SPICOSA Science and Policy Integration for Coastal System Assessment

Firth of Clyde, Scotland

Callum Whyte[1], Fiona Culhane[1], Branka Valcic[2], Tavis Potts[2], Teresa Fernandes[1], Paul Tett[1]

1 Edinburgh Napier University, 10 Colinton Road, Edinburgh, EH10 5DT, UK.
2 Scottish Association for Marine Science, Dunstaffnage Marine Laboratory, Dunbeg, Oban, Argyll, PA37 1QA, UK.

Figure 1. Loch Fyne is a sea loch which is part of the Firth of Clyde located on the west coast of Scotland

Introduction

The Clyde study site links an emerging policy issue (an increase in the leisure industry and tourist use in the Firth of Clyde) with an existing and growing sector (shellfish farming) in a fjordic sea loch, Loch Fyne. Connected to the Firth of Clyde (Fig. 1.) Loch Fyne is extensively exploited, both commercially (fisheries, aquaculture) and recreationally (diving, boating). Different users of these resource categories often find themselves in positions of incompatibility either through resource use, resource management or resource protection issues. Conflicts arising from commercial and recreational use of Loch Fyne may be enhanced with the Scottish Government drive for a 50% increase in Scottish tourism by 2015 (VisitScotland 2008).

This policy issue simulates and explores the impact of leisure boating through anti-fouling contaminants on shellfish farming across different forecast scenarios in Loch Fyne.

Methods

A conceptual model was created in consultation with stakeholders who included the Scottish Environment Protection Agency, the Firth of Clyde Forum and Argyll and Bute Council (Fig. 2). The conceptual model is a graphical representation of the main components of the system which attempts to encapsulate the fundamental nature of the system and represents a distillation of the many different processes involved. The model links ecology, the local economy and society both explicitly and implicitly. As such it provides a basis for further discussion and understanding of interactions in the system.

Figure 2 represents the final stage in an iterative process that began with the production of much more complicated diagrams. This was gradually simplified until a form was reached that captured the essence of the system and allowed it to be modelled in mathematical terms.

