DHI SOLUTION

CORAL REEF MODELLING

Modelling coral reef connectivity and impacts on mass coral spawning

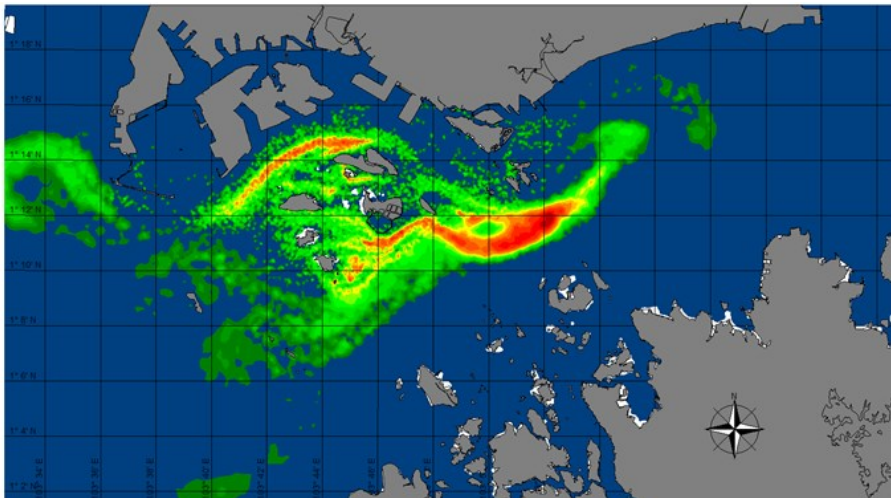
CORAL REEFS – OASES OF THE OCEANS

Coral reefs are the oceans' oases. They are among the most productive ecosystems in the world and support the highest level of marine biodiversity in tropical and sub-tropical regions. Coral reefs are sensitive to natural and anthropogenic disturbances. Today, they are seriously threatened by environmental changes, including declining water quality and increased sedimentation in coastal regions worldwide. Human activities (such as coastal and offshore infrastructure developments) contribute to these environmental changes.

FUNCTIONAL IMPORTANCE OF MASS CORAL SPAWNING

Corals, with a few exceptions, are clonal organisms that comprise colonies of thousands to millions of individuals. Different coral species have various strategies for reproduction and larvae dispersal. However, a large number of species are known to be broadcast spawners, which exhibit strong multi-species reproductive synchrony. This results in 'mass' coral spawning events that occur with a certain periodicity (often annual or bi-annual). This periodicity depends on local environmental conditions, specifically hydrodynamic features and lunar phases.

One of the most ecologically significant aspects of mass coral spawning is the



Temporal snapshot of the predicted concentration of larvae roughly 36 hours after the first spawning event on the evening of the 10 April 2012 (Reef source: Pulau Satumu, Singapore)

SUMMARY

CLIENT

- Coastal & offshore developers
- Environmental protection agencies & policy makers

CHALLENGE

- Need to establish coral reef connectivity patterns by assessing coral spawning patterns
- Need to determine potential environmental impacts on coral spawning by anthropogenic effects
- Need to ensure scientifically sound judgement of impacts

SOLUTION

- Modelling capabilities integrated with our biological expertise
- Realistic impact scenario and forecast generation
- Maximum security provision with respect to the reliability of the assessment

VALUE

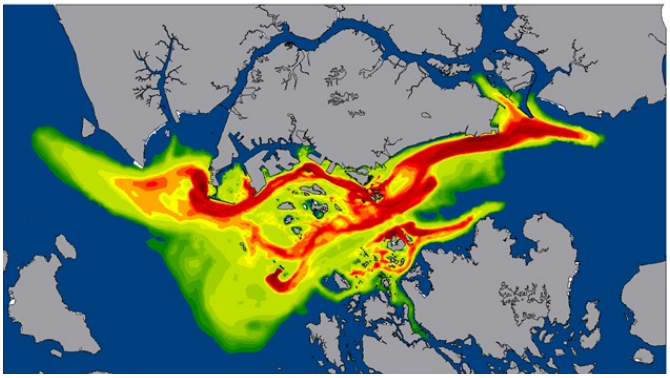
- Faster and smoother project approval, commencement, progress and operation
- An environmental management plan complying with legislative criteria
- Reduced environmental footprint
- Compliance with environmental protection objectives
- Improved protection of local sensitive habitats

synchronous release of the coral's entire year's reproductive output within a few nights. These mass coral spawning events are believed to be an important mechanism for maintaining coral populations. Thus, they help predict and understand the dispersal patterns in relation to individual reefs as well as the connectivity between reefs. These are important for successful Environmental Impact Assessments (EIAs) in coral reef regions.

OUR SOLUTION: MODELLING CORAL REPRODUCTION PROCESSES

To investigate coral connectivity in Singapore's coastal waters, an agent-based model (ABM) of coral larvae was developed and implemented via our integrated MIKE Powered by DHI's ECO Lab software module. This was a research project carried out by Singapore's National Parks Board (NParks) in collaboration with DHI.

MIKE ECO Lab supports a coupled Eulerian-Lagrangian framework allowing for an accurate representation of hydrodynamics and water quality within a spatially complex system. At the same time, it simulates characteristics such as the dispersal, larvae mortality and coral larvae settlement on an individual level. As simulated agents may react to Eulerian gradients (such as water temperature, suspended sediments or flow velocities for instance), it is possible to investigate potential effects of hydraulic and environmental cues on movement and survival of coral larvae on a complex spatial scale over time.



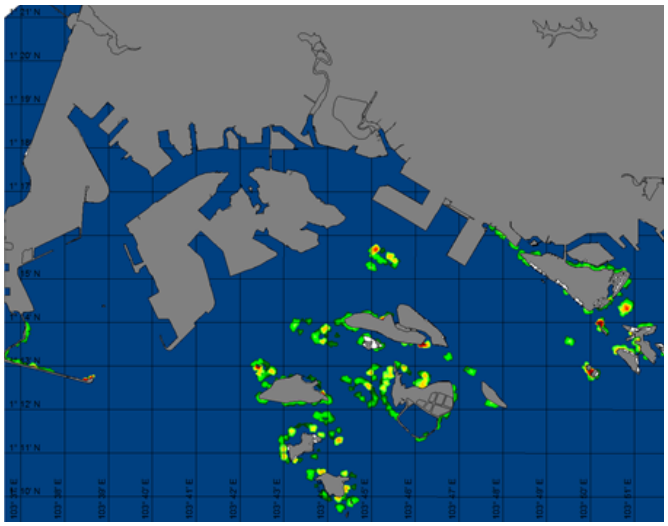
Connectivity corridors between five selected reefs shown as cumulative densities of larvae over a five-day period after spawning. Red coloration marks high concentration areas.

IMPORTANTLY, THE AGENT-BASED MODELLING APPROACH INCLUDES:

- accurate prediction of larval dispersion
- analyses of connectivity between coral reefs
- scientific documented sensitivities of larvae to environmental cues
- prediction of cumulative impacts on coral larvae dispersion
- prediction of cumulative impact on reef connectivity

PRESERVING CORAL REEFS FOR YEARS TO COME

Our comprehensive and flexible modelling tools enable easy development of tailor-made solutions to better understand complex biological/ecological problems. By including evidence -based sensitivities of coral reproductive processes to environmental stressors, we offer robust and reliable outcomes for our clients (for instance, by allowing development plans to advance in a sustainable manner, while protecting valuable coral reefs).



Mean number of settled larvae per square metre with Pulau Satumu acting as a source reef. Red coloration marks high concentration areas.

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