International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean

ISC/09/BILLWG-1/12

The market value of freshness: Preliminary evidence from a swordfish and blue shark pelagic longline fishery and market

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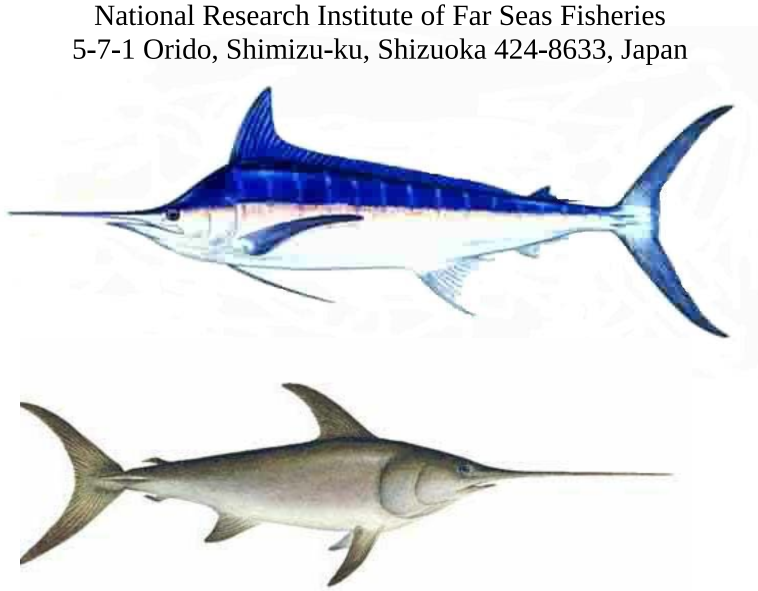

Working document submitted to the ISC Billfish Working Group Workshop, February 3-10, 2009, Honolulu, Hawaii, USA. Document not to be cited without author's written permission.

Introduction

The freshness of perishable food commodities, which is defined using the time period from production to delivery to the market or consumers, plays an important role in the determination of market value. When markets value freshness by a non-negligible degree, producers may have an incentive to differentiate their products by shortening the time between production and market delivery. Such incentives are prominent in the seafood market due to the rapid, perishable nature of seafood commodities. The opportunistic nature of marine capture fisheries, however, often motivates fishers (producers) to extend the duration of fishing operations to gain additional harvest while already holding harvested fish. Extending the duration of fishing operations allows fishers to search a spatially broader swath of ocean for additional harvest. Such operations tend to be far from a shore (market) so that they face additional costs for labor and fuel as well as the degradation of the freshness of already harvested fish. These factors imply that fishers face trade-offs between incurring costs and expected benefits by additional fishing opportunities from extending fishing operations. Although fishers may readily know the additional input costs to fishing operations, it is hard to figure out the amount of market value lost due to an inverse effect on the premium lost for freshness upon increasing fishing opportunities with extending the duration of fishing operations. In other words, when a freshness premium matters, the spatial choices of fishing location by fishers and the spatial fishing regulations by managers take on critical roles in determining the extracting rent from fishery resources. Therefore, the estimation of such premiums for freshness is essential not only for fishers, but also for fishery management's aim toward the sustainable development of industry and effective fishery resource uses. Yet, due to the confidentiality and available data on individual fishery operations and landing values of their harvests, studies about the trade-offs premium lost for freshness in fishery operations have never been done until now.

This study attempts to estimate the freshness premium of harvest attached to the coastal longline fishery in Kesen-numa, Japan. This study shows a robust statistical method to estimate the freshness premium revealed by auction participants. Detailed logbook records and daily auction price data are combined to construct a unique panel data set for statistical analysis. Our analysis focus on two types of landings, swordfish (*Xiphias gladius*) and blue shark (*Prionace glauca*) which dominate in the total landing values for the coastal longline fisheries. We find a significant freshness premium in the swordfish market where the majority of demand is for raw products, while little evidence is found for a freshness premium for blue shark, which is usually sold as relatively durable products for processing.

