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Noel Wai Wah Chan
Jeff Bennett
Brian Johnston

Crawford School of Economics and Government
THE AUSTRALIAN NATIONAL UNIVERSITY

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Consumer Demand for Sustainable Wild-caught and Cultured Live Reef Food Fish in Hong Kong

Noel Wai Wah Chan
Crawford School of Economic and Government
Australian National University

Jeff Bennett
Crawford School of Economic and Government
Australian National University

Brian Johnston
Crawford School of Economic and Government
Australian National University

Abstract

Live reef food fish (LRFF) is a popular dish in Hong Kong and the southern parts of China. The production of LRFF provides a valuable source of income for many coastal communities in Asia-Pacific countries. However, overexploitation and destructive fishing practices lead to questions about the sustainability of the LRFF trade. There are two ways of solving the problem. The first is managing the LRFF fishery in a sustainable way. Another is supplying LRFF from hatchery-based aquaculture. However, the acceptability of cultured LRFF and the premium that consumers are willing to pay for LRFF from sustainable sources are largely unknown.

This research applies a non-market valuation technique, discrete choice modelling, to estimate the willingness to pay (WTP) of Hong Kong consumers for sustainably sourced LRFF, and the difference in WTP between wild fish and cultured fish of four popular species: Humphead Wrasse (Ceilinus undulatus), Humpback Grouper (Cromiletus altivelis), Leopard Coralgrouper (Plectropomus leopardus) and Tiger Grouper (Epinephelus fuscoguttatus). The research results show that if Hong Kong consumers are provided with environmental information to guide their consumer choices, it is estimated that they would be willing to pay an average of HK$25.69 per tael for LRFF which come from a sustainable, rather than an unsustainable source of supply. Also, the premium that consumers are willing to pay for wild fish over cultured fish is estimated HK$12.76 per tael on average.

These results indicate that there is a potentially strong commercial incentive to source live reef fish from sustainable fisheries. Secondly, while there appears to be a strong consumer preference for wild-caught over aquaculture live reef fish, it is not known whether this preference difference is real or perceived. As consumers become more familiar with aquaculture product, the implied discount in price for aquaculture compared to wild-caught product may diminish. The limited consumer tasting research conducted to date indicates that the aquaculture product is likely to be highly acceptable (Chan 2006). Policies to engage consumers and restaurants in the acceptance of cultured LRFF as an alternative to wild-caught fish and the environmental issues associated with current LRFF production practices would be beneficial to the long term sustainability of the LRFF trade in the Asia-Pacific region.

Keywords

Choice modelling, live reef food fish, aquaculture, sustainabililty

Introduction

Live reef food fish (LRFF) is a popular dish in Hong Kong and the southern parts of China, particularly during special occasions such as wedding ceremonies, company celebrations and social dinners. Annual imports into Hong Kong have been estimated at approximately 22,000-28,000 tonnes (Graham 2001) to 30,000-35,000 tonnes (Lau and Parry-Jones 1999), and international trade in LRFF is estimated to be worth US$350 million per annum (Sadovy *et al.* 2003:4). This trade has become an important source for income to many coastal communities in the Asia-Pacific region.

However, the problems of over-exploitation and the application of destructive fishing methods have led to concerns regarding the sustainability of the trade. Cesar *et al.* (2000) suggest that a market transformation of the LRFF trade in Southeast Asia is needed to develop sustainable alternatives to cyanide-captured LRFF. Potential measures include the sustainable capture fisheries and the production of LRFF species using sustainable methods including hatchery-based aquaculture. These techniques have been developed over the last few decades and there are now a number of LRFF species that can be successfully raised from hatchery-based aquaculture production (Rimmer *et al.* 2005).

In order to provide fishers and aquaculture farmers with economic incentives to capture or produce LRFF in a sustainable way, it is important to understand the consumers' willingness to pay (WTP) for a sustainable source of LRFF over the traditional source of LRFF. Previous surveys (Chan 2000; WWF 2005; Mantel *et al.* 2006) have shown that if environmental information is provided, consumers in Hong Kong are willing to substitute an unsustainable source of LRFF with a sustainable alternative such as cultured fish. However, consumers prefer wild-caught fish over cultured fish (Chan 2000; WWF 2005). The extent of these off-setting consumer preferences is unknown due to a lack of market information. This paper seeks to redress this knowledge gap.