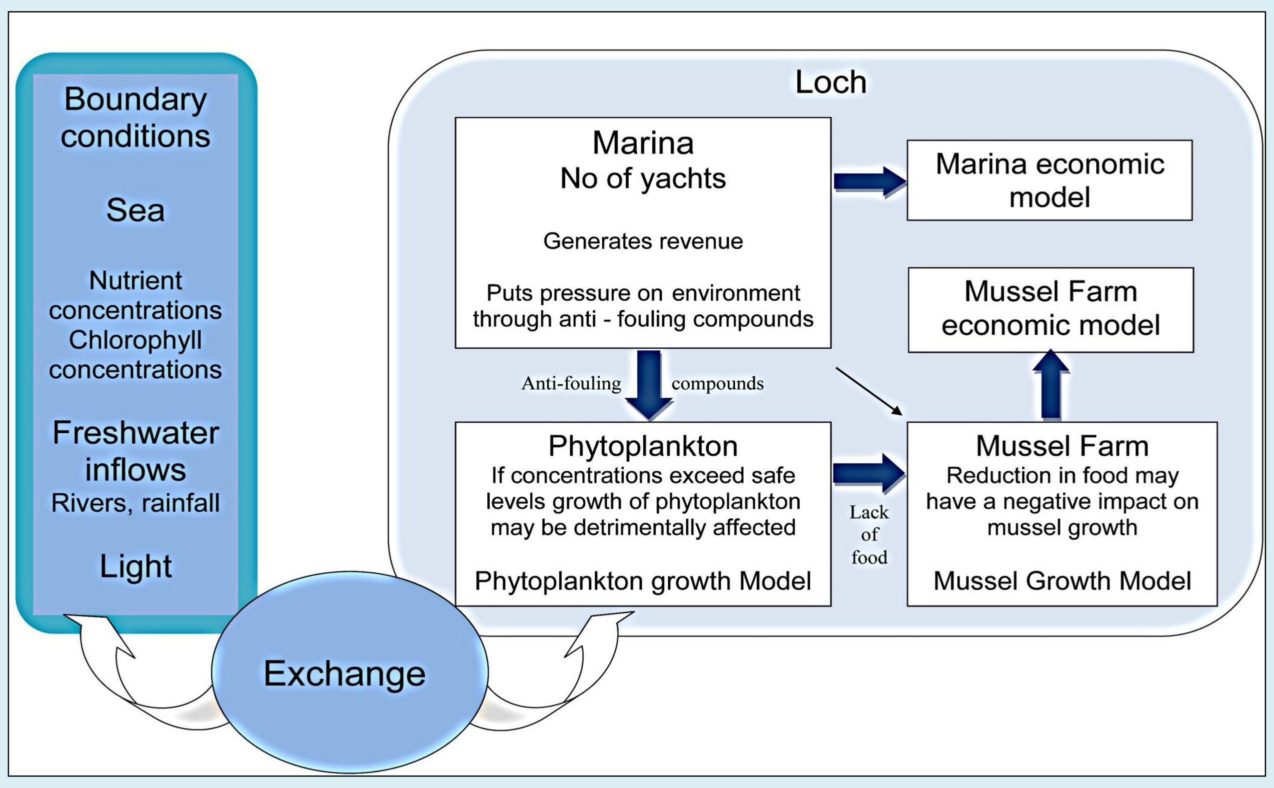

Figure 2. Conceptual Model of the loch and its surroundings

Mathematical Model

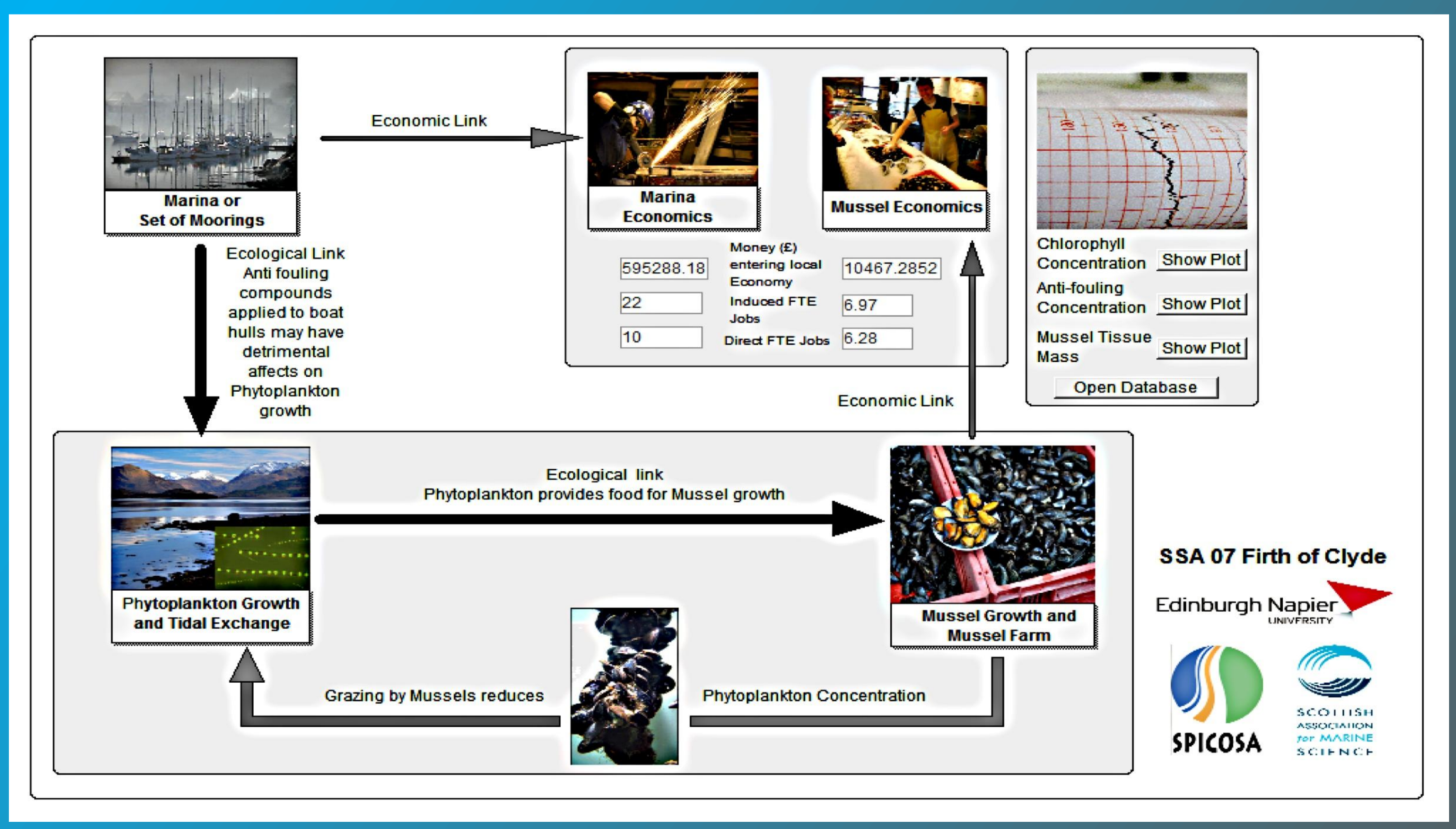

Figure 3. Hierarchical structure of the extend model

The model interface created using Extend Sim software includes drop down menus which allow the user to select the number of boats present in a marina and the anti -fouling compound to be modelled (Fig. 3). Results can be accessed via buttons which allow graphs ,such as chlorophyll concentration in the loch, mussel net revenue, and anti-foulant concentration to be displayed.

Results

