Assessing the potential for mesophotic coral reefs to ensure the survival of shallow coral reefs

Colin Scherpereel[1], Daniel M. Holstein[2], Jonathan Lambrechts[3], Emmanuel Hanert[1,3]

[1] Earth and Life Institute, UCLouvain, Louvain-la-Neuve, Belgium
[2] Department of Oceanography and Coastal Sciences, College of the Coast and Environment, Louisiana State University, Baton Rouge, LA, USA
[3] Institute of Mechanics, Materials and Civil Engineering, UCLouvain, Louvain-la-Neuve, Belgium

colin.scherpereel@uclouvain.be
www.slim-ocean.be

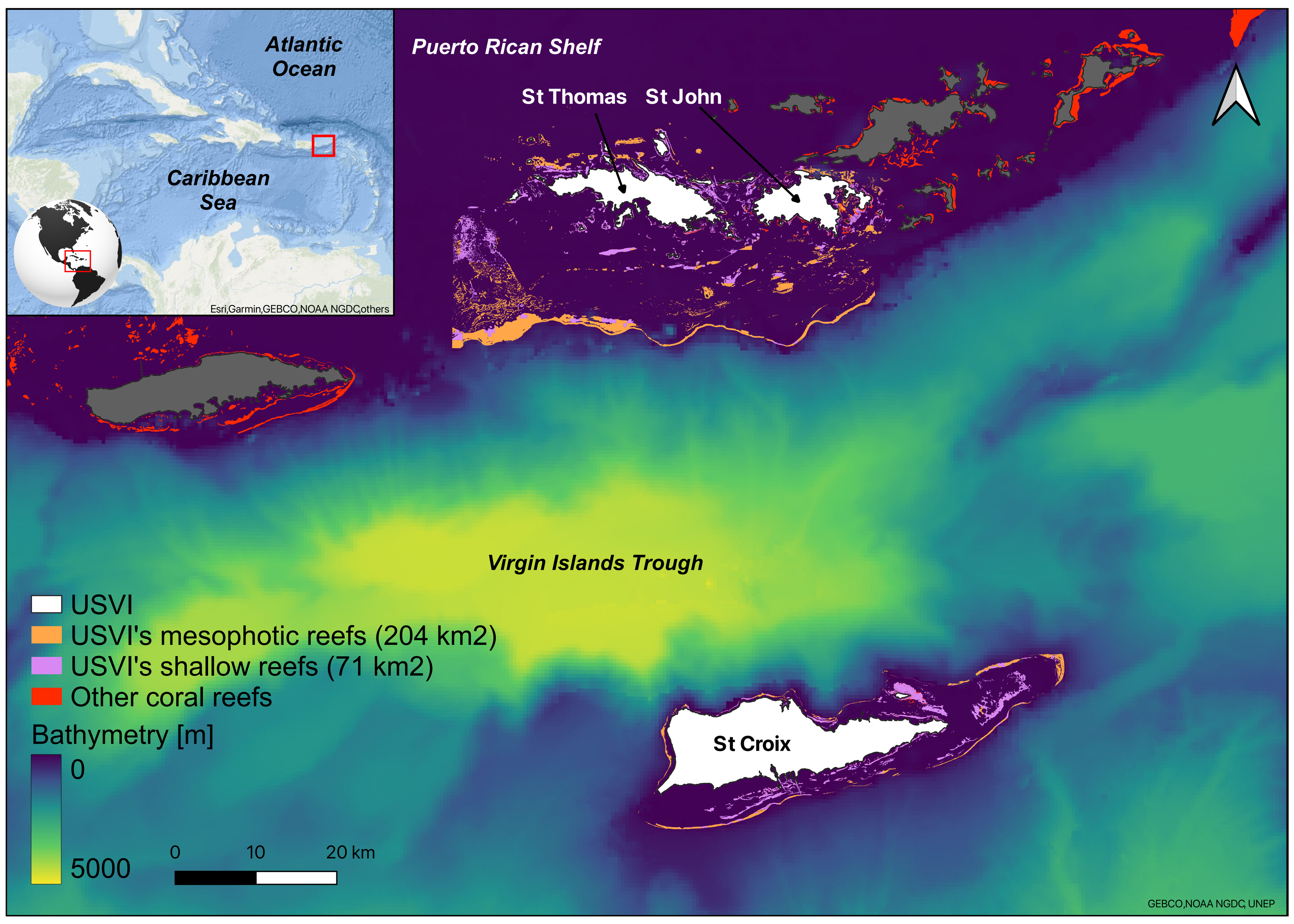
A glimmer of hope for endangered coral reef ecosystems