The following section describes the longline fishery in Kesen-numa. Secondly, we briefly conducted the literature review. Data sources and descriptive statistics are shown in the second section. The third section discusses empirical strategies and results. We conclude and present the next step of this project.

Longline fishery in Kesen-numa

The Kesen-numa fishing port, located in the northeast part of the Japanese mainland (Fig. 1), is known for its large landings of tuna, billfish and sharks (Table 1). Although the annual landings and annual sales have declined about 26% in the past decade[1], it is ranked as the ninth largest port for 2006 in total fishery landing values in Japan (City of Kesen-numa, 2007). Several factors have contributed to this decline including the low price of landings due to the saturated Japanese fish market with cheaper imported substitutions, the depletion of fishery resources, higher fuel prices and a lack of young labor in the fishery industry. Yet, the fishing industry, which includes processors, warehouses and transporters, is one of the main components of the economy at Kesen-numa City.

This study focuses on the coastal longline fishery ("*Kinkai Maguro Haenawa*") which accounted for about 30% of the 2007 total gross sales of fishery landings in Kesen-numa

[1] The mean and standard deviation of annual gross sales of fishery landings at Kesen-numa between 1990 and 1999 was 2885,95,40 USD and 32,101,960 USD respectively. The annual gross sales in 2006 was 213,580,330 USD.

City. In 2006, 24 vessels were registered in this category and 23 of them were active. Almost all vessels in this category have 119 MT capacities with 440 horse power engines. From 2004 - 2007, the average of the total annual gross sales in this category was 3,064,944 USD. The 2004-2007 average gross sales from swordfish and blue shark consisted of 46% and 39% of the annual gross sales, respectively. The remaining gross revenue came from a variety of tuna species (e.g., big eye tuna, northern blue fin tuna). The sum of two types of landing values, swordfish and blue shark, dominate within their total landing values. This fact verifies to focus the analysis of the premium of freshness for swordfish and blue shark, in this study.

Although the price of fuel is more than tripled from 1994 to 2007, fishing locations expanded east[2] into the Pacific Ocean because fishers found a severe scarcity of resources around Japanese coasts. This spatial expansion of fishing grounds increased the average days per trip from around 20 - 30 days in pre-1997 operations to around 40 - 45 days in post-1997 operations. A longer trip is expected to increase potential harvests but it is not clear whether it is efficient under high fuel prices if the premium of freshness is also non-negligible.

Literature review

The spatial choices of fishing locations play an important role in the analysis of fishery regulations (Smith 2000, Wilen 2000, Wilen 2004). Smith (2002) and Smith (2005) studied the location choice of day trips by California sea urchin fishers. Although some of the findings are applicable to pelagic fisheries, a fundamental difference between fishery operations that are benthic (sea urchin) and pelagic (swordfish and blue shark) is the duration of operations and searching activities on immobile (i.e., benthic) and mobile (i.e., pelagic). A pelagic fishery typically requires multi-day trips far away from ports; fishers operate several days during their trips but can sell their harvest only when they come back

[2] In 1997, the fishing regulations for this vessel category were changed to allow operations east of 160 W.

to markets at fishing ports. As a result, location choices involve concern for decay or freshness in addition to more common variables (e.g., fuel and labor cost) in fisheries. Naresh and Leung (2004a, 2004b) used the logbook record of Hawaiian longline vessels to model fishers' behavior in pelagic fisheries but did not explicitly deal with the premium of freshness for harvested fish.

Although a few studies present price formulation in fish markets with detailed transaction data, such as Barten and Bettendorf (1989), their emphasis was not the premium of freshness. Part of the reason could be the limitation of available data. It is not typically possible to find data on auction price at the individual transaction level and the date of detailed harvest activities due to the confidentiality. The next section briefly describes our data.

