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Fishing ground forecast in the offshore waters of CentralVietnam (experimental results for purse-seine and drift-gillnet fisheries)

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Abstract. This paper specifies that research, analysis and estimate on marine environmental and biological conditions are very important for fishing ground forecast in offshore waters.

The multi-variate regression equations among Catch Per Unit Efforts (CPUE), temperature structures and primary production have been established and used for monthly fishing ground forecast for purse-seine and drift-gillnet fisheries in the offshore waters of central Vietnam. The experiment forecast result in May, June and July, 2009 presented up to 60 percentage of acception. Meanwhile, the quantity of good forecasts are about 50% and the quantity of excellent forecasts ranks from 25 to 41%.

The Length base Cohort Analyis (LCA) and Thompson and Bell models have been used for annual fishing ground forecast for Skipjack tuna (*Katsuwonus pelamis*) population, which is main object of drift-gillnet fishery. The forecast results showed that when yield in 2009 is 17,831 tonnes, its biomass in early that year is 111,906 tonnes and its forecast yield in 2010 is 18,211 tonnes. If the fishing effort in 2009 is X=1.0, its value of MSY (19,319 tonnes/year) will be gained corresponding to X=2.0.

Keywords: Fishing ground forecast, offshore waters, purse-seine fishery, drift-gillnet fishery

1. Methodology

Changes of fish shoals under mutual influence of environment-biosphere-human factors are described by the following biomass balance equation [1]:

$$\partial N / \partial t = W + R - (F + M) + j \qquad (1)$$

where, N is the biomass of fish shoal (amount of individual), t - time, W - the growth rate of fish shoal, R - the biomass supplemented from new fish generations, F - the death rate due to catching (human factor), M - the death rate due to natural factors, and φ - the incidental factors which cannot be predicted.

If the impact of catching is considered as a decisive factor, then the hydrological and biological conditions must be at least considered in the research of fishery variations. Their influence on the R value is equally investigated. According to the evaluation of many researchers, no techniques have been successful in forecasting changes of fisheries without analyzing the complicated interactions

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of meteorological, oceanological and biological factors.

This methodology recognizes that there is a close relationship between the environmental conditions and the concentration of fish. Any change of environmental factors may lead to quantitative changes of the distribution of fish community. This has been confirmed by practice in the last several decades, where much knowledge about the nature of the marine ecosystems has been accumulated and longer data time series are available..

Most variable environmental factors include meteorological characteristics, atmospheric pressure patterns and synoptic patterns, temperature and salinity structures of the sea water, hydrological front and circulation structure, whereas such factors as sea floor topography and sediments are less variable. Biological factors of fish include distribution, community structure, reproduction, development in the first generations, growth, migration, traditional feed, prey-predator relationship, fishing and catching output.

Each fish species and each period of their development has certain ecological and environmental limit, which may be related to fluctuation periods of environmental factors, the interrelation between them, and the catching output. Corresponding with those fluctuation periods, there are the terms of fishing ground forecast, as following:

Short-term forecast has a term of one week, half month, one month and one quarter. Short-term fishery forecast is concentrated to the prediction of changes, which are likely to occur to the fish concentration in a very near future. The method of forecast includes the simultaneous use of oceanological information and the latest statistical data on fisheries. Short-term forecast only takes place within a limited space and the information released is fairly concrete, taking into consideration the most effective means of fishing. These are the differences from the long-term forecast. The changes of oceanological factors in the forecast area such as temperature, salinity, currents, disturbance and displacement of water masses would affect immediately the migration, change of location, density and size of the fish shoal.

