Fisheries Research 204 (2018) 224–230

Contents lists available at ScienceDirect

Fisheries Research

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

Influence of the fat content on the auction price of Pacific bluefin tuna *Thunnus orientalis* at Japanese fish markets

Tamaki Shimose[a,*], Minoru Kanaiwa[b], Toshiyuki Tanabe[c]

[a] Research Center for Subtropical Fisheries, Seikai National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 148, Fukai-Ohta, Ishigaki, Okinawa, 907-0451, Japan
[b] Mie University, Faculty of Bioresources, 1577 Kurimamachiya-cho, Tsu City, Mie, 514-8507, Japan
[c] Seikai National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 1551-8 Taira, Nagasaki, 851-2213, Japan

ARTICLE INFO

Handled by A.E. Punt

Keywords:
Auction price
Bluefin tuna
Fat content
Fish market
GLM

ABSTRACT

Tunas (genus *Thunnus*) with a high fat content are considered to be sold at higher market prices. On the other hand, other factors also influence the market price of tunas. In this study, how fat content affects the bid price at auction was investigated by using 150 Pacific bluefin tuna *Thunnus orientalis* caught around the Yaeyama Islands, southern Japan. Eight factors, year (2015 or 2016), auction site (four categories), date (calendar date), fishing gear (longline or pole-line), condition at catch (alive or dead), sex (female or male), body weight (108–350 kg), and fatness (four independent indicators listed below), were used as explanatory variables, and their effects on the bid price at auction were analyzed using a log-normal generalized linear model. The condition factor (body weight relative to the cube of length), percentage of fat content of the belly, near the first dorsal fin, and near the anal fin estimated by bioelectrical impedance were used as indices of fatness, and the use of fat content near the anal fin area reduced AIC the most. Fish still alive at catch, smaller fish, and fatter fish were sold at higher prices. Of the three areas, fat content near the anal fin had the highest correlation with condition factor, which is an objective indicator to predict fish fatness visually. Fat content near the anal fin is concluded to be a good indicator to predict fatness of the whole body of the fish and therefore the auction prices.

1. Introduction

Tunas (genus *Thunnus*) with a high fat content are considered to be sold with higher prices (e.g. Yokota et al., 2011; Hirose et al., 2016), and this is applicable for both fish buyers and customers who favor fatter tunas. Pacific bluefin tuna *Thunnus orientalis* is the largest tuna in the North Pacific Ocean and is caught by various countries and fisheries (Collette and Nauen, 1983; Bayliff, 1994). The species is the most expensive among all tunas (Matsuno et al., 2010) and large amounts are consumed in Japan. The highest price recorded for the species is 155.4 million yen (700,000 yen/kg for a 222 kg specimen) in the first auction of 2013 at Tsukiji fish market, Tokyo, Japan (Kitagawa and Kimura, 2015). The belly portion is called “ootoro”, contains much fat and is sold at particularly high prices (Collette and Nauen, 1983). A part near the “ootoro” is called “chuutoro” and is sold at relatively high prices. The rest of the flesh parts of the main body are called “akami” (literal meaning as ‘red meat’), contain less fat and account for > 60% of the main flesh. Tuna buyers have strong interest in the fat content in each flesh part because fat is strongly correlated with value. Fish buyers with higher skill and experience can evaluate fat content in tuna flesh more accurately.

There are two main spawning grounds for Pacific bluefin; south-western North Pacific and southern Sea of Japan, and the former is extensive from around the Ryukyu Islands to off the Philippines (Fig. 1). Pacific bluefin migrate to the south-western North Pacific spawning ground from mid-April to early-July for reproduction (Ashida et al., 2015; Shimose et al., 2016, 2018). Fatness of Pacific bluefin, both in relation to body proportions and the fat content of muscle, is known to decrease during the spawning season because of energy used for gamete production in multiple batch spawnings over the prolonged spawning season (Chen et al., 2006; Shimose et al., 2016). Body proportions also differ substantially between the early and the late spawning seasons (Fig. 2). The major fishery that targets Pacific bluefin around the Ryukyu Islands is longline, and their catch is sent to various fish auction sites in Japan. The price of the catch is empirically known to decrease with the number of days that pass from the start of the fishing season likely to be due to fat loss during the season. On the other hand, other factors also influence the market prices of tunas. In bigeye tuna *Thunnus obesus*, other factors (e.g. mortality, blemish, weight) affecting sales prices have been examined, and the influence of categorical variables “fat” or “not” has also investigated (Yokota et al., 2011). Fat content

* Corresponding author.
E-mail address: shimose@affrc.go.jp (T. Shimose).

https://doi.org/10.1016/j.fishres.2018.03.001
Received 4 October 2017; Received in revised form 28 February 2018; Accepted 1 March 2018