Since there is no market information available, a stated preference, non-market valuation method, discrete choice modelling (CM), is applied to investigate the strength of consumer preferences. The demands for four popular LRFF species, Humphead Wrasse (*Ceilinus undulatus*), Humpback Grouper (*Cromiletus altivelis*), Leopard Coralgrouper (*Plectropomus leopardus*) and Tiger Grouper (*Epinephelus fuscoguttatus*) are analysed. A sample of 343 restaurant consumers were interviewed in Hong Kong using CM. Specifically, the goal was to estimate the consumer WTP for wild-caught fish compared to cultured fish and the WTP for a sustainable source of supply of the four fish species relative to the status quo.

This paper is organised into seven sections. The following section provides background on the LRFF trade and the development of aquaculture production. The third section discusses the theoretical framework of non-market valuation and CM. The fourth section describes the CM design and survey implementation. The results and discussions of two multinomial logit (MNL) models and their policy implications to LRFF management follow. Some conclusions are drawn in the final section.

Background

Live reef food fish trade and environmental concerns

Between 1999 and 2002, the international LRFF trade was worth about US$350 million per year (Sadovy *et al.* 2003:4). Hong Kong accounts for 60 per cent of the LRFF trade with about half of that volume being re-exported to China (Sadovy *et al.* 2003:2; Muldoon *et al.* 2005:35). LRFF is popular amongst Chinese people not only due to its special flavour, but also because live fish represent fortune and blessings. Therefore, it is commonly served for special occasions such as wedding banquets and festival celebrations (Chan 2000).

As the economies of Hong Kong and southern China have grown over the last two decades, the demand for LRFF has risen substantially. The profitability of the LRFF trade has encouraged fishers to use destructive methods, such as the use of sodium cyanide to stun the fish. Such practices harm other marine organisms. Some fishers also target juvenile fish and spawning aggregations (Sadovy *et al.* 2003), and such practices also harm the sustainability of the LRFF population. Consequently, there have been signs of over-exploitation of the reef fish resource (Cesar *et al.* 2000:139). In particular, some LRFF species, such as Humphead Wrasse (*Cheilinus undulates*), are vulnerable to overfishing due to its slow growth and late maturity. The high demand for LRFF combined with the application of unsustainable fishing methods pose concerns for the sustainability of the trade.

To reduce the incentive for fishers to use destructive practices, Cesar *et al.* (2000:143) suggest supplying LRFF from sustainable sources. These include the sustainable wild capture of marketable size reef fish; full-cycle mariculture such as hatchery-based aquaculture production; and, a growing-out of sustainably captured wild fingerings. The goal is to ensure the sustainable use of marine resources and the conservation of coral reef habitats.

Aquaculture production

Aquaculture activities of LRFF can range from full-cycle aquaculture to short-term holding or feeding of reef fish to take advantage of market price fluctuations. Rimmer *et al.* (2005) describe the development of LRFF aquaculture in detail. Since 1999, the production of LRFF, mostly groupers (*Epinephelus* species), from aquaculture has expanded rapidly at an annual rate of 13 to 77 per cent. It is estimated that aquaculture supplies approximately 40 per cent of LRFF trade, mainly low to medium-valued grouper species. However, Sadovy *et al.* (2002) comments that the majority of grouper production relies on the growing-out of captured juvenile fish fed with by-catch. This creates pressure on wild LRFF stocks and other marine organisms. Therefore, the expansion of hatchery-based aquaculture and the use of pellets to replace by-catch to feed cultured fish is an important direction for sustainable aquaculture.

