SSA12 - Barcelona Coast Formulation Step

SPICOSA

1. Evolution of formulation

Issue: the effect of changes in water quality on the aesthetic and recreational aspects of the Barcelona beaches. It is hypothesised that the majority of changes are caused by runoff, combined sewer overflow (CSO) events during storms and transport by river. Water quality is defined in this issue as bacteria (coliforms) and water clarity (turbidity).

Conceptual Model 1 - First Formulation (black-box approach)

The first formulation was based on the conceptual model from System Design. There is one zone in the system through which flows all energy and matter. Attempts were made to find a correlation between rain and waves, and turbidity and bacteria using linear regression.

Challenges

- Low correlation between the variables
- The type of model was not the intended design for SPICOSA - it would not be useful for other future possible study sites or suitable for the block library
- Although linear regression is used in many published models for bacteria, it is not reliable in making predictions (Ge & Frick 2007)

Conceptual Model 1 - Second Formulation

The second formulation was again based on the conceptual model from System Design with one zone, however this time the flows of matter and energy were modelled explicitly. Bacteria is input to the system by the river and combined sewer overflow (CSO) events, and removed by decay (light) and dispersion (wave force and direction). Turbidity/water clarity is related to the input of suspended sediment from CSO events and waves.

Challenges

- Poor quality and quantity of data
- Poor relation between model output of water clarity and observed data - maybe due to aggregation of qualitative (discreet) data
- Difficulty in validation of bacteria model (see below)
- Difficulty in coupling wave re-suspension with suspended sediments from CSO events
- Difference in time step between sub models. Bacteria (hours) and water clarity (days) linked to beach users (days)

Conceptual Model 2 - Zoned approach

Due to the difficulties encountered with the water clarity model, an alternative approach was attempted in which each beach is modelled separately. It is unknown what quantity of sewer water is released through each discharge outlet so the current approach is to optimise these amounts as a percentage of total discharge released. An additional approach has also been attempted in which the flow of each sewer outlet is the same whilst the flushing rate for each beach (unknown) is optimised.

