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Decision Support for Stakeholders

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Abstract: Decision Support Systems (DSS) offer more transparency than traditional modelling approaches but are designed for use by government agents to use in the regulatory process. Stakeholders are in the position of looking over the shoulder of the person in charge, and while this is better than just waiting for answers it still separates them from the modelling process. If stakeholders were actually able to operate a DSS by themselves it could increase transparency, build confidence, and create possibilities for new approaches to environmentally significant developments which could benefit all parties concerned. This talk describes three simple DSS programs for aquaculture siting, two for finfish and one for shellfish, which are designed in such a way that they not only provide information relevant to the regulatory process but also can be used by fish farmers, NGOs and other interested parties to evaluate potential activities from their individual perspectives. For example, a fish farmer could use a DSS in private to explore potentials for site development without having to prepare a detailed proposal in advance and without having to share proprietary information with government scientists or anyone else. Furthermore the use of a publicly available DSS would lessen concerns about bias and preference in the regulation of the industry and could contribute to an attitude of mutual trust which might decrease the potential for social conflict about potential harmful developments.

***Keywords**:* Decision support; stakeholder participation; aquaculture siting.

1. INTRODUCTION

The use of decision support systems (DSS) for the management of complex systems is now widely accepted, and their potential applicability to aquaculture siting should be evident [Silvert 1994a,b,c; McKindsey et al. 2006]. However in most cases DSS are seen as tools for use by managers or technically trained specialists, which basically means that they remain in a "back office" and are neither understood nor trusted by stakeholders. This may make the managers' jobs easier and perhaps more efficient, but does not make their decisions any more credible.

There is however an increased emphasis on transparency in government, and this is an aspect of management where DSS can contribute and possibly lead to greater trust in the decision-making process. The fact that expert systems, including DSS, are designed to emulate experts rather than simply report their conclusions means that they can "talk" with their users rather than simply dictate to them.

With this concept in mind I have been looking into the design of DSS that can be presented interactively to stakeholders and that can even be used by them without requiring the intervention of live experts. This paper presents three prototypes to demonstrate the concept and the approach, and discusses the process and the problems involved with the development of more sophisticated operational models.

2. THREE PROTOTYPES

This paper describes three programs which I have developed to investigate the applicability of DSS to aquaculture siting. The first of these is strictly a prototype in the purest sense, a program that illustrates a concept of the kind of software that needs to be developed, but that cannot actually be applied to any real problem, at least not in its present form. The other two are actually working implementations of models which are currently in use, but they are so simple that it is perhaps better to think of them as "proof of concept" rather than functional DSS, and they are described here as simply prototypes.

2.1 The Original Prototype

Although the idea of developing a DSS for aquaculture siting goes back to my earliest involvement with aquaculture, early in the 1990s, it was difficult to convince my colleagues of the need or even describe adequately what I had in mind. We faced the problem that aquaculture was a rapidly growing field and fish farms were being set up all over Atlantic Canada, usually in remote locations, but we did not have enough scientifically trained staff to evaluate all license proposals and decisions were being made by poorly trained local officials with little grasp of the potential environmental risks. I had developed several models describing various kinds of impact [Silvert 1992] and although the use of several different models seemed confusing and intimidating, the models themselves were all very simple.

The process of evaluating license proposals seemed straightforward – enter the relevant data from the application in each of several models, and if any of the models predicted that the impact would be unacceptable, the proposal would have to be rejected or modified. Some of the models dealt with benthic carbon loading, some with nutrification, some with oxygen depletion. Unfortunately this proved too confusing for many of the potential users, and although there was a core group of scientists who felt comfortable with this kind of modelling approach, there were not enough to deal with the flood of license applications.

Given that the modelling procedure was fairly straightforward, algorithmic in fact, the idea of developing a computer program to implement it seemed obvious. How this actually came about is somewhat amusing. After a frustrating Friday meeting in 1993 where I tried to explain my concept to a mixed group of scientists and managers I came home in a foul temper and decided that if I couldn't describe an expert system in a way that they could understand, I would create one and throw it in their faces on Monday morning. But since I didn't have any programming tools in the house, I checked with the rest of the family and came up with a crude DOS-based program called QuickBasic, which proved more than adequate for the job at hand.

Rather than clutter the paper with a set of messy screen shots, a screen-by-screen description of the program follows. It is important to realise that this was written in such a way that it could be understood by someone with no technical training, and that to keep it simple some drastic simplifying assumptions had to be made. I have described the operation of the program in considerable detail so that the experience of the person using it can best be appreciated.

