Determinants of fish species composition in Abashiri River

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Introduction

Because natural organisms are a part of the factors constituting the ecosystem for each organism, it is important to clarify both physical and biological exploitable factors to determine species compositions which exist in that ecosystem. The variation in factors which constitute an ecosystem makes up the variation in species composition. At the same time, each species will interact and will make a dynamic ecosystem.

The Abashiri River is one of the longest rivers in eastern Hokkaido and flows into the Okhotsk Sea. Its drainage area is over 1380 km^2 and various types of environment are found along the river; *i.e.*, intact natural vegetation upriver, lots of farmland in the middle section and residential areas downriver. Such variations in the environment around the river affect the ecosystem in the river.

In the Abashiri River basin, rainbow trout were introduced after World War II. Some individuals settled in certain places of the river basin but were not able to settle in other parts of it. Alien species are one of the big interests in conservation biology. It is important to understand the difference in habitat requirements between alien and indigenous species in order to help control the number of alien species. In previous studies, analyses were independent of each species and there was a lack of analyses to determine the interaction among them.

Generalized Linear Models (GLM: Nelder and Wedderburn, 1972) allow for the variation of error distribution that includes multinomial distribution. GLMs are useful for finding out what factors will present the composition of fish species by a model selection method using information criteria. In this study, we evaluate a preliminary method to clarify the composition of fish species using a GLM with multinomial error distribution.

Materials and Method

Fish species and environmental data were gathered between June and November in 2007, at least once per each month for a total of 7 times. We set 5 survey areas (A1, A2, A3, H and K) in the upper reaches of Abashiri River (Fig. 1). Each survey area measured 100 m in length. We caught fishes using an electric fisher (Smith-Root Co., Model 12-b, DC100-1, 100V, Max 60A). We recorded pH, water temperature and water depth at 6 points (3 points upstream and 3 points downstream) in each survey location.

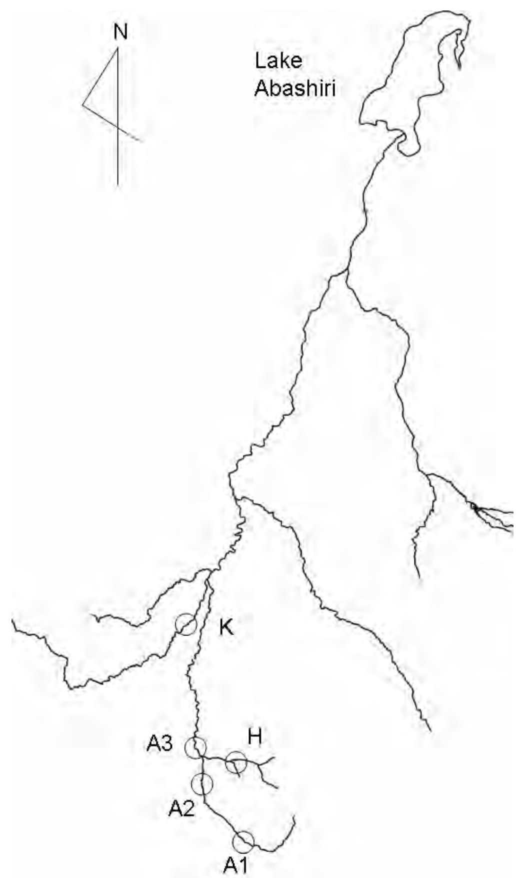

Fig. 1 Survey locations along the Abashiri River, from June to November 2007.

To clarify the explaining factors determining the composition of fish species, we used a GLM with multinomial error distribution (Araki, 2007). We used an average of 6 data points recorded in each survey location as environmental factors. Location name and month were the other explaining factors. So the initial model becomes

$$\text{composition of fish species} = a_1 p + a_2 t + a_3 d + a_4 m + a_5 l + \varepsilon.$$

Here, a_i, p, t, d, m and l are the coefficients of each explaining variable, pH, water temperature, water depth, month and survey location, respectively, and ε is an error variable followed by a multinomial distribution. We used a step-wise procedure with both directions (Burnham and Anderson, 2002) setting a Bayesian Information Criteria (BIC) as the estimating value to evaluate an optimal model and to find out which factors affect the composition of fish species. After getting the optimal model, if categorical explaining variables (*i.e.*, month and survey location) were selected, we clustered categorical explaining variables by using BIC as estimating values.

