Wave-Wake Interactions in Stratified Shelf Seas: Implications for Offshore Wind Infrastructure

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Introduction

Offshore wind farms in seasonally stratified waters introduce new challenges for understanding how turbine wakes affect the thermocline—critical for nutrient cycling, productivity, and carbon storage. Existing wake studies focus on unstratified environments, leaving a knowledge gap[1,2,3]. This research experimentally investigates wake-induced internal waves, vertical mixing, and their ecological implications.

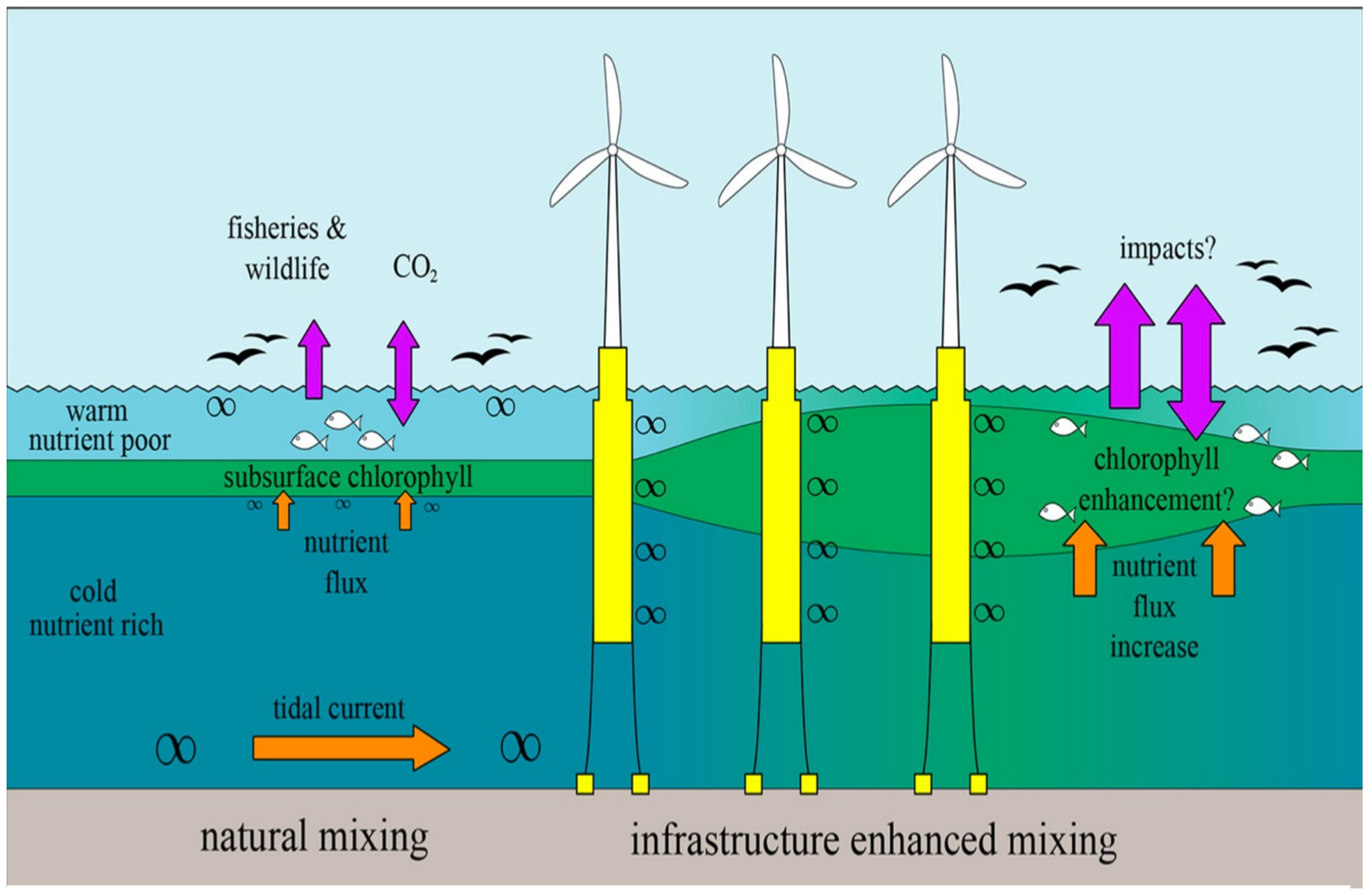

Figure 1. Illustration of sources of turbulent mixing, where floating offshore wind enhanced turbulent mixing may weaken stratification at the thermocline, which may have environmental implications in shelf seas[1].

Research Question

How do wakes generated by offshore wind infrastructure interact with internal waves in stratified shelf seas, and what are the implications for vertical mixing and marine ecosystem dynamics?

Methodology

Figure 2. Stratified Flow Flume setup at the Aura Innovation Centre (Credit: Brian Houston, University of Hull).