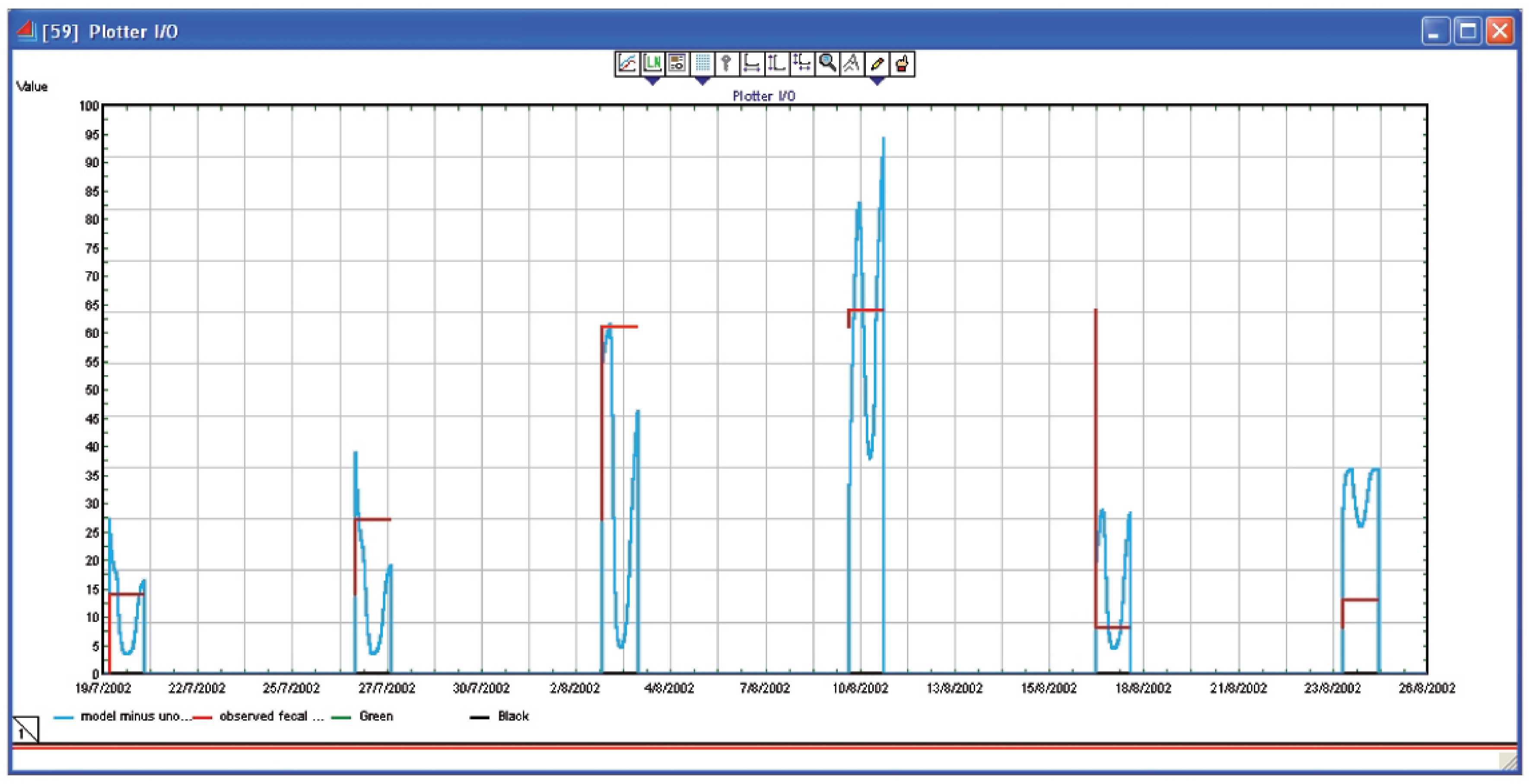
Challenges

- Difficulty in validation of output - unsure how to validate multiple discrete outputs
- There is still a difference in time step between bacteria and water clarity sub models but now also a difference in number of zones (one before, and now six)
- Instead of optimising the discharge between the outlets, a proxy could be used to determine the values (such as bacteria). However, it is currently unknown how to validate the bacteria results first
- Modelling the interaction of zones with each other

2. Challenges in formulation

Quantity and quality of data

- Data for validation only exists twice weekly during the summer months (bacteria; turbidity) seriously limiting the validity of any model produced
- The quality of observed data of turbidity is highly subjective as is collected during beach inspections by eye (as opposed to measuring suspended sediment or using a secchi disc)
- Only average values for suspended sediment and bacteria are known for the river, CSO outlets and wastewater treatment plant. This is obviously an over-simplification as concentrations change considerably during storms
- There is no data regarding the percent of runoff that is directed to the wastewater treatment or that is released directly. There are storm water deposits, but these are primarily for flood prevention. (The responsible company were not included in the stakeholder meeting and are unresponsive to queries)



Validation of bacteria sub-model

As can be seen from this example output of Extend, the model (blue) varies during the day whilst there is only one corresponding observed data point (horizontal red line) and the time at which it was taken is unknown. In the figure above, the first five observed points all fall within the model's output limits, whereas for the last point, the model produces values that are all above the observed value. During validation the range of values produced by the model means that the value of the sum of squared residuals is large.

Linking ecological and social components

Initially a correlation was sought between water clarity and the number of beach users using observed data. However, it became apparent that it is impossible to disentangle any perceived affects from meteorological considerations because the weather is normally adverse for visiting the beach during and shortly after CSO storm events, thus it is difficult to see the effect that poor water clarity has on the number of beach users. Therefore, a questionnaire is being prepared which will help determine beach user perceptions. The questionnaire will also help to determine the aesthetic and recreational "value" of the beach using non-market valuation techniques (the "travel-cost" method).

