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The Global Fish Tracking System for Impactful Marine Conservation

Tina Odaka[1], Anne Fouilloux[2], Daniel Wiesmann[3], Emmanuelle Autret[1], Mathieu Woillez[4], and Benjamin Ragan-Kelley[2]

1 LOPS (Laboratory for Ocean Physics and Satellite remote sensing), UMR 6523, Univ Brest-Ifremer-CNRS-IRD, Plouzané, France
2 Simula Research Laboratory, Oslo, Norway
3 Development Seed, Lisbon, Portugal
4 DECOD (Ecosystem Dynamics and Sustainability), IFREMER-Institut Agro-INRAE, Plouzané, France

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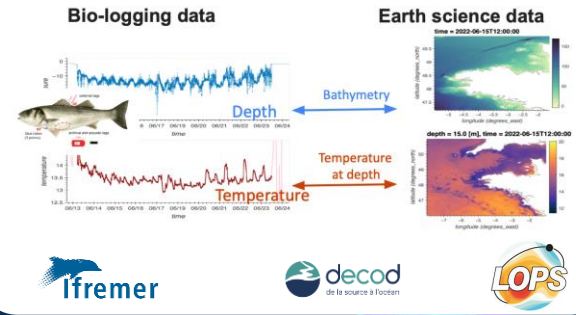
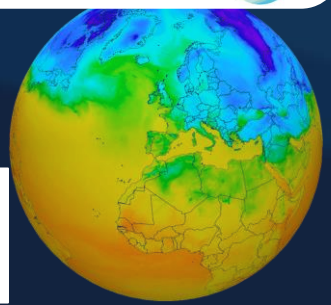
Overview of the GFTS

Understanding fish migration and behavior is crucial for marine conservation, particularly in addressing the challenges of climate change, overfishing, and habitat degradation.

Fish track modeling



Copernicus Marine Service



DestinE Climate DT

Pangeo infrastructure

simula

Visualisation & Decision tool

developmentSEED

Our goal is to exploit DestinE's capabilities in supporting environmental monitoring and conservation policy through the Climate Adaptation Digital Twin.

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Motivation for the GFTS

Why Fish tracking matters:

- **Ensures food security** and supports the sustainable exploitation of natural resources.
- **Helps study** how fish movements and migrations influence population dynamics.
- **Provides essential knowledge** for improving fishery management and defining conservation areas.
- **Addresses gaps in information** on fish spatial structure and essential habitats, as highlighted by the International Council for the Exploration of the Sea (ICES).

ICES
CIEM

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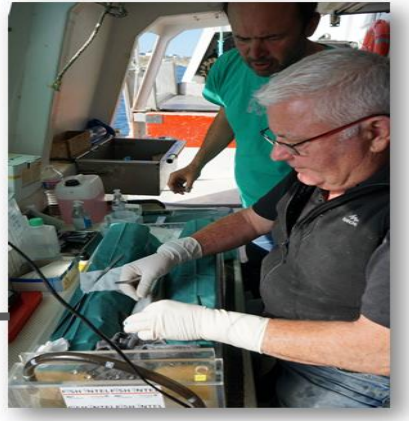
Bio-logging

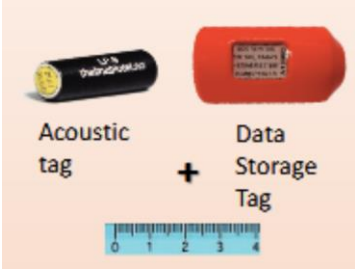
Attaching small devices to animals to track their behavior and gather environmental data

Fish capture

Stabulation, then anesthetize the fish

Implant the acoustic tag + Data Storage Tag (DST)





Fish release

Waking and housing fish

Data Storage Tag: **Store time series of observed temperature, depth in a tag.**
Acoustic Tag: **tag emits signal,** detect tagged fish using acoustic telemetry network
Combine both approaches together with earth science data: *Infer fish trajectory from individual environmental data histories using geolocation models*

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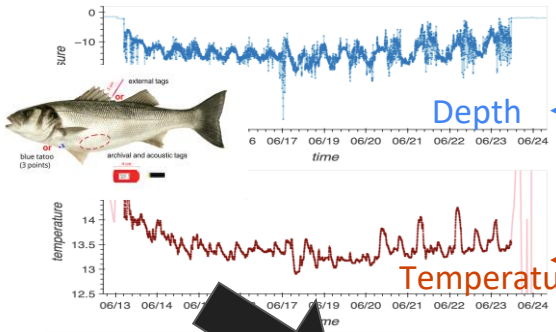
Fish Tracking Modeling

