Assessing the Market for Atlantic Bluefin Tuna: Implications for Management

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Introduction

- Bluefin tuna is a highly valued & highly migratory pelagic species.
- Located in both the Atlantic and Pacific Oceans, as well the Mediterranean Sea.
- Species include Atlantic Bluefin tuna *(Thunnus thynnus),* Pacific bluefin tuna *(Thunnus orientalis),* and Southern bluefin tuna (*Thunnus maccoyii).*
- Primary destination for bluefin tuna is the Tsukiji Market in Japan.
- Almost exclusively consumed raw as “sashimi” or with rice as “sushi”.

Introduction

- Japanese consumers are sensitive to quality when pricing bluefin tuna.
- Each individual tuna is inspected and graded prior to auction.
- The fish are graded on fat content, freshness, color and shape.
- These grades, in turn, influence the price for an individual tuna.

Hedonic Price Model

- Carroll et al. (2001) constructed a hedonic price model that captured the impact of quality attributes, in addition to other factors, on the ex vessel price of US North Atlantic Bluefin tuna.
- The Hedonic Model formally relates the market price to a defined set of individual fish attributes.

Hedonic Price Model

P = f (Attributes, Exchange rate, Quantity, Dummies)

- Data Sources: NMFS, industry
- Number of observations 12,072
- OLS, log-log, corrected for autocorrelation

Hedonic Price Model

- Ex-vessel price per pound of a single fish is the dependent variable.
- Four dummy quality attributes (freshness, fat content, color, shape)
- Eight addition independent variables.

Hedonic Price Model

- Weight (twice) as a linear and logarithmic variable
- Yen/US exchange rate
- Quantity of US bluefin tuna
- Quantity of Japanese domestic tuna
- Quantity of non-US Bluefin tuna
- Quantity of Bigeye and Southern Bluefin tuna
- Five other dummy variables

Hedonic Price Model

- Double log functional form
- Parameters estimated using least squares
- Variances re-estimated using the Newey-West algorithm to account for autocorrelation and heteroskedasticity.
- R-Square = .4734

  R-Square Adjusted = .4714

Hedonic Price Model Results

- Exponential values for dummy variable coefficients were taken.
- These values can be interpreted as multipliers of the price for the product.
- For the continuous independent variables, the coefficients were their actual price flexibilities.

Hedonic Price Model

$$\ln P = \alpha + \delta_1 \text{FRESH} + \delta_2 \text{FAT} + \delta_3 \text{COLOR} + \delta_4 \text{SHAPE} + \beta_1 \ln\text{DRW} + \beta_2 \text{DRW} + \beta_3 \text{CONS} + \beta_4 \text{XPORT} + \beta_5 \ln\text{XRATE} + \beta_6 \ln\text{US} + \beta_7 \ln\text{JAP} + \beta_8 \ln\text{OTH} + \beta_9 \ln\text{BE} + \beta_{10} \ln\text{SBF} + \beta_{11} \text{BON} + \beta_{12} \text{LDMTH} + \beta_{13} \text{FRIDAY} + \sum_{m=1}^{30} \gamma_m B_m$$

Hedonic Price Model Results

- All quality attributes significantly affect price.
- The parameters associated with fish weight were consistent with the hypothesized relationship between price and weight.
- The results supported the hypothesis that fresh bluefin tuna was priced on the basis of its multi-attribute properties.

Fat Content Grade

EXPECTED EX-VESSEL PRICE WHEN FAT CONTENT GRADE IMPROVES FROM "C" TO "B"

HEDONIC PRICE SIMULATION

VARIABLE	INPUT
DRW	*315*
FRESH	*4.28*
FAT	*3*
COLOR	*3.78*
SHAPE	*3.78*
XRATE	*106.16*
CONS	*1*
XPORT	*1*
BON	*0*
LDMTH	*0*
FRIDAY	*0*
US3A	*38*
JAP3A	*59*
OTH3A	*26*
SBF3A	*93*
BE3A	*287*
CONSTANT	1

