

ESTIMATING WHOLESALE DEMAND FOR LIVE REEF FOOD FISH IN HONG KONG

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ABSTRACT

Wholesale demand systems for live reef food fish in Hong Kong are analysed using the Linear Approximate Almost Ideal Demand System (LA/AIDS). Results suggest that price elasticities of demand are inelastic, with relatively high-valued species exhibiting greater elasticity than relatively low-valued species. Cross price elasticities are negative suggesting that different live reef fish species are complements. Live reef fish are found to be normal goods, with relatively high-valued species being less expenditure-elastic than relatively low-valued species. SARS is found to shift expenditure away from high-valued species to low-valued species. There is no evidence that Chinese New Year has a significant impact on demand. <P>

Keywords: LA/AIDS demand analysis, trade, live reef food fish

INTRODUCTION

The live reef food fish trade is based on the live transportation of fish caught on coral reefs to restaurants and quality supermarkets. The fish are kept alive until just prior to consumption to ensure their freshness (Lau and Parry Jones, 1999). They are generally high value-to-volume products, particularly in comparison to the fresh fish trade (Sadovy *et al.*, 2004), and can fetch prices up to five times that of freshly chilled reef fish (Gaiger, 1990).

Hong Kong is the locus of activity for the live reef food fish trade, being a major fish trading and import market (Johannes and Riepen, 1996). Approximately 60 percent of the international trade is exported to Hong Kong (Sadovy and Vincent, 2002), amounting to 15,000 to 20,000 tonnes each year at a value of US\$350 million (Muldoon and MacGilvray, 2004). Around 50 percent of Hong Kong's live reef fish are then shipped on to southern mainland China (Sadovy and Vincent, 2002). The main supplying countries include Australia, Malaysia, Indonesia, Philippines and Thailand, augmented by supply from as many as fifteen Asia-Pacific countries (ACFD, 2003).

Demand for live reef food fish can experience seasonality in response to events such as Chinese New Year and Mother's Day. At these times both wholesale and retail prices can be higher than usual for high-value fish and some medium-value species (Sadovy *et al.*, 2004). The preferred fish size for table consumption is approximately 600-1000g (Johannes and Riepen, 1996) with the highest prices achieved by fish 500-700g (Gaiger, 1990). Species may fetch higher prices due to their rarity. For example, both the Giant grouper and the Humphead wrasse are listed as vulnerable on the International Union for Conservation of Nature and Natural Resources (IUCN) Red List of Threatened Species and may sell for higher prices as a result (Lau and Parry Jones, 1999; Johnston, 2005).

The live reef food fish trade is susceptible to economic shocks, such as the recent Asian Economic Crisis. Despite the initial protection of Hong Kong's economy by the strong currency, rising unemployment and lowered economic activity had affected demand for reef fish by 1999 (Johnston, 2005). Lower value species were worst affected due to the low viability of collecting and transporting these species, particularly when faced with increasing supply costs (Johnston, 2005). The trade has failed to recover

since it declined by up to one third in 1999 as part of the impact of the Asian Economic Crisis (Sadovy *et al.*, 2004). The composition of trade has also changed in the wake of the Asian Economic Crisis. High-value species have experienced increasing demand 1,000 tonnes in 1998 to 2,500 tonnes in 2003 (Johnston, 2005). The import of lower valued species has decreased from 15,000 to 5,000 tonnes over the same time period (Johnston, 2005).

Demand for live reef fish has also been affected by Severe Acute Respiratory Syndrome (SARS), which was first identified in the Chinese province of Guandong in November 2002, and had reached Hong Kong by February 2003 (Pet-Soede *et al.*, 2004). The outbreak caused a short-term decrease in demand for live reef food fish due to the resulting decline in outdoor dining, tourism and air travel services (Pet-Soede *et al.*, 2004). By the end of June 2003, the World Health Organisation cleared Hong Kong from infection. Although SARS created a temporary downturn in consumer prices, there was a greater impact on the exporting countries (Sadovy *et al.*, 2004).

