Fisheries Research 195 (2017) 230–237

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Full length article

Evaluating the approaches of habitat suitability modelling for whitespotted conger (*Conger myriaster*)

Min Li, Chongliang Zhang, Binduo Xu, Ying Xue, Yiping Ren*

Fisheries College, Ocean University of China, Qingdao, 266100, China

ARTICLE INFO

Handled by A.E. Punt

Keywords:
Habitat suitability model
Presence-absence
Seasonality
Cross-validation

ABSTRACT

Habitat suitability models (HSMs) are effective for evaluating habitat suitability and guiding the conservation and exploitation of fishery resources. Using species presence-absence and environmental data collected from a 2011–2015 of bottom trawl survey, we developed and evaluated four habitat suitability models to examine the trends of habitat suitability for a long-distance migration fish, whitespotted conger (*Conger myriaster)*. Generalized additive model (GAM) showed a higher explanatory power than generalized linear model (GLM) and random forest model (RF). Depth and bottom temperature were the most powerful predictors for conger distribution in spring and fall, respectively. We conducted cross-validation study to evaluate the predictability of these models, and random forest model showed consistently better performance than the other models. The spatial distribution of suitable habitat predicted by the best model was mapped in the survey area to inform the exploitation of this species, which showed remarkable annual variations in autumn.

1. Introduction

Marine ecosystems are increasingly affected by the growing pressures from coastal exploitation and global climate changes (Doney et al., 2012). Environmental changes such as rising ocean temperature (Bindoff et al., 2005) and ocean acidification (Doney et al., 2009) as well as human exploitation have caused remarkable shifts in the populations abundance, size structure, and habitat distribution of many marine species (McGinn, 2002; Doney et al., 2012), and that the impacts tend to aggravate with the future global climate changes (Attrill and Power, 2002; Barton et al., 2002; Beaugrand, 2009). The shifts of biological characteristics, food relationships, and ecosystem functions can change the distribution of fishing grounds and harvest season, which can undoubtedly affect the livelihood of fishermen (Jones et al., 2012; King, 1995; Roessig et al., 2004). A better understanding of the fish habitat is helpful in coping with the further changes of climate and fisheries.

Species distribution models are powerful tools for understanding species spatial distribution, and a variety of modelling approaches have been developed to relate habitat distribution of fish species to environmental variables (Fausch et al., 1988; Heggenes, 1996; Olden et al., 2002). Amongst them, habitat suitability models (HSMs) are successfully applied to evaluate habitat suitability and has been used to guide the conservation of fishery resources (Wootton, 1992; Guisan and Thuiller, 2005). HSMs have shown good performances onto depicting habitat distribution and tolerance limit to environmental predictor variables using response surfaces inferred by statistical and theoretical methods (Guisan and Zimmermann, 2000; Pearson and Dawson, 2003; Mountrakis et al., 2011). However, those models are diverse in background information, mechanisms and performance (Elith et al., 2011; Wisz et al., 2008), and there are limited consistency on which type of models is superior to others or have a wider range of application. In addition, model selection and implementation are hampered by data availability, data quality and model complexity (Elith et al., 2011; Wisz et al., 2008; Jones et al., 2012). Some species appear to be more difficult for habitat distribution modelling as a result of their complex life history and ambiguous biological characteristics, such as long-distance migratory fishes (De la Morini & re et al., 2002; Smith and Moore, 2005). The evaluation of candidate modelling approaches would provide valuable information in guiding modelling practices in further studies.

The habitat protection of migratory fishery resources is one hotspot of relevant research (De la Morinière et al., 2002). In the present study, we chose whitespotted conger (*Conger myriaster*) as an example to evaluate the modelling approach for long-distance migratory marine fishes. Long-distance migratory fishes switch their habitats in different life stages to ensure the suitability of living environment for feeding or spawning; however, these fishes are relatively resident for each life history stage. We evaluated a variety of candidate modelling approach and used diverse criteria to measure the model performances. The

* Corresponding author at: Room 2216 Fisheries Hall, 5 Yushan Road, Qingdao, China.
E-mail address: renyip@ouc.edu.cn (Y. Ren).

http://dx.doi.org/10.1016/j.fishres.2017.07.024
Received 30 March 2017; Received in revised form 23 July 2017; Accepted 25 July 2017

objectives of this study are to: 1) identify the driving environment factors that determine the distribution of conger habitat; 2) examine the performance of different modelling approaches and find the optimal model for habitat prediction; and 3) test the different criteria of model selection. Our study could provide guidance for the assessment and management of fisheries of similar nature.

2. Materials and methods

2.1. Date collection

Whitespotted conger is a widespread species from northwest Pacific from the East China Sea to the coastal waters around Korea and Japan. Relevant studies have showed that whitespotted conger prefers shallow coastal water with rich prey foundation on sandy-muddy bottoms (Zhang and Tang 2003; Kim et al., 2011; Liu et al., 2015). The species is of high economic and nutritional values and contributes substantially to local fisheries with more than 10,000 mt being caught annually in East Asia (Kimura et al., 2004). However, the life history and habitat distribution of the species in the coastal Chinese Sea have been largely unknown due to the lack of sufficient information.