Long-term forecast has a term of half year, one year, 2 years, 5 years, 10 years and 20 years. Long-term forecast requires more diversified biological, oceanological and environmental information than short-term one. The variation effects with long periods of the oceanological conditions can cause changes in the population of the fish shoal, based on the success or failure of its reproduction, the surviving rate of the fish generation within its life cycle and the migration of additional fish shoals. Long-term forecast is aimed at three objectives: 1) to ensure efficiency for the “fishing campaign” of marine fishing enterprises and companies; 2) to ensure scientific basis for the national administrative coordination and management in fisheries; and 3) to ensure scientific basis for the short-term forecasting activities of fisheries research institutes. Thus, long-term forecast shows more academic characters than short-term forecast and it is under the responsibility of central institutions such as national institutes and universities. Nowadays, long-term forecast can be divided into two categories corresponding to the degree of reliability: 1) long-term forecast has a time extent of below one year and has a higher degree of reliability and especially in this forecast the fish communities traditionally caught are fully investigated; 2) superlong-term forecast has a forecast term from 2 to 20 years. The difficulty of the forecast is that it must be based on values which are still unknown, for example the forecast is made on the basis of meteorological and oceanological forecasts, although the forecasts of this kind have actually obtained considerable successes.

In this study, multidimensional correlation analysis method was selected as a research instrument, where the CPUE is dependent variable and environmental characteristics are independent variables. The method allows to detect the degree of correlation between CPUE and useful variables of the environmental conditions, whereby establishing forecast model with the use of regression equations for various terms based on the existing data.

Together with the forecast on CPUE, it is necessary to find out models for forecasting the changes of the quantity of the fish community which serves as a scientific basis for fish resource management. Based on the same opinion, the VPA (Virtual Population Analysis) and LCA (Length-based Cohort Analysis) model distributed by FAO [2, 3] not only allow to predict the quantitative changes of fish communities, but also are reliable instruments for calculating the rate of death due to fishing and value of MSY (Maximum Sustainable Yield) when statistical fisheries data are insufficient. Besides, VPA and LCA also provide effective measures for fish resource management (rational fishing and sustainable development of fish resources)

2. Results

With the objective to establish scientific basis for application of model on fishing ground forecast in the offshore waters of Central Vietnam, the problems rest on the monthly and annual periods. The data are exploited from the Research Institute for Marine Fisheries and the Faculty of Hydro-Meteorology and Oceanography, Hanoi Univesity of Science and the General Statistics Office of Vietnam [4, 5].

2.1. Monthly fishing ground forecast for purse-seine and drift-gillnet fisheries in the offshore waters of Central Vietnam

The experimental model of fishing ground forecast for purse-seine and drift-gillnet fisheries in the off-shore waters of Central Vietnam has been established basing on the relationship between fish resources and environmental parameters. This relationship was concretized by multi-variate regression equations among CPUE of the fisheries, temperature structures (environmental factors) and primary production (feed sources), as following:

$$CPUE = A_0 + \sum_{i=1}^{m} A_i . X_i \qquad (2)$$

where, CPUE has the unit of kg/draught for purse-seine fishery and kg/km-net for drift-gillnet fishery); A_0, A_i are coefficients, which can be calculated by the minimum square method; m is the number of independent variables; X_i are independent variables, including temperature structures and biological production, such as surface temperature and its anomaly, thickness of mixed layer, thickness and gradien of thermocline, depth of isothermal levels of $24^{O}C$, $20^{O}C$ and $15^{O}C$, biomass of phytoplankton and zooplankton, primary and secondary productivity... These variables are monthly calculated and forecasted for the grid of 0.5 degree.

By regression equations (2), some of the experimental results on fishing ground forecast for purse-seine and drift-gillnet fisheries in the off-shore waters of Central Vietnam in May, June and July 2009 (Fig. 1, 2 and Tab.1, 2) showed that acceptable forecasts are about 60.0% (with maximum of 87.5% in June, 2009 for drift-gillnet fishery). Meanwhile, good forecasts are about 50% and the quantity of excellent forecasts ranks from 25.0 to 41.0%.

