CHAPTER 45

Taxonomic Requirements in a Modelling Approach for Identifying Essential Fish

Abstract

In this lecture we are looking into the relevance of taxonomy while doing numerical modelling studies for identifying essential fish habitats. In order to develop a scientific system for developing the closed area approach, numerical models with outputs in integrated geographical information systems are used as decision supports in rightly identifying the essential fish habitats. Befitting to the fundamentals in the fisheries management concepts, numerical models are resorted for easily re-looking the fishing grounds, breeding areas and nursery areas relevant for a fish in a study domain. But while doing the simulation process, we often tend to make assumptions with respect to the biology and physiology of the fish. In this training lecture we will be looking into the taxonomic requirements which are useful in ascertaining the biological and physiological features of fish while doing a simulation experiment. Sciaenids commonly known as drums or corakers are taken as an example while simulating the larval movement of them in Gulf of Kachchh (GoK) using MIKE-21 model – a combination of hydrodynamic and particle tracking model. The model was resorted to know the amount of fish larvae retained at a particular site in the entire domain during the simulation study.

Background

It is fundamental to all fisheries management concepts that fishes have to be caught from their fishing grounds leaving a substantial number of adults to breed in their breeding grounds and further allowing the eggs and larvae to grow into juveniles or adults in their nursery grounds. We were always looking into blanket recommendations of ecologically sensitive areas such as corals, mangroves etc. to arrive at our conclusions on essential fish habitats. Off late, the researchers as well as developmental agencies are looking into the numerical simulations for identifying the essential fish habitats. For breeding grounds, we do exploratory surveys using zoo-plankton net to understand the quantity of eggs produced in a study location. The locations with the presence of more fish eggs are treated as the breeding grounds of the fishes. There are various methods to ascertain the fishing grounds as we can have established technologies such as integrated potential fishing zone advisories (IPFZ) for estimating the

Grinson George *SAARC Agriculture Centre (SAC), Dhaka, Bangladesh*

fishing grounds. The Hjort-Cushing's triangle redrawn below (Figure 1) indicates the approximate concept of fishing, breeding and nursery grounds relevant in a study.

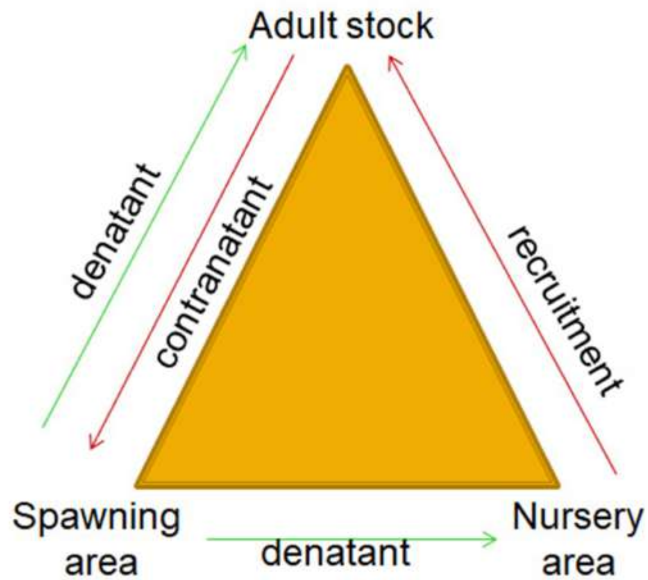

Figure 1: Hjorts-Cushing's Triangle on essential fish habitats

But as we study the delineation of nursery grounds, we understand the need for large volume of datasets in scientifically ascertaining the nursery areas. In this study we have dealt with a numerical modelling experiment where the physical forcing such as hydrodynamics and wind were superimposed on a particle tracking model to really arrive at the nursery areas of the fishes in the Gulf of Kachchh (GoK) region (George at.al., 2011). The fish eggs and larvae have to be properly defined in the particle transport model and the taxonomic relevance of this is discussed in the lecture.

How we have defined the fish eggs and larvae in the particle tracking model?

GoK region is famous for the fishery of demersal resources and the landing statistics from ICAR-CMFRI clearly indicates that the majority of fish reported from this region is belonging to the sciaenid family (CMFRI reports). Therefore, while defining the egg/ larval transport parameters in the model we have looked upon the fishes belonging to sciaenid family for setting a benchmark in the various attributes of the study. The estimates will have their best results as a model output when we give the near-real time values in defining the biology of the fish.

