Connectivity Patterns of Coastal and Neritic Fish Larvae in Deep Waters in the Western Gulf of Mexico: How Ichthyoplankton Surveys Can Be Helpful to Evaluate the Reliability of the Velocity Fields Provided by the Circulation Models?

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Abstract

Biological connectivity studies are crucial for explaining the structure of marine populations of species with a pelagic larval stage. Numerical modelling is a powerful tool for evaluating marine dispersal pathways of planktonic organisms. The high-resolution numerical circulation model HYCOM (HYbrid Coordinate Ocean Model) has been used to examine fish connectivity patterns in the Gulf of Mexico (GoM), but without biological validation. We examined the connectivity of fish larvae caught in the northwestern GoM by coupling ichthyoplankton surveys with numerical modelling and particle backtracking experiments. Fish larvae were collected with 200 m oblique bongo tows along two parallel transects extending from the edge of the shelf to deep waters of the Perdido region in the northwestern GoM (24°N to 26°N and 94.5°W to 97°W) during four cruises (June and October 2016, April and November 2017). Larvae of coastal and shelf-spawning species were used to infer offshore transport. In order to explore their dispersal pathways, the real-time HYCOM 1/25° model hourly output with the Navy Coupled Ocean Data Assimilation (NCODA) was used to simulate Lagrangian trajectories for each cruise and transect. Particles were seeded at sampling stations and the circulation model was run backward in time to infer larval origin. Patterns of spatial distribution and abundance of the coastal and shelf larvae caught in oceanic stations among cruises exhibited a reasonable agreement with the results of modelling exercises, and indicate the shelves of Tamaulipas and Texas were the main source of larvae to Perdido's deepwater region. Our results suggest the combined use of ichthyoplankton surveys and ocean circulation models can yield insight into the dispersal pathways of larvae of neritic fish species to deep waters regions in the GoM. Likewise, these results imply that fish larval distributions are a useful tool for evaluating the reliability of using 2-D velocity fields from circulation models to infer larval transport at time scales of several weeks.

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OCEAN SCIENCES MEETING

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1. INTRODUCTION

Numerical circulation models have traditionally been used to examine the connectivity of marine populations of species with a pelagic larval stage [1,2,3]. However, to date, biological validation of connectivity and transport patterns inferred from circulation models is limited.

OBJECTIVE

To use larval fish distributions for assessing the reliability of velocity fields from a circulation model (HYCOM), using the western Gulf of Mexico as a model system.

2. METHODS

ICHTHYOPLANKTON SURVEYS

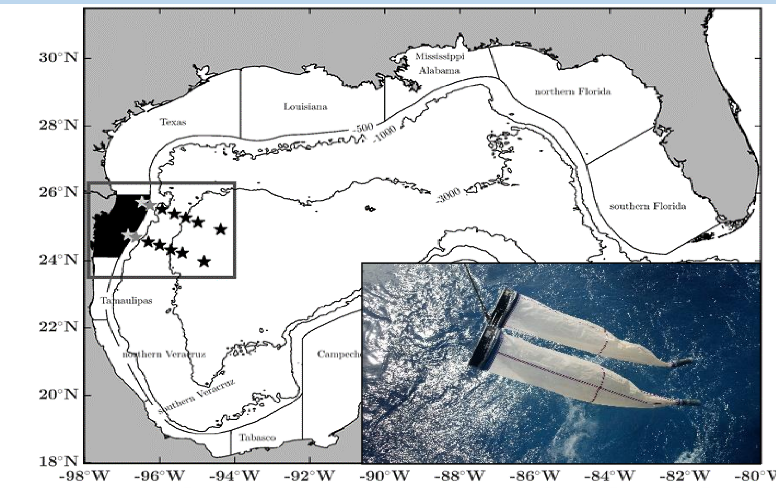
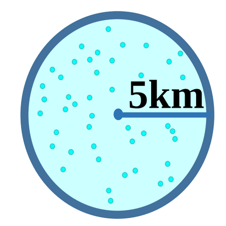


Fig. 1. Sampling stations in which oblique 0-200 m bongo tows were performed.

