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SKRETTING

Determining and locating sea cage production area for sustainable tropical aquaculture

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"How many fish can be grown without causing damage to the surrounding environment?" and "where is the area that will give the highest production?" are questions that may be asked by a profit-driven but environmentally-minded sea cage farmer. More specifically, given a set of environmental conditions, feeding regimes and sea cages arrangements, what monthly maximum production of fish can be sustained and where to find such a site in a particular coastal area? Answers to these questions are provided by a model called MOM developed by Stigebrand et al. (2004) and its implementation using a GIS tool. The original version of the model was intended to calculate holding capacity of fish species from temperate areas, such as salmon. More recently, the model has been expanded to include other tropical species such as grouper, rabbit fish and barramundi.

In this article, we report a result from simulations using the MOM model to answer the above questions. The aim is to select a set of key input parameters that will enable a sea cage farmer to determine his/her production based on certain selected inputs. The selected parameters from a particular coastal area are then imported to a GIS tool to generate a map showing areas with different production categories.

The sea cage at Awarange Bay during our Summer-trip in June 2007.

Maximum holding capacity

The inputs to MOM model are presented in Table 1 and the output is the monthly maximum production. The output generated from 100 simulations of these inputs ranges from 0 to 217 tonnes. We then classify the production into 3 (three) classes based on percentiles : low (0 to 5 tonnes – less than 33% percentiles), medium (6 to 31 tonnes – 34 to 67% percentiles) and high (32 to 217 tonnes – above 67% percentiles). Classifying parameters into several classes is commonly used for site selection exercises (Salam et al., 2005).

A stepwise discriminant analysis is used to select the pertinent input variables from 28 input variables in Table 1, with an additional variable RCW - the ratio of cage depth to water depth, associated with the three output classes. The selection is based on the F value criteria, ie. the F-value of 3.84 and 2.71 is used to keep and remove a variable, respectively. The selected variables are: sigma, SIG, (standard deviation of water flow), ammonium concentration

Functions:

1. F1 = 0.03 SIG – 7.30 AMO + 0.11 CD + 0.12 SC - 0.87 OXC + 2.59 RCW + 0.62
2. F2 = 0.17 SIG – 3.32 AMO + 0.06 CD – 0.05 SC + 0.50 OXC – 1.45 RCW - 2.8

in a cage (AMO), water current at the surface (SC), cage depth (CD), critical oxygen level in the cage (OXC), and the ratio of cage depth to water depth (RCW). The resulting canonical discriminant functions for the selected inputs are F1 and F2 and are presented in (1) and (2). Fig. 1 presents the three classes of production. Almost 77 % of the group cases are correctly classified. Fig 1 implies that in order to have a high production, irrespective of F2, F1 in (1) has to be positive. This can be achieved by large sigma and strong surface current for waste dispersion, low ammonium and critical oxygen concentrations in a cage for maintaining healthy fish, deep cages and a large ratio of cage depth to water depth for reducing waste accumulation. The mean values for these parameters for each production group are presented in Fig 2.

Figure 1. Territorial map for three production classes: low (1): 0-5 tonnes/month; medium (2): 6-31 tonnes/month; high (3): 32-217 tonnes/month.