Data

This study combined two data sources, 1) Logbook data of longline fishing vessels registered at Kesen-numa City Government from 2004 – 2007 and 2) Landings data at the public fish market of Kesen-numa from 2004 - 2007. Both data sets were compiled by the Fishery Research Agency of Japan. The 2004 - 2007 logbooks included species-specific harvest data for tuna (e.g., big eye, blue marlin), tuna-like species (e.g., swordfish), and sharks (e.g., blue shark), and operational descriptions (e.g., number of hooks, gear configurations, locations) for each operational day. The daily auction market data covers the time span from 2004 through 2007. Each observation is a transaction by each vessel on a certain auction day. Table 3a shows the descriptive statistics of 676 total observations. Three hundred and forty-eight observations can be matched with the logbook data. Table 3b shows the descriptive statistics from those matched data. There is considerable variation in the number of trip days, the weighted average days for each fish (defined in the next section) and the auction price of each fish.

This study focuses on two types of harvest, swordfish and blue shark, of which landings consist of around 80% of the coastal longline fishery in Kesen-numa (Table 2). Swordfish landings at Kesen-numa take an 80% of share of the Japanese swordfish market, and blue shark landings at Kesen-numa take a 90% of the share of Japanese blue shark market (Kesen-numa City, 2005). While swordfish products are limited to direct human consumption (e.g., sashimi or fillet for steak or other cooking), blue shark products have a variety of uses. Fins go to a high value food market in China. After being processed in Kesen-numa, skins are exported to Italy for leather products. Meats go to surimi. Bones are used for raw materials for medicine and cosmetics. There is almost no waste from the blue shark harvest. Note that direct human consumption of swordfish implies that the market value of swordfish would include a freshness premium. Processed uses of blue shark imply that the freshness premium of blue shark could be negligible.

Empirical strategies

Freshness is determined by the duration (days) between harvest and market. This study defines the freshness premium of fish commodities as the sensitivity of price change to freshness change. We expect heterogeneous freshness premiums for heterogeneous seafood commodities; high for raw consumption markets (e.g., sashimi or sushi) and low for processed consumption markets (e.g., surimi).

Vessel i leaves the port at time s and returns to the market at time t. We define $Catch^{j}_{id}$ (kg), the harvest of fish type j (swordfish or blue shark) at operation date d and $TotalCatch^{j}_{it}$ (kg), its total harvest per trip. When it returns to the market, each fish is sold by auction with price P^{j}_{it} (yen/kg). A longer trip allows a broader search and more operation days though the vessel may lose a freshness premium.

The primary objective of this study is to estimate how markets value the freshness of fish in pelagic fisheries, or the freshness premium. To evaluate the market value of a freshness premium, we consider two measures of freshness. The first measure is the total number of days in a trip, or how many days a vessel spends on a certain trip.

(1) $DaysTotal_{it} = t - s$

Although this simple measure does not capture accurate information on the freshness of each individual harvested fish, buyers may rely on simple objective information (i.e., the total days per trip) instead of careful investigation of each individual fish[3]. The second measure of freshness is the weighted average days of freshness defined as follows;

(2) $DaysWeighted_{it}^{j} = \dfrac{1}{Total\,Catch_{it}^{j}} \cdot \left[\sum_{d \in Dates\,of\,Operation} Catch_{id}^{j} \cdot (t-d) \right]$

In other words, the first measure of freshness assumes that buyers at the market use the duration of the total days of a trip. The second measure captures the freshness of individually harvested fish more accurately than simply counting the total days of trips because the number of operation days and the amount of harvest is usually not distributed uniformly during trips.

We start with a simple graphical analysis. Figure 3 shows a scatter plot of auction price against the trip days, $DaysTotal_{it}$. There is a clear negative relationship between the price and the duration of trips in the market for swordfish, while the negative correlation is much smaller in the market for blue shark. Figure 4 presents the same scatter plot but with $DaysWeighted^{j}_{it}$ in the horizontal axis. The 95% confidence intervals are wider since not all price data can be matched with the logbook data, and the slope (in level) is expected to be

[3] In the Kesen-numa market, harvested day for individual fish is not available for buyers while the total days of trip and locations where each individual fish harvested indicate.

smaller because $DaysTotal_{it}$ is greater than $DaysWeighted^j_{it}$ in level by definition. A basic finding is that Figure 4 is the same as Figure 3. The negative relationship in the market for swordfish is significant even with larger standard errors. However, the 95% confidence intervals include the possibility of zero effect in the market for blue shark.