This planned study employs a **unique Stratified Flow Flume** at the Aura Innovation Centre to simulate seasonally stratified seas using carefully layered hot and cold water. Three sequential experiments will investigate internal wave–obstacle interactions, the effects of fixed-bottom offshore wind structures, and floating wind models.

Laser Induced Fluorescence (LIF) will track dye-based mixing, while **Tomographic Particle Tracking Velocimetry** (PTV) captures 3D velocity and density fields, for exploring complex wave–wake interactions downstream of various turbine configurations[5].

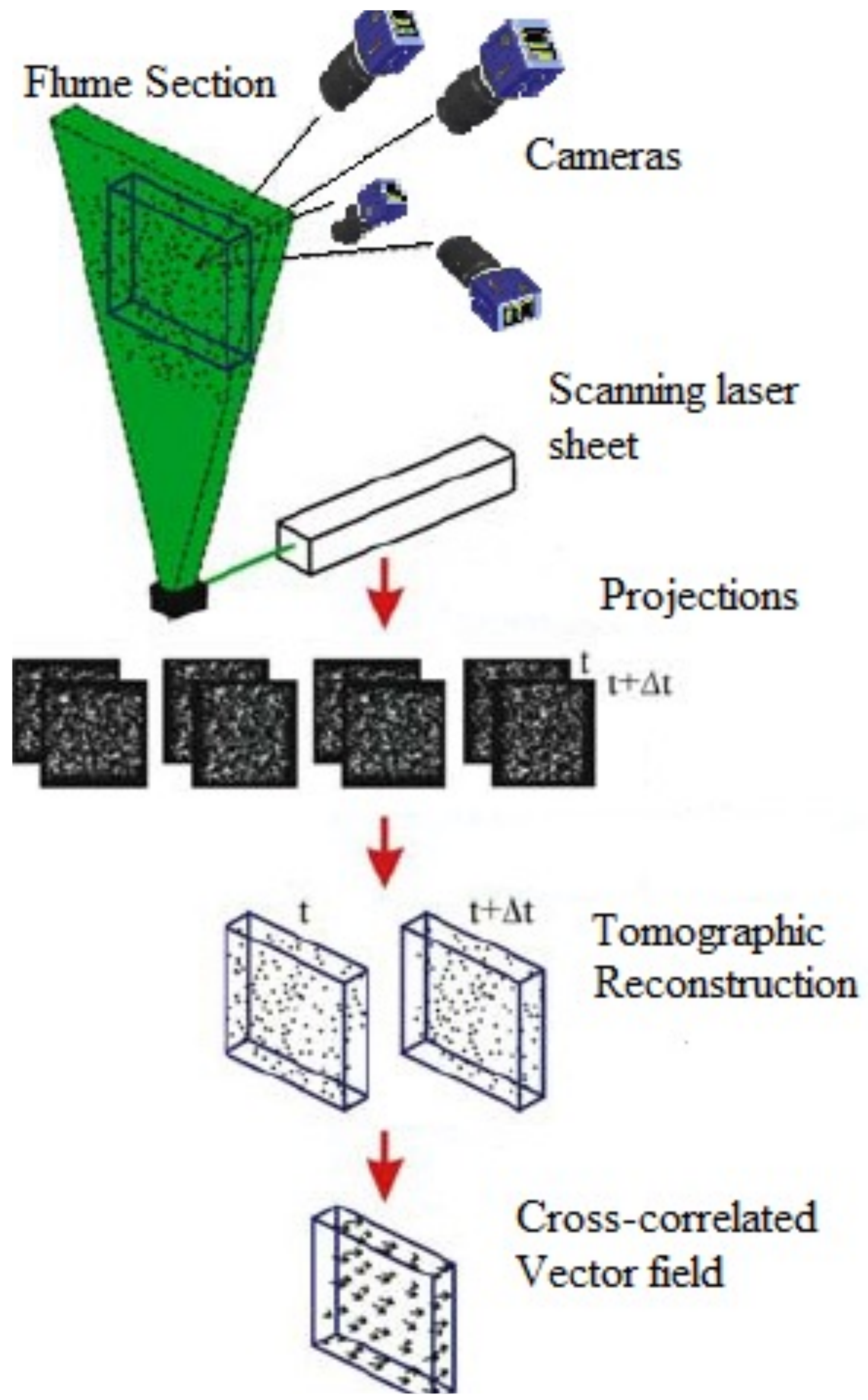

Figure 3. Working principle of 3D tomographic PIV adapted from Elsinga *et al.*, 2008[4].

Expected Impact

•Offshore wind generated internal waves have the potential for enhancing or suppressing vertical mixing, possibly affecting shelf sea nutrient fluxes, primary productivity, and carbon storage.

•Findings may inform the design and environmental assessment of offshore wind farms.

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