3. Socio-economic issues

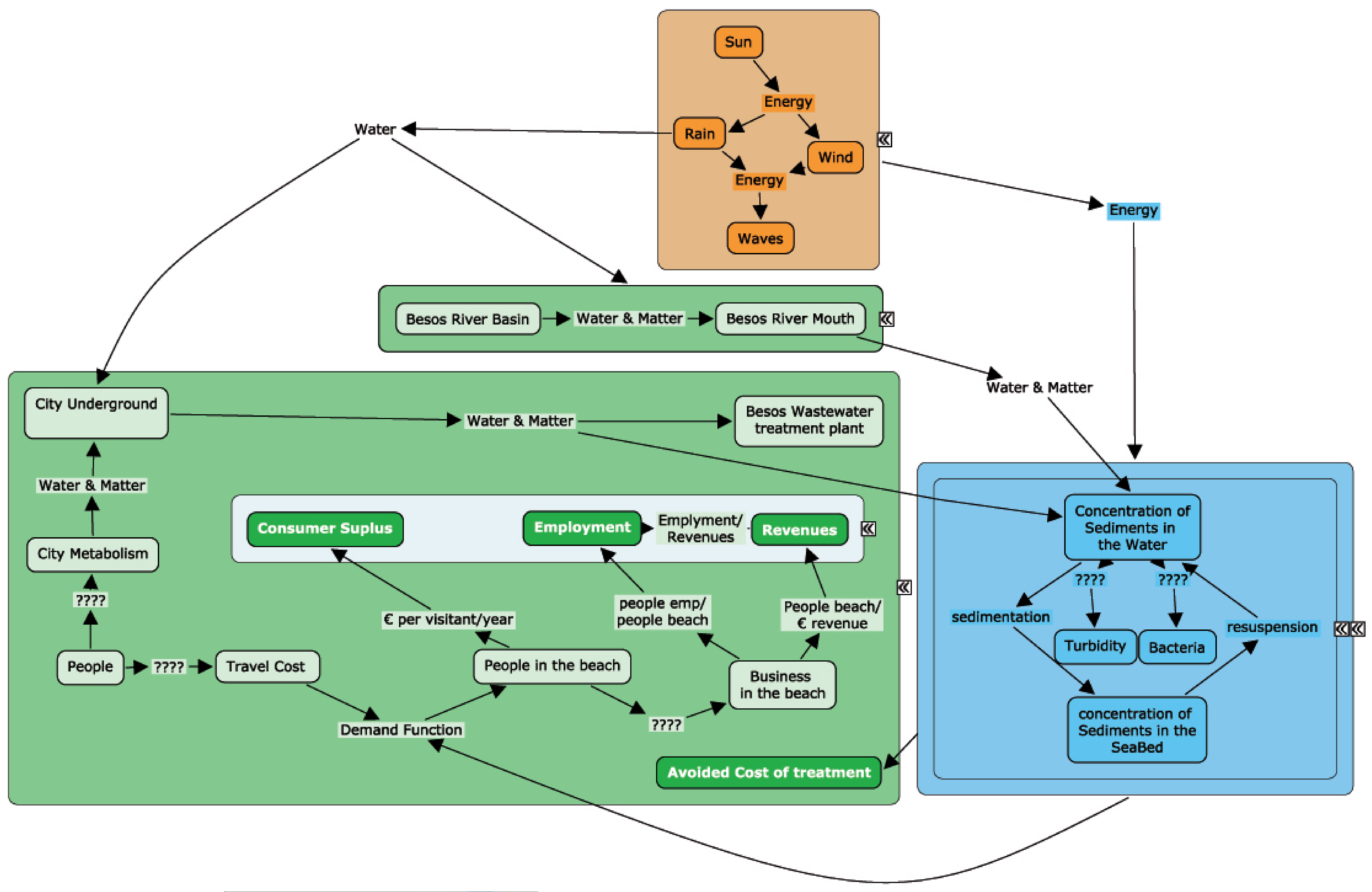
The socio-economic dimension of SSA12 is based upon the Ecosystem Services Framework, following the Millennium Ecosystem Assessment. In order to include the socio-economic dimension in the model, we are measuring the benefits of the Ecosystem Services relevant within our issue. They include:

Regulating Services (Water Purification): Barcelona City is using this service in the beach ecosystem, since there is a fraction of untreated waste water going directly from sewage to the beach waters. The formulation of this service is done following the "avoided costs" approach. We calculate how much water is not treated and we apply the closest waste water treatment plan costs structure to estimate how much money has been saved as an indicator of the monetary value of this service.

Cultural Services (Recreation and Aesthetics): The beach ecosystem provides cultural services since it allows recreation and a nice aesthetic experience. In order to include the benefits of this service, we are formulating an Individual Travel Costs Model by which the ecosystem works as a "service supplier" and so we can measure demand of its services through a well-known method. Using this model, we can approach the social determinants of demand as well as an estimate of the use (monetary) value of the beaches (calculating consumer surplus). The calculation is made in several steps:

- Calculate the demand function in which demand (Q) is the dependent variable and price (calculated as travel costs), income and other social variables are independent variables. The parameters of such a function are obtained by ordinary least squares regression analysis
- The next step is to build a demand curve equation. The independent variable price (P) changes while the others are held constant. A curve is obtained that allows calculation of consumer surplus

The main achievement of our socio-economic model is reaching a representation of non-marketed ecosystem services. However, the model will not be strictly dynamic, and the link between the social and ecological system (water quality) is very weak. A good point is that the methods chosen can give a lot of social information to be included in the model.



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SIXTH FRAMEWORK PROGRAMME

http://cordis.europa.eu/fp6/dc

http://ec.europa.eu/sustainable