

# Experimental Validation of a Drifting Model for Submerged Fishing Nets

*Galway Bay, Irish Western Coast*

Sara Cloux · Eoghan Daly · Tomasz Dabrowski · Vicente Pérez-Muñuzuri  
Marine Institute, Galway | CRETUS – University of Santiago de Compostela

**Interreg**  
Atlantic Area



Co-funded by  
the European Union



# Why Does It Matter?

## Ghost Gear

Abandoned, lost or discarded fishing gear (ALDFG) is a major component of marine debris worldwide

Continues to capture marine organisms – ghost fishing

Long persistence due to modern synthetic materials

## Plastic Pollution

Discarded nets are a substantial fraction of large plastic debris in the ocean

Estimated thousands of tonnes of gear lost annually

Impacts benthic habitats and protected species

## Modelling Gap

Passive Lagrangian particles overestimate drift and ignore deformation

Flexible mechanics + distributed hydrodynamic forcing are essential

Few field-validated net models exist

# Objectives

01

## Field Experiment

Deploy a fishing net in Galway Bay and record drift & sinking trajectories with CTD sensors.

02

## Mechanical Net Model

Develop a 3-D flexible net model with distributed hydrodynamic drag, lift, and elastic tension.

03

## Validation

Compare model predictions with observed trajectories and CTD depth time series.

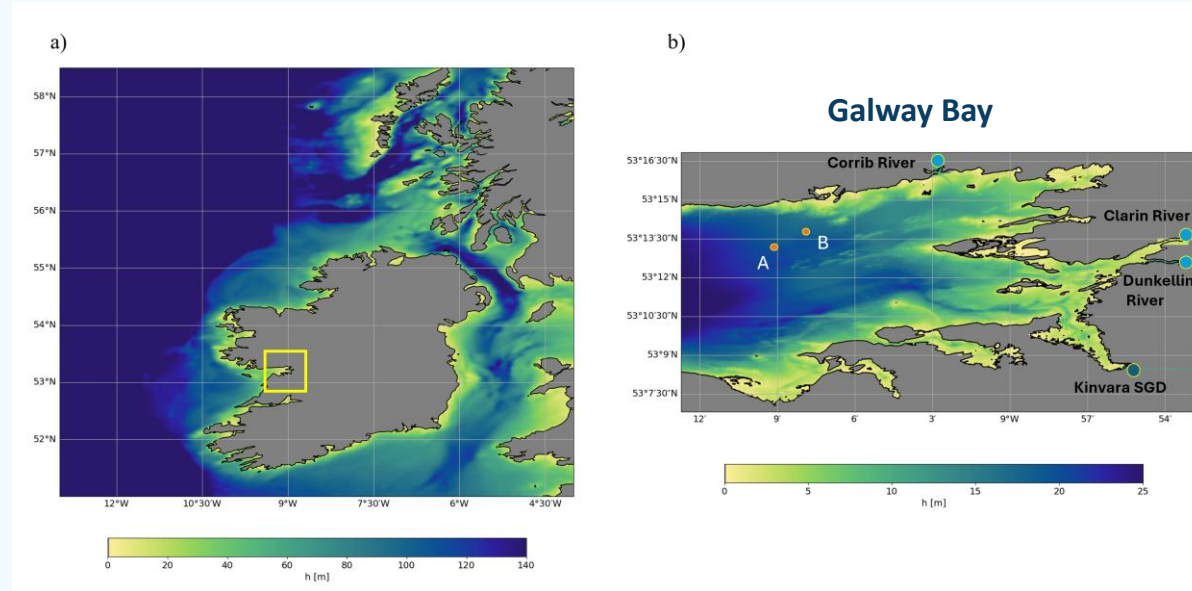
04

## Sensitivity Analysis

Identify key material parameters controlling net transport, deformation, and seabed interaction.