CRUISES
- I) Jun 2016
- II) Oct 2016
- III) Apr 2017
- IV) Nov 2017

BACKWARD PARTICLE TRACKING EXPERIMENTS



25500 passive particles randomly distributed from 0 to 200m (17 layers) per station and cruise

HYCOM (+ NCODA) u – v (1/25°) t = 1 h

Backward T = 28 d

- **A. Percentage of particles coming from neritic provinces (depths <500 m)**
- **B. Possible dispersal pathways of neritic fish larvae**

3. RESULTS

(A) There was a higher (lower) percentage of particles originating in neritic provinces in the cruises in which more (less) fish larvae of neritic taxa were caught (Fig. 2).

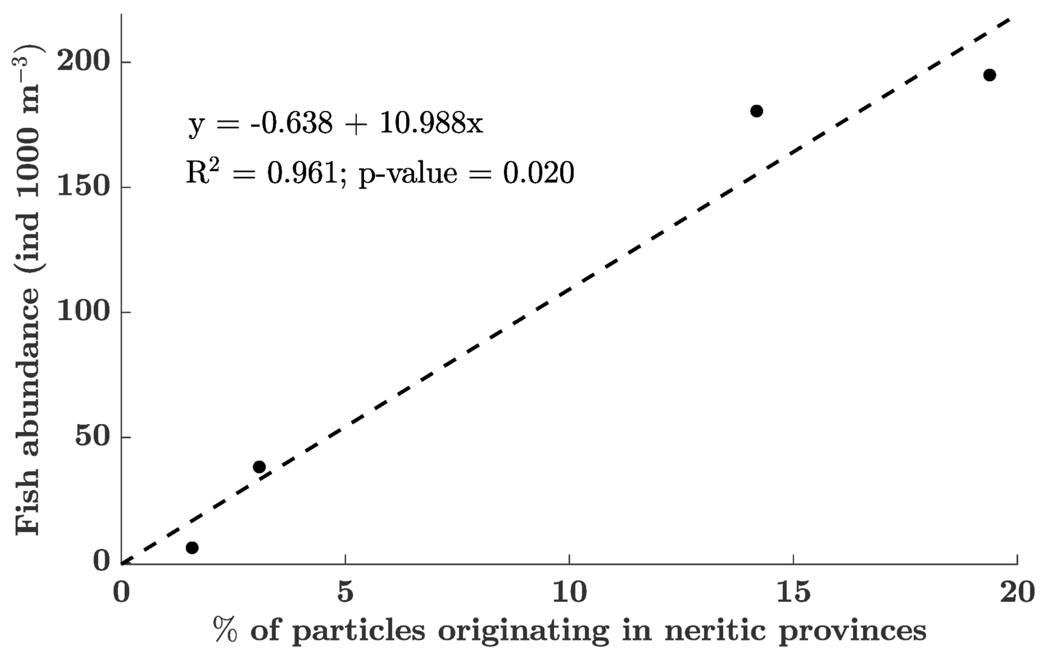


Fig. 2. Average percentage of particles originating in neritic provinces relative to all released particles vs the average abundance of fish larvae of taxa that inhabit the coast and shelf during the adult stage that were caught at oceanic stations (depths >1000 m).

(B) The Perdido, Tamaulipas and Texas neritic provinces are the main sources of particles to Perdido's deepwater region, while the contribution of northern Veracruz, Campeche, Yucatan, Louisiana, and Mississippi-Alabama were much lower (Fig. 3).

