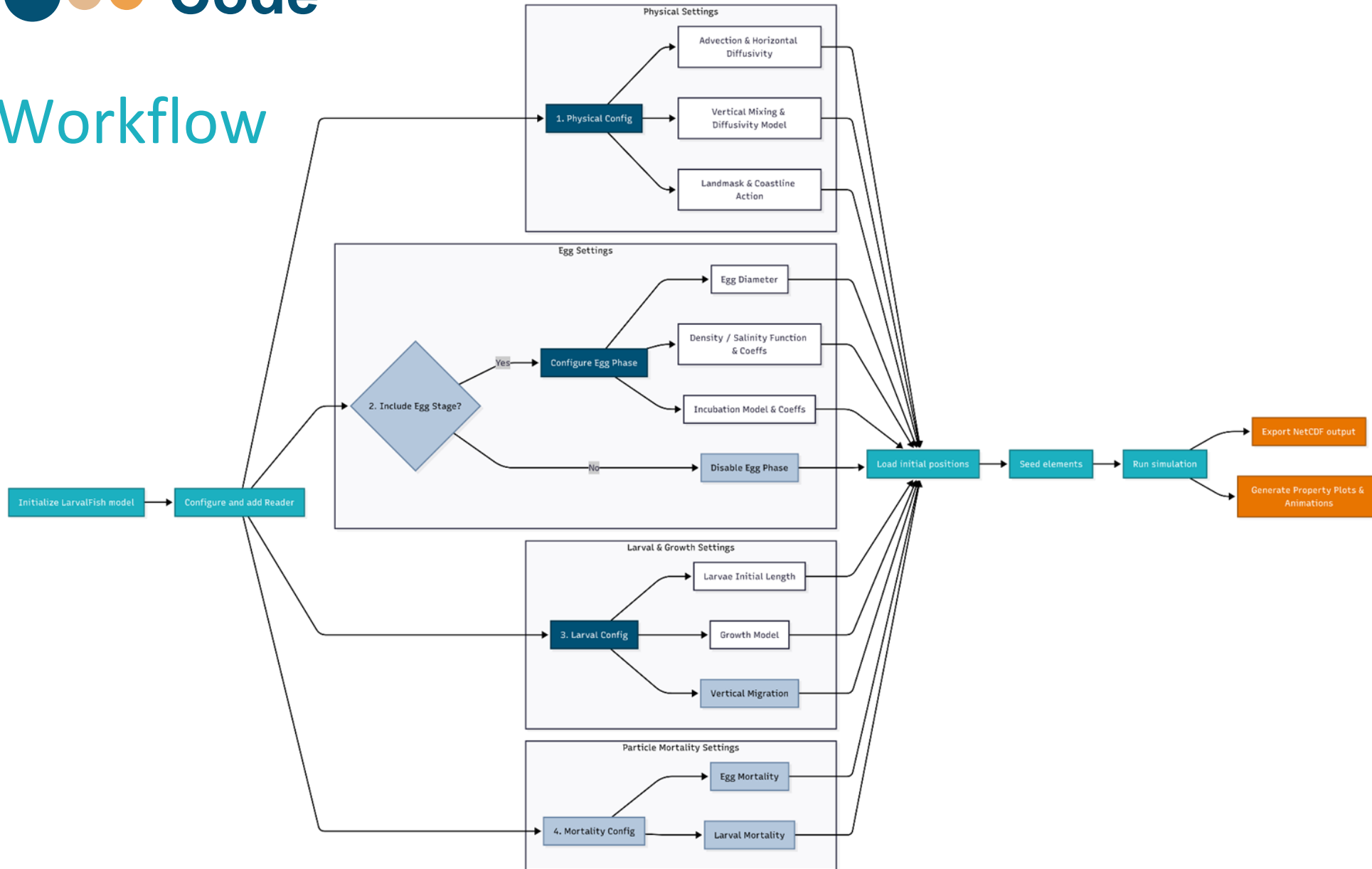


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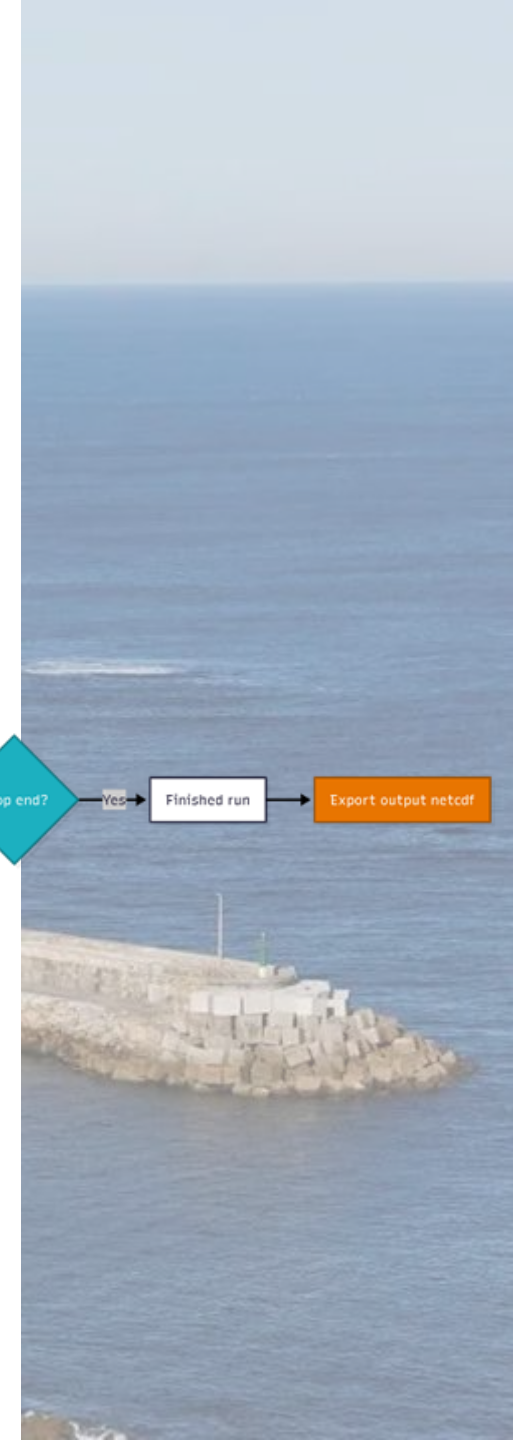
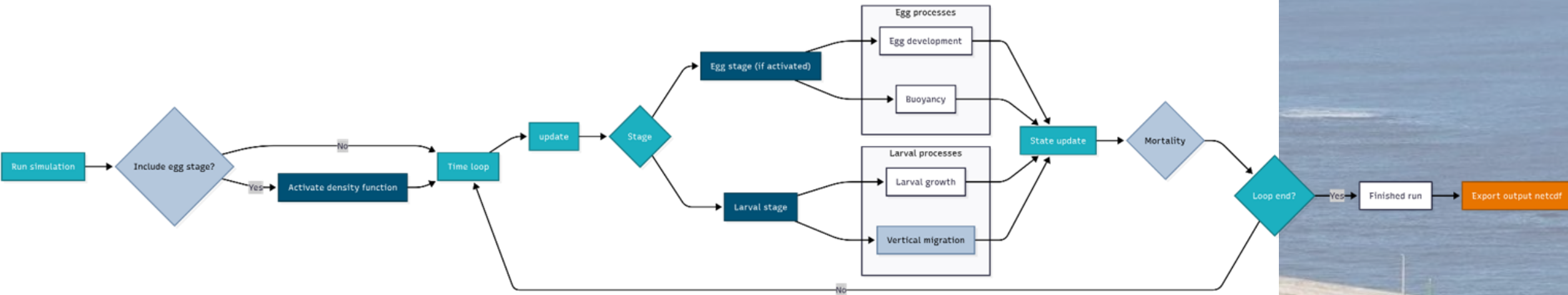
/
└─ Larvalfish Generic
    ├── data
    │   └─ initial_positions.csv
    ├── docker
    │   ├── Dockerfile
    │   └─ docker-compose.yml
    ├── output
    │   ├── Animations
    │   ├── Figures
    │   └─ Netcdf
    ├── scripts
    │   ├── anchovy_test.py