The purpose of this paper is to estimate demand functions for wholesale live reef fish prices in Hong Kong. The Linear Approximate Almost Ideal Demand System (LA/AIDS) is employed and time-series data from January 1999 to July 2003 was sourced from the International Marinelife Alliance (IMA). Quantity data was sourced from formal data collected by the Hong Kong Agriculture, Fisheries and Conservation Department (AFCD). Unfortunately, the IMA no longer collects this data, so analyses could not be extended to more recent times.

This analysis is part of a larger project on the economics and marketing of live reef food fish funded by the Australian Centre for International Agricultural Research (ACIAR). Results from this paper will be integrated with estimated supply functions (by species and country of origin) to analyse the impact of likely future changes in supply and demand (such as new technology, changing management practices and economic growth).

The paper proceeds as follows. The methodology of the study is presented in Section 2 along with a brief discussion of hypotheses on expected own-price, cross-price and income elasticities for live reef fish based on demand theory. The results are presented and discussed in Section 3 and conclusions are drawn in Section 4.

DEMAND THEORY AND ITS APPLICATION TO LIVE REEF FISH

Demand theory proposes that many factors contribute to the demand for a good, including price, consumer income, market size, relative prices of substitutes/complements, consumer preferences, and other special influences (such as special events) (Sloman and Norris, 2002). The effect of the price of the good, the price of substitute/complement goods and consumer income on quantity demanded can be determined and quantified by own-price, cross-price and income elasticities, respectively (Sections 2.1 to 2.3).

The first empirical demand studies estimated single equation demand functions that were linear in their parameters, of which the double log was the most common functional specification (e.g. DeVoretz (1982), Kabir and Ridler (1984), Bird (1986), Hermann and Lin (1988), DeVoretz and Salvanes (1993), Hermann *et al.* (1993)). The double log specification remains common today, however single equation models are generally not theoretically consistent as they do not take into account price changes of other goods which may subsequently affect the demand for the considered good. To account for this, a growing number of demand analyses are estimating a system of demand functions using the concept of weak separability. This concept assumes that a consumer separates their consumption into discrete groups, and

that the preferences for such groups can be described independently of each other. The demand function for each group of goods is then specified within a system of demand functions.

The AIDS (Almost Ideal Demand System) framework has become the most common functional form for specifying demand systems since it was devised by Deaton and Muellbauer (1980). It is based on using a system of budget share equations in order to estimate parameters and individual demand elasticities (Smith *et al.*, 1996). The Linear Approximate AIDS model (LA/AIDS) has been used previously in other seafood market analyses (Smith *et al.*, 1996; Johnson *et al.*, 1998) and will be adopted for this paper. It removes the non-linear component of the budget share equations by introducing the Stone's Price Index, P (Equation 2) (Smith *et al.*, 1996). This simplifies the estimation by reducing the number of parameters to be estimated, thereby improving the efficiency of the parameter estimates (Smith *et al.*, 1996). The LA/AIDS model can be expressed in the general form:

$$w_i = \alpha_i + \varphi_{it}t + \sum \varphi_{ij} \ln p_j + \beta_i \ln \left(\frac{e}{P} \right) + v_i \quad (1)$$

where α_i , φ_{it} , φ_{ij} and β_i are coefficients to be estimated econometrically, w_i is the share of total fish expenditure allocated to the i th fish species $\left(w_i = \frac{p_i q_i}{e} \right)$, t denotes a linear time trend (included to account for demographic changes), p_j is the price of the j th group of fish, e is the total expenditure on live reef fish and P is the Stone's Price Index calculated as:

$$\ln P = \sum_{i=1}^n w_i \ln p_i. \quad (2)$$

Income and market size does not need to be specified in the model, as e increases with these factors. The impact of seasonality (due to festival events) and the economic shock of SARS on demand will be tested through the introduction of dummy variables (a methodology adopted from Johnson *et al.* (1998)). The integration of a dummy variable requires the intercept to be respecified as:

$$\alpha_i = \gamma_i + \theta_i C + \omega_i S \quad (3)$$

where θ_i and ω_i are coefficients to be estimated econometrically, C is a dummy variable indicating the presence of a seasonal factor, in this case Chinese New Year, and S is a dummy variable indicating the presences of an economic shock, in this case, SARS. Hence, the dummy variables may be used as intercept shifters, and the price elasticities of demand may be allowed to vary as budget shares vary during the year.

