DHI SOLUTION

AGENT-BASED MODELLING

Modelling the behaviour of organisms in response to the environment

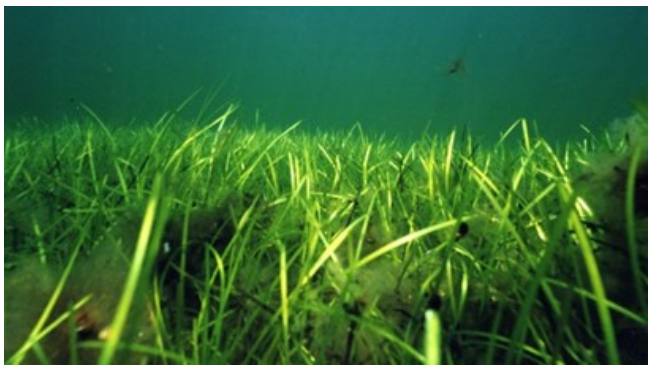
BEHAVIOUR AND STATES OF INDIVIDUALS OR PARTICLES

Dynamics and functions of many aquatic ecosystems arise from traits of individual organisms and particles and their interactions with the environment. Examples include:

- foraging behaviour
- predator-prey interactions
- flocking
- mating
- migrations
- bioenergetics
- transport
- ageing

Individual organisms in the model comprise both small organisms (such as planktonic species and larvae) as well as larger organisms (including macro-algae, seabirds, fishes and whales). The impact of anthropogenic disturbances on these organisms can be successfully evaluated by analysing the pattern of individual responses.

Agent-based Modelling (ABM) is used for advanced simulations of behaviour and states of individuals or particles (which act as the agents driving aquatic ecosystem dynamics). ABM Lab – now a new feature in our ecological modelling tool MIKE ECO Lab – offers a unique integration of agent-based modelling with classical water quality and hydrodynamic modelling.



Reproduction and succession mechanisms determining the re-colonisation of eelgrass (Zostera marina) in Danish marine waters

SUMMARY

CLIENT

- Coastal and offshore constructers
- Environmental protection agencies and policy makers
- Aquaculture companies

CHALLENGE

- Need to determine potential environmental impacts on large aquatic animals
- Need to establish patterns of connectivity between marine habitats (for example, stone reefs & coral reefs)
- Need to track drifting organisms (such as fish larvae or eggs)
- Need to manage release of ballast water and threats from invasive species
- Need to optimise aquaculture production
- Improper identification of the environmental footprint
- Need to determine the impact on fish stocks from hydropower operations

SOLUTION

- Advanced Environmental Impact Assessments (EIAs) based on Agent-based Modelling (ABM), combined with the knowledge of biological processes
- Science-based model development
- Tailor-made solutions for a better understanding of complex biological/ ecological problems

VALUE

- Faster and smoother project approval, commencement, progress and operation
- Improved understanding of complex ecosystems
- Reduced environmental footprint
- Improved protection of local sensitive habitats

ABM LAB

ABM Lab (among others) allows for:

- discrete representations of unique individuals
- local interactions
- use of adaptive, fitness-seeking behaviour
- explicit representation of how individuals and their environment affect each other
- representation of full life cycles

These can for instance, be used to predict the behaviour of large marine animals or identify hot-spots for connectivity between key habitats by studying the dispersal of larvae or spores. Agent (animals, larvae and so on) movements and states can be described as a response to local conditions or gradients, such as current velocities, water temperature, water quality, food availability and anthropogenic pressures.

ABM Lab may also be used to back-track agents (for example, the origin of fish larvae or eggs found in a particular area).

ABM Lab is fully integrated with MIKE ECO Lab and runs in conjunction with our most advanced flexible hydrodynamic modelling software – MIKE 21/3 FM. ABM Lab offers full access to model algorithms through an open equation solver interface – for editing existing ABM model descriptions or building new ABM models from scratch. MIKE 3 FM utilises flexible mesh for defining the computational grid, thereby allowing ABM to be applied to both freshwater and marine ecosystems.

ADVANCED EIAS FOR AQUATIC ORGANISMS

ABM Lab offers advanced solutions to Environmental Impact Assessments (EIAs) for aquatic organisms – whether it involves the behaviour of large animals such as mammals & fish or dispersal units like larvae, seeds and spores of aquatic organisms. For example, the response of large animals to disturbances like underwater noise from drilling or seismic surveys should preferably be based on baseline behaviour modelling. This takes into account seasonal migrations as well as meteorological and hydrodynamic changes.

Linking movement behaviour modelling of Bull sharks (Carcharhinusleucas) with observation data from acoustic tagging of juvenile sharks in a semi-enclosed ecosystem, Australia

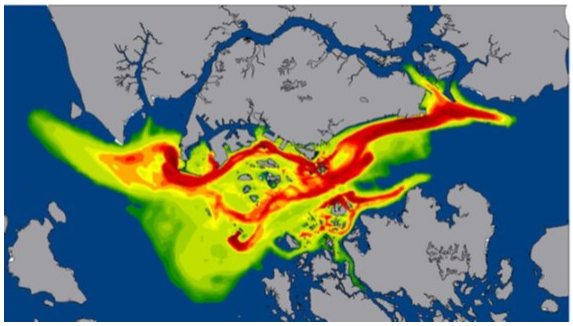
EVALUATING THE IMPORTANCE OF MARINE PROTECTED AREA NETWORKS

Marine protected areas are important for protection of the local environment. However, the importance of the network is related to the role of these protected areas as sources or sink areas for the dispersal of plants and animals. Using ABM Lab, it's possible to determine the connectivity between such areas and define the importance of the protected area networks.

For example, models of coral larvae dispersal can be developed, simulating:

- mortality
- larvae settlement
- individual reaction to environmental and anthropogenic gradients

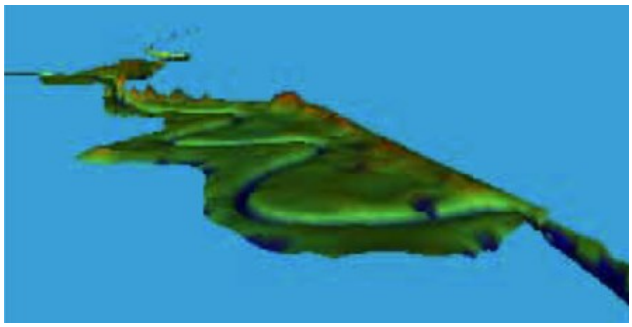
Important connectivity corridors between coral reefs can then be identified based on these models.



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

PLANNING RESTORATION MEASURES

ABM Lab can be used in the planning phase for projects aiming to restore natural habitats and enhance abundance & survival of fish, for instance. An example: ABM modelling of the migration of salmonide fish larvae *(Coregonus oxyrhynchus)* through two different wetland reconstruction designs was used to evaluate which of the two designs had the most positive effects on larvae retention in the wetland. In another example, ABM was used to study the factors determining re-colonisation of eelgrass.



ABM used for testing wetland reconstruction designs

Contact: info@dhigroup.com
For more information visit: www.dhigroup.com