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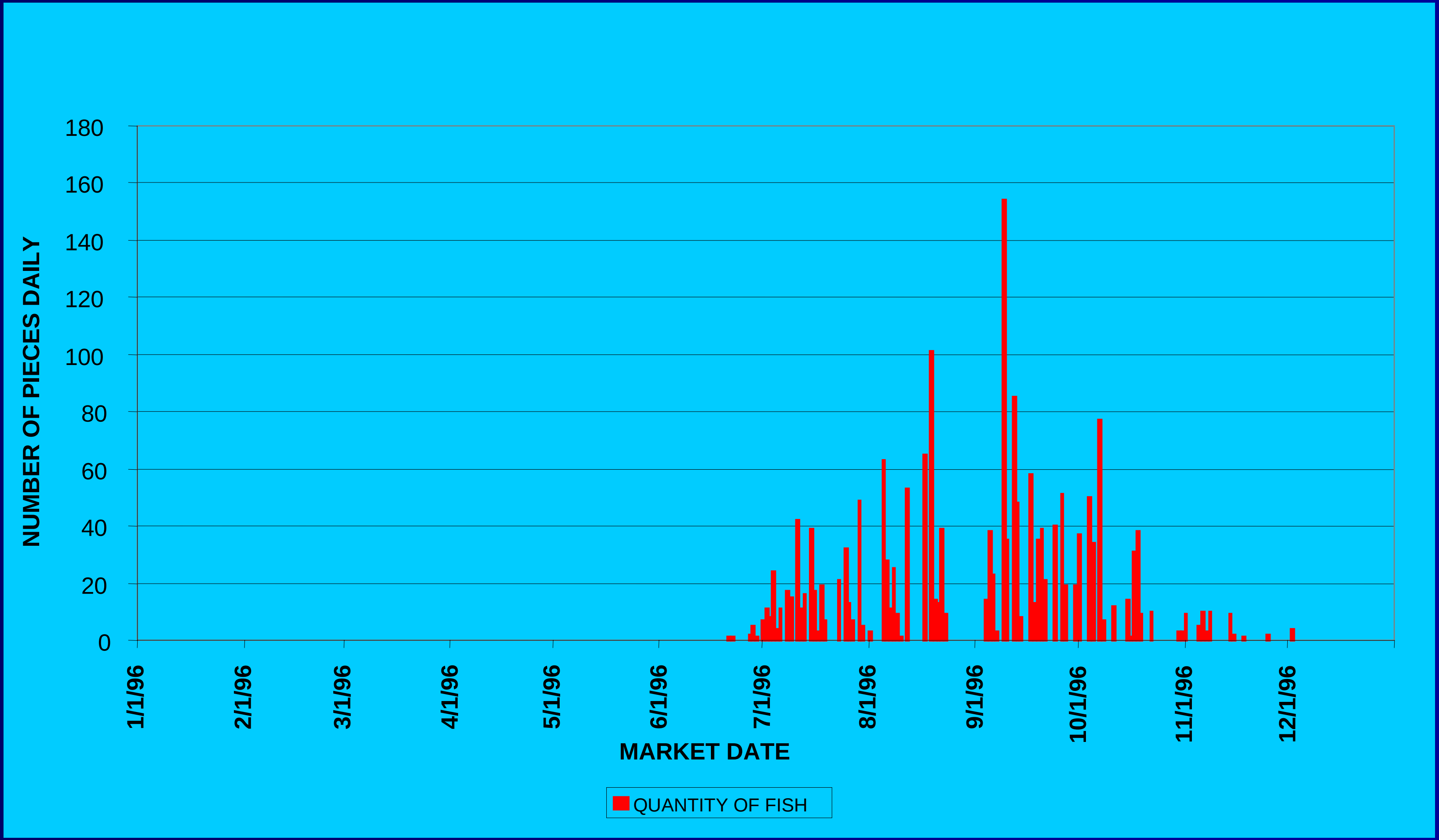
	PREDICTIONS	% CHANGE	PREDICTIONS
FAT CONTENT GRADE	3	33%	4
EX-VESSEL PRICE	$ 6.93	48%	$ 10.22
REVENUE PER FISH	$ 2,183.16		$ 3,220.71

* ALL OTHER CONTINUOUS VARIABLES ARE SAMPLE MEANS

Lower Fat Content

Higher Fat Content

U.S. Bluefin Tuna on Tsukiji Market 1996



Implications for Harvesting and Management

- Given this knowledge regarding the pricing of fresh bluefin tuna, two additional questions emerge.
  - If product attributes affect the ex-vessel price received for a tuna, (better grades = higher price), then is there any way to influence those product attributes (such as harvesting and handling techniques)?
  - If product attributes can be influenced, then what implications does this have for the harvesting and management of bluefin tuna?