The model indicates a correlation between anti-fouling contaminants and the mussel farm through their impact on phytoplankton. Mussel growth was highly sensitive to food availability in the form of phytoplankton (Fig. 4). This implies that negative impacts on phytoplankton growth would have a negative impact on the mussel farm. However, no effect of antifoulants on phytoplankton was found due to the low concentration of these compounds in the loch.

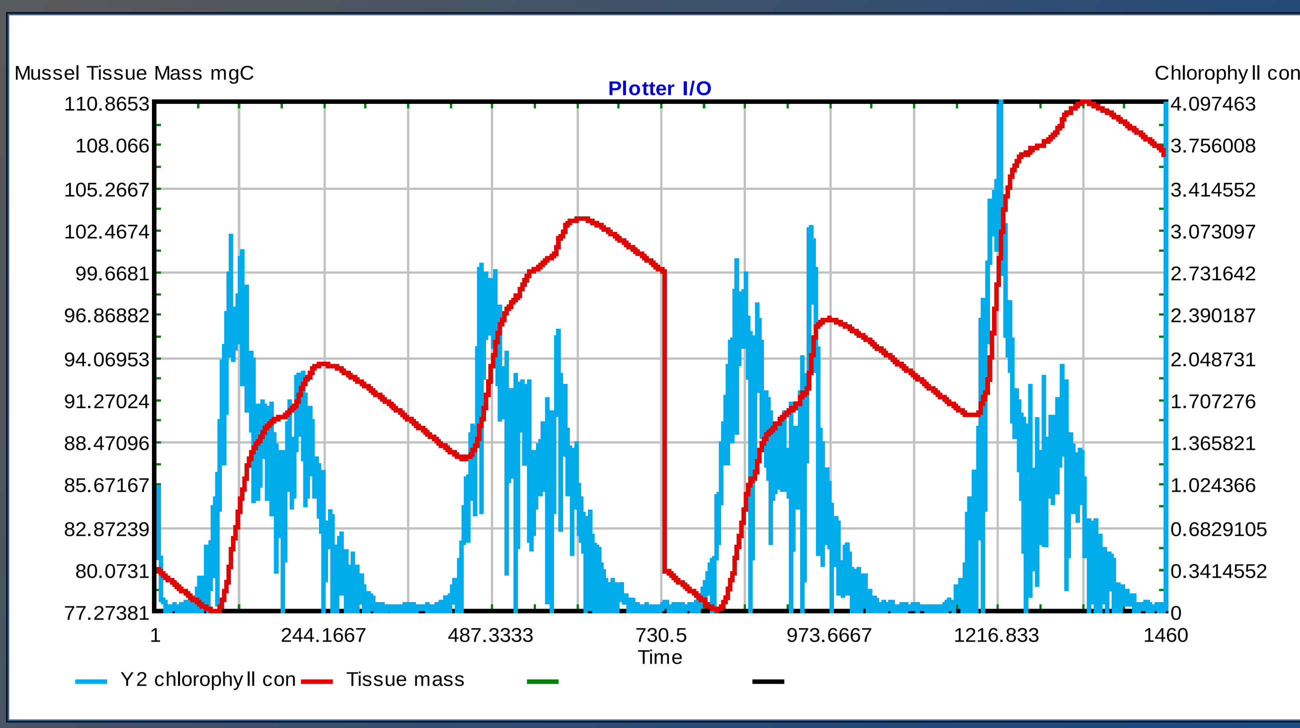

Figure 4. Phytoplankton concentration (mg/m^3)(blue trace) plotted alongside mussel mass (red trace) for four consecutive years