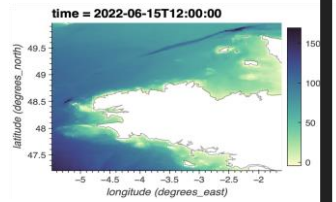
Bio-logging data

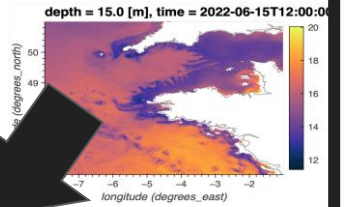


Bathymetry

Temperature at depth

Earth science data





- ***Model: Hidden Markov Method***

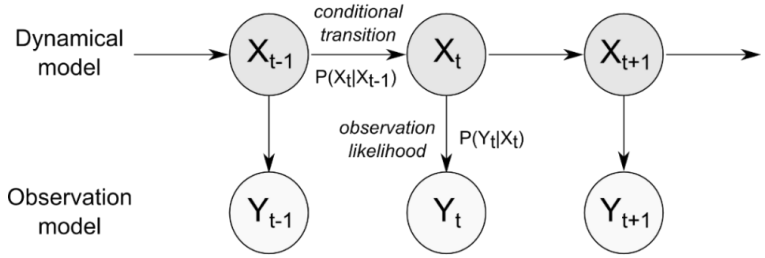
Geolocation model developed by Woillez et al. (2016), temperature and bathymetry as reference fields, adapted from Pedersen et al. (2008)

- ***Constrains:***
  - ***acoustic detection,***
  - ***bathymetry***
  - ***release location***
  - ***recapture location***
- ***Likelihood of Observed Temperature at depth by fish from earth science data***

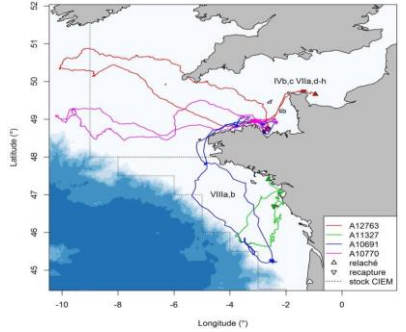
Copernicus Marine Service

Hidden Markov Method

Hidden states sequence
(here the daily fish positions)



Observations sequence
(here the temperature and depth conditions)



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Software for track reconstruction

- **Quality and resolution** (both spatial and temporal) **of Earth science data, such as** sea temperature**, are crucial for accurate track reconstruction.**
- The **original HMM software**, developed in 2016, was **not scalable**
- Software workflow:
  - Accessing in-situ observed environmental data (biologging data)
  - Accessing large Earth science datasets (IO-intensive computation)
  - Computation in Python
  - Visualization

⇒ Make our data, software and workflows FAIR (as FAIR as possible)

⇒ Leverage the Pangeo ecosystem to make it easier to deploy our solution on DestinE

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Infrastructure for the GFTS

- **JupyterHub with Dask Gateway** based on the Pangeo ecosystem has been deployed on OVH for fish track modeling.
- kbatch papermill is being developed to provide scientists with an easy-to-use interface (Jupyter notebooks) for scaling fish track modeling. It enables users to submit parameterized notebooks as jobs via papermill and kbatch on Kubernetes cloud infrastructure.
- **Pre-processing Climate Digital Twin (DT) data** into Zarr format to retain the native Healpix grid for the area of interest.
- A **STAC server** to enable easy access to both Copernicus Marine Data and DestinE Climate DT data (historical and future projections).
- A s3-bucket for **storing and sharing reconstructed fish tracks** and prepare future interfacing with the European Tracking Network (ETN).