Effect of Harvesting on Product Attributes

- In fact, product attributes are known to vary with the harvest method, area of harvest, and period of capture (Martinez, Anderson and Carroll 2000).
- Overall quality attributes, specifically fat and shape, increase substantially over the course of the fishing season.

Effect of Harvesting on Product Attributes

- Five main harvesting technologies in the US East Coast Fishery
    - Harpoon
    - Handline
    - Rod and reel
    - Longline
    - Purse seine

Effect of Harvesting on Product Attributes

- Can one relate individual tuna's attribute grades and weight to the gear employed, area of capture and time of year?

Effect of Harvesting on Product Attributes

Attribute = f (Gear, Area, Time, Broker)

- Data source: NMFS
- Number of observations 12,309
- OLS, log-linear, corrected for autocorrelation
- Examines June to November weekly time periods

Effect of Harvesting on Product Attributes

$$A_i = \sum_{g=1}^{4} \beta_{ig0} D_g + \sum_{a=1}^{9} \beta_{ia1} D_a + \sum_{w=1}^{18} \beta_{iw2} D_w + \sum_{b=1}^{28} \beta_{ib3} D_b + e$$

for all i= fat, freshness, color and shape

Effect of Harvesting on Product Attributes

- *A* is the grade of attribute *i*
- *β*s are coefficients of the independent variables
- *D*s are dummy variables for 4 gears (g), 9 areas (a), 18 weeks (w), and 28 brokers (b).
- Rod and reel, in area 1, during week 0 are dropped to avoid perfect multicollinearity.

Effect of Harvesting on Product Attributes

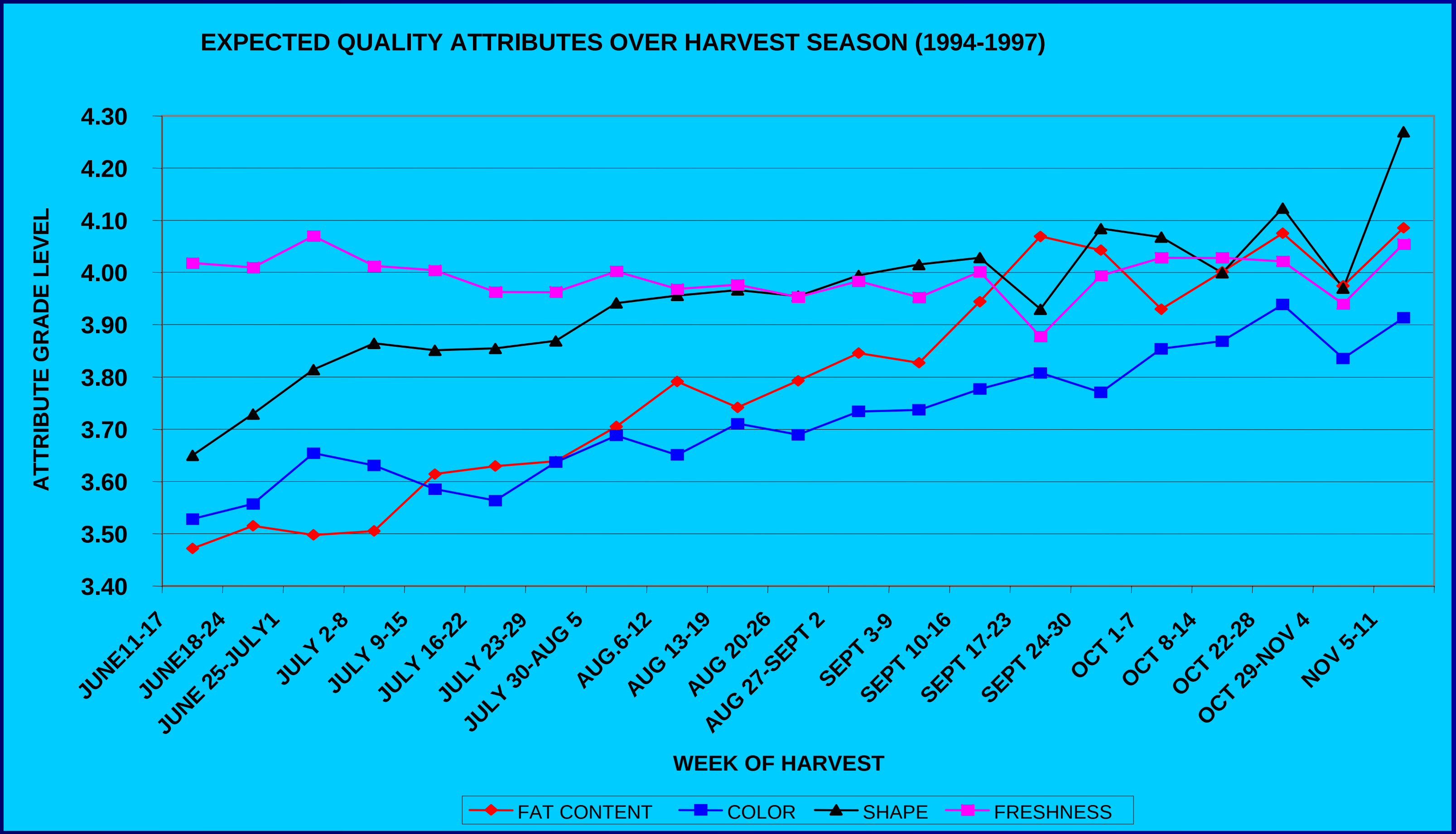
$$DRW = \delta + \sum_{g=1}^{4} \alpha_{g0} D_g + \sum_{a=1}^{9} \alpha_{a1} D_a + \sum_{w=1}^{18} \alpha_{w2} D_w$$