Mesophotic coral ecosystems (**MCEs**), formally corals living in low light conditions (> ~30m depth), are one of the last lifeboats of coral reefs around the World. Being partly **sheltered** from global warming, human activities, and hurricanes, they could fare better than shallower reefs in the next decades. Since similar coral species can live on shallow and deeper reefs, MCEs could act as a refuge and help repopulate shallow reefs after disturbances through **larval exchanges**. However, MCEs keep on being discovered and few studies have tried to estimate the exchanges between MCEs and shallow reefs.

The U.S. Virgin Islands (**USVI**) are home to many mesophotic habitats with a high potential for connectivity with shallow reefs. However, they have been impacted by a severe outbreak of stony coral tissue loss disease (**SCTLD**) since 2019. It has been shown that **ocean currents** are one of the main drivers of disease dispersal through the transport of sediments carrying the disease agents. Connectivity is thus a **double-edge sword** that is both responsible for larval exchanges and disease transmission. It is therefore particularly challenging to identify which reefs would have to be protected and/or restored in priority.

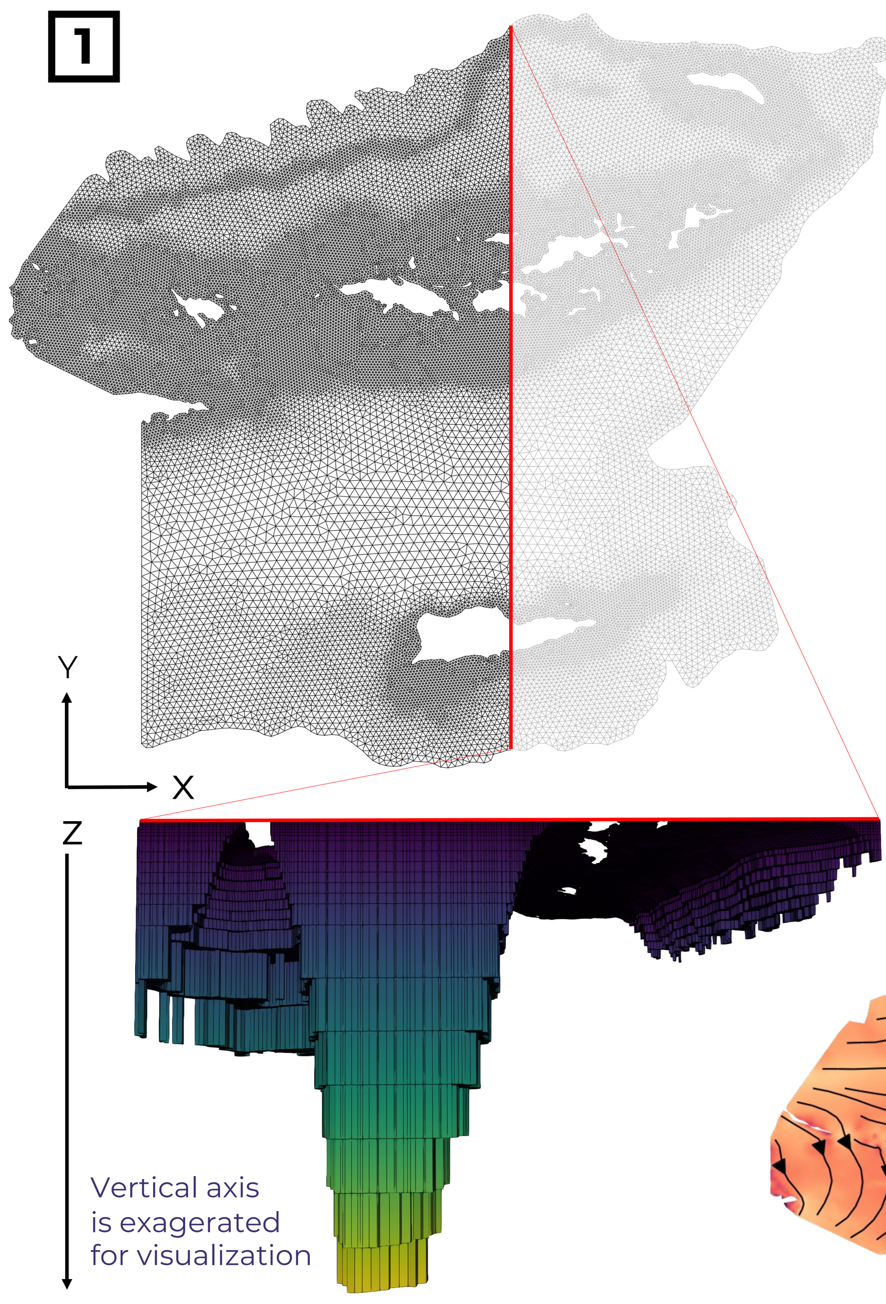
Pristine MCEs keep on being discovered!