    │   ├── cod_test.py
    │   ├── hake_test.py
    │   ├── octopus_test.py
    │   └─ sardine_test.py
    ├── setup
    │   └─ setup.sh
    ├── src
    │   ├── larvalfish_generic.py
    │   └─ aux.py
    ├── README.md
    └─ run
  
```



Workflow



Workflow



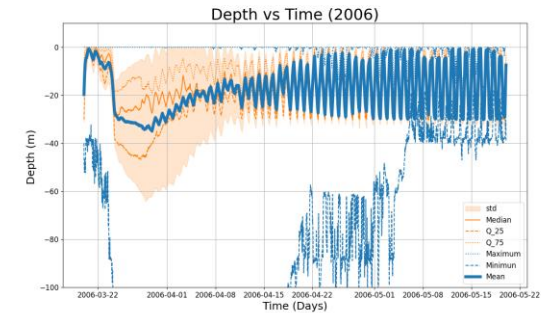
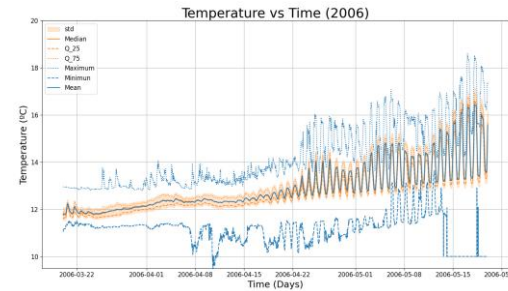
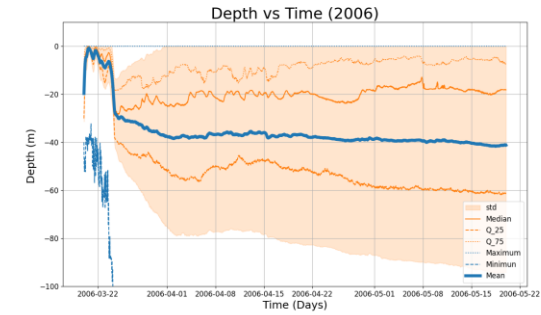
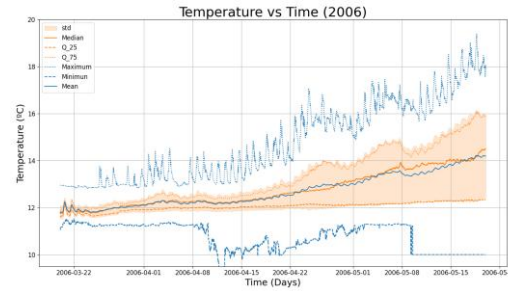