To be consistent with demand theory, the following restrictions should be imposed on the model:

$$\sum_j \rho_{ij} = 0 \text{ (homogeneity)}$$

$$\rho_{ij} = \rho_{ji} \text{ (symmetry)}$$

$$\sum_i \alpha_i = 1 \text{ and } \sum_i \beta_i = \sum_i \rho_{ij} = 0 \text{ (the adding up conditions).}$$

Monthly price data was sourced from the IMA who conducted surveys of wholesale and retail outlets over the time period from January 1999 to July 2003. Wholesale prices were monitored monthly at wholesalers/distributors in Quarry Bay and Wanchai, and twice weekly from markets in Kwun Tong and Aberdeen. Quantity data was sourced from formal data collected by the Hong Kong Census and Statistics Department (CSD) and data provided voluntarily by traders to the Hong Kong Agriculture, Fisheries and Conservation Department (AFCD).¹

The following subsections review the literature and propose hypotheses regarding own-price, cross-price and income elasticities of demand for live reef fish.

Price elasticity of demand

Price elasticities of demand measure the responsiveness of quantity demanded to a change in price, and are specific to the product, market conditions and time period over which the analysis is done. To the author's knowledge, there has been no previous demand analysis of the live reef fish market. However, there are several trends that may be extrapolated from demand analysis of seafood in general (see Asche and Bjorndal (1999)). First, the demand for fish is elastic for most species. There are a few exceptions to this such as demand for canned tuna (e.g. Wallstrom and Wessells (1995)). Second, more valuable seafood generally exhibit more elastic demand. Third, retail demand, which is closer to the consumer, is generally more elastic than demand closer to the producer (such as ex-vessel demand), which may be attributable to the inelasticity of supply over the short term.

Applying these generalisations to the live reef fish trade, it is expected that the price elasticities of live reef fish price are high as most live reef fish are relatively highly priced compared with fresh fish. It is also expected that relatively high-value species exhibit greater elasticities than relatively low-value species. During festival events, such as Chinese New Year and Mother's Day, price elasticities may be less elastic.

¹ The reliability of this data is hindered as Hong Kong-licensed live-fish transport vessels are not required to declare imports by sea. This totals approximately 100 vessels. The voluntarily declaration of imports from these vessels to the AFCD is estimated to be underreported by half. This analysis uses both CSD data, which reflects imports by air, and AFCD data, which reflects transport by sea.

Cross-price elasticities of demand

Cross price elasticities measure the responsiveness of the demand for one good to a change in price of another. The closest substitutes tend to be similar species as well as similar product forms (eg. live, freshly chilled, frozen, canned). Substitution between seafood and other meats is considerably less than the substitution between seafood products (Sloman and Norris, 2002). Furthermore, there is little substitution between fish caught from the wild and those farmed for different species (Jaffry *et al.*, 2000), with some substitution for similar species (Asche *et al.*, 2001). It is expected that individual live reef fish species will be substitutes, especially species of similar value, and this substitutability is likely to be affected by seasonality.

Income elasticities of demand

Income elasticities measure the responsiveness of demand to a change in consumer incomes, and is affected by the time period over which they are measured (the shorter the time period the lower the income elasticity of demand) and the degree of necessity of the good (the more necessary the good, the lower the income elasticity of demand) (Sloman and Norris 2002). Most fish species exhibit positive elasticities and are termed 'normal goods', such that an increase in income will result in increased demand. Dey (2000) argue that live fish have a higher income elasticity compared to other presentations of seafood, and Gaiger (1990) notes that the consumption of live reef food fish in Hong Kong is dependent on income rather than price, and could be considered a luxury good (where the income elasticity is greater than 1).

It is expected that live reef fish are normal goods, with the relatively higher-valued species exhibiting higher income elasticities than the relatively lower-valued species. Moreover, it is expected that demand is susceptible to events that affect income, such as the recent Asian Economic Crisis (the data do not cover this time period so this will not be tested) and the SARS outbreak.