In short, the previous graphical analysis implies that a freshness premium is evident in the swordfish market while it is small or statistically insignificant in the blue shark market. This finding is consistent with the economics of these two heterogeneous markets as mentioned in the previous section. Swordfish is consumed for sushi or sashimi (i.e., for consumption as raw fish), therefore, freshness matters to its market value. On the other hand, blue shark is almost always processed and never eaten raw.

Although graphical analysis is intuitively appealing, it does not control for possible confounding factors such as seasonality, demand and supply shocks, heterogeneous technology, or market power. To control for these factors, we provide the following rigorous regression analysis. For each fish type j, the auctioned price P^j_{it} can be described as a function of vessel specific characteristics X_i, auction-day specific conditions A_t, and time variant effects W_{it}.

(3) $P_{it} = f\ (X_i\ , A_t\ , W_{it})$

Note that the superscript j is dropped for ease of notation. Although our analysis includes only 119 MT longline vessels whose technologies are supposed to be homogeneous, each vessel may carry relatively heterogeneous technologies, skipper's experiences or market power, which can be examples of X_i. In addition, seasonality affects both harvesting and market conditions. Aggregate supply and any demand shock at t would affect the price at t, which are examples of $A_{t,}$ auction-day specific effects on price. A log-linear functional form is assumed for f and the following equation is separately estimated for each fish type by the method of ordinary least squares (OLS).

(4) $\ln P_{it} = \alpha \ln Days_{it} + \theta_i + \delta_t + \varepsilon_{it}$

The variable $Days_{it}$ is either of the two measures defined above. The inclusion of vessel fixed effects θ_i and auction-day fixed effects δ_t controls for X_i and A_t in a nonparametric way. By definition, what this coefficient represents is the freshness premium, which is defined as the elasticity in price upon changes of freshness (Day: days between harvest and market)[4].

Three hundred forty-seven observations in the price data match with the logbook data. Including auction-day fixed effects reduces the number of samples to 75. Although one could use all 347 samples with week-fixed effects, regression with auction-day fixed effects provides more robust estimates when there are unobservable daily shocks on market price.

The first two columns in Table 4 show statistically estimated relationships between $DaysTotal_{it}$ and P^j_{it}. Note that this is estimated as – 0.490 for swordfish with a 1 % significance level, and that it has a negative sign. This number implies the percentage change in price as one percent change of the freshness. This can be seen as how sensitive the price of swordfish is to changes in freshness; percentage unit days change induce 0.49% reduction in the freshness premium. Again what we estimated was the freshness premium given unit days; if 10 days have passed since a fish is harvested (e.g., an unit day is 10

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[4] Take a first derivative of the variable, *Days* for equation (4);

$$\frac{\frac{\Delta P}{\Delta Days}}{P} = \frac{\alpha}{Days}$$

Therefore,

$$\alpha = \frac{\partial P}{P} / \frac{\partial Days}{Days}$$

The right hand side is an elasticity of price upon changes of the freshness.

days), the additional 10 days of operation reduce the price of a fish 49.0%, or an additional 1 day of operation reduces the price of a fish at the market by 4.9%. Interestingly, no statistically significant effect is found in the blue shark market. Similarly, the regression result of $DaysWeighted^{j}_{it}$ is presented in the last two columns. The freshness premium is estimated to be 0.299%. There is negative effect for blue shark, but it is not statistically significant.

Overall, the regression results provide statistical evidence that there exists a considerable freshness premium in the swordfish market but not in the blue shark market, which is consistent with the market structure of each type of fish as discussed above.