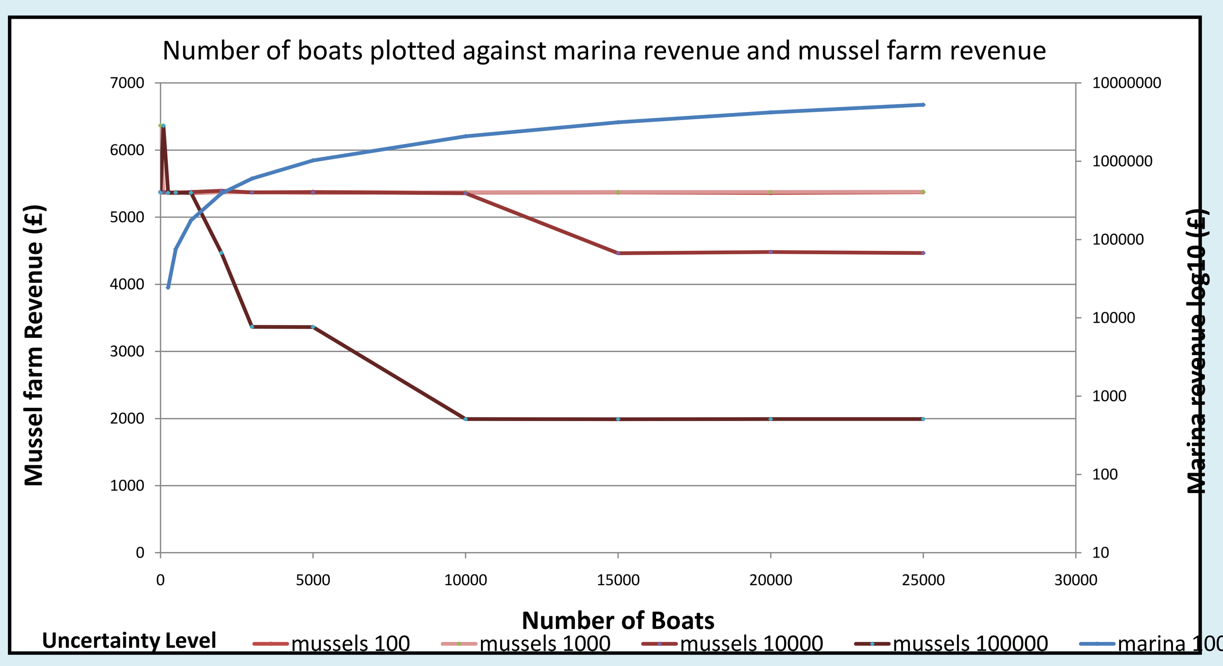

Figure 5. Marina Revenue $\log_{10}$ (£) and Mussel Revenues (£) plotted against the number of boats in the loch illustrating the affect of applying different levels of uncertainty.

Increasing the number of boats in the loch may alter the economic output of the mussel farm. Antifoulants can inhibit the growth of phytoplankton, a major food source for the mussels. This will affect the productivity and thus the profit of the mussel farm. Modelling different levels of uncertainty with respect to the impact of antifoulants on the growth of phytoplankton (Fig. 5), allows stakeholders the opportunity to explore the different possible outcomes of management decisions.

Conclusions: Uncertainty and Social Complexity

Uncertainty is inherent in the modelling process but models are useful tools to explore the system (Fig. 5). *"it may not be possible to determine the exact outcome of certain actions but simply show that certain outcomes may be possible ...When this is the case uncertainty in some parts of the system doesn't need to be accounted for but can be included as a range of scenarios"* (Brugnach *et al* 2008).

Given the multitude of pressures on our coastal zones, managers face problems that often have a high degree of social complexity. SPICOSA uses a systems approach framework which can address a wide range of socially complex problems. Systems thinking can reduce the ambiguities and improve communication amongst stakeholders by providing an easily accessible visual language that includes the use of conceptual maps and diagrams; by taking a holistic approach which considers the whole system and the connections inherent within it; by allowing a fuller examination and enquiry; and by adding precision. Combining these techniques with a collaborative approach, where stakeholders are first identified through stakeholder mapping techniques and then actively involved in ongoing discussion, further reduces the level of complexity. When converted into the ecological, social and economic model which is presented to stakeholders, these models become useful tools to explore the system.

References
Brugnach M. (2008), "Complexity and uncertainty: Rethinking the modelling activity" in *Environmental modelling, software and decision support*, Elsevier
VisitScotland 2008 http://www.visitscotland.org/allfv_tourism_action_plan_2006.pdf.

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