- DRW is dressed weight of a fish in pounds
- δ is the intercept.
- α are parameters for the previously mentioned variables.

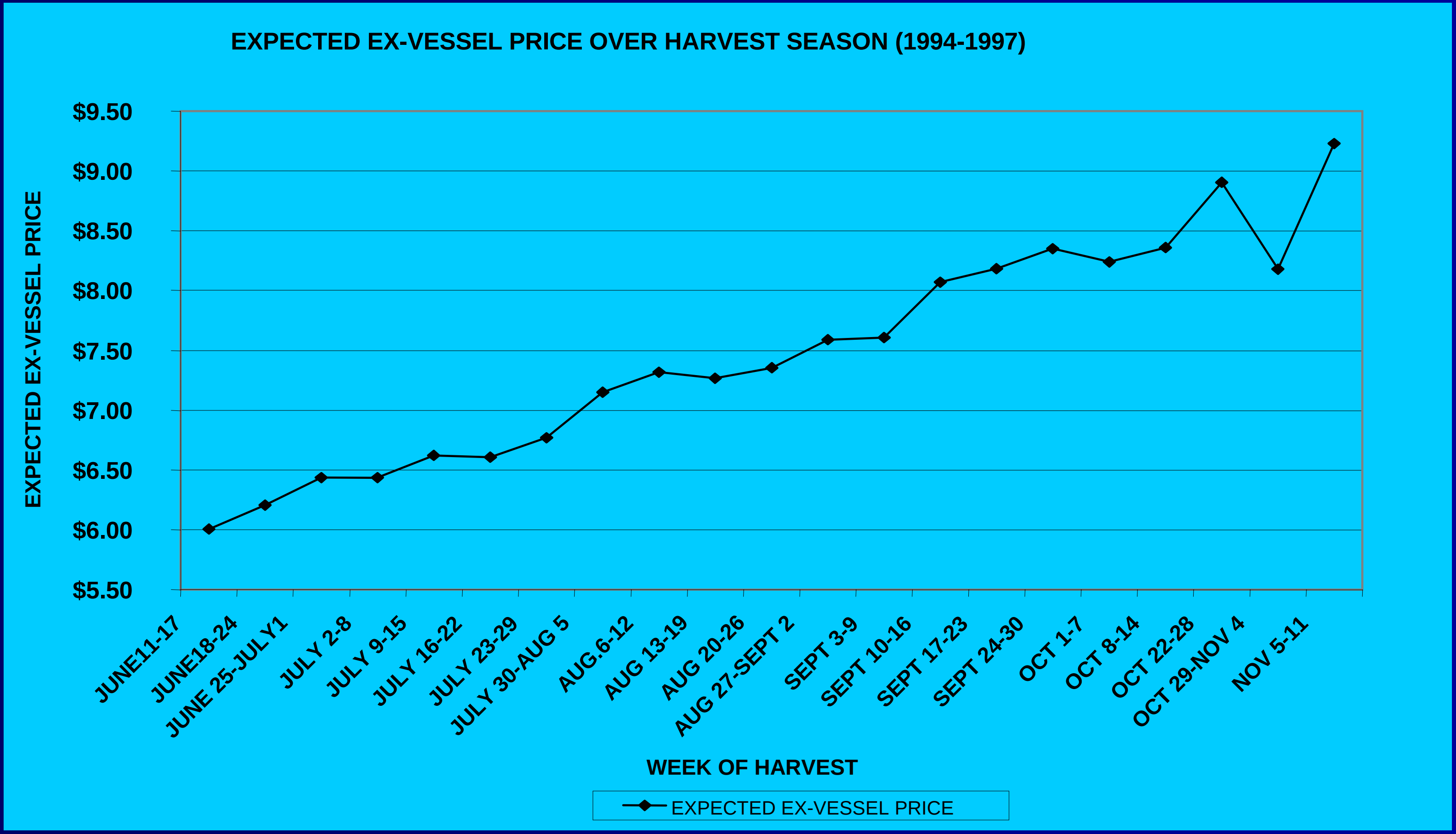
Effect of Harvesting on Product Attributes Results

