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Temporal and operational effects on the catch rates of Skipjack Tuna (*Katsuwonus pelamis*) in gillnet fishery of Sri Lanka

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Abstract

The aim of the present study is to examine the relative influence of temporal and operational factors to change the catch rates of skipjack tuna (*Katsuwonus pelamis*) in the gillnet fishery of Sri Lanka. Skipjack tuna is the key target species in the gillnet fishery. Gillnets are sometimes operated as a gear combination and the most popular gear combination is gillnet–longline combination. Apart from that, gillnet-handline and gillnet-ringnet are other frequently used gear combinations in Sri Lankan tuna fishery. Skipjack tuna landed by Sri Lankan fishing vessels were monitored during the period January 2005 – December 2012 at the major tuna landing sites and fishery harbours in Sri Lanka. Five types of vessels which are operated targeting tuna and tuna-like fish, catch skipjack tuna. At the field, the unloaded skipjack tuna catch of the vessels was recorded. In addition, the parameters related to fishing operations were recorded: boat type, used gear/ gear combination, number of days taken for completion of the fishing trip and number of net panels used per fishing operation. Two temporal variables used for this study are "year" and "month". A monthly series of skipjack tuna CPUE (Catch Per Boat Per Trip) was derived from the catch data. A Gamma based Generalized Linear Model (GLM) was fitted to determine the relationship between the explanatory variables and monthly average CPUE. All zero-catch rates of skipjack tuna were excluded for the analysis. All main effects and their first order interactions were taken into the account. The fitted GLM model explains 85.8% of the deviance and the vessel type was found to be the most significant factor for determining the catch rates of skipjack tuna. Among the first order interactions, year : month was found to be the key explanatory variable.

Introduction

Tuna fishery resources in Sri Lanka comprise of both neritic tuna and oceanic tuna species. The oceanic tuna species which are mostly caught outside the continental shelf including high seas comprise of yellowfin tuna (*Thunnus albacares),* big eye tuna (*T. obsesus*) and skipjack tuna (*Katsuwonus pelamis*). A considerable proportion of above oceanic tuna species is caught within the continental shelf and therefore included in the coastal fish production. The oceanic tuna catch is dominated by skipjack tuna followed by yellowfin tuna and big eye tuna. The total tuna production of Sri Lanka in 2014 was 89,603Mt (PELAGOS, 2014), of which skipjack tuna contributed more than 54% of the total tuna production. Skipjack tuna is mostly consumed locally and sometimes used for producing dry fish and maldive fish.

A wide range of gear is used in the tuna fishery. Gillnet, longline and ringnet are the main gears used. Skipjack tuna is the key species in the gillnet fishery. Gillnets are sometimes operated as gear combinations and most popular gear combination in the gillnet fishery is gillnet –longline combination. Gillnet-handline and gillnet-ringnet are other frequently used gear combinations in the gillnet fishery. Around 85% of the total skipjack tuna landed in 2014 were caught by gillnets (PELAGOS, 2014). The aim of the present study was to examine the relative influence of selected temporal and operational factors to change the catch rates of skipjack tuna (*Katsuwonus pelamis*) in the gillnet fishery of Sri Lanka.

Fisheries data

The fisheries data used for this analysis was obtained from the port sampling programme conducted by National Aquatic Resources Research and Development Agency (NARA), Sri Lanka. The sampling programme is conducted at the major large pelagic fish landing sites and fishery harbours in Sri Lanka. The skipjack tuna landed by the fishing vessels operated during the period January 2005 – December 2012 with above described gears were considered for this audit. The unloaded skipjack tuna catch by the fishing vessels was recorded with other parameters: boat type, used gear/ gear combination, number of days taken for completion of the fishing trip and number of net panels used per fishing trip etc. For the data collection, enumerators were stationed by NARA at the major ports and fish landing sites.

Selection of temporal and operational factors for catch rate analysis

The gear types which included gillnet (GN) and key gear combinations operated with gillnet (i.e. gillnet–longline (GL), gilllnet-handline (GH) and gillnet-ringnet (GR) combinations) was considered as one operational factor for the catch rate analysis of skipjack tuna. The vessel type is also considered as another fishing operation related parameter. Five vessel categories were operated during this period potentially targeting skipjack tuna (Table 1).

Table 1. Classification of fishing vessels in Sri Lanka operated during 2005-2012 period potentially targeting skipjack tuna

Class	Fishery	Category	Description
1	Costal Fishery	UN1	5.5 - 7.2 M (17' - 21') FRP dinghy Outboard engine - 8-40 HP (usually 15 - 40 HP) may have GPS Single day boats - assumed to be fishing in COASTAL WATERS
2	Costal Fishery	UN2A	8.8 - 9.8 mm (28' - 34') displacement hull. FRP or wooden. Inboard engine (single) - 40 HP No ice box or insulated fish hold, no gear hauler, or acoustic equipments but, may have GPS Single day boats - assumed to be fishing in COASTAL WATERS
3	Offshore/ deep sea fishery	UN2B	8.8 - 9.8 m (28' - 34') displacement hull. FRP wooden. Inboard engine (single) - 40 HP Insulated fish hold - no gear hauler, may have GPS/sounder/fish finder Multi-day boats-assumed to be fishing in OFFSHORE/ DEEP SEA WATERS