Here in Tahiti (2022)



Developing a 3D modeling sequence to study the exchanges between shallow and mesophotic reefs

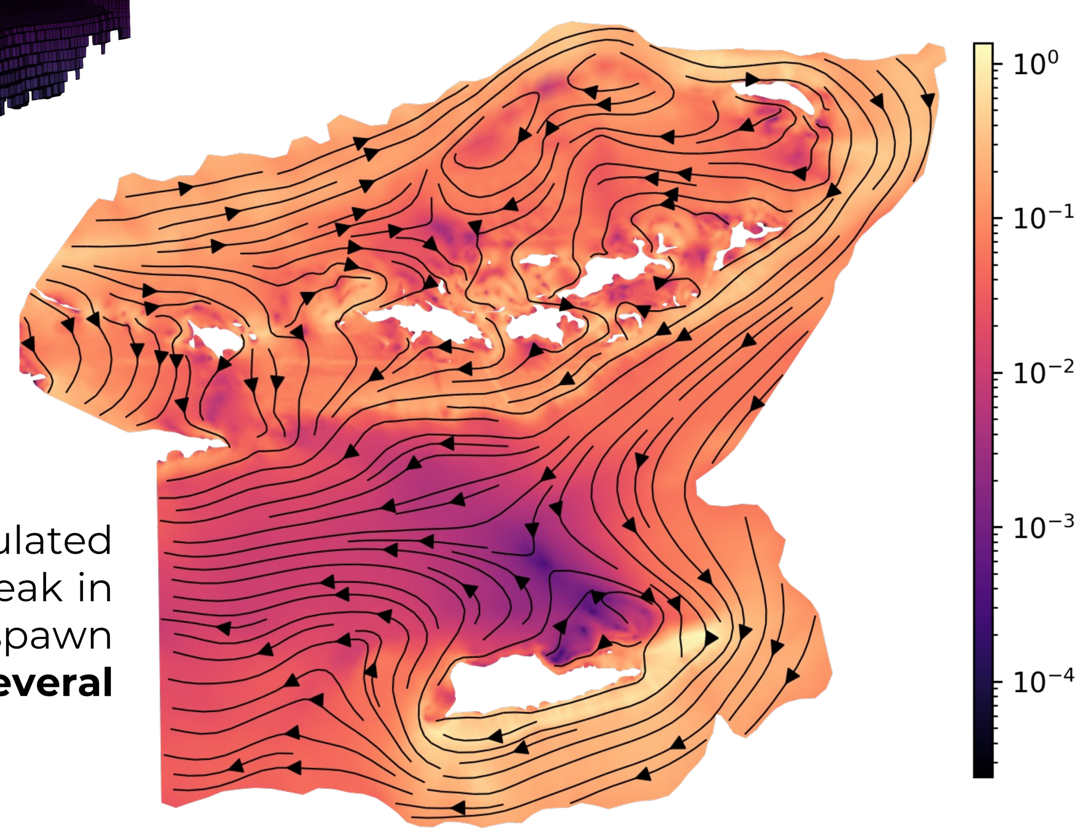
1



We will simulate the ocean circulation in the USVI basin with the **unstructured-mesh multi-scale ocean model SLIM**. The USVI are a challenging environment due to the large trough extending to 5000m depth and splitting the area in two. The high bathymetry gradients will require a **specific 3D setup** with adapted resolution along the vertical.