# Study Area – Galway Bay, Ireland

- Inner Galway Bay, west coast of Ireland (53°N, max depth ~30 m)
- Tidal + wind-driven circulation; semi-permanent gyre in outer bay
- Freshwater inputs: Corrib, Clarin & Dunkellin rivers + karst SGD near Kinvara
- Experiment: **21 Nov 2025** — deployed at low tide (11:34 AM), recovered at 12:55 PM
- Points A (deployment) and B (recovery) ~1 km apart, driven by incoming tidal flood



Deploy (A): 11:34 AM · Retrieve (B): 12:55 PM  
Net drift direction: SW → NE (tidal flood)

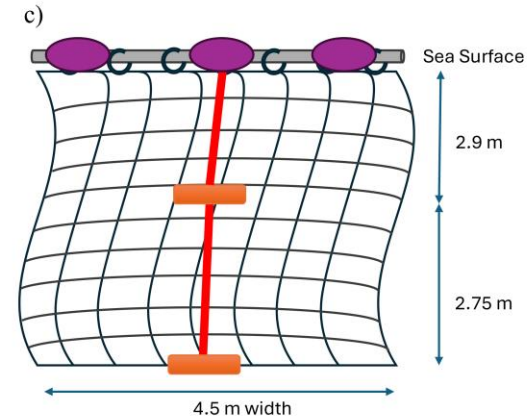
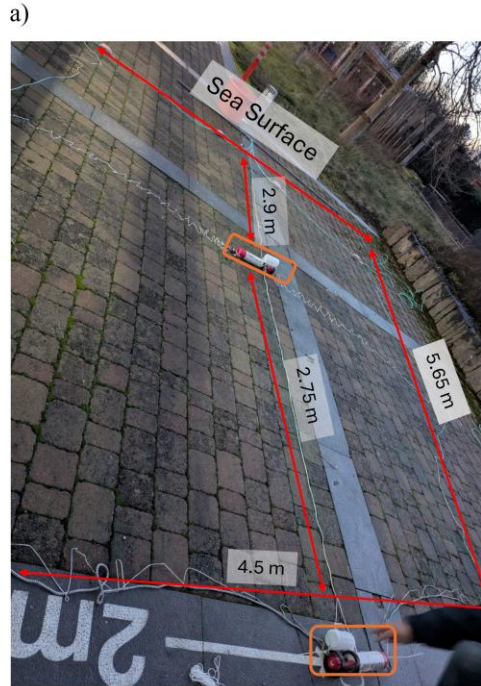
# Experimental Setup

## The Net

- Nylon fishing net: 4.5 m wide × 5.65 m deep
- Minimal intrinsic buoyancy
- PVC pipe along top edge (keeps net extended)
- Surface flotation element — upper edge at sea surface
- Small tracking buoys attached (minimal windage)

## Instrumentation

- 2 compact CTD sensors (pressure, temperature, salinity)
- Positioned: mid-depth + lower edge of net
- Near-neutral buoyancy — minimal influence on dynamics
- Tidal range: -0.4 m to +5.8 m; experiment during early flood



4.5 m

# Mechanical Net Model

## Structure Discretization

Net represented as  $N_{yx}N_z$  nodes connected by quadrilateral panels. Each panel has 4 edges + 2 diagonals (6 truss elements). Panel area and normal recomputed dynamically.

## Tension Forces

Tension-only truss elements with nonlinear Hookean law:  $F = A\gamma(\varepsilon + \alpha\varepsilon^2)$  for  $\varepsilon > 0$  ( $\varepsilon$  axial strain). Accounts for strain hardening in braided synthetic fibres. Axial stiffness  $A\gamma$  is the key parameter.

## Hydrodynamic Forces

Drag and lift computed at each panel using empirical coefficients  $C_D$ ,  $C_L$  as functions of angle-of-attack  $\theta$  and solidity ratio  $S_n$ .  $S_n$  evolves with mesh deformation.

$$C_D = 0.04 + (-0.04 + S_n - 1.24S_n^2 + 13.7S_n^3) \cos \theta,$$
$$C_L = (0.57S_n - 3.54S_n^2 + 10.1S_n^3) \sin(2\theta),$$

$$F = \begin{cases} A\gamma(\varepsilon + \alpha\varepsilon^2), & \varepsilon > 0 \\ 0, & \varepsilon \leq 0 \end{cases}$$