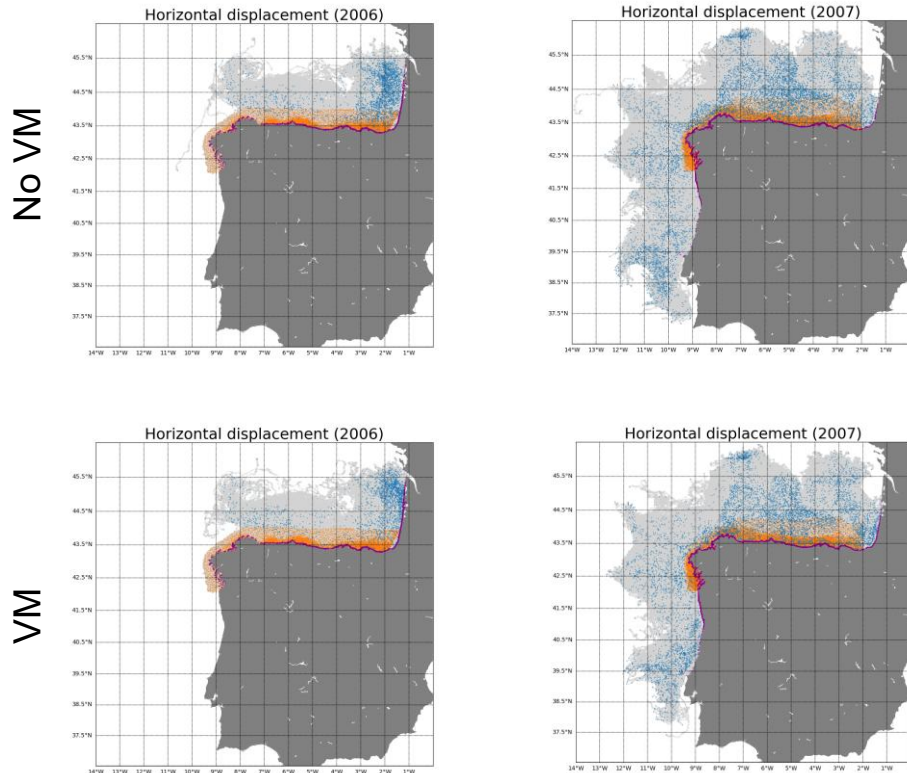
Species: Sardine

Model: ROMS + Opendrift
Period: 22Mar06/07 - 22May06/07
Particles: 06 - 7193 / 07 - 15170
Run: Advection+Dispersion (H&V)
+ behaviour (growth depending on temperature)

Success: reaching a length of 25 mm at 45 days post hatching

Temperature

Depth

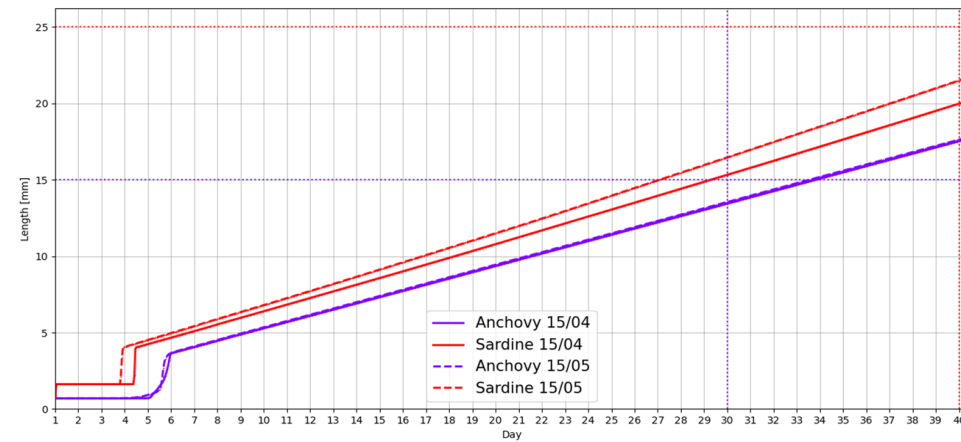
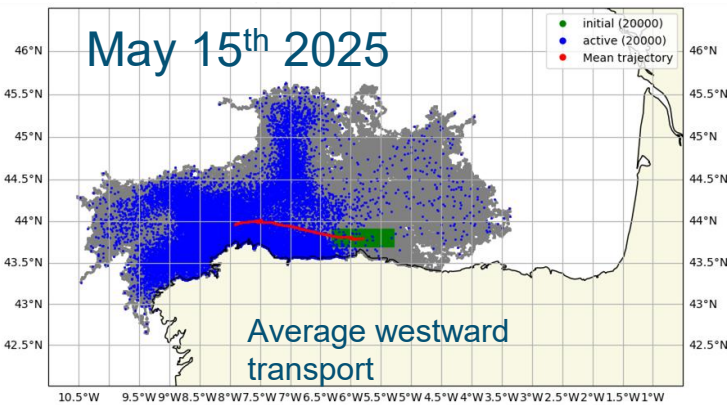
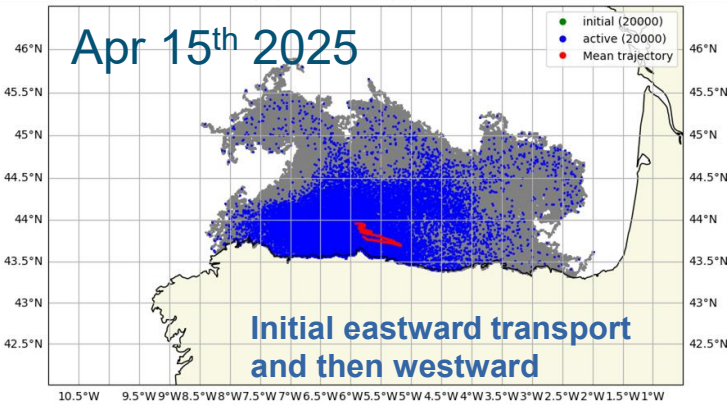
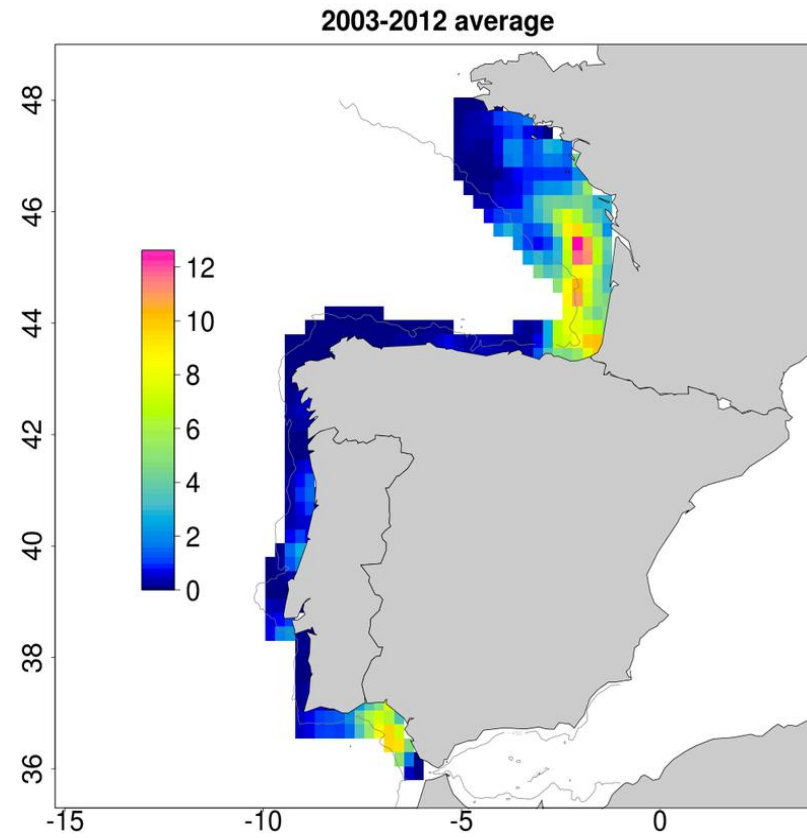


