The Algoa Marine Systems Analysis Tool: Visual User Interface Manual

Background

This document is intended to accompany the Algoa Marine Systems Analysis Tool (AlgoaMSAT) visual user interface (VUI), which was developed as part of a research project under the Algoa Bay Marine Spatial Planning Project (visit www.algoabayproject.com).

The Algoa Marine Systems Analysis Tool (AlgoaMSAT) is an exploratory management framework and simulation model that applies system dynamics modelling (SDM) to facilitate and support Integrated Ocean Management (IOM), specifically Marine Spatial Planning (MSP) in Algoa Bay, South Africa. SDMs incorporate temporal dynamics and can support MSP processes by evaluating changes in marine uses and interconnections, possible synergies and conflicts between marine uses, as well as between marine uses and requirements for marine health. As a management framework, the exploratory tool provides a holistic, cross-sectoral overview of marine use dynamics in terms of sustainable management, and as a simulation model, it provides a platform for scenario and trade-off analyses in relation to sustainable use of the bay. Moreover, the framework and the model provide a communication tool, which can be used to facilitate collaborative stakeholder engagement and provide strategic guidance and decision-support to MSP.

AlgoaMSAT consists of seven sub-models (Figure 1). Five of these sub-models represent selected marine uses in Algoa Bay, whereas the sixth and seventh sub-model integrate the outputs from each marine use in terms of sustainable management and development outputs, namely marine health, and marine wealth and labour (Figure 1). The model additionally investigates the temporal dynamics in the growth of marine activities in the bay, recognising reinforcing feedback behaviour and balancing effects through the health of the marine environment (Figure 1).

The model was built in Stella Architect software (isee Systems© Stella® version 2.1.1) on a Windows system. The model time units is 'years' and the selected time horizon and simulation period for the model is 40 years from 2010-2050.