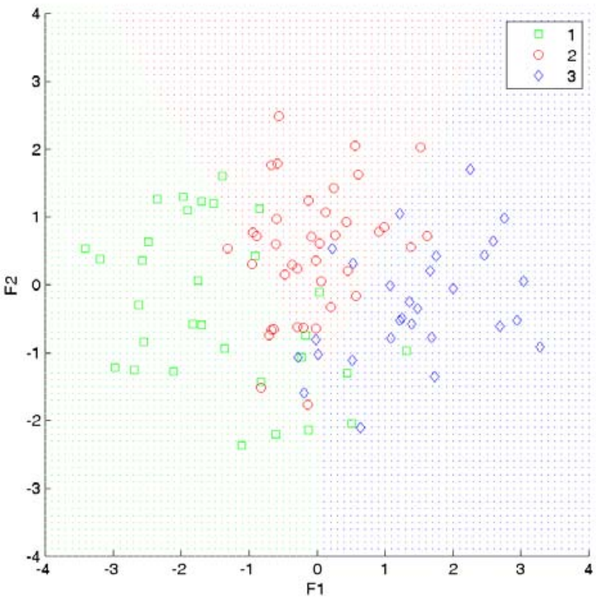
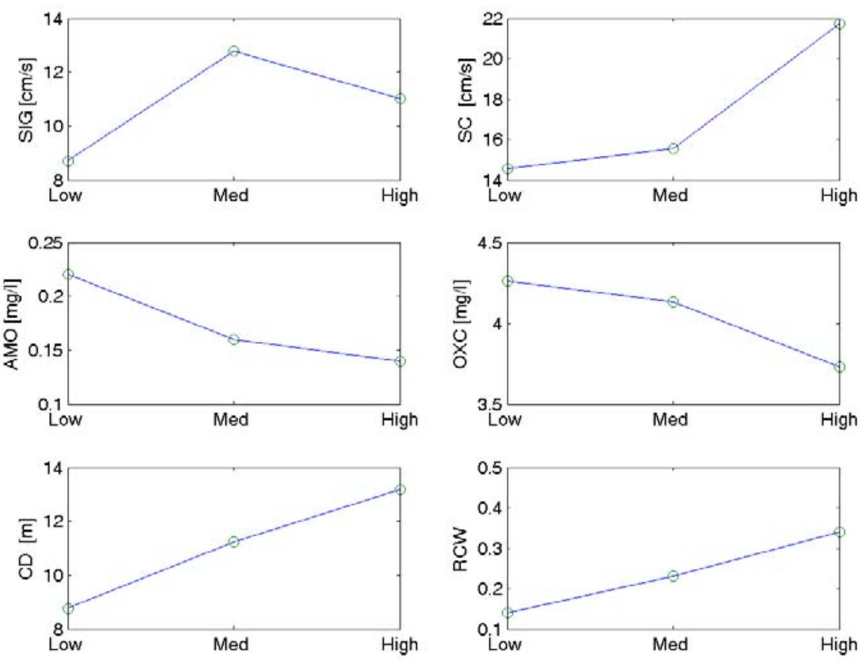


Figure 2. Mean value of the selected input parameters associated with low, medium and high production.



Production map

Spatial values of each of these selected parameters are generated and put into layers using GIS tool. These values are obtained either from measurements or resulting from hydrodynamic modelling. Mathematical relations (1) and (2) are then applied to spatially determine production categories based on these layers. Fig 3 demonstrates the mapping of potential sea cage areas from Awarange Bay in South Sulawesi, Indonesia. The map also shows the location of a sea cage operated by a government institution RICA (Research Institute of Coastal Aquaculture). A picture taken of this sea cage unit is shown in Fig 4.

The development of the MOM model and its application to the aquaculture of tropical finfish is part of our ACIAR project FIS/2003/027 Planning tools for environmentally sustainable finfish cage culture in Indonesia and northern Australia. The main study sites for this project are located in Indonesia, but we envisage the main project outputs will be applicable anywhere in the region.

References

Salam, MA, Khatun, NA, Ali, MM. 2005. Carp farming potential in Barhatta Upazilla, Bangladesh: A GIS methodological perspective. Aquaculture 245: 75-87.

Stigebrandt, A., Aure, J., Ervik, A., Hansen, PK. 2004. Regulating the local environmental impact of intensive marine fish farming III. A model for estimation of the holding capacity in the Modelling–Ongrowing fish farm–Monitoring system. Aquaculture 234: 239-261.

Figure 3. Sea cage production map for Awarange bay in South Sulawesi. A sea cage plotted in 'x' is also shown.