Species: Anchovy

April 15th 2025

Model: GLO1.2° + Opendrift
 Period: 15Apr25,15May25,40 days
 Particles: 20000
 Run: Advection (No V+Dispersion
 (H&V) + behaviour (growth
 depending on temperature)

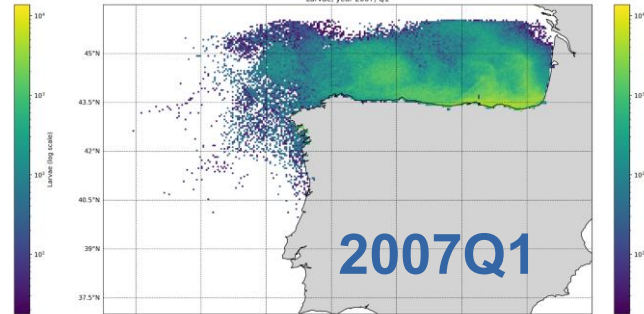
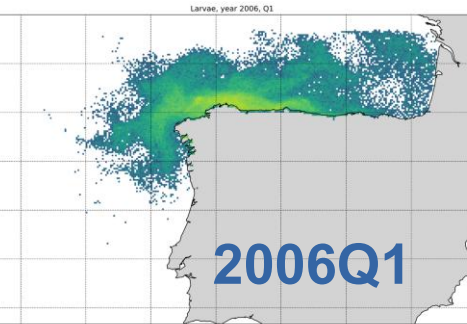
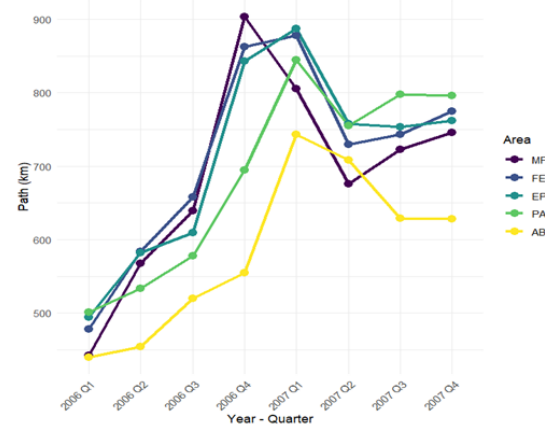
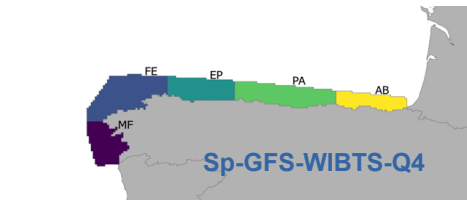
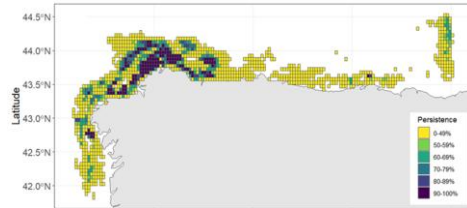
Success: reaching a