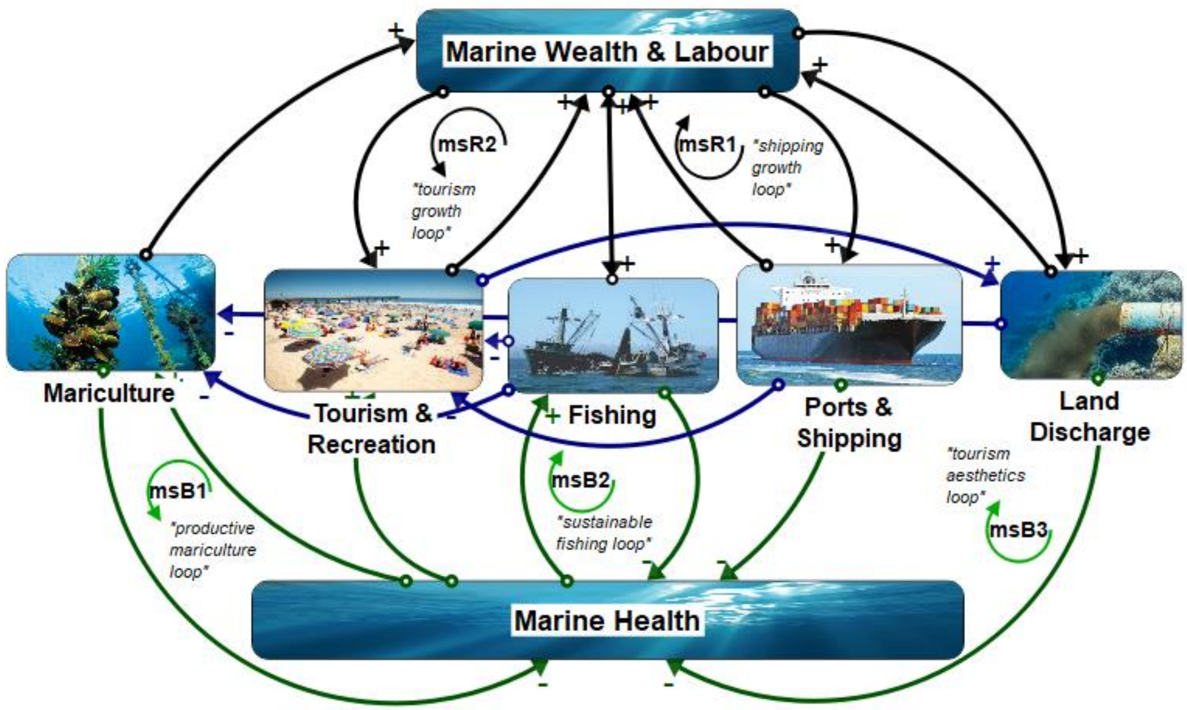
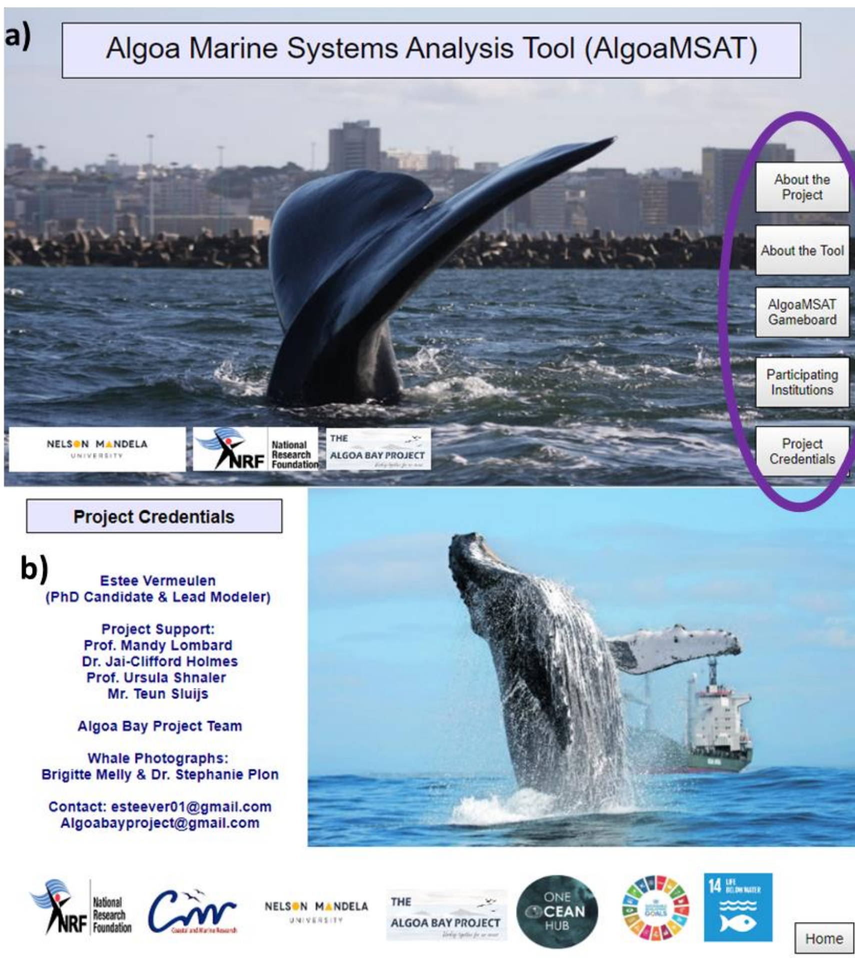


Figure 1. The AlgoaMSAT model framework. The model is composed of seven sub-models (or Stella® modules according to the software language) for the selected marine uses and for the social-ecological marine sustainability outputs. Loops are labelled according to the model structure, where 'ms' refers to 'marine sustainability' loop and B represents a balancing (negative) loop and R a reinforcing (positive) loop. Positive (negative) arrows represent a change in the same (opposite) direction.

An additional output of the research project and in complement to the AlgoaMSAT model is the visual user interface (VUI) (Figure 2). The VUI has been developed for purpose of providing a 'user-friendly' portal to engage with the model, specifically for users who are unfamiliar with the method of SDM or do not have access to the model software. Decision-makers or stakeholders can therefore investigate model scenarios by adjusting the inclusive model variables through 'levers' on the interface. The VUI can additionally be used in a multi-sectoral stakeholder setting, whereby stakeholders representing different marine uses can implement alternative management interventions and thereby compare scenarios, such as what was demonstrated during a pilot multi-sectoral stakeholder meeting during the Algoa Bay Collaborative Dynamic Modelling (AB CoDyM) process (Figure 9). The following section explains how to use the AlgoaMSAT VUI.