1. To open the program some introductory screens describe the purpose, limitations and some technical aspects of the program. Every program should begin with this kind of explicit documentation.
2. The user is then asked to enter some data. In this simple version it is assumed that the farm consists of a single rectangular cage and that only one kind of fish is being raised, so the data consist of length, width and production level.
3. Although the location of the farm could be entered numerically as latitude and longitude, the program actually uses a crude interactive screen where the cursor is moved around with arrow keys against a background of DOS pixels. As the cursor moves, a window displays the latitude and longitude, the depth, current speed, and type of bottom under the site. This is intended to emulate the kind of information that would be obtained from a Geographical Information System (GIS).

4. After confirming all the input data, the program begins diligently crunching numbers as it runs a suite of five different models. Since the models are all very simple this of course only takes a few milliseconds, but for the sake of impressing the user the process is extended for a few seconds with the DOS equivalent of a rotating hourglass.
5. Now comes the key point in the operation of the program: the results, shown in Figure 1. There is no technical jargon, no reference to moles or other units that are only meaningful to specialists, just a brief and universally intelligible summary. The readability of the output is enhanced by using text colours to reflect whether the information is favourable or not with regard to the proposal (this is a crude step towards the traffic light methodology used in the later examples). And note that the program only makes a recommendation, because no one wants to be ordered about by a computer!
6. Finally the user is offered a set of options for what to do next. One important option is to ask for a detailed explanation of what these results mean – for example, the program can explain the relationship between current, flushing and waste production, or why depositional bottoms are more vulnerable than erosional ones. Other options include revising the proposal by changing the production level, modifying the geometry of the cage, or moving to a different site.

There is really nothing here that one does not find in many other DSS and other kinds of expert systems, but the key point is that this program can be run and understood by anyone without any need for special training. Even though this example is truly ancient, in our field 1993 is part of prehistory, the essence of this program remains valid today.

RECOMMENDATION

The application for an aquaculture permit should probably be rejected, because:
Depth Is OK – (7 / 10)
Current speed is OK – (7 / 10)
Oxygen depletion is marginal – (6 / 10)
Ammonia production is marginal – (5 / 10)
The bottom cannot assimilate the wastes from this farm – (2 / 10)

Figure 1. Sample output of the first prototype, where each quantity is ranked on a scale of 0 to 10. Values of 7 to 10 are acceptable, values below 4 are grounds for recommending rejection, and intermediate values are marginal.

2.2 The CSTT (Comprehensive Studies Task Team) Model

A model was developed by Paul Tett and his colleagues [CSTT 1994; Tett 2000] to determine whether a proposed fish farm is likely to exceed the Environmental Quality Standard (EQS) for chlorophyll of 10 μg-chl/L that is used in Scotland. The model is quite simple and was implemented as a spreadsheet, but it is still not straightforward for users who are not comfortable with spreadsheets and computers. Furthermore the requirement for numerical entry can easily lead to errors, even with trained operators. As part of the ECASA (Ecosystem Approach to Sustainable Aquaculture) project [ECASA 2007] I developed a DSS version of the CSTT model that had a graphical interface with sliders for data entry. Two of the screens are shown in Figure 2, the final data entry screen and then the result of the computation. Data is entered by moving a slider and the bounds of the slider are displayed in such a way that only values within a reasonable range can be entered – in this case the maximum possible level for nitrogen loading is 2 μmol-N/L/d averaged over the water body. Of course this is the kind of number that only a scientist would know, so there is also the option to enter the production level and the area and depth of the water body and let the program do the calculation.

The output of the model is shown on the right side of Figure 2 and illustrates another feature that makes the DSS more user-friendly, the traffic light display to show that in this case the chlorophyll level is well below the EQS and thus the proposal is acceptable, at least so far as chlorophyll is concerned. While the traffic light may seem superfluous in this example, for a more sophisticated DSS where several potential impacts are evaluated, an array of traffic lights can help clarify a confusing display. This was anticipated in a crude way in the original prototype shown in Figure 1, where coloured text was used to indicate where the trouble areas lay.