- Area and gear type coefficients indicated significantly better results for targeted fishery.
- Importance of time of harvest on:
  - Fat content
  - Color
  - Shape
- The most consistent conclusion is the importance of time of capture as a determinant of grade for all attributes.

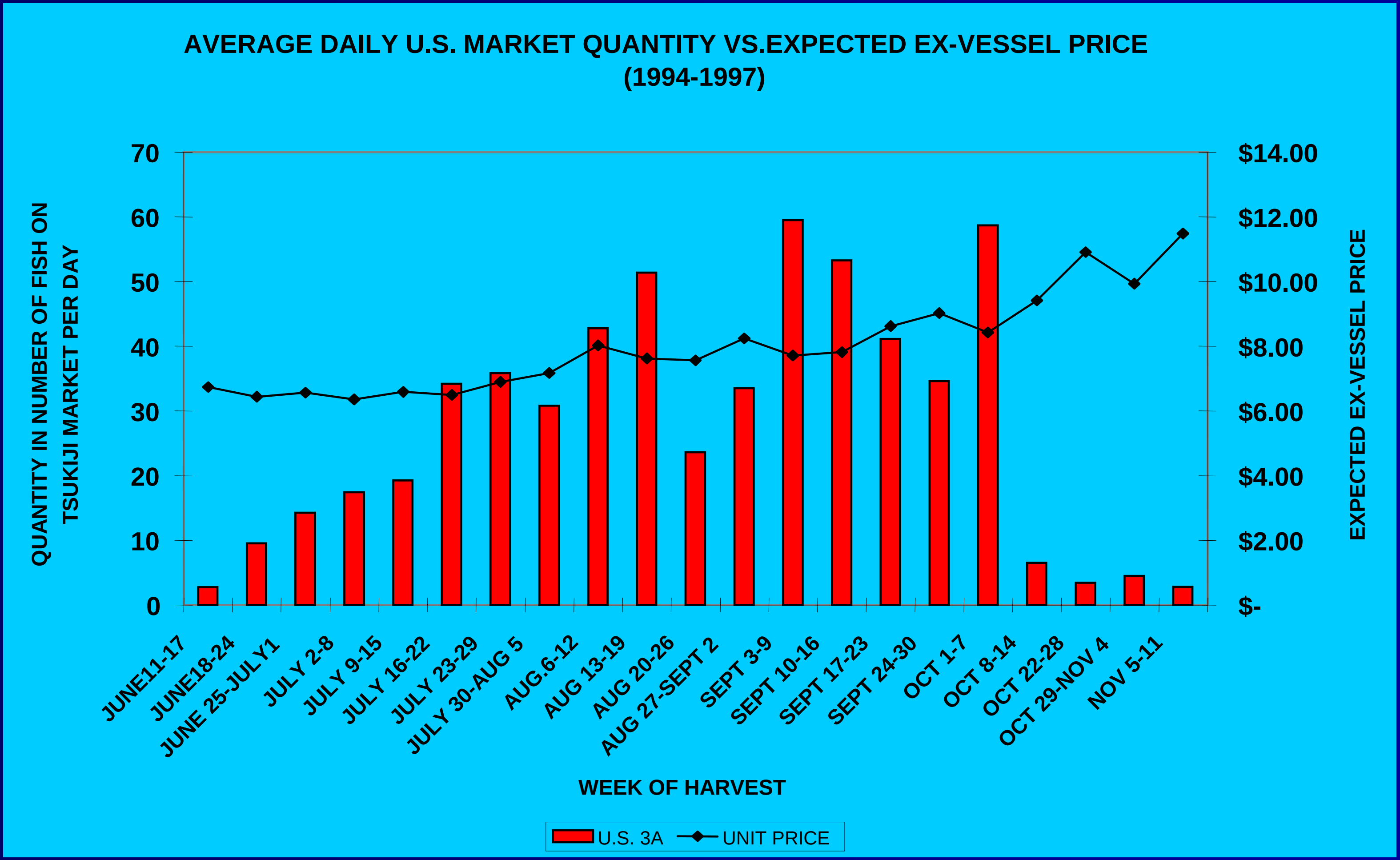
Quality over Harvest Season