Instruction Manual

The AlgoaMSAT VUI is published online on the iSee Systems model exchange platform, accessible via the following link: https://exchange.iseesystems.com/public/esteevermeulen/the-algoa-marine-systems-analysis-tool-algoamsat-user-interface or through the project website: www.algoabayproject.com. Figure 2a shows the homepage of the interface with buttons that can take you to different pages providing an overview of the project, the model, the model gameboard, the participating institutions and finally the project credentials (Figure 2b).



'Click' on the buttons to read more about the project and the model. Alternatively, scroll through the interface using keyboard arrows.

Figure 2. AlgoaMSAT visual user interface homepage (a) and the final credential page (b). See the instructions on how to navigate the model interface. Background photographs by Brigette Melly and Dr. Stephanie Plön.

Figure 3. Information slides on the model interface that provide a brief overview of the research project and development process. About the Algoa Bay Project (a), the AlgoaMSAT gameboard (b), a brief overview of the AlgoaMSAT (c), the AB CoDyM stakeholder engagement process (d) and participating stakeholder institutions (e).

On the model gameboard page (Figure 4), users are directed to the 'Algoa Bay marine sustainability story' that explains the general logic and model dynamics through a simplified causal-loop and stock-flow diagram (Figure 5). Both diagrams emphasise the main variables and feedback loops in the model structure. It is important to note that each marine use sub-model further consists of its own model structure that is not shown in the interface but can be viewed in the supplementary research publication.

The model gameboard additionally directs users to the sub-model panels of each marine use (Figures 6 and 7). In the sub-model panels users can run the model and view the model results under alternative scenarios by adjusting the model levers. These 'levers' are intervention points that were identified through a multivariate sensitivity and statistical screening analysis in the research project to determine which variables hold a degree of leverage on the dynamics in the system. Model lever descriptions (shown in Table 1 at the end of this document) can be viewed by clicking on the 'levers' button in each sub-model panel. Once you have reviewed the model lever descriptions, you have the options of navigating between the different sub-models and exploring model behaviour through the analysis of the comparative behaviour-over-time graphs.

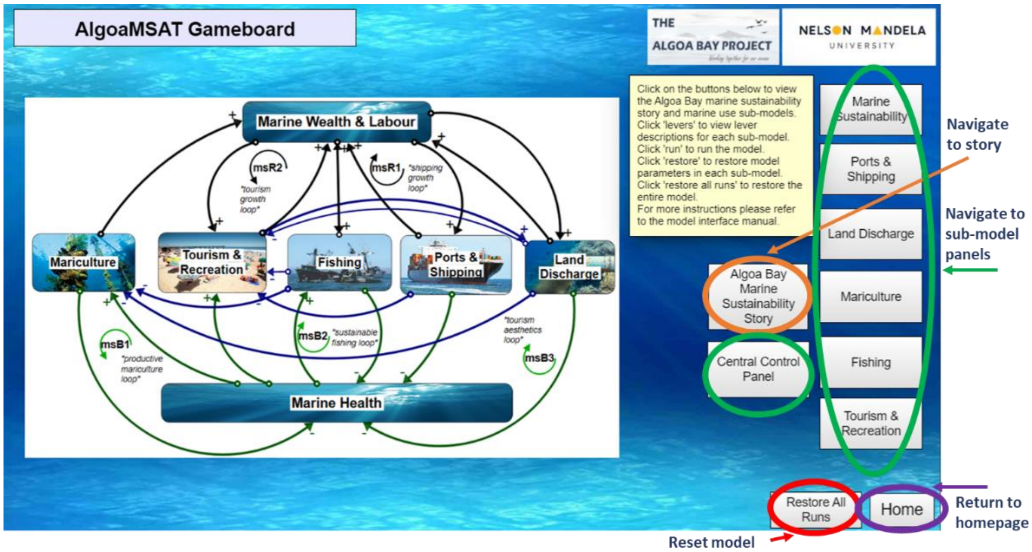


Figure 4. Model gameboard page. See text for interface instructions.