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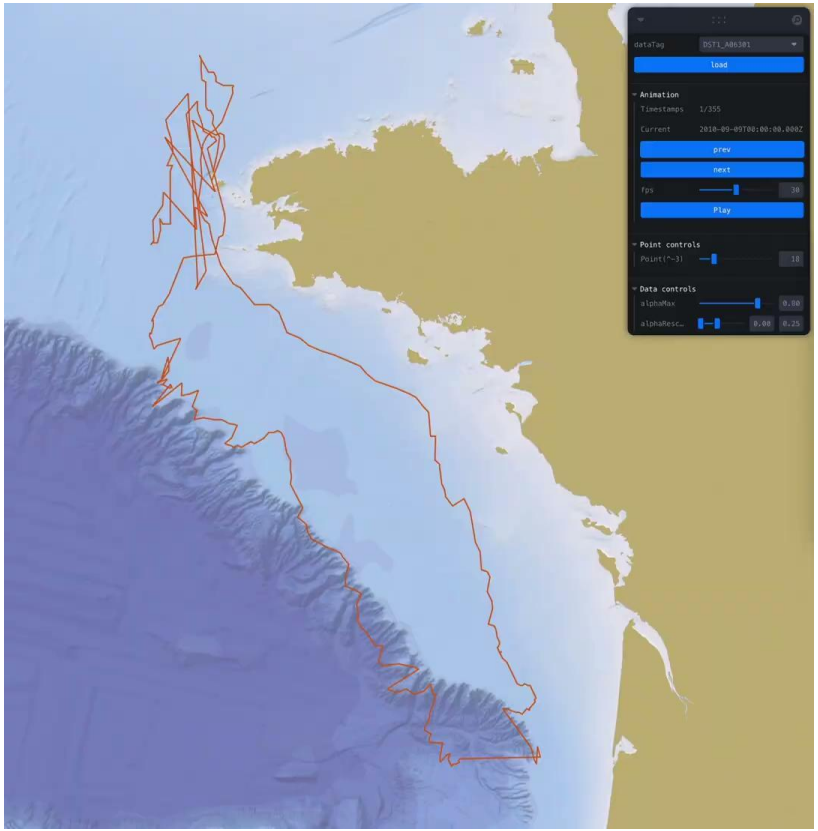
GFTS: Decision support tools

Tools for analyzing reconstructed fish track together with Digital Twin data.

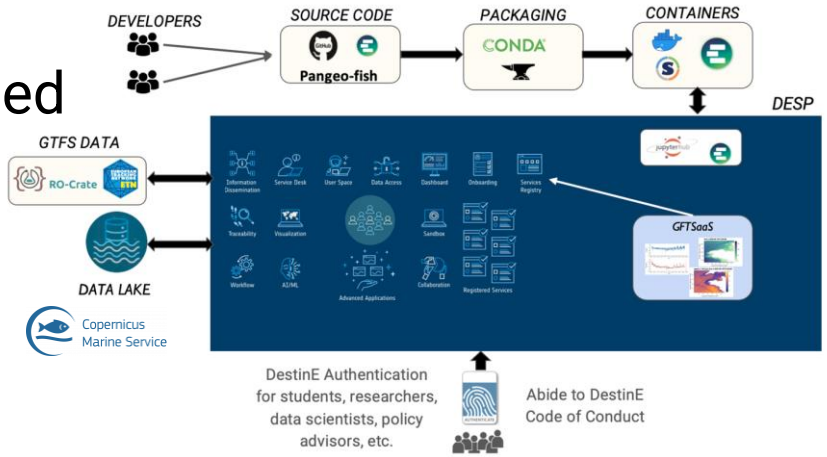
Answer questions and help decision-making:

- Where do fish spawn ?
- Where are the fish swimways ?
- Are these essential fish habitats stable over years ?
- How robust is the positioning of these habitats to errors and biases from reference geophysical fields ?
- Which ocean conditions fish encounter during their journey ?



Open Science & FAIR Principles

- GFTS adheres to Open Science guidelines.
- Decision Support Tool (DST) aids in result interpretation.
- Accessibility, usability, and data sharing are compliant with FAIR principles.
- Operationalizing GFTS is simplified by following Open Science and FAIR principles.



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Roadmap for future work

Next Steps and Future Enhancements

- **Short-term:**
  - Integrate DestinE's Climate Digital Twin data (when data is available);
  - Enhance the decision tool based on user inputs;
  - Integrate our tools with the DestinE platform;
- **Medium-term:**
  - Expand for more species and regions;
  - Collaborate tightly with the ETN to develop together user interface & APIs for storing, sharing and accessing the reconstructed fish tracks (and other species too!) from the ETN;
- **Long-term:**
  - Build a global marine species modelling and monitoring network linked to DestinE for cross-species and ecosystem-level conservation;
  - Feed the Climate Digital Twin with new in-situ and satellite data, such as river plumes and precise SST measurements, to incorporate real-world changes back into the model for more accurate and adaptive simulations.

THANK YOU

Contact us

Tina Odaka[1], tina.odaka@ifremer.fr

Anne Fouilloux[2], annef@simula.no

Daniel Wiesmann[3], danielwiesmann@developmentseed.org

Benjamin Ragan-Kelley[2], minrk@simula.no

Mathieu Woillez[4] , mathieu.woillez@ifremer.fr

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