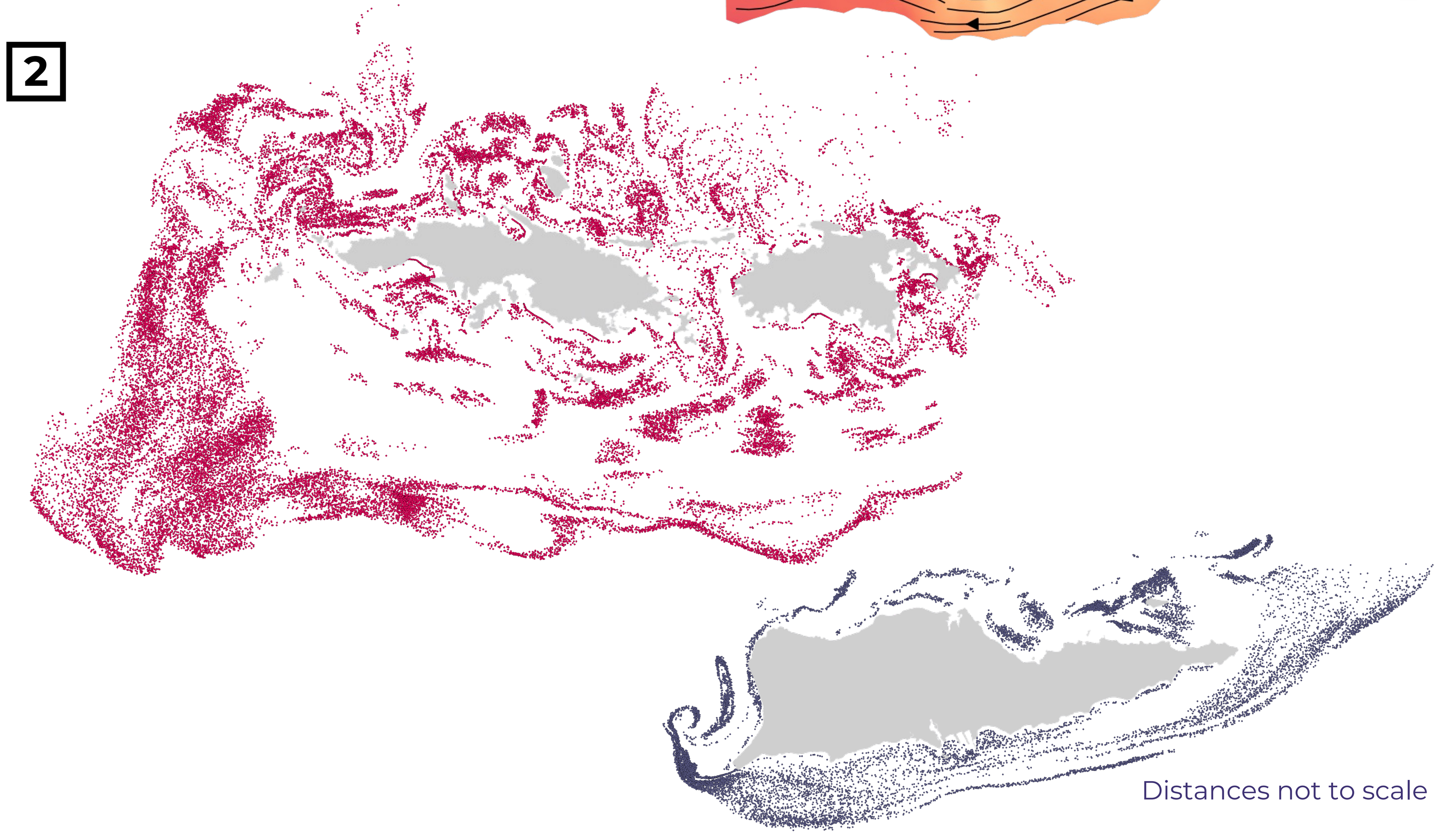
Depth-averaged current velocities (m/s)

(average for January 2019)



The hydrodynamics will be simulated from the onset of the SCTLD outbreak in early 2019 up to now. As corals spawn once a year, this will give us **several spawning seasons** to consider.