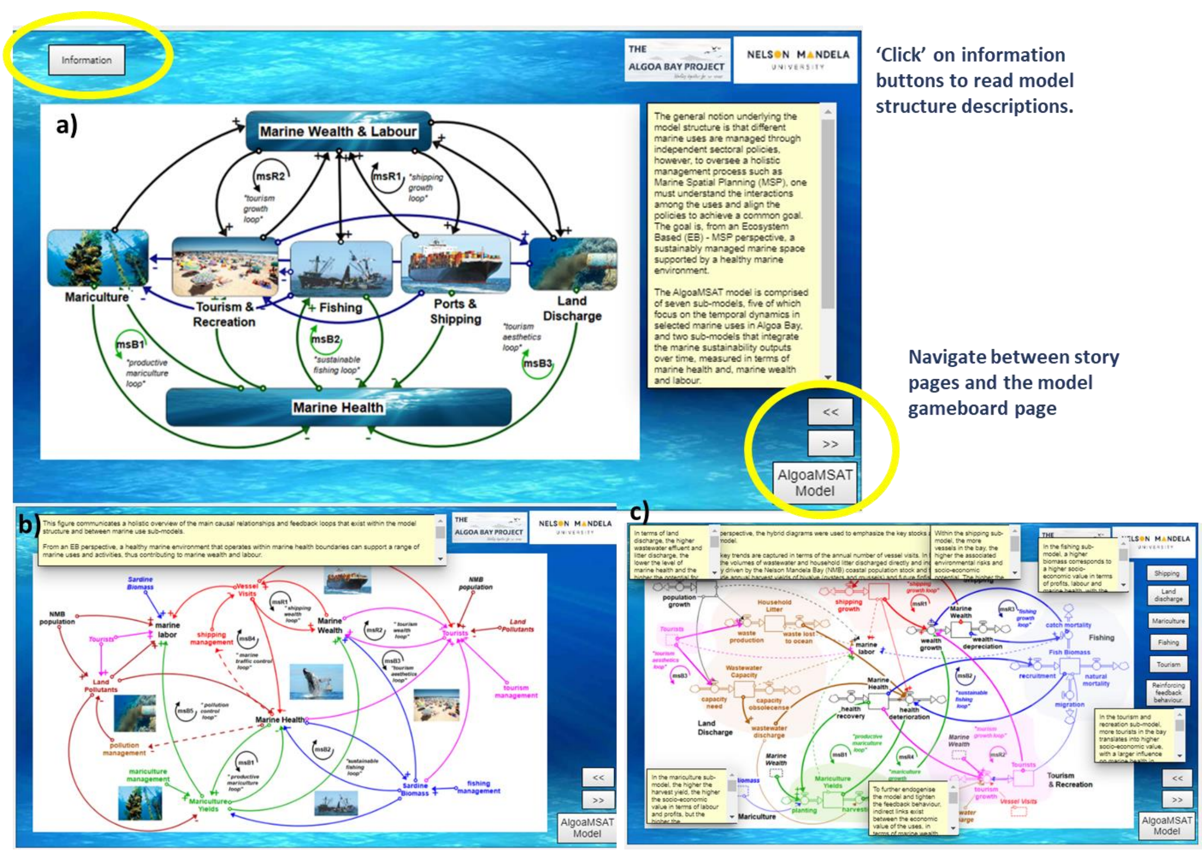


Figure 5. The 'Algoa Bay marine sustainability story' button on the model gameboard redirects the user to the story pages (a,b,c). See text for interface instructions.