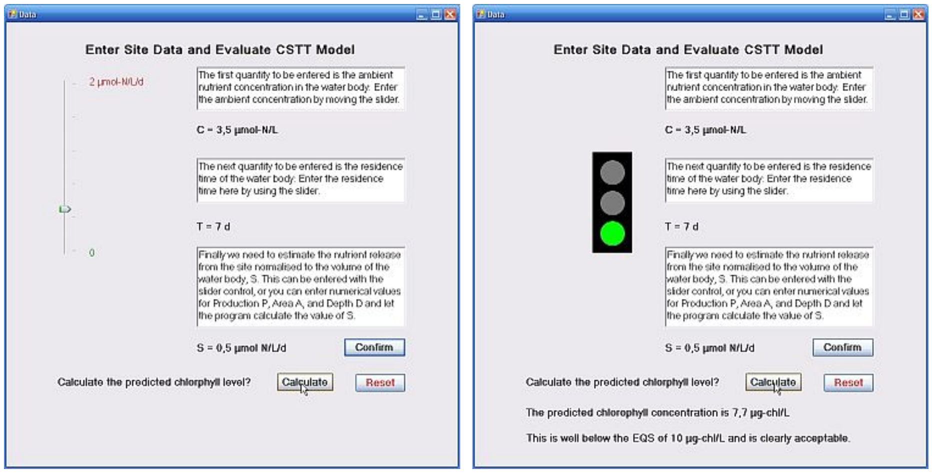

Figure 2. Final data entry screen and evaluation screen of CSTT model.

2.3 Shellfish Siting

Following a review of shellfish siting which recommended the development of tools such as DSS for the management of shellfish leases [McKindsey et al. 2006], I collaborated with Aad Smaal on a DSS version of a model he had developed for calculating the carrying capacity of a water body for bivalves [Smaal et al. 1997] which was presented in a revised form at the Annual Science Conference of the International Council for the Exploration of the Sea (ICES) in 2008. A typical output page for the DSS is shown in Figure 3. There are five input parameters, all entered with sliders as in the CSTT model, and once all five sliders have been moved the carrying capacity is calculated. There is a minor bioeconomic component to this model in that a traffic light is displayed to indicate whether the site is likely to be economically viable – in this case the value of about 2000 t-AFDW (ash-free dry weight) is only marginally profitable, so a yellow warning light is displayed.

In this case it is difficult to avoid using variables which are fairly technical in nature, but two of them, the Clearance Rate and the Critical Concentration (the lowest food level at which the bivalves can be maintained) are species-specific and can be obtained by simply specifying which bivalves are going to be farmed and obtaining these values from a database.

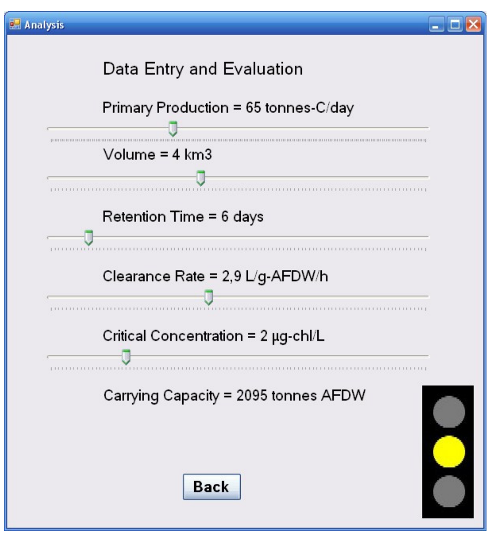

Figure 3. A DSS for shellfish siting.

2.4 Common Features

These three examples have several points in common. Most important of these is clarity and transparency so that they can be understood by concerned parties despite a lack of technical knowledge. Although it may not always be possible to avoid reference to scientific terms, as in the CSTT model where we need to know the background nutrient levels, we can try to keep these obstacles to understanding to a minimum.

A good user interface is also important, a point that seems to be far better understood by commercial software developers than by scientists. Clear data entry forms, graphical interfaces, the use of mouse-driven inputs rather than typing numbers, all contribute to an easy and comfortable interaction with the program. Graphical outputs are even more important, and by producing graphs, charts, images and traffic light indicators the results are far easier to understand.

3. DEVELOPING A DSS FOR AQUACULTURE SITING

The above examples raise some obvious questions, such as who would use a DSS, how would they be constructed, and why aren't they in use now. The answers to these questions are not trivial.

3.1 Who Would Use a DSS?

Although it seems reasonable to put a DSS in the hands of, or at least in front of, the stakeholders, we need to ask whether they really are interested – if we make DSS available, will anyone want to use them? What after all is the value of DSS or any other management tool to the stakeholders, other than showing them what we are doing and perhaps giving them the ammunition they need to criticise management?

I think that putting DSS in the hands of stakeholders could be very beneficial to them. Consider first the primary stakeholders, namely fish farmers. Getting a license for a fish farm is a difficult, expensive and time-consuming process. It usually requires hiring a certified consultant to make a site survey and prepare an environmental impact statement (EIS), even if the farmer has much of the information in hand already. Imagine being able to sit down at a computer and enter the relevant data and immediately getting feedback on what the management decision is likely to be. Of course in most cases the data entered would only be approximate and the output just an indication, but it would give the fish farmer enough of an idea so that knowing whether to go ahead with the full EIS would be an informed decision.