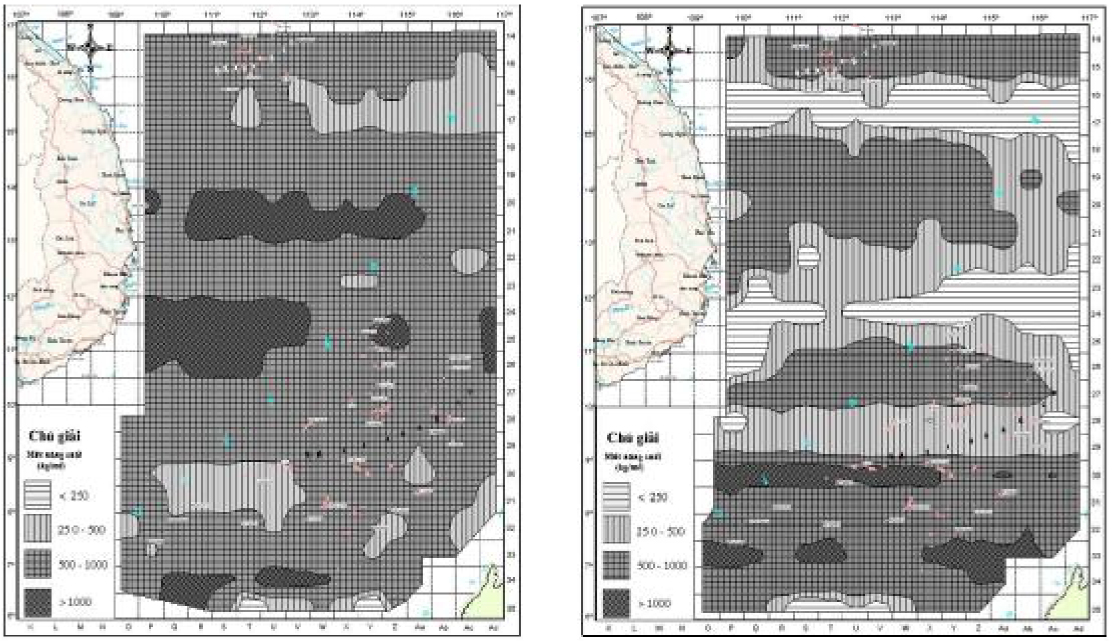

Fig. 1. Experimental result on fishing ground forecast for purse-seine fishery in May (left) and in June (right), 2009.