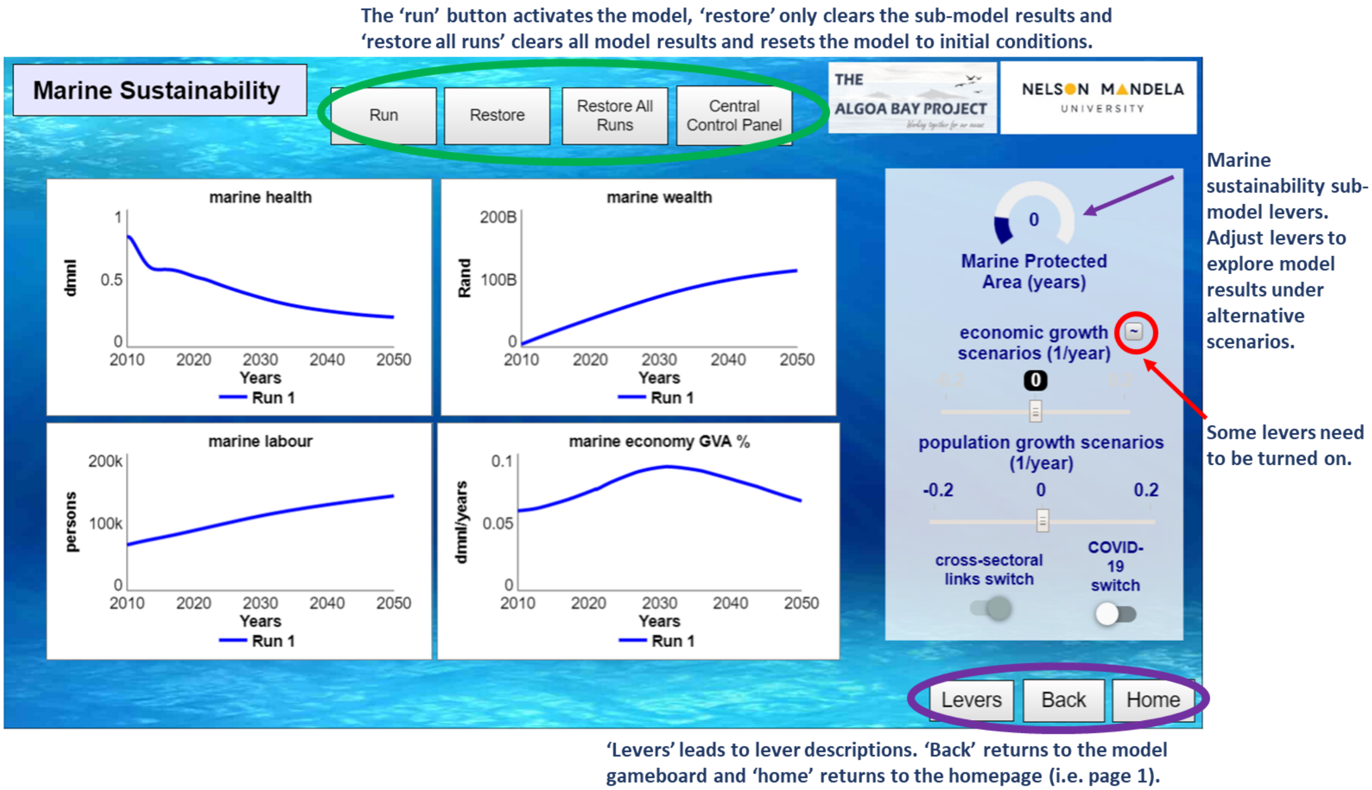


Figure 6. An example of the sub-model panel for marine sustainability sub-mode outputs. This panel is available for every marine use sub-model. See text for interface instructions.