 length of 15 mm at 30
 days post spawning



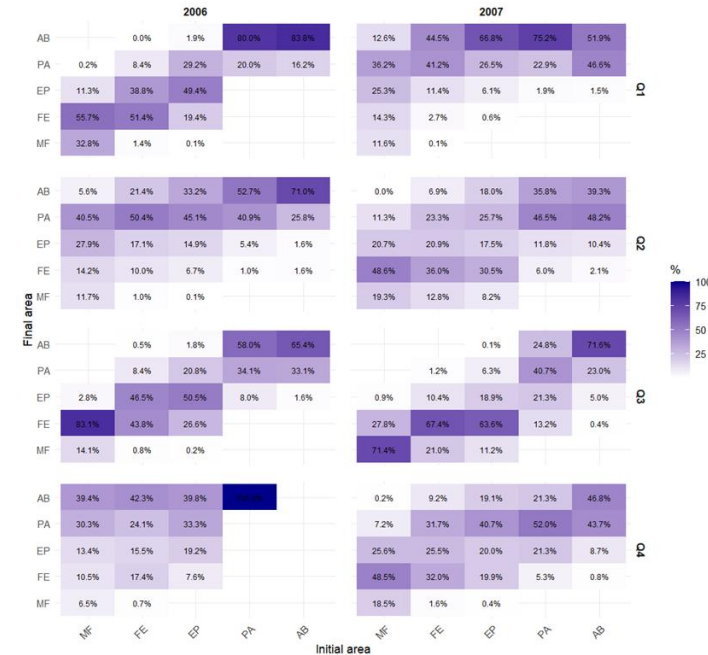
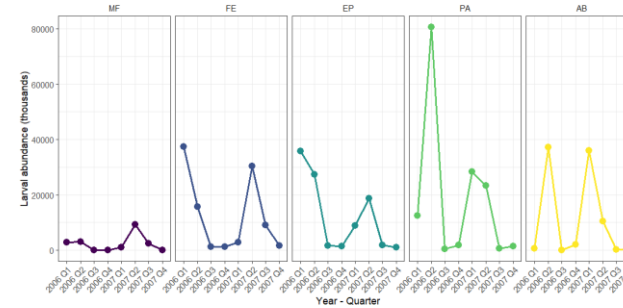
Species: Hake

Model: ROMS + Opendrift
Period: 5Jan06 - 31Dec07
Particles: 24510
Run: Advection+Dispersion (H&V)
+ behaviour (growth depending on temperature) + mortality

Success: reaching Sp-GFS-WIBTS-Q4 areas. Overcome mortality models (depth 330, surface dehydration, 22°C). Influence of seasonality in spawning.