RESULTS AND DISCUSSION

Analysis of wholesale demand for live reef fish in Hong Kong is performed in two stages. First, the nine major live reef fish species are divided into two categories – high and low-valued species – according to Table 1. A demand system is estimated using these two species categories (Section 3.1). A second demand system is estimated on the two most traded species only, Leopard coral trout and Green grouper (Section 3.2). Leopard coral trout is a relatively high-value species that is largely sourced from wild-stocks (either as adults, or as juveniles and then cultured), where Green grouper is a relatively low-value species that is largely cultured (approximately 60 percent are cultured from hatchery-bred juveniles and 40 percent from wild-caught juveniles) (Mike Rimmer, pers comm.)².

The inclusion of dummy variables indicating Chinese New Year and Mothers' Day were not significant and reduced the significance of the overall models. They have therefore been omitted from the analyses.

² Mike Rimmer, Principal Fisheries Biologist, Queensland Department of Primary Industries, Australia

Also, for each regression the Durbin-Watson values were all significant indicating that the error terms are autocorrelated. Subsequent results should be viewed in the light of this.

Table 1: Average monthly quantity traded and weighted average wholesale price of key live reef fish species imported into Hong Kong (January 1999 to December 2003)

	Average monthly quantity traded (t)	Weighted average wholesale price (HK\$/kg)
Aggregate of all species	351	177
<i>High-value species</i>	195	264
- Highfin grouper	1	513
- Humphead wrasse	2	451
- Leopard coral trout	160	281
- Giant grouper	2	191
- Tiger grouper	8	184
- Spotted coral trout	7	177
- Flowery grouper	15	169
<i>Low-value species</i>	156	85
- Green grouper	126	92
- Mangrove snapper	30	53

Demand for live reef fish - aggregated into high and low-valued species

Results for the individual budget share equations (provided in Appendix Table A.1) are significant at the 5 percent level. Parameter estimates from Appendix Table A.1 are used to obtain price elasticities (Table 2) and expenditure elasticities (Table 3) of demand for each category of high and low-value species. All price and expenditure elasticities are significant at the 5 percent level.

The own-price elasticities of both the high and low-value categories (bolded in Table 2) are inelastic. The high-value own-price elasticity is larger than the low-value own-price elasticity in accordance with expectations. The cross-price elasticities are negative (against expectations) indicating they are complementary goods. For example, when the price of high-value species increases, the quantity demanded of low-value species also increases. While this is unexpected and may be due to data deficiencies, it may also indicate that a range of fish is consumed simultaneously. For example, quantities of high-value species may be complemented by the consumption of low-value species at the same meal, and vice versa.

Table 2: Price elasticities for high and low-value species^a

	Elasticity of demand for:	
	High-value species	Low-value species
With respect to the price of:		
High-value	-0.81** (16.08)	-0.12** (2.91)
Low-value	-0.82** (3.76)	-0.48** (2.72)

^a Own-price (in bold) and cross-price elasticities are calculated using the uncompensated elasticity formula:

$$\dot{E} = (\varphi_{ij} - \beta_i w_j) / w_i - \delta_{ij}, \text{ where } \delta_{ij} \text{ is the Kronecker delta which is equal to 1 where } i = j \text{ and zero otherwise.}$$

Values in parentheses are t-statistics. ** indicates significance at the 5 percent level.

The expenditure elasticities (Table 3) are positive indicating that they are normal goods – as expenditure on live reef fish increases, the consumption of live reef fish also increases (in keeping with expectations). The expenditure elasticity of low-value species is elastic, indicating that when expenditure on live reef fish increases, relatively more Green grouper will be purchased. Contrary to expectations, the expenditure elasticity of high-value species is inelastic (although, only slightly lower than unity), indicating that when expenditure on live reef fish increases, relatively less Leopard coral trout will be purchased.

Table 3: Live reef food fish expenditure elasticities for high and low-value species^a

High-value species	Low-value species
0.93** (25.48)	1.30** (8.26)

^a The uncompensated expenditure elasticity was calculated using the formula: $\dot{I} = 1 + \beta_i / w_i$. Values in parentheses are t-statistics, ** indicates significance at the 5 percent level.

A SARS dummy variable was introduced to analyse the impact of economic shocks on demand (Table 4). The results indicate that SARS caused expenditure shares to shift from high-value species to low-value species by approximately 7 percent.