We then evaluated how the model would predict fish species composition. Two criteria provided by Sato (2002) were applied for this evaluation. The first criterion was the proportion that when a species ‘A’ is observed and predicted one is correct. This means the predicted performance for an occurrence ratio. The second criterion was the proportion when an observed species is not A and predicted one is not A either. This means the predicted performance for a non-occurrence ratio. If these criteria are high, it means this model can figure out a real situation well. We calculated these criteria for three main species, masu-salmon (*Oncorhynchus masou*), white spotted char (*Salvelinus leucomaenis*) and a kind of loach (*Noemacheilus barbatulus toni*).

Results and Discussion

Catch

There were 5 fish families containing 7 species in the catch. The catch for each species is shown in Table 1.

Optimal model

For the optimal model, variables of water temperature (t) and survey location (l) were selected. Survey locations grouped into 3 clusters, *i.e.*, A1 + H, A2 + A3 and K. The estimated values of each species were compared to *Salvelinus leucomaenis* (A) which was given the value 0. The coefficients and standard errors of the survey locations were compared to that of A2 + A3. Each estimated coefficient and standard error are shown in Table 2 and 3, respectively.

Looking at Table 2, we see that if the estimated value for various species is positive, it means the variable tested is more favorable for an individual of that species compared to white spotted char. If the value increases, the number of fish increases. So, sculpin prefer A1 + H more than other species and Japanese dace prefer K. Japanese dace prefer the lowest temperatures compared to other species. However, if the standard error is higher, the confidence interval will become larger.

Table 1 Catch for each species.

Japanese name	English name	Scientific name	Abbrev.	Catch (No. of individuals)
Yamame	Masu salmon*	*Oncorhynchus masou*	Y	822
Niji-Masu	Rainbow trout	*Oncorhynchus mykiss*	N	32
Ame-Masu	White spotted char*	*Salvelinus leucomaenis*	A	346
Ugui	Japanese dace	*Tribolodon hakonensis*	U	86
Fuku-Dojo	type of loach	*Noemacheilus barbatulus toni*	F	227
Hana-Kajika	Sculpin	*Cottus nozawae*	J	8
Siberia Yatsume Unagi	Siberian lamprey	*Lethenteron kessleri*	S	3

***** Salmonids included landlocked individuals because there were few smolts in our survey areas.

Table 2 Estimated coefficient compared to white spotted char *Salvelinus leucomaenis* (A).

Sp.	Intercept	Cluster A1 + H	Cluster K	water temp., *t* (°C)
Y	0.74	– 0.69	0.21	0.06
N	– 9.37	– 0.81	9.93	0.08
U	– 9.55	– 0.08	12.00	– 0.02
F	– 2.12	– 3.30	3.75	0.13
J	– 9.56	5.37	1.11	0.07
S	– 15.10	– 0.74	– 5.26	1.01

Survey location variables are compared to A2 + A3. The criteria for model evaluation are shown in Table 4.

Table 3 Estimated standard errors.

Sp.	Intercept	Cluster A1 + H	Cluster K	water temp., *t* (°C)
Y	0.22	0.15	0.37	0.02
N	8.71	11.06	8.71	0.03
U	15.43	17.20	15.43	0.03
F	0.33	0.55	0.39	0.03
J	10.07	10.00	17.60	0.12
S	6.01	1.41	3.78	0.47

Table 4 Model evaluation criteria.

Sp.	1st criterion	2nd criterion
Y	0.9396	0.5039
A	0.0000	1.0000
F	0.8048	0.8954

Water temperature was the only environmental variable, except survey location, used to explain fish species composition. The survey location variable may represent all other factors which we did not set in the initial model. So we cannot say that fish species composition depends on only water temperature. However, we found it is one of the most important habitat requirements. White spotted char especially favor a habitat of lower temperature compared to the other species. This fits to the results of a former study (Nakamura, 2007). Rainbow trout favor warmer locations compared to other salmonids. The cluster of survey locations was found to be appropriate because the clusters shared similar physical relationships, *i.e.*, upriver cluster (A1 + H), middle river cluster (A2 + A3) and tributary river (K).

The model performed well for masu-salmon and a kind of loach, but not for white spotted char (Table 4). This could be because we used a simple model without any interacting terms among the variables. In addition, the niches of masu-salmon and white spotted char overlapped in many situations and the number of white spotted char was less than for masu salmon. This may make it hard to distinguish the habitat preference of white spotted char. Our study shows such a possibility, and modification of the initial model is required in a future study.

The methodology used to predict habitat requirements was provided, and the selected model is appropriate. Except for white spotted char, the optimal model can predict fish species fairly well.

This is still a preliminary study and we need to improve our selection of explaining variables to be included in the initial model. However, we believe this type of approach will provide an objective model to explain habitat requirements of fish species. For the analysis of ecosystems, we recommend adopting this type of strategy because if there are various factors constituting an ecosystem, this type of analysis is the only way to get appropriate results.

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