DTU Aqua
National Institute of Aquatic Resources

Proposal for end project for a M.Sc. thesis:

Developing an Individual-Based Model of spatio-temporal fishing activities for use in fine-scaled fisheries management strategies: application on Danish fisheries

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Fisheries management is still largely operated at the single fish stock and large area level, but the increasing focus on ecosystem-based fisheries management requires a much better understanding of the interactions between fishing fleets and fish stocks at the local scale, Advanced modelling frameworks are being developed to anticipate the effect of fishing activities on the dynamics of exploited stocks, under different management scenarios. In turn, the effect of spatial distribution of stocks and stock-, season- and area-specific regulations on fisher's decision searching for resources is often poorly known and is still largely under-investigated. However, behavioural response of fishers in adjusting the distribution of their effort, in reaction to regulations and/or stock availability fluctuations and/or economic price signals, is crucial information in designing efficient management solutions for mitigating the effect of fishing activities on the marine ecosystem.

DTU-Aqua is involved in developing models to anticipate the fisher's decision on where to go fishing, when and for which stocks. Our current finest models represent effort as an aggregate variable of vessel activities (at most, sets of homogeneous vessels acting on grid-based spatial resolution at a month time step) embedding statistical models to predict the fishing effort reallocation between different activities, space and time (Ulrich et al. 2007, Andersen et al. 2009, Bastardie et al. 2010). But one of the weaknesses of these aggregated models is that it may ignore important aspects of differentiation among fishers in regards to their various economic drivers or other motivations.

An alternative way would be to develop a finer scale model to encompass mechanistic processes at the individual scale (i.e. the vessel) and let the overall pattern of effort allocation between fisheries, space and time emerge from all the individual fisher's decisions. Given that individual-based models (IBMs; http://www.red3d.com/cwr /ibm.html, or http://en.wikipedia.org/wiki/Agent-based_model) deliberately include heterogeneity among individuals, this requires less needs for a priori subjective grouping of heterogeneous practices, and this may thus improve the economic realism of our models.

In addition, many recent developments in the fisheries call towards an increasing focus on the individual behaviour. In particular, (i) individual effort and quotas regulations are being more widely used as a management tool, often in combination with fine spatial management such as area closures, (ii) the recent availability of Danish VMS (Vessel Monitoring Systems, http://en.wikipedia.org/wiki/Vessel_monitoring_system) data for fishery scientists use give us for the first time the opportunity to develop vessel-based modelling of the fishing activities.

In this project, we aim thus at developing a vessel-oriented model for testing the effect of fishing activities in space and time on exploited stocks, including features of fishers' dynamic change in behaviour adjusting to e.g. management rules, environmental or economic events.

The steps of this project would be:

1- To design an IBM model for modelling the vessels movements on the fishery region knowing their specific features (mean trip duration, max. distance to ports, carrying capacity, etc.) combines to a grid-based stock distribution model (age-specific migration between cells, etc.).
2- To develop the IBM so that it can support mechanistic vs. statistical decision–choice models but at the vessel scale for fishers' effort allocation choice between activities, space and time (using e.g. Random Utility Model, Neural Networks, etc.) based e.g. on economic state, information from other fishers, recent catch records, distance to fishing ground, weather conditions, vessel characteristic, fishing strategy, or management regulations.
3- To develop a basic visualisation tool to display the output statistics such as economic indicators (e.g., income, energy consumption), underlying resource abundance and exploitation indicators, and a tool for mapping the effort allocation on the fishery region.
4- To use the IBM in a 'descriptive way' by fitting the decision choice models on data for the identification of the key variables explaining the observed patterns in effort allocation.
5- To use the IBM in a 'predictive way' (or test platform) by evaluating alternative scenarios regarding to stock dynamics (e.g., stock depletion or recovery), number of vessels in each classes of behaviour (e.g., 'risk prone' vs. 'risk adverse', etc.), existing and new management regulations (e.g., effort reduction, quota changes, selective gear, closed areas, etc.), the economic forcing environment (e.g., fish market price, rising oil price)

For communication/dissemination purpose the model is expected to be implemented in the R language. R also provides a number of statistical and graphical facilities that could be relevant.

It will not be asked to compile and analyse the required individual-based fishery data to condition the model (e.g. vessel logbooks, analysis of vessel tracks, gear-selectivity, economic data, etc.) as well as the spatio-temporal distribution of exploited stocks, as this should be the tasks of the supervisors at DTU Aqua.

The adequate candidate should preferably have a background in informatics or scientific computing, with potentially interests in ecology and population dynamics. Basic knowledge in economy would be appreciated.

References

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