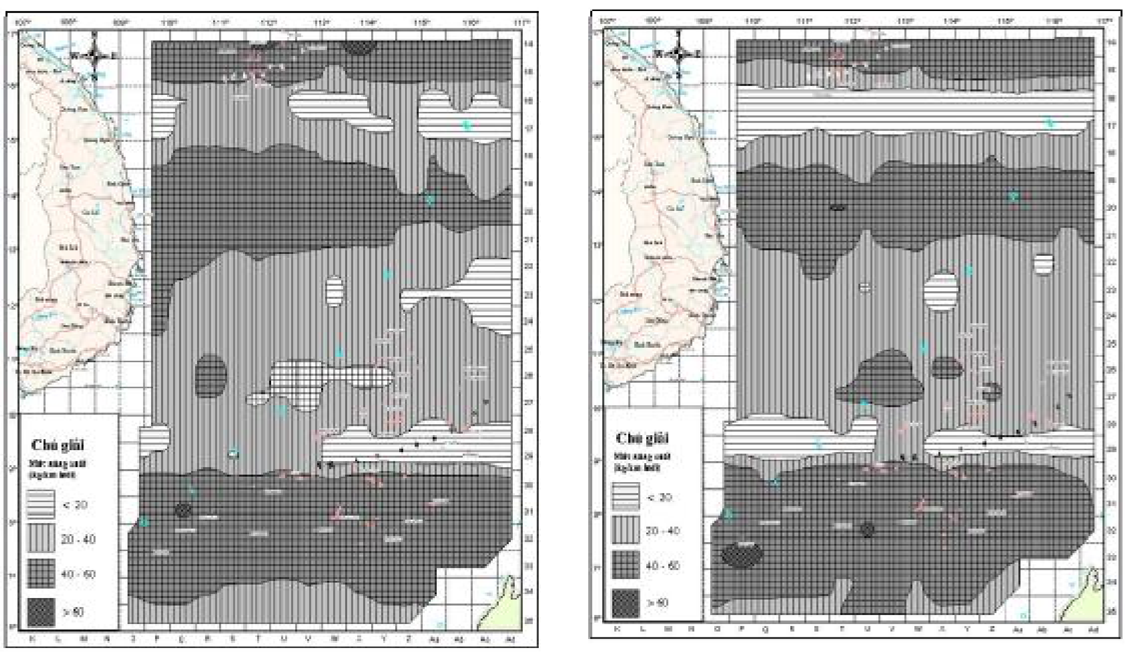

Fig. 2. Experimental result on fishing ground forecast for drift-gillnet fishery in June (left) and in July (right), 2009.

Tab. 1. Results of checking on fishing ground forecast for purse-seine fishery

Absolute error of CPUE (kg/draught)	**May 2009**			**June 2009**		
	Grade	Rate (%)	Accumulated rate (%)	Grade	Rate (%)	Accumulated rate (%)
<=125	Excellent	41.67	41.67	Excellent	33.33	33.33
125-250	Good	8.33	50.00	Good	16.67	50.00
250-375	Acceptable	8.33	58.33	Acceptable	16.67	66.67

Tab. 2. Results of checking on fishing ground forecast for drift-gillnet fishery

Absolute error of CPUE (kg/km-net)	**June 2009**			**July 2009**		
	Grade	Rate (%)	Accumulated rate (%)	Grade	Rate (%)	Accumulated rate (%)
<=10	Excellent	25.00	25.00	Excellent	41.30	41.30
10-20	Good	37.50	62.50	Good	21.74	63.04
20-30	Acceptable	25.00	87.50	Acceptable	21.74	84.78

2.2. Annual forecast for drift-gillnet fishery catching in the offshore waters of Central Vietnam

Skipjack tuna (*Katsuwonus pelamis*) is the main object, which occupies about 35-50% yield of drift-gillnet fishery in the offshore waters of Central Vietnam [4]. In order to make the fish stock assessment for rational fishery management on this species, the Length-based Cohort Analysis (LCA) and Thompson and Bell models have been used.

Analyzing data of fishery survey and observation from 2000 to 2009 and data from the General Statistics Office of Vietnam showed the parameterization values for Skipjack tuna are the followings taken as models' input: L_{max}=84.0 cm, L_{min}=13.0 cm, L_{∞}= 87.54cm, K=0.394, T_0=-0.12, q=3E-9, b=3.2963, M=0.72, F=0.85, amount of length group =7, yield in 2009=17,831 tonnes.

The obtained results (Tab.3) from this model show that when yield of Skipjack tuna population in 2009 is 17,831 tonnes (6,918,700 individuals), its biomass in early that year is 111,906 tonnes (83,067,400 individuals). If the fishing effort of 2009 is X=1.0, its value of MSY (19,319 tonnes/year) will be gained corresponding to X=2.0 and the decrease of its yield will happen when X is over 2.0 (Fig 3). With annual increasing rate of fishing effort of 10% (X=1.1), forecast yield of Skipjack tuna population in 2010 will be 18,211 tonnes.

The results also point out that fishing yield in 2009 for Skipjack tuna has not reached its limit, and the managers can choose becoming value of X for fishery strategy in the future.