Dispersion and connectivity



Species: Octopus

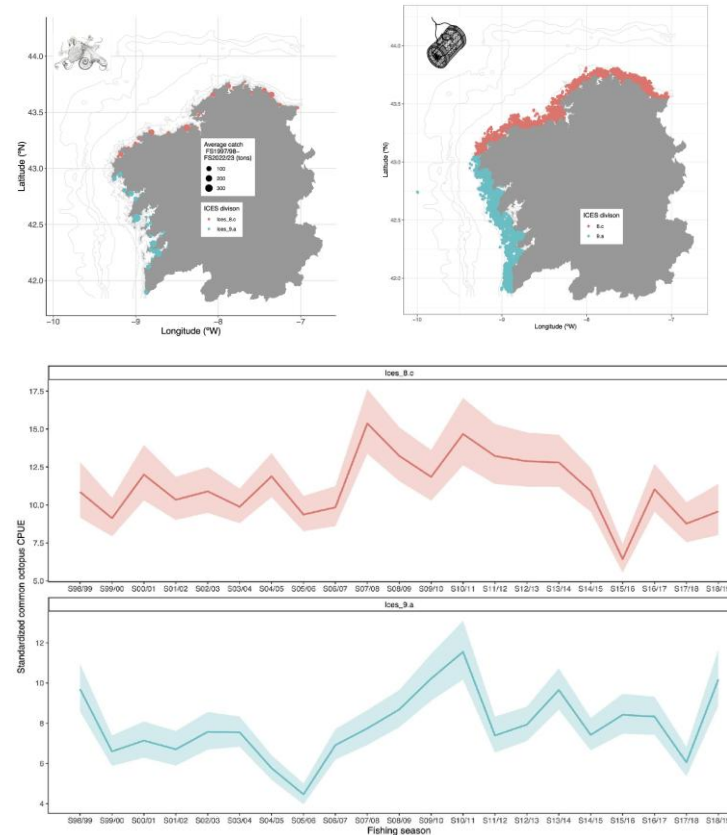
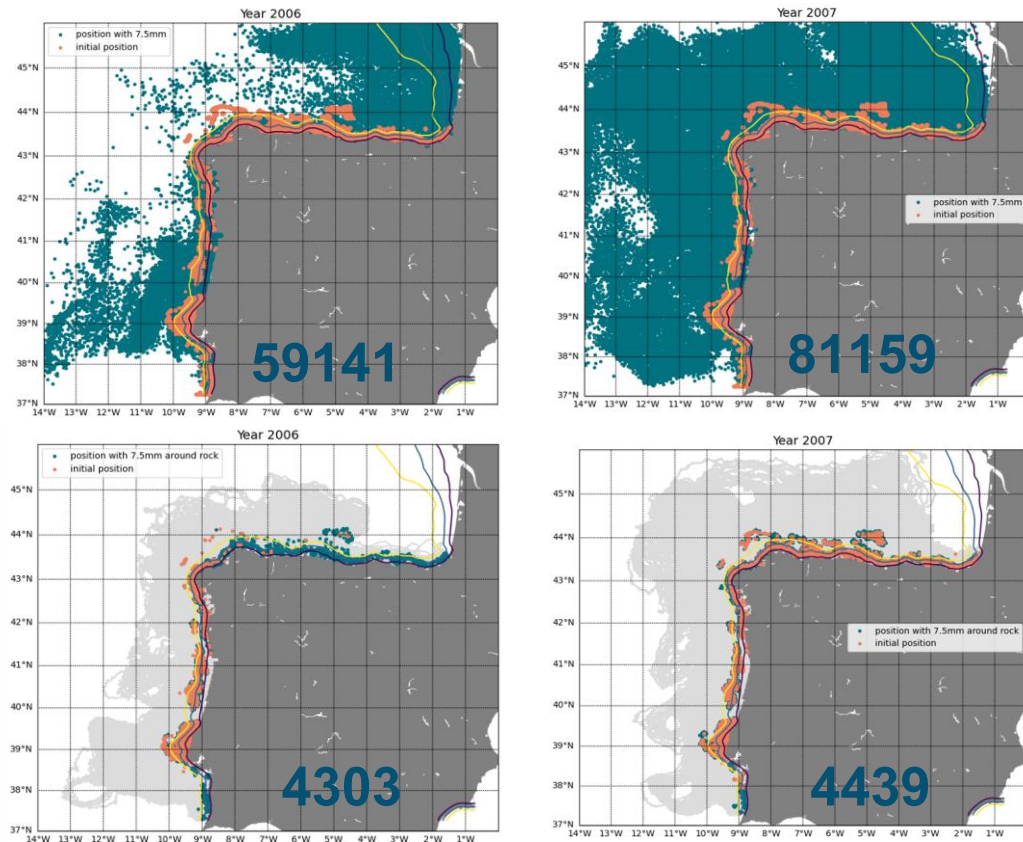
Model: ROMS + Opendrift
Period: 1Sept - 31Dec
Particles: 100000
Run: Advection+Dispersion (H&V)
+ behaviour (growth depending on temperature)

Success: reaching 7.5mm close to rocks. Higher possibility of settling.