# Mechanical Net Model

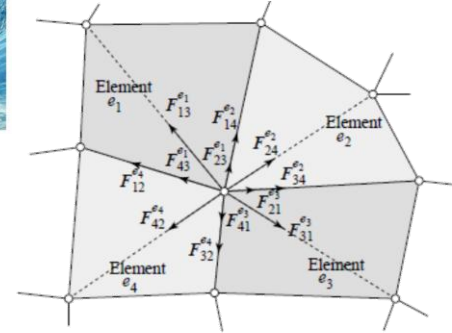
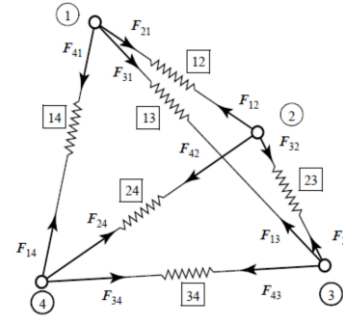
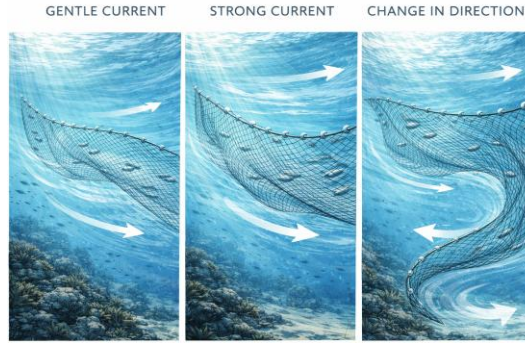
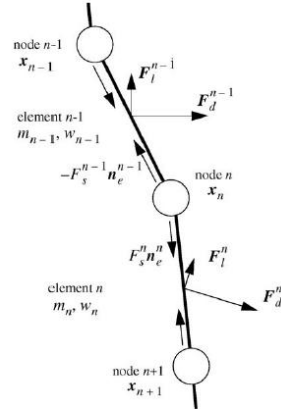
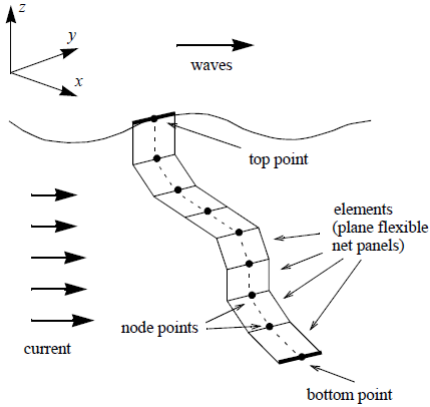
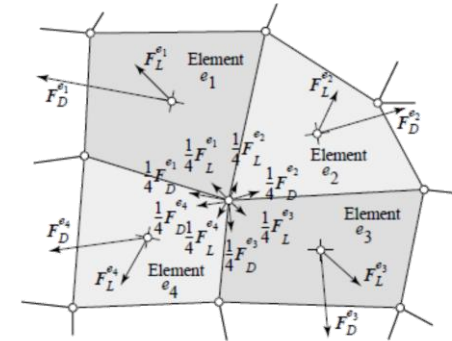


Fig. 5: Structural forces in one node.



$$\left(m_p + \frac{1}{2}m_f\right) \frac{dv_p}{dt} = \frac{3}{2}m_f \frac{Du_f}{Dt} + F_{buo} + F_{drag} + F_{lift} + F_{struct} + D\nabla^2 v_p$$

$$\frac{d}{dt} = \frac{\partial}{\partial t} + u_j \frac{\partial}{\partial x_j}$$

The model does not consider twist of the net

# Hydrodynamic Forcing – ROMS Model

## ROMS (Regional Ocean Modeling System)

Free-surface primitive-equation model following terrain. 3-level nested system for Irish coastal waters.

## Resolution

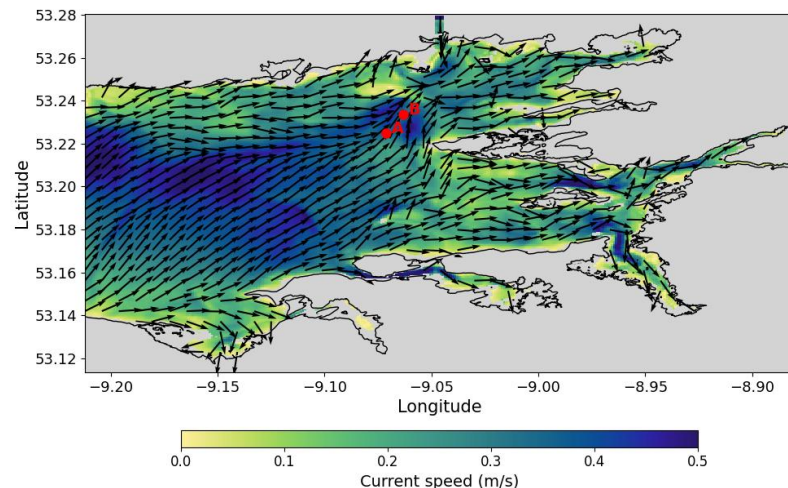
Inner Galway Bay: 70 m mesh. Regional coastal: ~200 m. NE Atlantic: ~2 km.