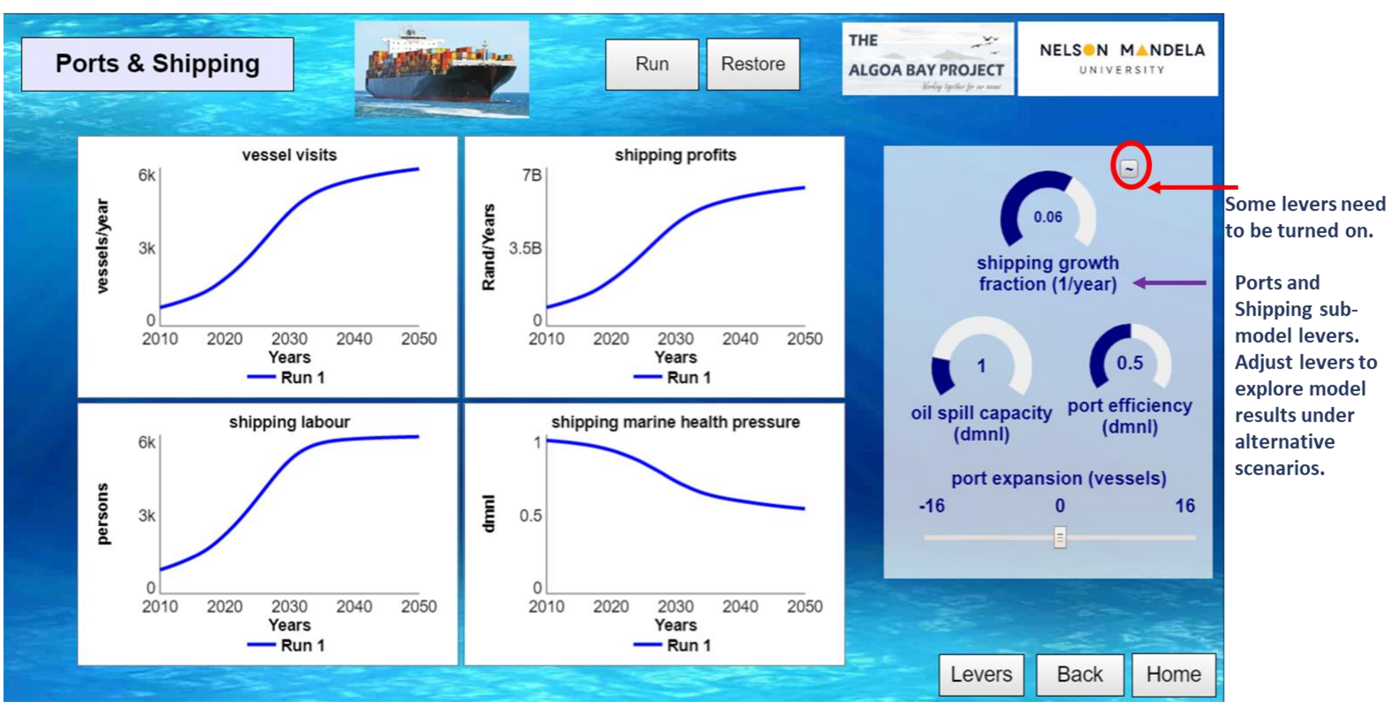


Figure 7. The ports and shipping sub-model panel. See text for interface instructions.

The central control panel displays all the model levers that can be adjusted to investigate changes in the overall system behaviour (Figure 8).

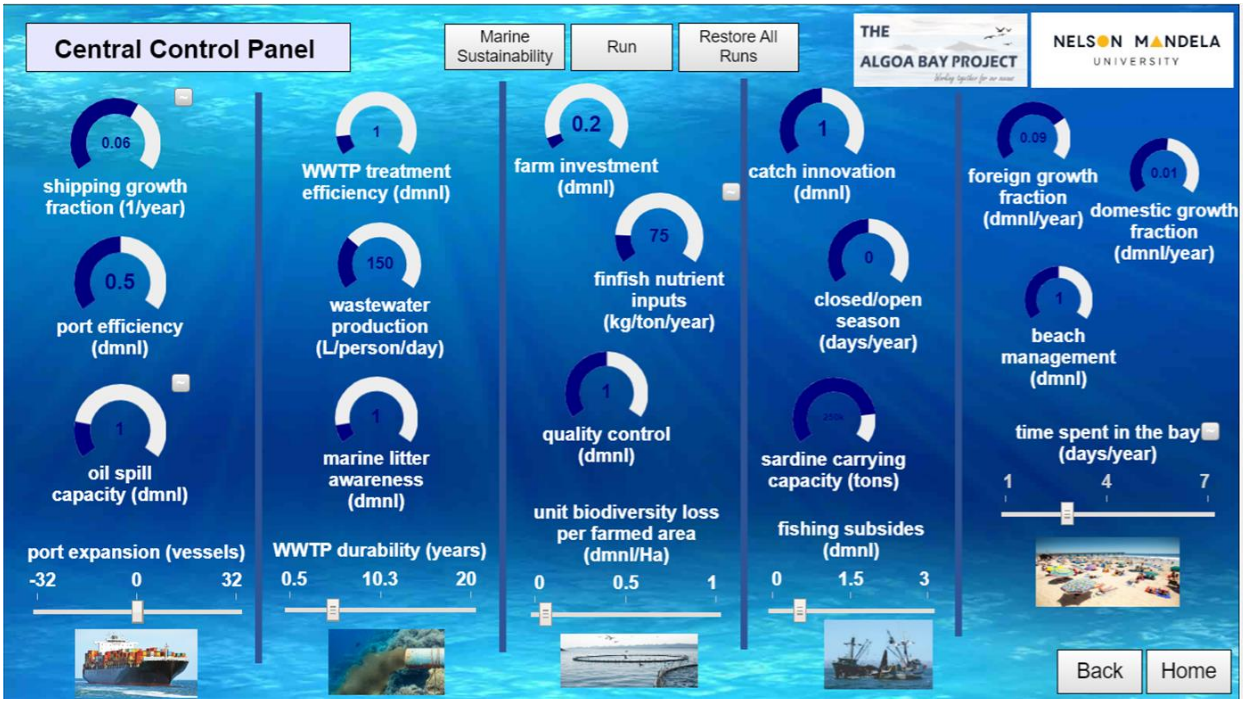


Figure 8. Model Interface slide showing the central control panel with levers that can be adjusted to investigate model results under alternative scenarios.