Metric for recruitment!?

Data for model validation

Captures

Observers on artesanal fishing vessels



Conclusions and future work

- Flexible framework for individual-based models within OpenDrift.
- Simple configuration and execution workflow.
- Applicable to a wide range of ecological and dispersal studies.
- Easily extensible to additional species and life-history strategies.
- Modular structure facilitates the incorporation of new biological processes.
- Ongoing development with planned improvements and validation.
- Future work includes enhancing compatibility and maintenance across new OpenDrift releases.
- Planned publication of the framework alongside a dedicated scientific paper.



Thank you for your attention

Questions?

Introduction



●●●● Material & Methods



Material & Methods

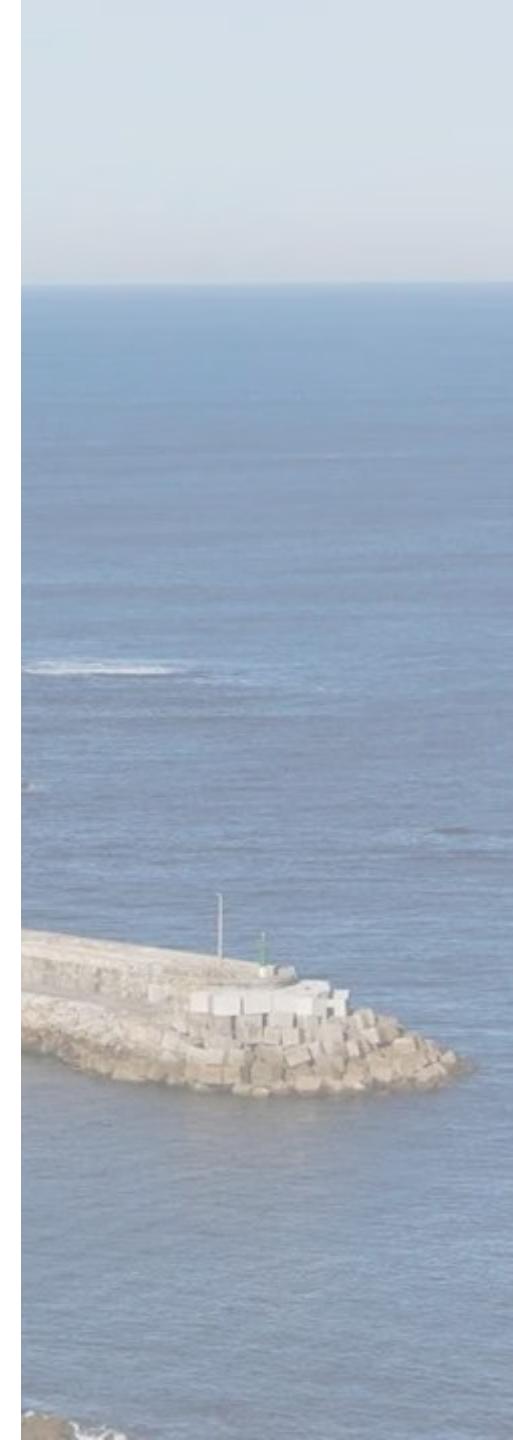
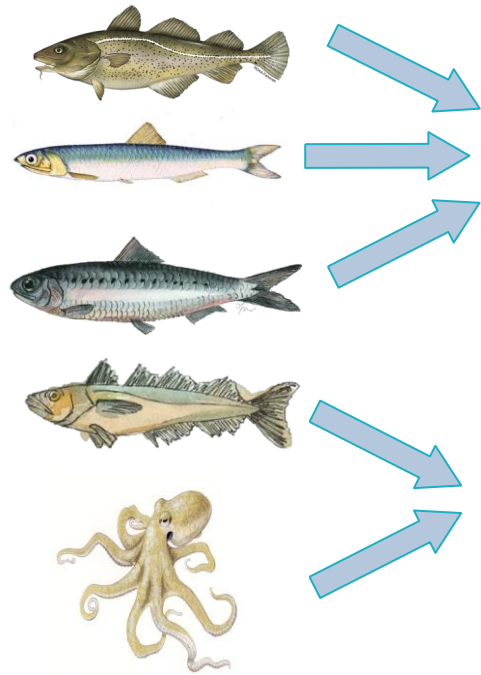
```
graph TD
    A[Run simulation] --> C{Include  
egg stage?}
    C -->|Yes| D[Activate density  
function]
    C -->|No| F[Time loop]
    D --> F
    F --> G[update]
    G --> H{Stage}
    H --> I_egg["Egg stage (if  