## Forcing

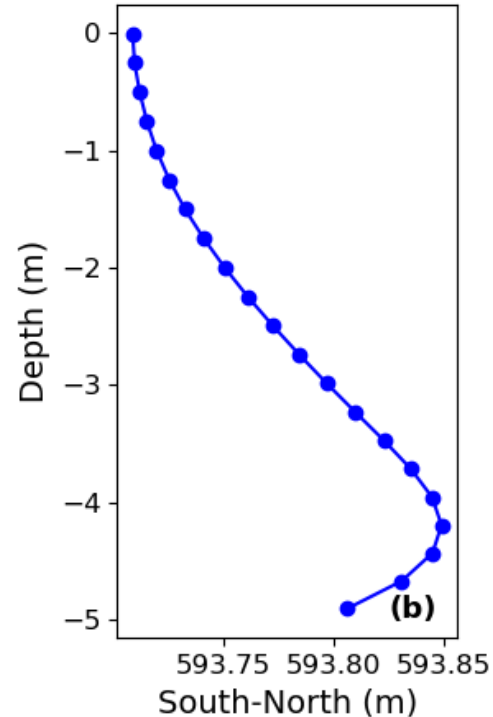
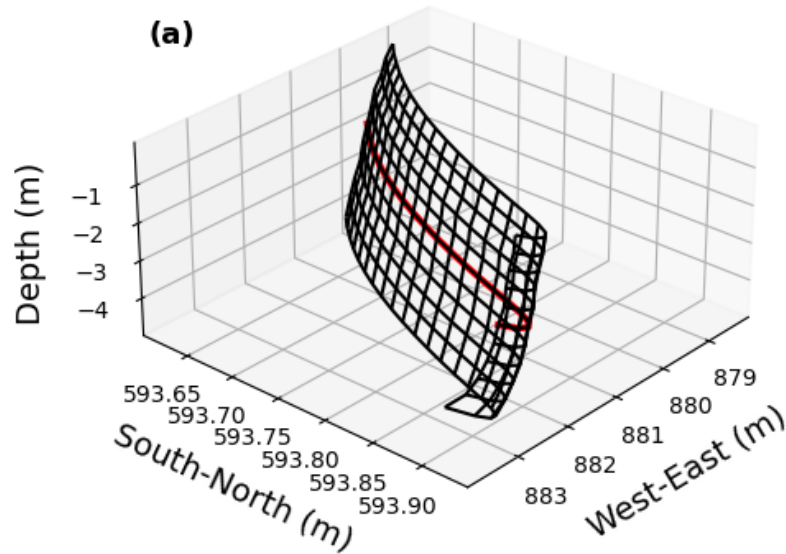
ECMWF 0.1° atmospheric forcing. River discharge from OPW (Corrib, Clarin, Dunkellin). Karst SGD near Kinvara.