The various factors to be considered regarding the biology of the fish and the modelling parameters are as follows:

(i) Duration of simulation

The duration of the numerical simulation is relevant in deciding the dispersal distance of egg/ larvae which are planktonic and move at the mercy of the currents. Technically we define this time as the Planktonic Larval Duration (PLD) phase of the fish. This PLD phase vary from species to species. Therefore, it is important to know the PLD of a particular commercially important fish species and we have to develop species specific database of fishes with their corresponding PLD if we are preparing ourselves for a long-term simulation study. Similar species can have similar PLD and can be utilized for a study if proper data sets are not available. But as we go for mores assumptions, the model accuracy may go down. Based on the PLD of the sciaenid, which is similar to other tropical fish species, the larvae complete this crucial period in approximately 20 days, as for most tropical fish larvae (Wellington and Victor, 1989).

(ii) Particle size of released eggs

During the model simulation studies, we release eggs or larvae as particles. The particles have to be defined properly as eggs or larvae. Else it can lead to erroneous model outputs. For example, if we are simulating the model for sciaenid, we have to define the praticels released in the model as the egg or larvae of the sciaenid. Therefore, in our study we were in search of such an input. We came to know that Gustavo et al., 2003, based on the egg size, weight and fecundity of sciaenids, have estimated time of hatch based on the sampling point time with each egg weighing 0.02 mg. Therefore, we also estimated the same weight and defined the particles released for sciaenid in tropical waters (the most dominant group of fish found in the Gulf) and timed the release of larvae at select spawning sites.

(iii) Possibility of passive drifting

In a typical hydrodynamic regime, the larvae may be undergoing passive drifting which will necessarily be based on swimming speed of the fish which is a sciaenid in this study. The assumption of a purely pelagic phase is supported in some systems, but lab/field observations sometimes contradict the assumption that the larval component is completely passive (Leis, 2006). In a macro-tidal regime such as the GoK, weak swimmers will not contribute to dispersal trajectories because of strong currents. Tropical sciaenid fishes have a swimming speed of 0.6–1.4 cm/s (Leis et al., 2006), but the current speed is of the order of 150–200 cm/s.

(iv) Total particles released

Total particles in a modelling study indicates the total number of eggs released or the larvae that are recruited into the study domain at a particular point of time. The particles which are defines as eggs were estimated based on the fecundity of the sciaenid in this study. Particle release time is based on the spawning time of sciaenid. One particle released in the model is estimated to be equivalent to 100 eggs as fecundity of tropical fishes tend to vary from 0.1 to 1 million (Pandian, 2003). Release of 10 million eggs is achieved by assuming that a minimum of 10 fishes are spawning in a site during the active breeding phase. To visualize the movement of fish larvae, particle-tracking (numerical experiment using PA model) simulations have been carried out for the 6 spawning locations surveyed for egg abundance in the Gulf and tracked for 30 days. Final site selection for egg release in the PA model was decided based on the egg abundance and dispersal pattern observed from the particle tracking results.

(v) Nature of virtual fish eggs

The nature of the fish eggs is simulated as neutrally buoyant passive particles. In this study, we assume that fish larvae are transported with the flow without settling. Released eggs form larvae in a day in tropical conditions as their hatching time is reported to be less than a day (Pauly and Pullin, 1988). For a smooth illustration of events during larval transport, the tracer particles used in the model are termed as eggs at the spawning site, and larvae thereafter, as eggs develop into larvae in a day in sciaenid fishes. Hence, hypothetical larvae were allowed to disperse following the egg release from two major sites identified for each season. The larvae are tracked hourly in this experiment to identify their patterns of dispersal and retention. Dispersed patterns are presented as snap shots at different time steps (day 1, day 5, day 10 and day 16).

(vi) Vertical migration

Active fish larvae tend to migrate vertically. But in a well-mixed current regime such as the Gulf tends to carry forward the larvae. The difference in trajectory may result in a shift in their distribution to the order of hundreds of meters, but limitations of a 2-D depth averaged model in a 500 m grid spacing make it difficult to consider this possibility and it is assumed that the changes in distribution of larvae due to vertical migration is negligible for the study.

(vii) Predation, mortality and behaviour

The larval abundance in a region is affected by predation, mortality and behaviour. In this study, these aspects were neglected as the variation in these parameters in the study domain is not known, and it is difficult to interpolate the same in spatial scales in the numerical model.

Conclusion

The study is an indication of the various model related assumptions which we take casually while defining the biological parameters related to fish. The taxonomic identification of the species used in the study with a supplementary biological (physiological) and behvioural data set can improve the scope of the simulation studies. We have mentioned few indicative assumptions which can go wrong if the species studied is devoid of some important biological variables. It is important for fisheries biologists to record and disseminate such relevant biological data sets so that the new scientific framework using decision support systems can in a long way provide reliable results in rightly identifying the essential fish habitats.

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