We collected samples of whitespotted conger in Haizhou Bay, a typical open bay along the coast of the central Yellow Sea, which serves as an important fishing ground for conger. This bay used to be a critical feeding and spawning habitat for many fish species, and was one of the largest fishing grounds in China in the 1980s (Zhang et al., 2006). However, the structure and diversity of the fishery community have changed and fisheries productivity have declined since the 1990s resulting from overfishing and climate change (Bojie et al., 2001).

Bottom trawl surveys were carried out in Spring and Autumn of 2011, 2013, 2014 and 2015 in Haizhou Bay (34°25′ − 35°35′N, 119°25′ − 121°5′E). A stratified random survey was conducted with five strata A-E based on depth (from 6.57 m to 39.86 m) and latitude to determine the 18 stations. The sites were not necessarily the same for each survey, however, the sum of the four-year survey stations basically covered the area of Haizhou Bay (Fig. 1). The survey vessels were otter trawl ship of 161.8 kW, with a trawl net of 25 m width and cod-end mesh size of 17 mm. The survey vessels trawled for one hour at a speed of around 2–3 knots in each station. The relative abundance of white-spotted conger and its forage species were standardized to a sampling effort of 2 kn*h. Environmental data including bottom sea temperature, bottom sea salinity and depth were measured by CTD system (XR-420) for each station during sampling. The sediment data of Haizhou Bay were provided by College of Environmental Science and Engineering, Ocean University of China (unpublished data).

Table 1
The main dataset attributes.

variables	spring	autumn
year	2011, 2013, 2014, 2015	2011, 2013, 2014, 2015
Bottom temperature	5.95 °C–17.75 °C	19.2 °C–22.87 °C
Bottom salinity	10.90–41.00	12.99–31.54
depth	6.37 m–35.83 m	9.58 m–39.86 m
sediment	clay/silt/soil, sand-silt, sand, medium grit, medium sand, clayey silt, clayey sand, sandy silt, sand/silt/clay	same as spring
distance	1.332 km–91.797 km	0.777 km–83.361 km
prey	relative density of *Syngnathus acus*, *Alpheus distinguendus* and *Loligo* sp.	same as spring

The environment variables considered in modelling included bottom temperature, bottom salinity, bottom sediment types, water depth, the shortest distance to shore, and prey density. The sediment types included coarse- sand, clay/silt/soil, sand-silt, sand, medium grit, medium sand, clayey silt, clayey sand, sandy silt and sand/silt/clay. Prey density was considered critical in the distribution of whitespotted conger (Soberón, 2007; Liu et al., 2015; Peck et al., 2016), and main forage species was selected according to a study of 516 stomach samples in the same area. In addition to the sediment types, the other explanatory variables were continuous. With regard to the large differences in the environmental condition and the distribution of conger between spring and fall, the spring and fall survey data were separate in the following analyses (Table 1), and habitat distribution models were built for spring and fall, separately.

2.2. Model building

We modelled the probability of conger occurrence as a measure of their habitat suitability, in which the presence-absence data of conger in the survey was used as response variable in the modelling process. We chose four commonly used methods to build habitat suitability models for the conger, including GLM (generalized linear model), GAM (generalized additive model), RF (random forest model) and Maxent (maximum entropy model). The modelling methods were described briefly below.

(1) Generalized linear model:

GLM is an extension of familiar general linear model based on an assumed relationship between response and explanation variables regardless of whether the data are linear or continuous. Models use

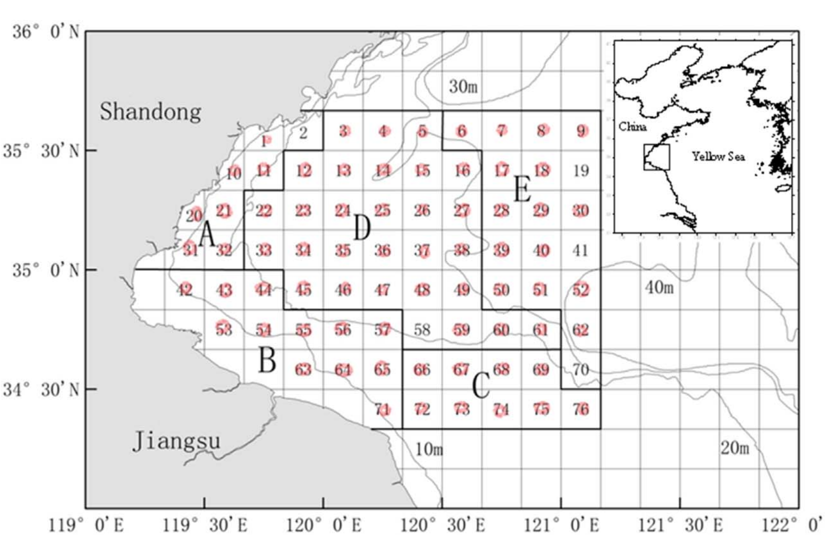

Fig. 1. Survey stations of 2011–2015 in Haizhou Bay and adjacent waters.