Conclusion

As we expected, graphical analysis and statistical exercise show that a freshness premium exists in the swordfish market while no premium is statistically significant in the blue shark market. This finding is consistent with their market structure where the major demand of swordfish is for its raw products while most blue shark is sold as processed products.

Our result implies that it may not be beneficial to operate far from a shore or add more days of operations which affect the freshness and subsequent market value of already harvested swordfish, especially when a fisher targets only swordfish. If a fisher targets only blue shark, such considerations would not be significant. In the case of the coastal longline fishery at Kesen-numa, which targets both swordfish and blue shark, our estimated freshness premium of swordfish would help decisions about the duration of operations on board. Furthermore, the heterogeneous nature of the freshness premium for swordfish and blue shark would help fishers to decide on the allocation of efforts between swordfish and blue shark toward their optimal fishery operations.

This analysis has been the first step of our study in exploring optimal fishery operations of the coastal longline fisheries. Next, we plan to estimate the tradeoff between the cost of adding days of operations and expected revenue from additional harvest. Furthermore, updated information on operations in 2008 reveal the effect of operation change upon the scarcity of resources and high oil prices.

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Table 1
Landings and gross sales in Kesen-numa in 2006

	Landings (ton)	Gross sales (1000yen)	Ave. Price (yen/kg)
Bonito	27,804	6,173,906	222
Blue shark	11,369	2,220,376	195
Swordfish	5,150	4,211,824	818
Tunas	7,938	4,107,677	517
Others	54,866	4,644,250	85
Total	107,127	21,358,033	199

Note: Tunas includes all types of tuna. Source: City of Kesen-numa (2007)

Table 2:

Annual average accounting of fishing vessels under the category of the coastal longline fishery in Kesen-numa.

		2004	2005	2006	2007
Bluefin tuna	Landing(MT)	10.9	7.8	3.7	2.8
	Unit ex-vessel price (1000 USD/MT)	19.2	20.9	17.1	16.8
	Landing value (1000 USD)	209.9	161.7	63.8	47.3
	Species landing share in the value (%)	0.0	0.0	0.0	0.0
Bigeye	Landing(MT)	100.5	59.8	40.6	103.7
	Unit ex-vessel price (USD/MT)	13.4	16.6	18.4	15.4
	Landing value (1000 USD)	1,346.5	989.4	745.4	1,596.1
	Species landing share in the value (%)	0.0	0.0	0.0	0.0
Small bigeye	Landing (MT)	12.6	5.5	2.3	5.6
	Unit ex-vessel price (1000 USD/MT)	5.7	6.6	5.9	8.0
	Landing value (1000 USD)	1,343.2	840.2	282.2	4,152.9
	Species landing share in the value (%)	0.0	0.0	0.0	0.1
Swordfish	Landing (MT)	2,010.5	1,748.2	1,726.4	2,223.3
	Unit ex-vessel price (1000 USD/MT)	7.2	8.5	6.9	8.2
	Landing value (1000 USD)	14,495.0	14,825.0	11,927.3	18,222.7
	Species landing share in the value (%)	**0.47**	**0.46**	**0.49**	**0.49**
Striped marlin	Landing (MT)	58.5	66.3	59.6	48.4
	Unit ex-vessel price (1000 USD/MT)	4.8	5.3	4.0	4.7
	Landing value (1000 USD)	279.9	349.1	237.4	226.7
	Species landing share in the value (%)	0.0	0.0	0.0	0.0
Albacore	Landing (MT)	12.8	13.8	7.3	13.0
	Unit ex-vessel price (1000 USD/MT)	2.9	3.0	2.8	2.3
	Landing value (1000 USD)	510.6	595.2	298.6	319.7
	Species landing share in the value (%)	0.0	0.0	0.0	0.0
Blue shark	Landing (MT)	8,278.6	8,774.2	6,148.8	5,785.2
	Unit ex-vessel price (1000 USD/MT)	1.5	1.7	1.8	2.1
	Landing value (1000 USD)	12,591.4	14,673.8	10,804.3	12,255.5
	Species landing share in the value (%)	**0.41**	**0.45**	**0.44**	**0.33**
Total	Landing (MT)	11,770.7	12,182.5	8,897.1	9,458.0
	Landing value (1000 USD)	32,759.8	35,218.2	25,447.9	35,787.1
Swordfish+Blue shark	Landing value (1000 USD)	27,086.4	29,498.8	22,731.6	30,478.2
	Species landing share in the value (%)	**0.88**	**0.91**	**0.93**	**0.83**