activated)"]
    H --> J_larva[Larval stage]
    subgraph Egg_processes [Egg  
processes]
        direction TB
        I_egg1[Egg development]
        I_egg2[Buoyancy]
    end
    subgraph Larval_processes [Larval  
processes]
        direction TB
        J_larval1[Larval growth]
        J_larval2[Vertical migration]
```

flowchart LR

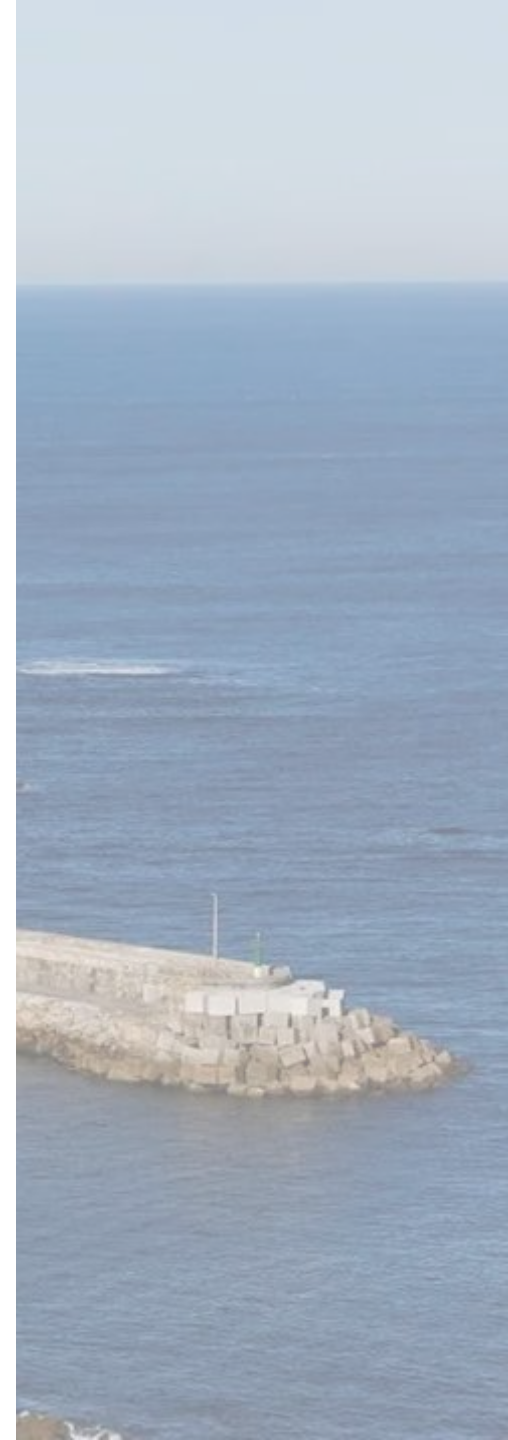
```
graph TD
    A[Initialize LarvalFish model] --> B[Configure and add Reader]
    B --> P_start["1. Physical  
Config"]
    P_start --> E_check["2. Include Egg  
Stage?"]
    E_check --> L_start["3. Larval Config"]
    E_check --> M_start["4. Mortality  
Config"]
    subgraph Physics_Config [Physics_Config  
[Physical Settings]]
        direction TB
        P_start --> P1[Advection &  
Horizontal Diffusivity]
        P_start --> P2[Vertical  
Mixing & Diffusivity Model]
        P_start --> P3[Landmask &  
Coastline Action]
    end
    subgraph Egg_Config [Egg  
Settings]
        direction TB
        E_check --> E_setup[Configure Egg Phase]
```



Project



●●●● Results and discussion



●●●● Conclusions and future work