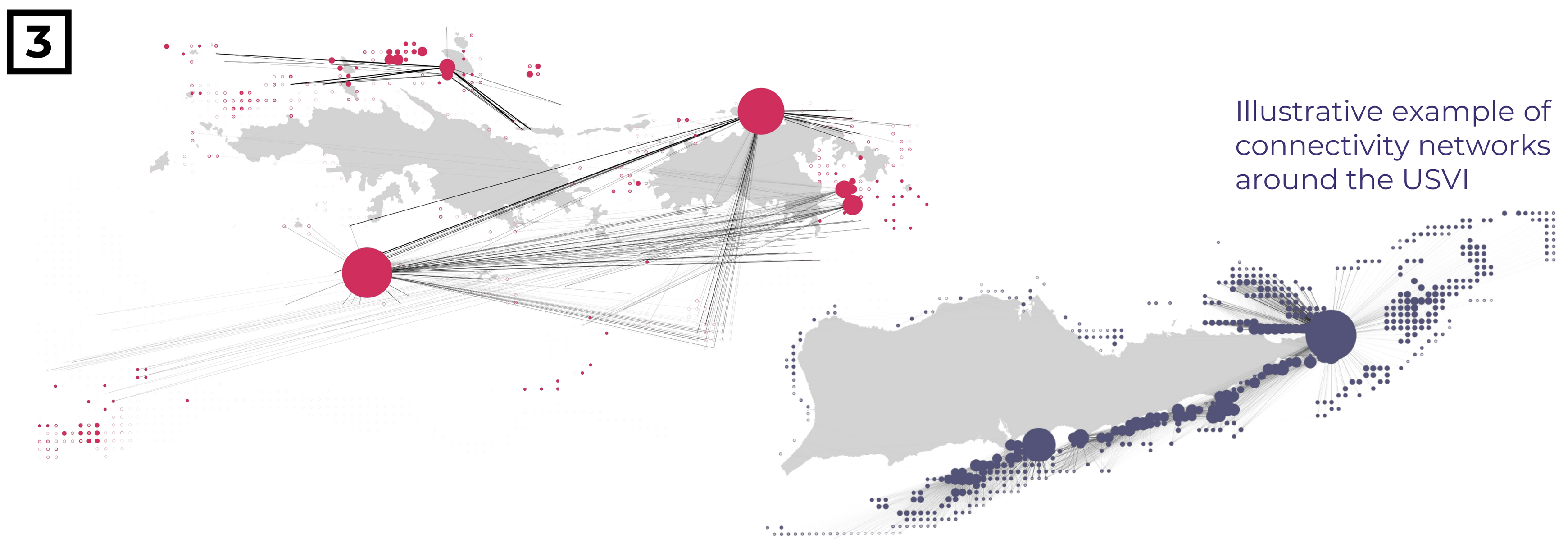
2



The hydrodynamics will then be used in combination of **SLIM's biophysical transport model** to simulate the dispersal of both coral larvae (for each spawning season) and disease agents (throughout the year).

We will consider coral species that are present on both shallow and mesophotic reefs, with different susceptibilities to SCTLD, and **whose larval traits have been quantified** (pelagic larval duration, competency acquisition, death rate, etc), such as *C. natans*, *Orbicella spp.*, or *Porites spp.*

3



The resulting connectivity matrices for different years and species can be interpreted as **large graphs** describing the probabilities of larval and disease exchange between reefs.

They will be analyzed with **graph-theory algorithms** to identify the best larvae exporters and weakest disease importers. The two indicators will then be combined into a **conservation score** to highlight the reefs that are the most useful to the long-term resilience of the system.

Going further

- Improve SLIM3D for high bathymetry gradients areas
- Use a metapopulation model to assess MCEs' potential to repopulate shallow reefs
- Simulate the effects of global warming on connectivity
- Share recommendations for conservation/protection efforts in the area

This research will help...

- Quantify MCEs' potential to repopulate shallow reefs
- Identify USVI marine areas that need to be protected or restored in priority
- Highlight the importance of mesophotic ecosystems
- Create a modeling sequence applicable to other locations

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