Table 3a Descriptive statistics of all market data

Variable	Mean	Std. Dev.	Min	Max
Trip Days	41.18	7.46	8	58
Operation Days	24.78	4.54	3	33
Total landings (ton)	62.87	20.88	7.9	128
Total revenues (10,000yen)	2147.72	605.78	326	4339
Price (swordfish)	847.53	151.28	419	1331
Price (blue shark)	198.56	27.68	130	270
Transaction date	22jun2006		04jan2005	27dec2007

Note: 676 total observations. The number of vessels is 44.

Table 3b Descriptive statistics of logbook data that can be matched with the market data

Variable	Mean	Std. Dev.	Min	Max
TripDays	40.84	6.54	16	54
OperationDays	24.57	4.20	6	33
Total lndings (ton)	68.30	20.90	7.9	128
Total revenues (10,000yen)	2171.16	510.03	326	3600
Price (swordfish, yen/kg)	832.97	144.90	520	1303
Price (blue shark, yen/kg)	186.74	24.92	130	250
Arrival date	05jan2006		03jan2005	05feb2007
[From logbook data]				
East longitude	163.20	13.85	139.70	196.67
Latitude	35.03	3.52	27.33	41.88
Surfice temperature	19.16	1.46	16.04	24.00
Total hooks	3569.17	378.64	1275	4400
Catch by trip (swordfish,kg)	224.26	159.79	1	873
Catch by trip (blue shark,kg)	3468.23	2963.56	0	13057
DaysWeighted (swordfish)	20.45	4.83	4.32	38.59
DaysWeighted (blue shark)	17.96	6.19	8.82	35.33

Note: 348 observations match with the logbook data, where the number of vessels is 26. DaysWeight is defined in the main text.

Table 4 Estimated market value of the freshness premium

	Sword Fish	Blue Shark	Sword Fish	Blue Shark
	(1)	(2)	(3)	(4)
ln DaysTotal	-0.490***	0.074		
	0.075	0.135		
ln DaysWeighted			-0.299***	-0.139
			0.077	0.082
Vessel fixed effect	Yes	Yes	Yes	Yes
Day fixed effect	Yes	Yes	Yes	Yes
Num. of obs.	75	70	75	70
Num. of vessels	25	24	25	24

Note: Dependent variable is the log of the auction price/kg by vessel i at landing date t. DaysTotal and DaysWeighted are defined in the paragraph. Robust standard errors clustered by vessels are in parentheses. Statistical significance: 1% ***, 5% **, and 10% *.