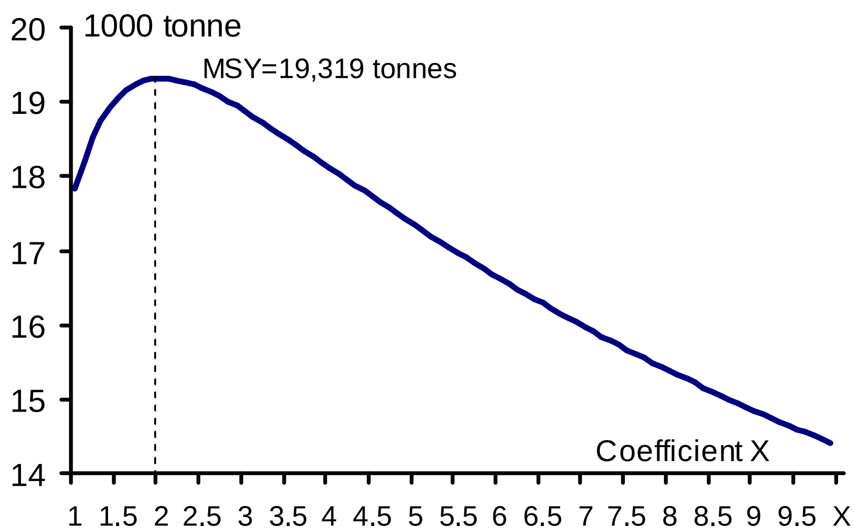

Fig. 3. The change of fishing yield (tonne) and effort coefficient for Skipjack tuna.

Tab. 3. Results from LCA model for Skipjack tuna population

Length group (cm)	Yield		Biomass	
	1000 Individuals	Tonne	1000 Individuals	Tonne
A. Analysis of yield and estimate of biomass in 2009				
<15	70.6	2.5	4,414.7	157.1
15-27	263.6	35.7	23,998.5	3,251.1
27-39	312.8	188.0	20,265.7	12,180.4
39-51	3,786.3	6,325.9	20,881.8	34,887.7
51-63	1,880.7	6,849.1	10,067.2	36,662.5
63-75	532.1	3,637.6	3,131.4	21,407.3
>75	72.7	792.2	308.1	3,359.6
Total	**6,918.7**	**17,831.0**	**83,067.4**	**111,905.8**
B. Forecast of yield and biomass when varying coefficient of fishing effort				
Coefficient (X)	Yield		Biomass	
0	0.0	0.0	88,309.7	180,956.4
1.0 (*)	**6,918.7**	**17,831.0**	**83,067.4**	**111,905.8**
1.1	7,301.4	18,211.4	82,777.4	108,260.6
1.2	7,655.4	18,511.8	82,509.2	104,923.0
…	…	…	…	…
1.8	9,331.2	19,285.9	81,239.4	89,690.6
1.9	9,554.0	19,311.3	81,070.6	87,749.1
2.0 (**)	**9,764.5**	**19,319.1**	**80,911.1**	**85,936.0**
2.1	9,963.7	19,312.2	80,760.2	84,239.4
2.2	10,152.6	19,292.9	80,617.1	82,648.9
…	…	…	…	…

Legend: (*) – The values in 2009;
(**) – The values of MSY

3. Conclusion

1- By multi-variate regression equations among CPUE, temperature structures and primary production, the results of monthly fishing ground forecast for purse-seine and drift-gillnet fisheries in the offshore waters of Central Vietnam in May, June and July 2009 showed that acceptable forecasts are about 60%. Meanwhile, the quantity of good forecasts are about 50% and the quantity of excellent forecasts ranks from 25 to 41%.

2- The results of LCA and Thompson and Bell models for Skipjack tuna (Katsuwonus pelamis) population are listed indices as following: when yield in 2009 is 17,831 tonnes, its biomass in early that year is 111,906 tonnes and its forecast yield in 2010 is 18,211 tonnes. If the fishing effort in 2009 is X=1.0, its value of MSY (19,319 tonnes/year) will be gained corresponding to X=2.0. The results also point out that fishing yield in 2009 for the population has not reached its limit.

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