Table 4: Parameter estimates for the SARS dummy variable, by value category

High-value species	Low-value species
-0.072** (3.88)	0.072** (3.87)

Note: Values in parentheses are t-statistics. ** indicates significance at the 5 percent level.

Demand for live reef fish - individual species

Results for the individual budget share equations for Leopard coral trout and Green grouper (provided in Appendix Table A.2) are significant at the 5 percent level. Parameter estimates from Appendix Table A.2 are used to obtain wholesale price elasticities (Table 5) and expenditure elasticities (Table 6) of demand for each species. In general, the individual species results follow the category results of the previous section.

The own-price elasticities are significant and inelastic. The Leopard coral trout own-price elasticity is higher than the Green grouper own-price elasticity in keeping with the expectation that the higher valued species would have a higher own-price elasticity. The cross-price elasticity of Leopard coral trout with respect to Green grouper is significant, negative (indicating that the two species are complements) and inelastic, although not greatly less than unity.

The expenditure elasticities shown in Table 6 are positive suggesting that both species are normal goods. The results suggest that Leopard coral trout is expenditure-inelastic (0.95) whereas Green grouper is expenditure-elastic (1.27). The expenditure-elastic nature of Green grouper suggests a relatively large sensitivity of demand to changes in expenditure, which is consistent with the findings of Hanson et al. (2001) for aquacultured catfish. On the otherhand, the expenditure-inelastic nature of Leopard coral trout

suggests a relatively small sensitivity of demand to expenditure, which was not expected given that Leopard coral trout is a higher-valued fish compared with Green grouper.

Table 5: Price elasticities for two species, Leopard coral trout and Green grouper^a

	Leopard coral trout	Green grouper
With respect to:		
Leopard coral trout	-0.83** (14.30)	-0.12** (2.74)
Green grouper	-0.92** (2.94)	-0.34 (1.44)

^a Own-price (in bold) and cross-price elasticities are calculated using the uncompensated elasticity formula:

$$\dot{E} = (\rho_{ij} - \beta_i w_j) / w_i - \delta_{ij}, \text{ where } \delta_{ij} \text{ is the Kronecker delta which is equal to 1 where } i = j \text{ and zero otherwise.}$$

Values in parentheses are t-statistics. ** indicates significance at the 5 percent level, * indicates significance at the 10 percent level.

Table 6: Live reef food fish expenditure elasticities for Leopard coral trout and Green grouper^a

Leopard coral trout	Green grouper
0.95** (26.66)	1.27** (6.56)

^a The uncompensated expenditure elasticity was calculated using the formula: $\dot{I} = 1 + \beta_i / w_i$. Values in parentheses are t-statistics, ** indicates significance at the 5 percent level.

Parameter estimates for the SARS dummy variable by species are shown in Table 7. The results indicate that SARS caused expenditure shares to shift from Leopard coral trout to Green grouper by approximately 10 percent.

Table 7: Parameter estimates for the SARS dummy variable, by species

Leopard coral trout	Green grouper
-0.10** (4.67)	0.10** (4.67)

Note: Values in parentheses are t-statistics. ** indicates significance at the 5 percent level, * indicates significance at the 10 percent level.

CONCLUSIONS

Wholesale demand systems for live reef food fish consumed in Hong Kong were estimated using the Linear Approximate Almost Ideal Demand System (LA/AIDS). Monthly time series data for January 1999 to July 2003 was obtained from the International Marinelife Alliance (for prices) and the Hong Kong Agriculture, Fisheries and Conservation Department (for quantities). The demand systems were estimated first for live reef fish aggregated by high and low-value, and second for the two most highly traded fish species; Leopard coral trout (relatively high-value and mostly wild caught) and Green grouper (relatively low-value and mostly cultured).

For both the aggregated and individual species results, the own-price elasticities are negative and inelastic, indicating that quantity demanded changes by a smaller percentage than price. The relatively high-valued species exhibit a higher own-price elasticity than the relatively low-valued species. The cross price elasticities are negative and inelastic, indicating that live reef fish species are generally

complements – high-value species are complemented by the consumption of low-value species at the same meal.