Figure 1: Location of Kesen-numa City

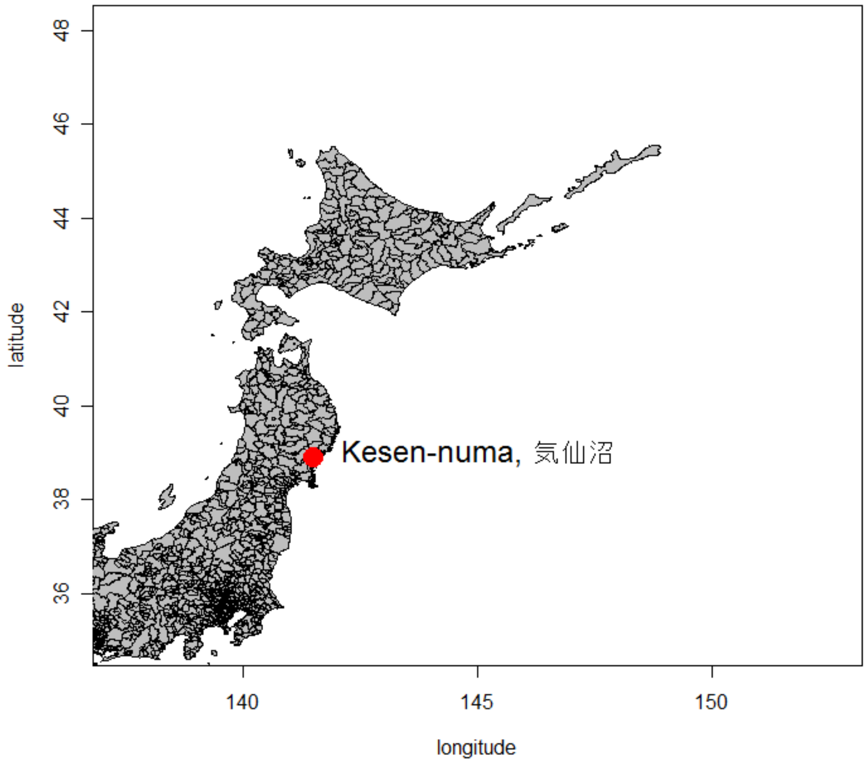
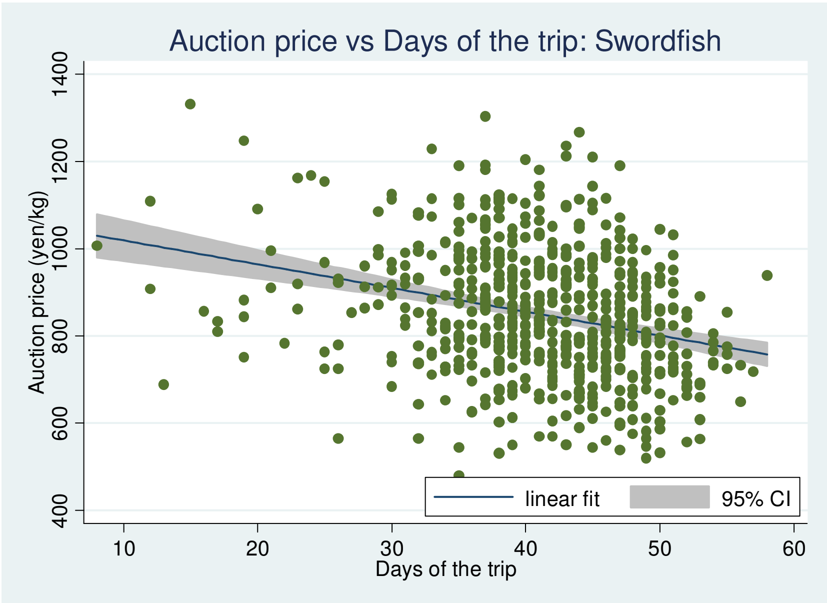
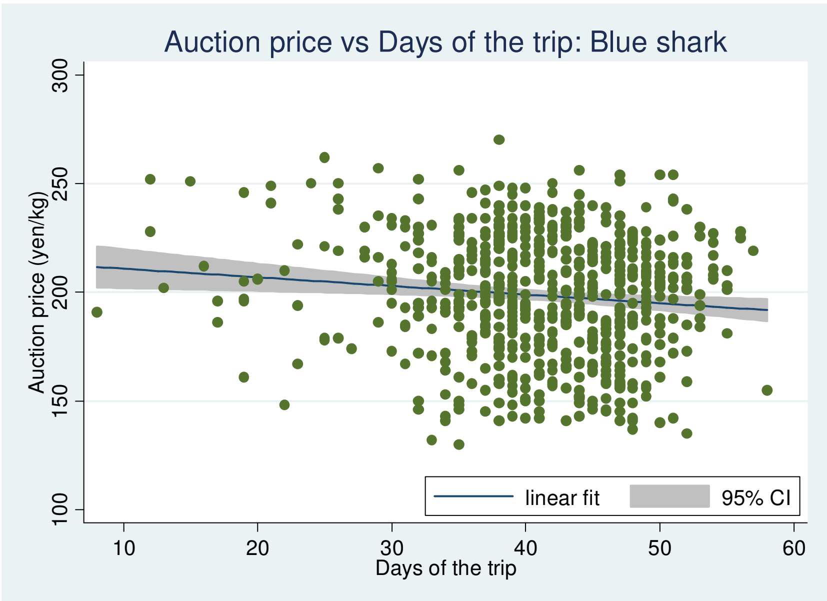