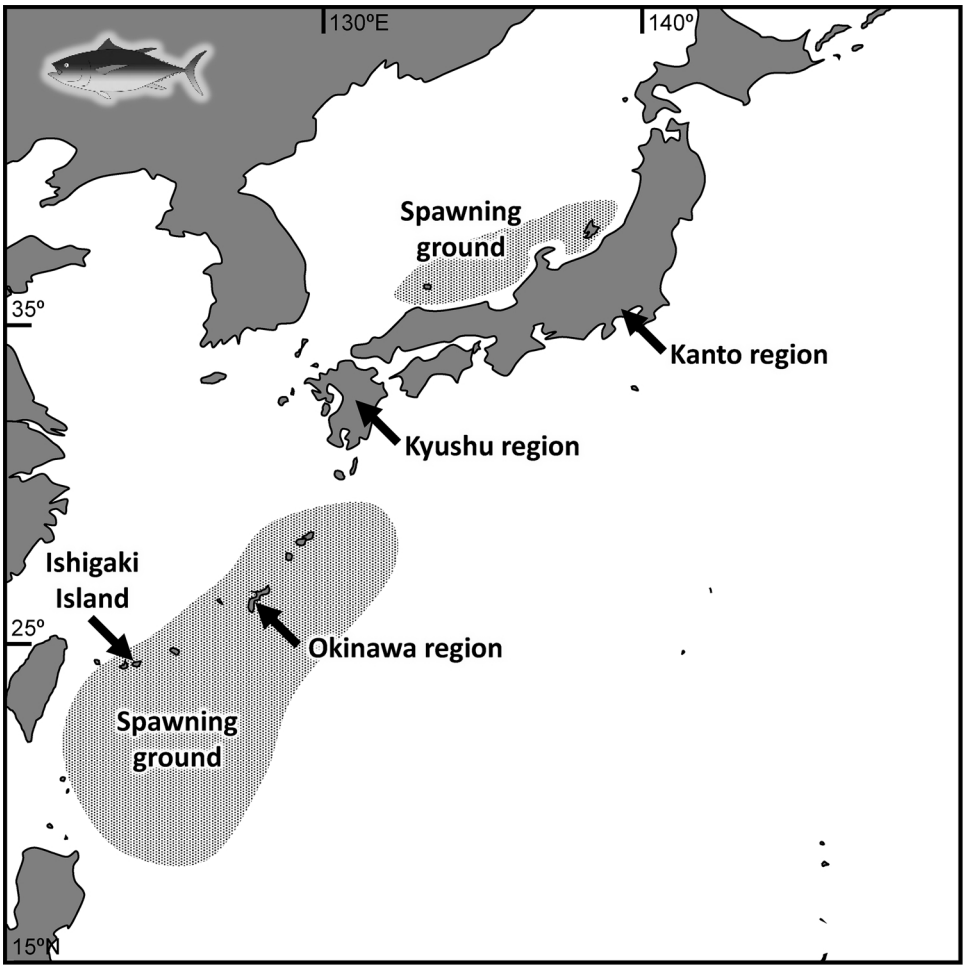

Fig. 1. Locations of Ishigaki Island, three major fish auction regions, and two main spawning grounds of Pacific bluefin tuna *Thunnus orientalis*.

can be easily measured as continuous values using recently developed equipment that measures non-destructive bioelectrical impedance (Kubo et al., 2014, 2016). However there are no studies comparing price formation for Pacific bluefin with actual values of fat content of tissues despite the high commercial value of the species. In this study, how impedance-based fatness measurements of Pacific bluefin affect its price at Japanese fish markets were investigated using fish caught around Yaeyama Islands: part of the Ryukyu Islands, southern Japan. This information provides basic knowledge; 1) to enable prediction of the quality of flesh in wild captured Pacific bluefin before cutting, 2) to enable effective strategies for distribution of tuna for maximum economic return, and 3) to enable planning related to when and how Pacific bluefin should be targeted.

2. Materials and methods

2.1. Fishery and auction

Data were collected at Ishigaki Fishing Port (24°21′N, 124°09′E), Ishigaki Island, Yaeyama Islands, southern Japan (Fig. 1). Sixteen longline and some pole-line fishing vessels targeted Pacific bluefin with other tunas near the island during the study period (2015–2016). The catch of Pacific bluefin by these vessels is concentrated in 23°40′–24°20′N and 124°20′–125°00′E based on interviews with the fishers, and the area is located near the center of the south-western North Pacific spawning ground. Longline fishers bring their catch to the port within eight days, and 91% of the Pacific bluefin were landed 1–4 days after catch during the study period. Longline fishers cool their catch in iced seawater for more than 24 h, but pole-line fishers usually for less than 12 h before bringing them back to the port. Pacific bluefin are placed in iced seawater for cooling before being sent to market if they are not sufficiently cooled. Gills and viscera are removed on the deck in longline vessels or after being landed in pole-line vessels.

The caudal fin of each Pacific bluefin is cut near the fifth dorsal finlet to evaluate the flesh quality (e.g., fat quality, flesh burn) at the surface of the cross section before the decision of where they send the fish is made. Pacific bluefin with a high flesh quality are sent to various fish auction sites in Japan; i.e. Ishikawa, Tsukiji, Yokohama, Kawasaki, Nagoya, Kyoto, Osaka, Kobe, Tokushima, Kumamoto, Kagoshima, and Naha which incur transportation costs. Those with low quality tend to be consumed in Ishigaki Island without requiring such costs or auction. Pacific bluefin sent to Japan are auctioned at each site with other Pacific bluefin sent from various fishing ports in Japan.

2.2. Data collection

Individual Pacific bluefin data were collected during mid-April to early July 2015 and 2016. The following data were recorded at port for each individual fish as often as possible: 1) whether the fish was alive or dead when fish caught, 2) sex, 3) fork length in cm (FL), 4) gilled and gutted body weight in kg (BW), and 5) percentage of fat content at three locations of fish body (see below). Fulton's condition factor (CF) was calculated for each individual fish using the equation; $CF = BW \times 10^6 / FL^3$ (Bolger and Connolly, 1989). Auction sites and bid prices were obtained from the Yaeyama Fisheries Cooperative, which handles most Pacific bluefin landed at the Ishigaki Fishing Port. Data for fish sold on