An added benefit would be secrecy. Businessmen are often reluctant to let anyone know their plans, including government administrators, and the ability to explore siting options without letting anyone know about it could be very attractive.

Secondary stakeholders, by which I mean local residents, NGOs and other interested parties, might also appreciate the chance to see how licensing decisions are being made. They would see this as a chance to level the playing field and could improve community confidence in the regulatory process.

3.2 How Would One Construct a DSS?

The simple prototypes I have described are only poor representations of what is really needed, even though two of them actually implement models that are currently in use. A fully developed DSS would go far beyond what would be described here. For one thing, much more input data would be required, and this would require a very sophisticated interface – rectangular pens are overly simplistic. The full geometry of the proposed site may be needed, as well as the kinds and even genetic strains of the fish, how they will be fed, the grow-out period and many other factors. Furthermore it has be a cooperative project, one in which all concerned parties participate so that they have a degree of confidence in the resulting program and can see that it meets their needs and expectations.

This paper has not tried to address the difficult question of what data are needed and where they come from. This is determined primarily by the models that are used and built into the DSS, but most data are available from different sources with corresponding differences in availability, cost and quality. Consider just the depth of the water under the site – in a preliminary assessment this can be obtained from a chart (possibly a digital chart), but since these tend to have coarse grids, the farmer can get a better value by direct measurement, and a licensing agency would probably require measurement by a certified consultant. The data needed would also depend on the region to be covered, as the larger the area the more data and the greater the size of the database. Stakeholders should be involved in selecting the data to ensure that the data used are acceptable to all of them, especially since some may have access to data that is not publicly available or may question some of the values used.

Perhaps the greatest challenge in constructing a fully detailed DSS is the need to incorporate geographic data, meaning interfacing with a GIS. Why ask someone to enter the depth of the site when the bathymetric data can be automatically extracted from a digital chart? Many other data, such as currents and temperature ranges, could be automatically obtained from a GIS. Perhaps more important, by linking to a GIS the manager can easily address issues of interaction with other users of the space, such as transportation channels, recreational facilities, capture fisheries and sewage outlets. It seems unlikely that decisions on aquaculture siting could be made in any case without reference to the kind of data that is commonly stored in a GIS, so a DSS would have to include these data automatically.

Going from the conceptual examples given in this paper to a complex, robust and comprehensive program is a huge step. It cannot be taken lightly.

3.3 Where are They?

The ultimate question that has to be asked about the DSS for aquaculture siting is why they are not being used, at least not widely (a few test studies have been carried out). Perhaps the previous section contains the answer, that it is a large and difficult, and expensive, task to build a really good DSS. Some government agencies have played with the idea, but when it comes down to serious funding none have made the necessary investment. Perhaps the conceptual gap between throwing together a simple prototype over the weekend and then having to spend a few hundred thousand dollars to turn it into the real thing is more than the funding agencies can fathom.

4. CONCLUSIONS AND RECOMMENDATIONS

The present reality is that although aquaculture siting is largely based on models, and to a slight extent these models have been incorporated into DSS and other kinds of expert systems, the full potential of a DSS approach has not been reached. This can be attributed in part to a reluctance on the part of funding agencies to invest in something new and unfamiliar, especially when it involves computers.

Another problem with the implementation of DSS for aquaculture siting is the need to set up a suitable infrastructure for its use. When I originally formulated some simple prototypes I had in mind that anyone who was interested could obtain the program on a CD-ROM or download it from the internet and use it at home or in the office, totally conveniently and privately. However I soon realised that once one started to incorporate georeferenced data in the program, which would mean incorporating GIS functionality, the magnitude of the project would escalate. Most GIS programs are costly, but even though free ones exist, they generally require very large computer resources in both storage space and computing power which would place them beyond the capabilities of all but the largest firms.

Although some small DSS packages could be widely distributed, and could be a valuable aid to those who are just developing interests or concerns about aquaculture, any major DSS would have to be maintained in an institutional context. This could be in a government laboratory or other installation, or perhaps in a public library, but although these scenarios could certainly be possible, they would require novel initiatives and may not be easy to implement.

So there are many challenges and obstacles to developing DSS for aquaculture siting, and the problem is not merely creating the programs, but making them available to all of the stakeholders – not just to managers, not just to fish farmers, but to anyone who wants to see what is going on and who wants to see and understand the process. This will require both money and initiative. It may not happen soon, but we have to face the fact that aquaculture is growing faster than is the scientific community, and this is perhaps the best way of addressing a growing gap in our ability to manage aquaculture effectively.

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