Figure 2: Scatter plot: Auction price vs. the days of trips

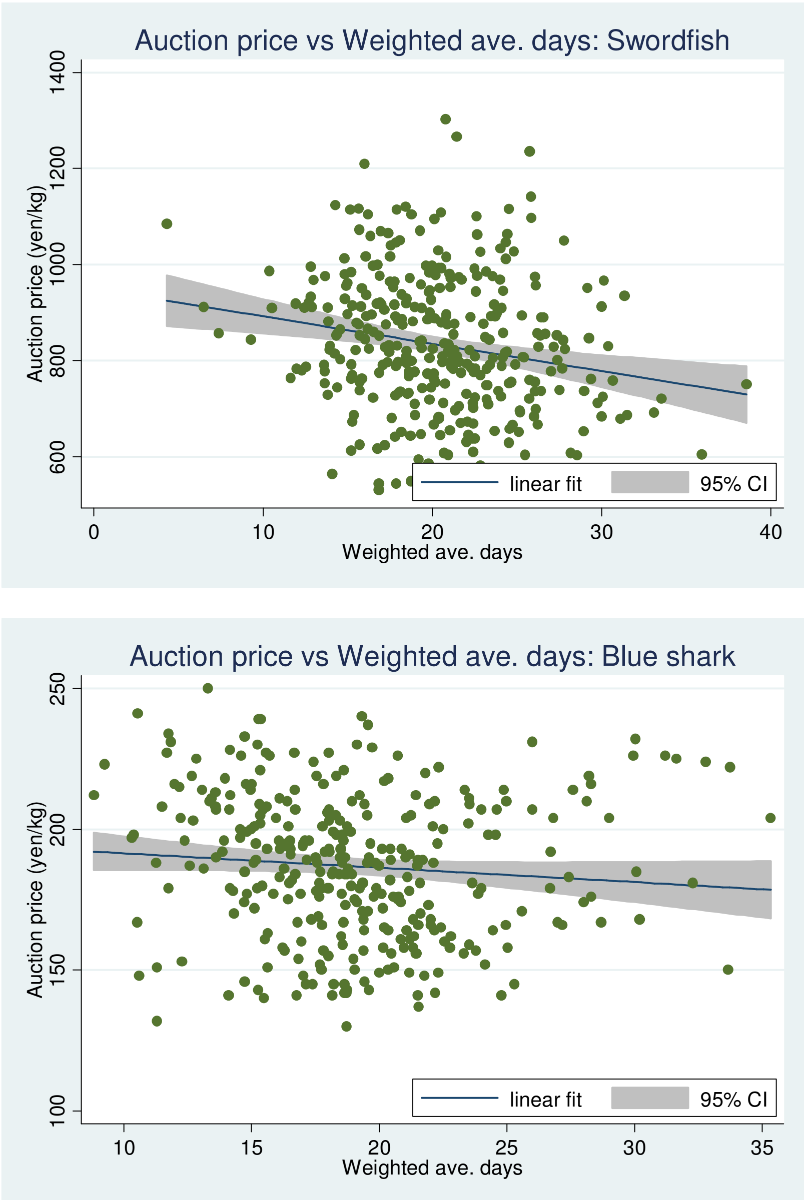




Note: 676 observations in 2005 to 2007 are included.

Figure 3

Scatter plot: Auction price vs. weighted average days



Note: 348 observations in the price data can be matched with the logbook data in 2005 to 2007.