Ocean Prediction for Aquaculture: An Interview-based system

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Abstract
An interview with aquaculturist was conducted using the Grid Evaluation Method to elicit what predicted information is required from aquaculturist. Interview’s outcome indicated that the salinity of nearshore water is critical information to reduce mortal risk of scallop in the nursery stage. The nearshore low-salinity water can increase mortality of young scallop cultured in aquafarm. This study showed that the coupled land-ocean, high-resolution model is essential to predict the nearshore low-salinity water in the enclosed bay having the aquafarm. The proposed visualization to concurrently exhibit the low-salinity water, snow cover, and river runoffs may be preferable to provide the helpful information.

Keywords – real-time prediction, coupled land-ocean, Grid Evaluation Method, Funka Bay, aquaculture, scallop

1 Introduction
The state-of-the-art ocean simulations with spatiotemporally high resolutions has yielded practical applications to ship routing, rescue operations, flooding or surges forecasts, [1], and the smart fishing [2]. In general, many real-time ocean predictions (forecasts and hindcasts) can daily provide the large amount of raw data of velocity, temperature and sea-level, and so on to general public. The predicted results should be interpreted to easily understand information for stakeholders [3].

Aquaculture is operated mainly in enclosed bays or inland seas [4] and currently contributes about 48% of the aquatic animal food destined for human consumption. Therefore, the helpful information from the prediction system has to be effectively informed to the fishermen in enclosed bays having aquafarm. Before distributing the prediction, we need to know what predicted properties are beneficial to effective aquaculture operations.

The objective of the present study is to answer the question: what prediction system and visualization are necessary to provide information required from aquaculturist? To address this question, we attempted to interview with the aquaculturist by using the Grid Evaluation Method (EGM) [5], and developed the ocean prediction system that can be conducted during various periods from several days to interannual timescales.

We select Funka Bay located in Northern Japan, Hokkaido (Figure 1) as a pilot study area. Funka Bay is a typical enclosed bay and produces vast production of scallops and kelps around the coastal ocean every year.

2 Evaluation Grid Method (EGM)

2.1 Methodology
An efficient interview method called by the EGM [5] is an extension of Kelly’s Repertory Grid Method [6], and the EGM has been utilized by many researches in Japan. The EGM has following advantages. 1) The EGM enables to structurally elicit user requirements without special skills. 2) The outcome can be presented in a hierarchical network diagram which is quite comprehensible to researchers and users. 3) A systematic interview procedure of the EGM can minimize the distortions caused by the interviewers.

2.2 Results
The evaluation structure derived by the EGM (Figure 2) shows that the aquaculturist prioritizes four important items: mortal risk and productivity of scallop, safety and efficiency of operations in superordinate concept area. These items closely relate to the ocean properties, and the priorities of the items depend on seasonality. For example, the evaluation structure (red solid lines) indicates that the aquaculturist pays attention to the sea surface temperature related to the efficient operation and mortal risk of the scallop from early spring to autumn. Most interesting structure (green solid lines and square) is that the aquaculturist cares about the nearshore low-salinity water located in front of their scallop industries to reduce the mortal risk.
risk of young scallop. The nearshore water is pumped up to the nursery scallop industry but the scallop cannot survive in low-salinity (< 30 ‰). The aquaculturist also pays attention to the snowmelt and heavy rain that can generate the freshwater discharges from the rivers and form the low-salinity water along the coastal ocean. Thus, it is found that the ocean prediction system should implement the predictive ability for the land-surface conditions and river runoffs to tackle the nearshore low-salinity prediction required by aquaculturist.

The coastal ocean. Thus, it is found that the ocean prediction discharges from the rivers and form the low-salinity water areas (red color), snow cover (rainbow colors), and river runoff (colored lines) in 1 and 5 April 2009.

3 Prediction system

3.1 System overview

A coupled land-ocean model was developed in this study, which consists of both hydrometeorological model [7] and a three-dimensional OGCM developed at Kyoto University [8]. The coupled model was used to reproduce more realistic salinity distributions around the coastal ocean or aquafarm by using nesting method [9] (Figure 1). The ocean simulation was conducted by using the initial condition and the spun-up calculation following Nakada et al. (2012) [7].

Re-analysis and predicted meteorological datasets GPVMSM were used to be input to the coupled model, which are mean hourly air temperature, precipitation, cloud cover, relative humidity, and wind speed. The coupled model was validated by using observational data and showed both quantitative and qualitative reproducibility of the temporal variations in the bay after several calibrations [7, 10]. The analysis period of 2009 was selected since a significant river runoff in spring was observed then which should be influenced by the runoffs into the bay.

3.2 Preferable Visualization of predicted results

Figure 3 is the proposed visualization to concurrently show the nearshore low-salinity water (red areas) in the bay, river runoffs into the bay, and snow cover areas simulated by the coupled model. The graphics includes all necessary information to reduce the mortal risk revealed by the EGM. The aquaculturist can know the rough period to stop pumping seawater judging from the predicted temporal variation of the nearshore low-salinity water. The map of snow cover can quantitatively inform the possibility of the substantial snowmelt runoffs. Three levels of runoff volume are depicted by red, pink, and white lines along the rivers, indicating the pathways of the snowmelt runoffs into the nearshore waters. In 2009, the system informed that the nearshore low-salinity water were significant in the period of middle April (e.g. Figure 3) and early May.

4 Conclusions and Discussions

This study showed that the coupled land-ocean model is essential to inform the nearshore low-salinity water around the aquafarm to aquaculturist. The proposed visualization to concurrently exhibit the low-salinity water, snow cover, and river runoffs may be preferable to provide the helpful information to reduce the mortal risk of scallop in the nursery industries.

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References