	Offshore/ deep sea fishery	UN3A	9.8 - 12.2 m (34' - 40') displacement hull. FRP wooden. Inboard engine (single) - 60 HP - Insulated fish hold and may have gear hauler/GPS/sounder/fish finder Multi-day boats-assumed to be fishing in OFFSHORE/ DEEP SEA WATERS
4	Offshore/ deep sea fishery	UN3B	12.2 m - (40' - 50') displacement hull. FRP or wooden Inboard engine (single) - 60 + HP Insulated fish hold and may have freezer facilities. Gear hauler/GPS/sounder/fish finder Multi-day boats-assumed to be fishing in OFFSHORE/ DEEP SEA WATERS

Two more fishing operation-related parameters were also considered: number of days taken for completion of the fishing trip and number of net panels used per fishing operation. Apart from that, “year” and “month” were included for the catch rates analysis of skipjack tuna as operational factors.

Use of Generalized Linear Models (GLM) for catch rates analysis

The Generalized Linear Model (GLM) (McCullagh and Nelder, 1989) is a generalization of the linear regression model such that non-linear, as well as linear, effects can be tested for categorical predictor variables, as well as for continuous predictor variables, using any dependent variable, the distribution of which follows several special members of the exponential family of distributions (e.g., gamma, Poisson, binomial, etc.), as well as for any normally-distributed dependent variable. Moreover, the dependent variable values are predicted from a linear combination of predictor variables, which are "connected" to the dependent variable via a link function.

GLM model fitting

A monthly series of skipjack tuna CPUE (Catch Per Boat Per Trip) was derived from the catch data. All zero-catch rates of skipjack tuna were excluded for the analysis. When zero values were eliminated, distribution of the positive values was approximately lognormal and a gamma distribution was found to be appropriated. Accordingly, a gamma based Generalized Linear Model (GLM) was fitted using “log” link function to determine the relationship between the five explanatory variables and monthly average CPUE. All main effects and their first order interactions were taken into account. The models were fitted using R statistical software (R Development Core Team, 2015).

GLM results

The analysis of deviance for gamma-based GLM model fitted to skipjack tuna data shows that all main effects and all first-order interactions are significant ($p < 0.05$) (Table 2). When considering the interaction between year and month for example, meaning the monthly variation in catch rates is not the same in all years. The model explained 85.8% of the deviance, most of which is explained by the difference between the vessel types (64.8%). However, the variation in ln (CPUE) explained by net panels is very small (0.2% only) in comparison with other main effect factors. Also, it may be important to notice that year: month interaction explains 4.5% of the deviance. Finally, main effects factors and first order interactions explain 74.1% and 11.7% of the deviance respectively.

Table 2. Analysis of deviance table for the gamma-based GLM fitted to skipjack tuna catch rate data (BT- Boat type, GT- Gear Type, DF- number of days taken for completion of the fishing trip, NP- number of net panels used per fishing operation)

Source	d. f .	Deviance	% explained	Residual d. f.	Residual Deviance	F value	Pr (F)
Null				732	1024.29		
Year	7	17.50	1.7	725	1006.78	10.2469	4.913e-12 ***
Month	11	13.54	1.3	714	993.24	5.0448	1.705e-07 ***
BT	4	664.24	64.8	710	329.00	680.4901	< 2.2e-16 ***
GT	3	14.38	1.4	707	314.62	19.6391	4.652e-12 ***
DF	1	47.39	4.6	706	267.23	194.1994	< 2.2e-16 ***
NP	1	1.90	0.2	705	265.33	7.7965	0.0054323 **
year:month	75	46.02	4.5	630	219.31	2.5143	1.633e-09 ***
year:BT	28	17.07	1.7	602	202.24	2.4976	4.587e-05 ***
year:GT	16	6.69	0.7	586	195.55	1.7134	0.0407740 *
year:DF	7	8.79	0.9	579	186.76	5.1469	1.130e-05 ***
month:BT	43	16.06	1.6	536	170.70	1.5306	0.0191158 *
month:NP	11	7.44	0.7	525	163.26	2.7718	0.0016614 **
BT:GT	10	6.42	0.6	515	156.84	2.6302	0.0039569 **
BT:NP	4	3.08	0.3	511	153.76	3.1535	0.0140924 *
GT:DF	3	4.67	0.5	508	149.09	6.3778	0.0003008 ***
DF:NP	1	3.51	0.3	507	145.58	14.3979	0.0001658 ***
Total Explained	225	878.7	85.8				

Conclusion

This catch analysis provided substantial knowledge on the variation of the CPUE of skipjack tuna in the gillnet fishery of Sri Lanka. The GLM results have been encouraging since the model explained more than 85% of the total deviance. A similar data set collected for an extended time period could be utilized for the standardization of CPUE in the gillnet fishery of Sri Lanka.

Acknowledgements

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