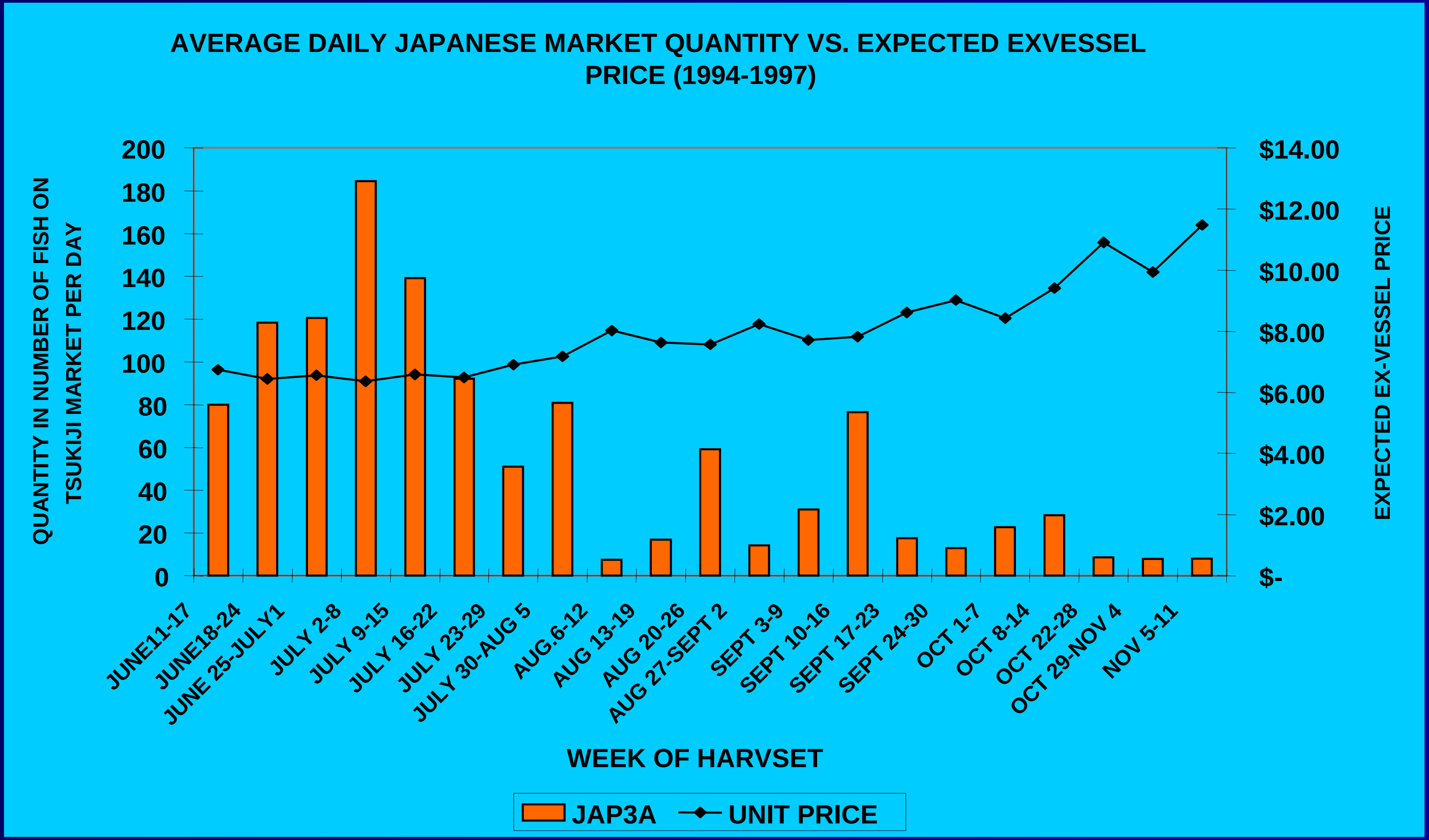
U.S. Price over Harvest Season



U.S. Quantity and U.S. Price over Harvest Season



Japanese Quantity and U.S. Price over Harvest Season



Effect of Harvesting on Product Attributes Implications

- These results could have important implications for public management of North Atlantic bluefin tuna exploitation.