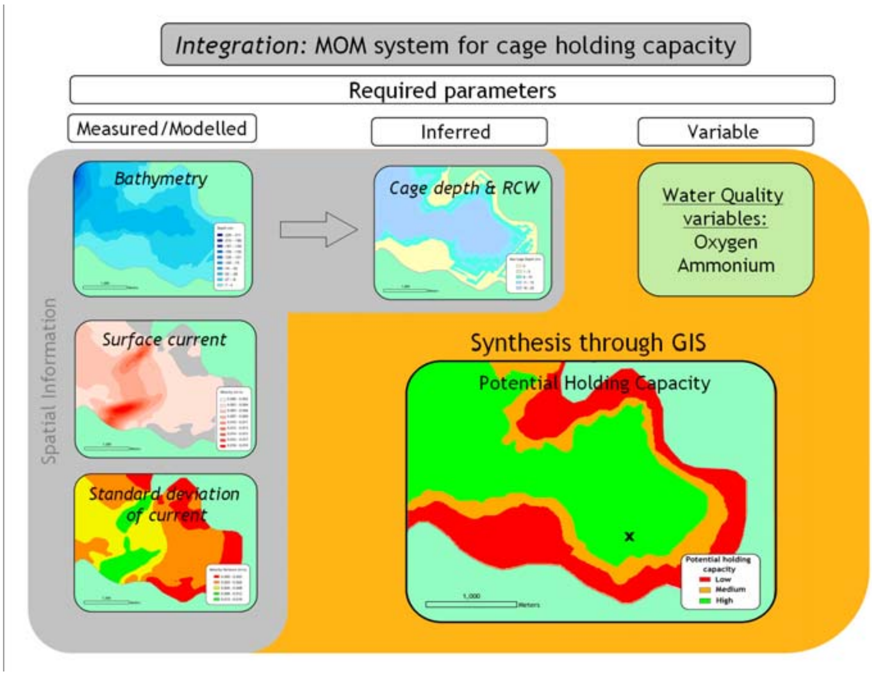


Table 1. Input parameters used in 100 simulation for computing maximum holding capacity for tropical fish species (grouper, rabbit fish and barramundi). Six parameters, denoted by asterix, are selected by a stepwise discriminant analysis in classifying production into low, medium and high holding capacity.

Input Parameters	Range
Temperature (°C)	28-32
Water depth (m)	21-100
Sigma* (cm/s) [SIG]	2-20
Salinity (ppt)	29-33
Bottom oxygen (mg/l)	1-6
Ammonium* (mg/l) [AMO]	0.01-0.38
Surface current* (cm/s) [SC]	1-30
Bottom current (cm/s)	1-29
Number of cage rows	1-3
Cage area (m^2)	36-100
Cage length (m)	6-100
Cage depth* (m) [CD]	1-20
Distance between cage rows (m)	0-2
Reduction factor	0.7-0.8
Critical oxygen in cage (mg/l)	3-5
Critical ammonium in cage (mg/l)	0.12-0.50
Critical oxygen at the bottom* (mg/l) [OXC]	1-3
FCR (food conversion ratio)	1-3
Protein content of feed (%)	43-80
Fat content of feed (%)	15-53
Carbohydrate content of feed (%)	2-10
Ash content of feed (%)	10-15
Sinking velocity of feed (cm/s)	5.68-13.88
Fish initial weight (g)	30-40
Fish final weight (g)	122-398
Protein content of fish carcass (%)	10-20
Fat content of fish carcass (%)	5-10
Sinking velocity of fish faeces (cm/s)	1-9.07

SPC Pacific-Asia marine fish mariculture technical workshop: "Farming Marine Fishes for our Future"

Antoine Teitelbaum & Ben Ponia

Advances in marine finfish aquaculture are being made at a rapid pace. Traditionally this has been led by large commercial interests such as the European salmon farming industry. More recently the strong market demand for the live reef fish trade (LRFT) in Asia has also led to a rapid increase in localised production. The quantity of farmed marine finfish production in the world is 900 thousand metric tonnes in Asia and 1.5 million metric tonnes for the rest of the world (FAO 2004). These well developed industries pose relevant lessons for the Pacific region to learn from.

There has been considerable interest within the Pacific Islands to investigate the options of marine finfish aquaculture to supply domestic or international markets for food and ornamental species. Several countries have achieved commercial production of high value species and there is an increasing list of public and private sectors organisations involved in the industry.

At the 2nd SPC Regional Aquaculture Meeting held in November 2006 the SPC member countries identified marine finfish as an important commodity for development. Subsequently the SPC has become more involved in this field. One recent example is a three week course for Pacific Islanders marine finfish hatchery training held in Thailand in May 2007. The SPC approach is also to advise countries by utilizing its links with Pacific, Asian and Australian counterparts.

As a result of this, the SPC decided to organise a consultative forum among technical persons to enable a face-to-face exchange of ideas and discussion