## Outputs used

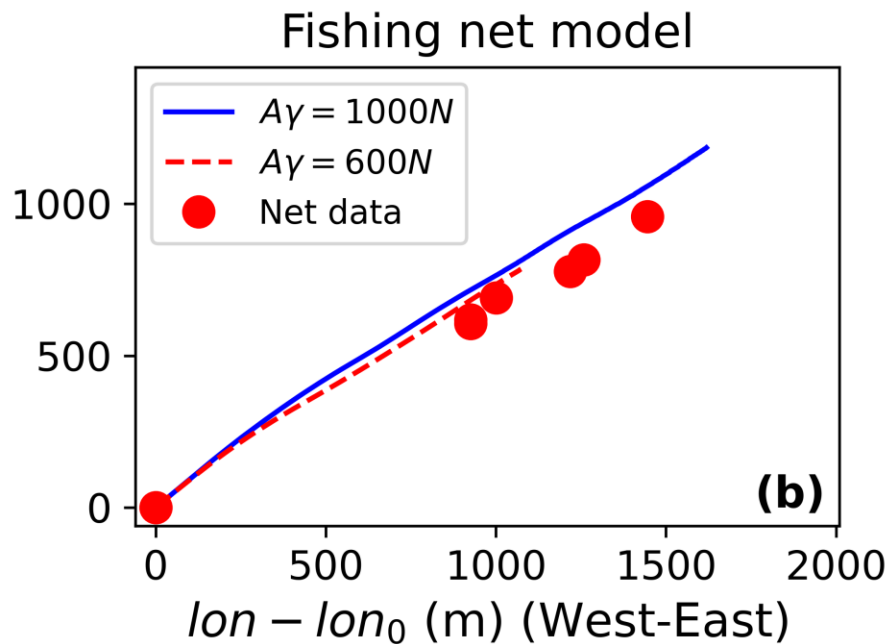
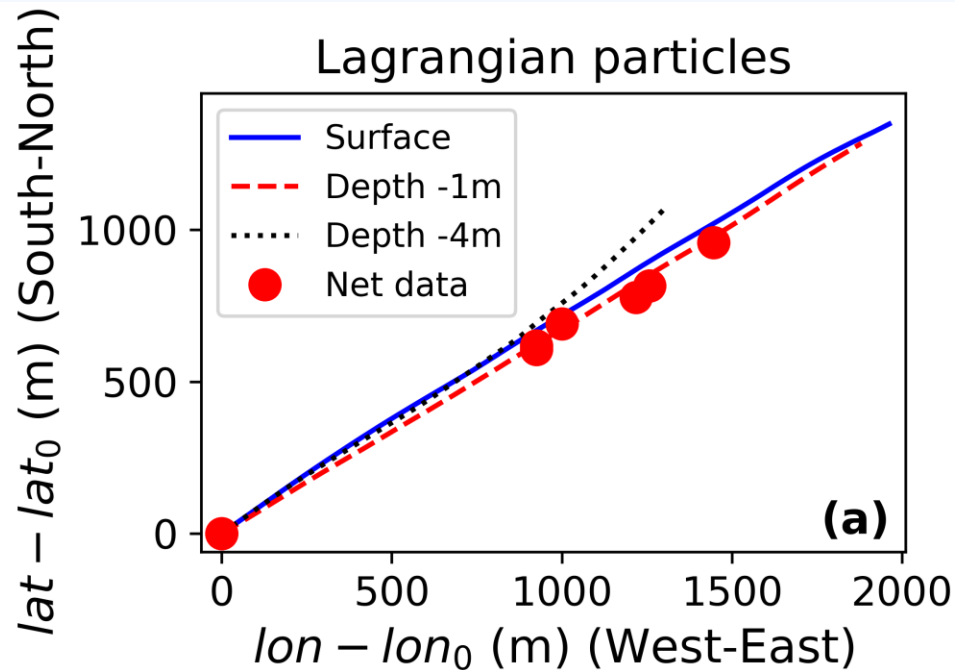
3-D current velocity fields interpolated to net node positions at each timestep.



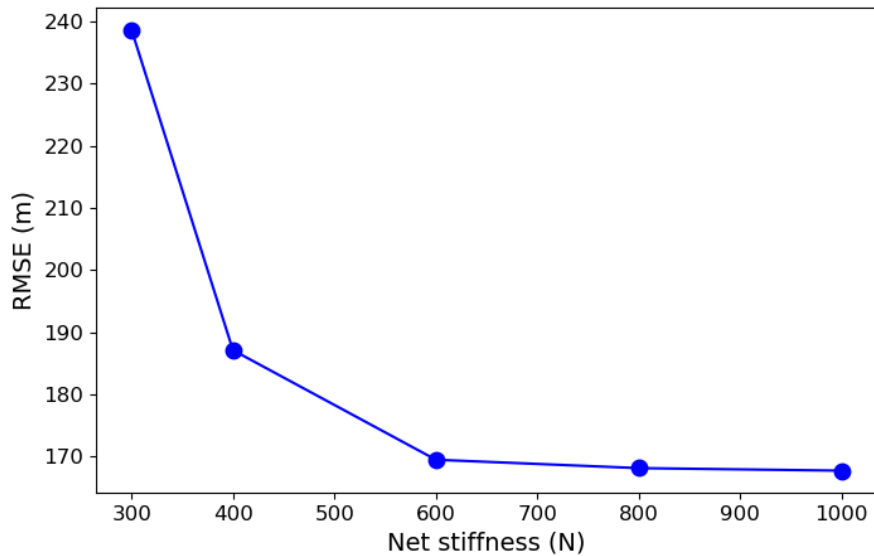
# Drift Trajectories – Model vs. Observations