The way forward

Model development of the AlgoaMSAT was complemented by the Algoa Bay Collaborative Dynamic Modelling (AB CoDyM) process, a sub project within the broader Algoa Bay Project. The AB CoDyM team consisted of the lead researcher and fellow research members from the Algoa Bay Project. The involvement of stakeholders through the AB CoDyM process assisted in model formulation and verification in order to get an adequate, 'real-world' representation of the social-ecological marine system in Algoa Bay.

During the AB CoDyM process, a preliminary version of the model interface was used during a pilot multi-sectoral workshop among members of the Algoa Bay project team (Figure 9). The workshop took place in November 2019. During the pilot workshop, a refined version of the interface was demonstrated and applied in a scenario planning game, wherein 'stakeholders' were categorised into the different marine sectors and required to represent or 'role-play' a stakeholder or manager from one of the five marine sectors. The pilot workshop was mainly intended to test and get feedback on the application of the model and the interface and to get an idea of how it can be applied in a sectoral and multi-sectoral stakeholder setting to support collaborative engagement and planning during integrated ocean management and marine spatial planning processes.

Figure 9. Photo collage of the stakeholder meetings hosted during the AB CoDyM process that applied versions of the AlgoaMSAT VUI. Excursion to the Cape Recife Wastewater Treatment Works Facility (a) and Fishing Harbor (b). Pilot multi-sector workshop (c-e).

Acknowledgements and Credentials

This document summarises work from a PhD research project registered at Nelson Mandela University at the Institute for Coastal and Marine Research. The project falls under the outputs from the Algoa Bay project funded by the South African research chair in Marine Spatial Planning (grant 98574). The authors acknowledge Mr. Teun Sluijs for his inputs in model support, as well as for his role in the AB CoDyM process. This document adapted guidelines from the Association for Water and Rural Development (AWARD) 'Resimod' tool explainer.

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Table.1. Description of the model levers for each marine use sub-model in the AlgoaMSAT visual user interface. Dimensionless (dmnl) are used to represent the units of ratios and proportions when physical units are cancelled out and are similarly used to represent the value of an index or metric.

Model lever (units)	**Lever description**
Marine Sustainability sub-model levers	
Marine Protected Area (years)	Marine Protected Areas are area-based management tools that can increase the resilience of natural functioning marine ecosystems. The size and zoning of the MPA can determine the amount of resilience (measured in years) that it can provide to the area. The MPA intervention can also be interpreted as a discount factor, by which it reduces negative impacts from marine activities due to being more resilient. This logic is adapted according to Sink et al., 2019. Marine health recovery time is set to 5 years, and the MPA 0 years. The MPA intervention therefore adds or subtracts years from marine health recovery in the model.
Economic growth scenario (1/year)	Influences the Nelson Mandela Bay (NMB) economy through changes in the GVA stock variable. The baseline value for economic growth is 0.02/year.
Population growth scenario (1/year)	Influences the NMB population stock variable, which in turn effects tourism and land discharge through wastewater demand and waste production. The baseline value is 0.015/year.
Cross-sectoral links switch (dmnl)	The cross-sectoral links switch is by default on (1) but can be switched off (0) to investigate cross-sectoral effects in the model.
COVID-19 switch (dmnl)	The COVID-19 switch is a model scenario that is by default off (0) but can be switched on (1) to explore the impacts of the COVID-19 pandemic on marine sectors in Algoa Bay. Note that this is an exploratory scenario and that projections are estimates.
Ports and Shipping sub-model levers	
Shipping growth fraction (1/year)	This is to investigate the changing shipping trends under different transport globalisation scenarios. Base value is 0.06/year.
Oil spill capacity (dmnl)	The level of oil spill response capacity can further mitigate the impacts in an event of an oil spill, therefore minimising the impacts of the spill on other marine uses and on marine wildlife. Oil spill response capacity includes training, permanent employment of clean up teams, response equipment and wildlife response funding. This multiplier is set to the standard oil spill capacity of 1 and can either increase or decrease between 0.5 (half the capacity) to 3 (3 times the capacity).
Port efficiency (dmnl)	Port efficiency can influence ship turnaround time in the model, where 0 is the lowest efficiency and 1 the highest level of efficiency. The baseline value is set at 0.5dmnl which translates into a turnaround time of 2 days.