Live reef fish species were found to be normal goods. The results suggest that low-value species (including Green grouper) are expenditure-elastic, whereas high-value species (Leopard coral trout) are expenditure-inelastic.

When analysing the impact of SARS on demand for live reef fish, it was found to shift expenditure from high-value species to low-value species by 7 percent. When investigating the main live reef fish species from each of these value categories, this shift was estimated to be 10 percent. This may be the result of a decrease in patronage at restaurants where Leopard coral trout is largely purchased, and an increase in consumption of supermarket-purchased live reef fish where Green grouper is largely purchased. Chinese New Year was not found to have a significant impact on demand. This may be because income growth was low during the time period over which the data was collected. Chinese New Year may be found to have a significant impact during periods of strong economic growth.

Unreported results provide some evidence that retail demand for aggregated live reef fish is more elastic than wholesale demand, which is similar to the results of analysis of other seafood studies. However, in general, very little difference was found between results using wholesale and retail prices, indicating strong competition in these nodes of the market chain. This is supported by Petersen and Muldoon (2006) who found that wholesale and retail live reef fish prices in Hong Kong are not independent, but cointegrated as part of a system of live reef fish prices.

These results have a number of supply implications. Demand for live reef fish is relatively unresponsive to price compared with other fish products (most fish products are price elastic (Asche and Bjorndal 1999)). Hence, quantity supplied may be determined more by supply-side factors (such as availability of stock, and transport and transaction costs) than demand-side factors (such as price). Furthermore, consumers were found to substitute high-value species for low-value species during the SARS outbreak. Hence, while low-value species provide the lowest gross revenue per unit volume (net revenue minus supply and transaction costs) compared with high-value species, they may pose the lowest supply risk, at least when considering demand-related influences. These results should be considered with caution given the deficiency of data. Unfortunately, price data is no longer being collected and hence, prevents analysis for a longer time-period.

This analysis has been performed as part of a larger study on the economics and marketing of the live reef fish trade. Further research that will be conducted as part of this larger study includes estimation of supply curves from major importing countries, integration of supply and demand analysis collectively, and disaggregated by country of origin and species, and market chain analysis for major supplying country. Implications of mariculture developments on supply, demand and stock sustainability, and possible inefficiencies and market power along the supply chain will be investigated. The results will be used to inform policy recommendations aimed at poverty reduction for fishers in low-income countries, and sustainability of the live reef fisheries.

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APPENDIX

Table A.1: LA/AIDS parameter results for high and low-value species

	Dependent variable:	Dependent variable:
	$W_{\text{high-value species}}$	$W_{\text{low-value species}}$
Constant	1.32** (3.46)	-0.32 (0.84)
Ln(high price)	0.11** (3.27)	-0.11** (3.27)
Ln(low price)	-0.11** (3.27)	0.11** (3.27)
ln(e/P)	-0.06* (1.90)	0.06* (1.91)
Time	0.00** (5.31)	-0.00** (5.31)
Sars	-0.07** (3.88)	0.07** (3.87)
F-stat (p-value)	17.05** (0.00)	17.08** (0.00)
DW	0.98	0.98

Note: Values in parentheses are t-statistics except for the F-stat where numbers in parenthesis are p-values. ** indicates significance at the 5 percent level, * indicates significance at the 10 percent level.

Table A.2: LA/AIDS parameter results for Leopard coral trout and Green grouper

	Dependent variable:	Dependent variable:
	$W_{\text{Leopard coral trout}}$	$W_{\text{Green grouper}}$
Constant	1.12** (3.00)	-0.12 (-0.32)
Ln(LCT price)	0.11** (2.87)	-0.11** (2.87)
Ln(GG price)	-0.11** (2.87)	0.11** (2.87)
ln(e/P)	-0.04 (1.38)	0.04 (1.38)
Time	0.00** (4.90)	-0.00** (4.90)
Sars	-0.10** (4.67)	0.10** (4.67)
F-stat (p-value)	12.36** (0.00)	12.36** (0.00)
DW	1.14	1.14

Note: Values in parentheses are t-statistics except for the F-stat where numbers in parenthesis are p-values. ** indicates significance at the 5 percent level, * indicates significance at the 10 percent level.