# Drift Trajectories – Model vs. Observations

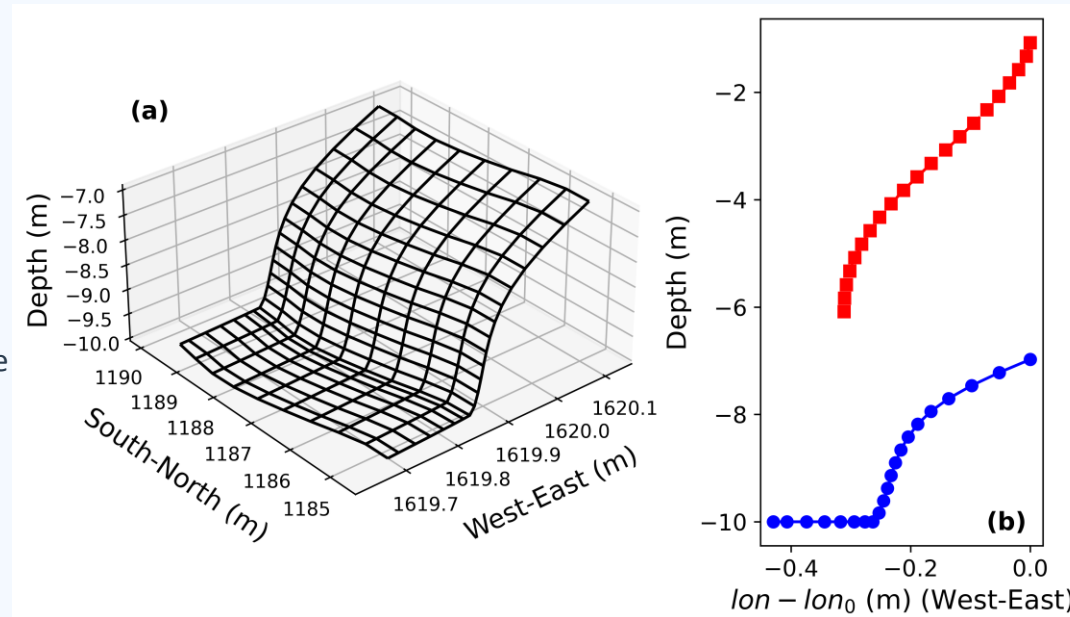


# Drift Trajectories – Model vs. Observations



# Sinking Dynamics – Net Deformation

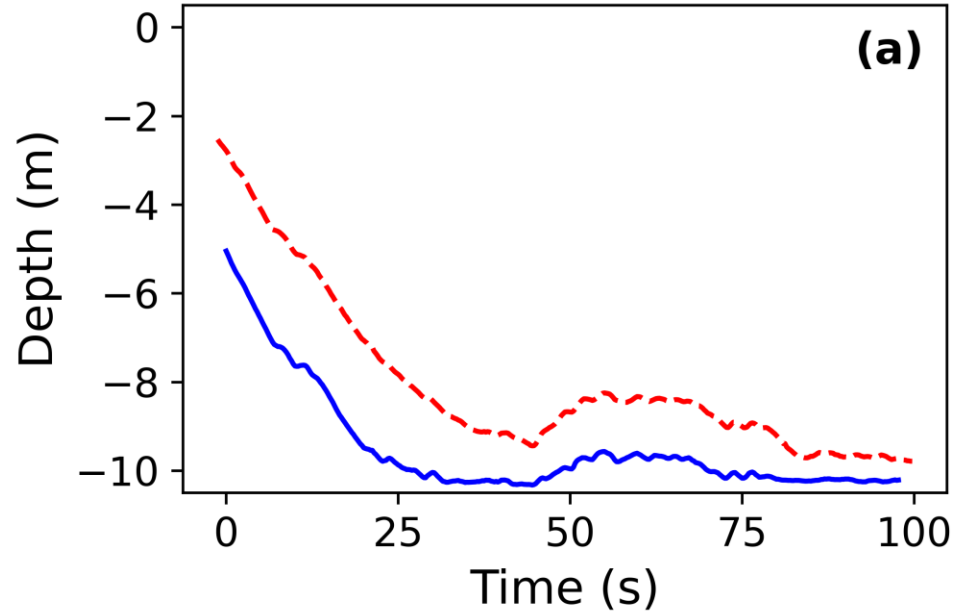
- After top-node release, the net sinks freely under gravity and hydrodynamic forcing
- Approaches seabed at ~10 m depth
- Non-uniform descent: each net segment experiences different drag
- Upper nodes lag behind lower nodes → curved, banded configuration
- Lower nodes reach bottom first; upper nodes continue to drift horizontally
- Internal tension transmits forces progressively along the structure