Model lever (units)	Lever description
Port expansion (vessels)	A possibility to increase shipping in the bay can be through port expansion, by expanding on berthing spaces within the port. The more berthing spaces in the port the more ships can enter the bay up until it reaches the holding capacity. The current total berthing capacity between both ports is 16 vessels.
Land Discharge sub-model levers	
WWTP treatment efficiency (dmnl)	The WWTP treatment efficiency can determine the standard of treatment, where a higher treatment efficiency corresponds to stricter treatments and hence lower levels of nutrients in effluent and vice versa. The baseline value is 1 dmnl. Treatment can either increase or decrease between 0.5 – 5dmnl.
Wastewater production (L/person/day)	The baseline value for domestic wastewater production is set at 150 L/person/day, this value can be changed under alternative production scenarios between 0-500 L/person/day.
Wastewater recycling switch (dmnl)	Policies to reduce wastewater discharge into the marine environment include a wastewater reuse and recycling strategy. 1- on and 0-off.
Marine litter awareness (dmnl)	Litter campaigns can increase recycling, reuse and ultimately lower production of waste, thus reducing waste to landfills and the ocean. The base value is 1.
WWTP durability (years)	This is the estimated lifespan of sanitation infrastructure before it requires general maintenance. The baseline value is set to 5 years, assuming the plants require maintenance every 5 years to prevent malfunction.
Nutrient loads variability switch (dmnl)	The nutrient loads variability switch is by default off (0) but can be switched on (1) to investigate how stochastic variability from observed nutrient data can influence projected trends.
Mariculture sub-model levers	
Farm investment (dmnl)	This is the normal level of mariculture investment and the percentage of profits reinvested into the farm. The baseline value is set at 0.20 dmnl and can be adjusted to simulate changes in mariculture expansion.
Quality control (dmnl)	Adjusting the quality purification lever can decrease the quantity of harvest that have to be discarded owing to poor water quality. Increasing purification innovation does come with increased costs. Current quality control is set on 1.
Finfish nutrient inputs (kg/ton/year)	This is the estimated nutrient discharge from finfish mariculture. The baseline value is set on 75kg/ton/year and can change under different scenarios.
Unit biodiversity loss per farmed area (dmnl/ha)	It is assumed that 5% of the benthos may be negatively impacted or lost per hectare of farming space. This is an assumption and may vary depending on the species being farmed, where indigenous species may cause less damage

Model lever (units)	Lever description
	to benthos than alien, invasive species through biofouling and competing effects.
Finfish pilot phase switch (dmnl)	This switch (0 -off) and (1-on) is the management switch whereby finfish mariculture is upscaled from the pilot phase of 1000ton/annum to 3000ton/annum. Under baseline conditions the switch is off.
Fishing sub-model levers	
Catch per boat (ton/boat/day)	Changes in catch innovation can either increase or decrease catch per boat through increases in fishing technology, boat size etc. The baseline value of 1 corresponds to a catch of 6ton/boat.day. Catch innovation can range between 0-2.
Closed/open season (days/year)	The closed or open season variable can either increase or decrease the number of days fishing, by adding or subtracting to the baseline value set to 100 days/year.
Sardine carrying capacity (tons)	Sardine carrying capacity or the environment carrying capacity for sardine is set to 250 000 tons, which can be explored in scenarios.
Fishing subsides (dmnl)	Fishing subsides influences the fraction of profits invested on the fleet, where more subsides can increase fleet investment and levels of catch. The baseline value is set at 0.5 dmnl.
Tourism and Recreation sub-model levers	
Beach management (dmnl)	Beach management refers to the level of management towards ensuring clean and safe beaches. This may additionally include more frequent beach monitoring programmes to ensure safe and clean in terms of water quality. 1 is the normal level of beach management, with anything above 1 being better or below 1 being worse.
Domestic tourist growth fraction (1/year)	The number of tourists (domestic and international) may be evaluated under different growth scenarios. The baseline value is set at 0.005/year.
Foreign tourist growth fraction (1/year)	The number of tourists (domestic and international) may be evaluated under different growth scenarios. The baseline value is set at 0.085/year.
Time spent in the bay (days/year)	Scenarios on how long tourists spend in the bay and how it can change the accommodation and socio-economic dynamics in the sector. The baseline value is set at 2.8 days/year.