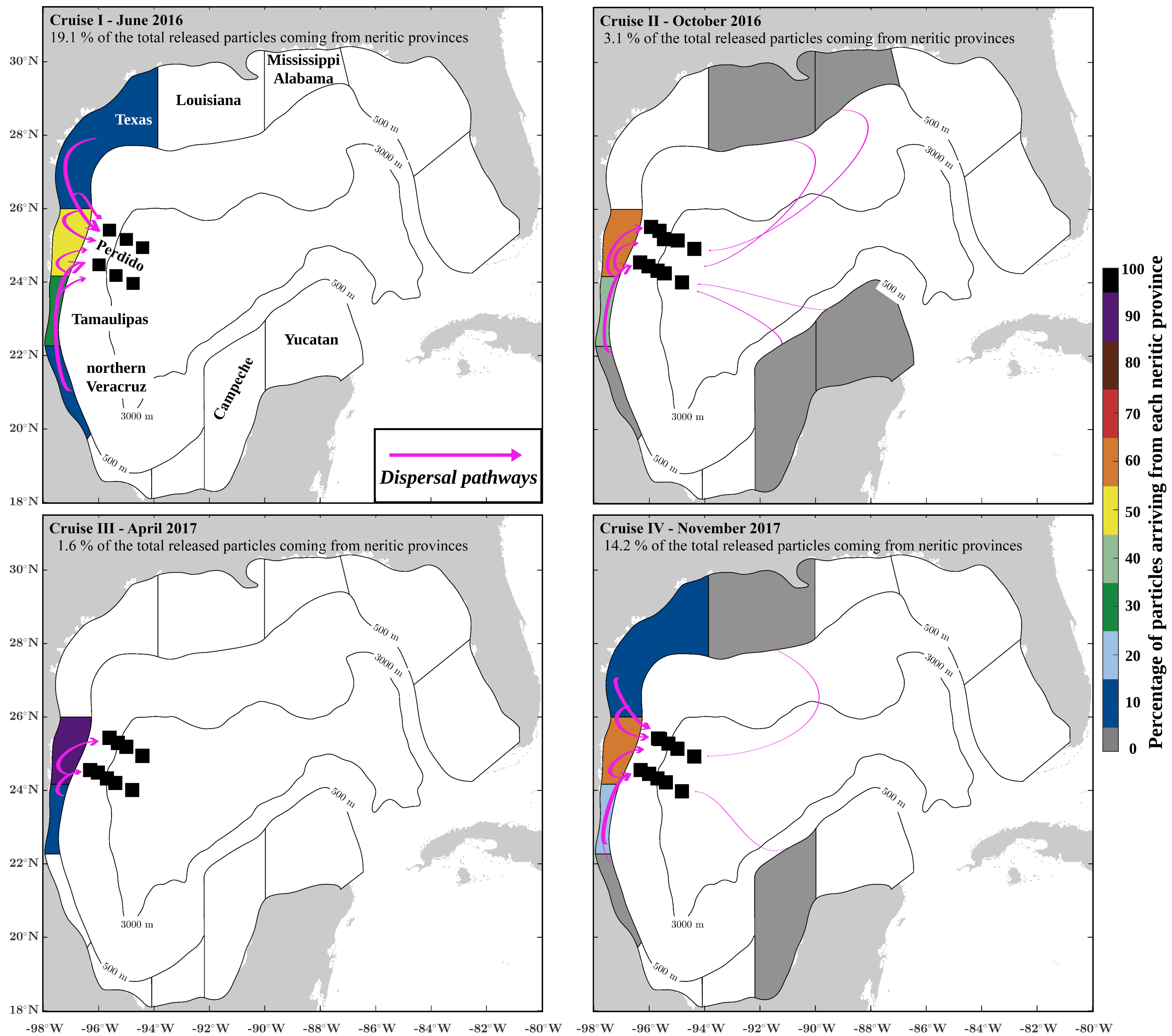


Fig. 3. The percentage of particles coming from all neritic regions with respect to the total number of particles released for each cruise is shown in the figure's header, while the percentage of particles coming from each province is shown according to the colour scale. The simplified results of dispersal pathways of passive particles are shown by arrows.

4. CONCLUSIONS

There was high agreement between biological tracers and numerical experimental results. The Gulf of Mexico's HYCOM model is a suitable tool for evaluating the dispersal pathways of the larval stages of marine populations from the shelf to deep waters.

Fish larval distributions are a useful tool for evaluating the reliability of using 2-D velocity fields from circulation models to infer larval transport at time scales of several weeks.

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