- While time of harvest has a clear impact on product attributes, the impact resulting from area of harvest and choice of gear technology were less definitive given the structure of the model.

Optimal Management: Integrating Market Considerations

- By formulating a more comprehensive and systemic model, Martinez and Anderson (2005) addressed the importance of market considerations for optimal management of the North Atlantic Bluefin tuna fishery.
  - Does the potential to increase rent extraction in the fishery exist?
  - If so, by what measures?
  - And are those measures cost effective?

Optimal Management: Integrating Market Considerations

- They empirically integrated market, fishing technology and fish population information into the regulatory process.
- What is the effect of regulations on markets and consumers?
  - This ultimately determines the level of profitability and survival of the fishing industry.

Optimal Management: Integrating Market Considerations

$$\text{Max } \pi = \sum_{\substack{w=24}}^{42} \sum_{\substack{a=1,2,3,4,\\ 5\&6,\ 7,8}} \sum_{\substack{g=RR,HARP1\\ HARP2,\ PS,\ LL}} x_{w,a,g} \left[DRW(x_{w,a,g}) P_{w,a,g} - c_g \right]$$

Optimal Management: Integrating Market Considerations

- Two part conservation problem:

  1.) Ensure a sustainable harvest (through a harvest cap/quota system).

  2.) Ensure fish that are harvested attain their greatest social use.

Optimal Management: Integrating Market Considerations

- The International Commission for the Conservation of Atlantic Tunas (ICCAT) imposes a quota of 1,344 MT.
- National Marine Fisheries Service (NMFS) establishes additional national regulations for bluefin tuna harvest.

Optimal Management: Integrating Market Considerations

- US Quota 2006-2007 2,847.3 MT
  - General, 1163.3 MT (41%)
  - Purse Seine, 624.1 MT (22%)
  - Angling, 380.1 MT (13%)
  - Longline, 268.2 MT (9%)
  - Harpoon, 124.0 MT (4%)
  - Trap, 6.3 MT (<1%)
  - Reserve, 282.3 MT (10%)

Optimal Management: Integrating Market Considerations

- Additionally, the General Category has daily and seasonal limits.
  - One fish per boat per day, with a limited number of fishing days per week.
  - 60% of the quota: June-August
  - 30% September and 10% October
- The other categories do not have seasonal and daily catch limits.

Optimal Management: Integrating Market Considerations

- Determining the net revenue maximizing harvest:

  – Compare rents under current quota allocation to rents under an “optimal” flexible quota allocation.

Optimal Management: Integrating Market Considerations

- The ex-post optimization of the current allocation leads to an increase of 24% in gross revenues ($18.8MM to $23.3MM).

- Net Revenues increase 92% ($6.1MM to $11.7MM).

Optimal Management: Integrating Market Considerations

- Comparing the ex-post optimization to the net-revenue maximizing scenario
  - Gross Revenues increases 14% to \$26.6MM
  - Net Revenues increase 19% to \$13.9MM
- These gains are largely due to market gains opposed to cost savings. (Costs remain similar in both optimizations)

Optimal Management: Integrating Market Considerations

- The integration of market information into the management process leads to a 19% increase in rents for the US bluefin tuna industry.
- Optimal results include moving away from gears such as purse seine and long lines in favor of harpoons and rod and reels, and concentrating catch towards the end of the season.
- Fewer tuna with a greater size and quality is preferable to a great number of fish captured. (Quality over Quantity)

Conclusions

- Understanding and incorporating market information is critical to optimally managing the resource both in terms of sustainability and maximization of rents.
- Carroll, Anderson & Martinez. (2001) demonstrated that price is a function of product attributes
- Martinez, Anderson & Carroll (2000) demonstrated that product attributes are influenced by harvesting method.
- Martinez and Anderson (2005) incorporated this information in order to formulate an optimal management plan that maximizes the social use of the resource.