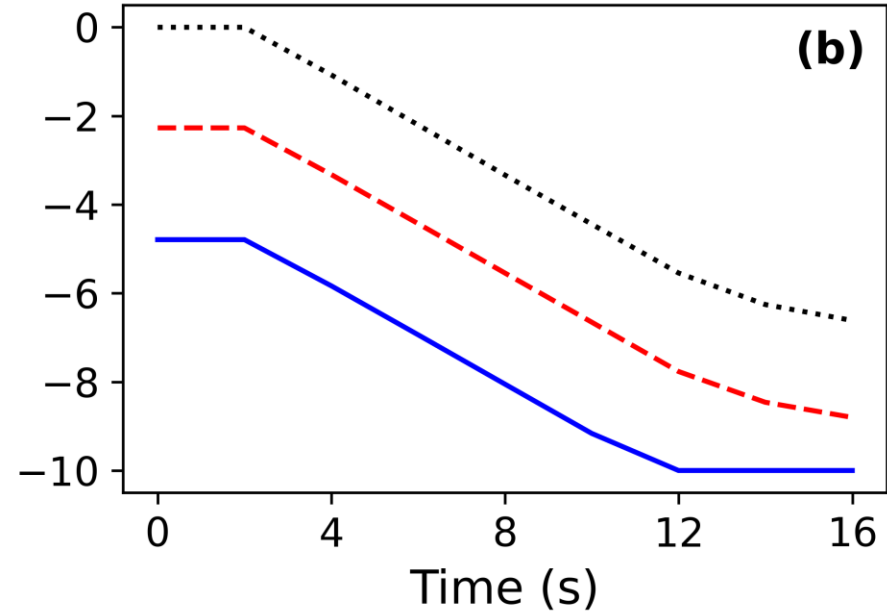
**Both distributed forcing AND internal tension control 3-D sinking behaviour**

# Node Depth Time Series – Model vs. CTD

(a) Experiment (CTD sensors)



(b) Numerical Model



# Discussion

## ✓ Passive particles are insufficient

They neglect deformation and internal forces, systematically overestimating drift speed.

## ✓ Net depth matters

Agreement with  $-1$  m subsurface particles confirms vertical shear controls effective transport depth.

## ⚠ Limitations

No small-scale turbulence or wave–current coupling. One-way flow coupling. Homogeneous net properties. Single deployment.

## → Future work

Higher-resolution hydrodynamics with waves; fully-coupled FSI; heterogeneous materials and biofouling; multi-deployment datasets.

**New experiment!! – August 2026 (Ireland Sea)**

# Conclusions

- 1 Passive Lagrangian particles overestimate drift and must be replaced by flexible mechanical models for fishing gear.
- 2 The proposed 3-D net model reproduces observed trajectories, deformation patterns, and sinking behaviour.
- 3 Axial stiffness ( $A\gamma$ ) is the dominant parameter: accurate material characterisation is essential.
- 4 Non-uniform sinking and partial seabed contact have direct implications for ghost fishing and benthic disturbance.
- 5 Approach improves predictions of ALDFG transport pathways and marine plastic pollution.

# Thank you

*Questions?*