Non-market valuation and choice modelling

Non-market valuation techniques are usually applied to estimate the value of products or services that are not marketed. Valuing externalities such as the environmental impacts of an activity is one application (Habb and McConnell 2002). In the LRFF case, wild-caught and cultured fish of the same species are sold collectively in the same market. Unlike other products with labeled information on the package, comprehensive information, such as species of fish, countries of origin, wild or cultured produced and environmental information, are seldom available to consumers when they purchase LRFF. Since this information has not been reflected in existing markets, a stated preference (SP) method has been applied to estimate the consumer WTP for different LRFF product attributes.

There are two primary types of SP methods: contingent valuation method (CVM) and choice modelling (CM). Both methods involve asking survey respondents their WTP for a hypothetical change situation compared to a 'status quo'. Over the last decade, CVM has been widely applied to environmental valuation. However, CVM is limited, primarily because it can focus on changes in only one product attribute at a time (Bennett and Adamowiz 2001). CM, also known as choice experiments, has become a preferred method on non-market valuation because it involves variations in multiple attributes (Morrison *et al.* 1996). A CM question does not directly ask respondents of their WTP for a change of attribute, characteristic or situation. Rather, it involves asking survey respondents to reveal their preferences by choosing between different proposed 'alternatives', which are combinations of different attribute levels, compared with the 'status quo' situation. The results can be used to assess the trade-offs between different attributes, including monetary attributes (Bennett and Blamey 2001:9; Blamey and Bennett 2001).

The basis of non-market valuation is welfare economic theory, specifically Lancaster's characteristic demand theory (LCDT) and random utility theory (RUT).

The basis of non-market valuation is the estimation of individual welfare or utility, in monetary terms, given a change of situation. In a rational choice decision, individuals maximise their utility in their choice or preference subject to their budget constraints. For example, if there is an improvement of environmental quality, the individual is better off. The amount of money that an individual is WTP to achieve the better off situation compared to the 'status quo' indicates the associated increase in well-being or utility (Grafton *et al.* 2003:230-240).

Traditional demand theory provides an analysis of individual preferences for goods chosen under different relative prices (Nicholson 2000:66-89). However, an individual may prefer one fish over another simply because he/she prefers the colour or size of the fish. Lancaster (1971, 1991) suggests that a good or product can be disaggregated as a bundle of characteristics or attributes. A consumer who chooses across alternative goods, thus, considers a bundle of attributes subject to his/her budget constraint. Therefore, we can express the utility function of a good as:

$$\text{Max } U(a_1, a_2, ..., a_n) \text{ subject to } Y = p_1 x_1 + p_2 x_2 + ...p_j x_j \text{ and } a_i = f(x_j)$$

where U is the utility of individual, $a_1, a_2, ..., a_n$ are nth goods attributes, Y is the disposable income, p_j is the prices of j goods, and x_j is the amount consumed of j goods.

CM is based on RUT. In a utility function of an individual i, U_i, there are two components, an indirect utility V_i and an error componant ε_i ($U_i = V_i(a_{xn}, s_i) + \varepsilon_i$). Indirect utility is the component, which is systematic and deterministic, and can be observed by the researcher. It is determined by the utility of good x's attributes $a_1, a_2, ..., a_n$ as well as the consumer's individual socio-economic characteristics s_i. The error component is unobserved by the researcher and may be due to omitted variables or measurement errors (Adamowicz *et al.* 1998:9). In a multinomial logit (MNL) model of utility, the random error component is assumed to be independently and identically distributed (IID). Thus, a consumer choosing fish f over a set of m alternative fish j, has a probability distribution described by (Greene 2002a; 2002b; 2003):

$$\text{Prob[choice fish } f] = \Pr[U_{if} > U_{ij}] = \Pr[(V_{if} + \varepsilon_{if}) > (V_{ij} + \varepsilon_{ij})], \quad \forall\ f \in J$$

$$\text{Prob[choice fish } f] = \frac{\exp(\boldsymbol{\beta}'_{xf}\mathbf{x}_f + \boldsymbol{\beta}'_{sf}\mathbf{s}_i)}{\sum_{m=1}^{J}\exp(\boldsymbol{\beta}'_{xj}\mathbf{x}_j + \boldsymbol{\beta}'_{sj}\mathbf{s}_i)}, \quad m = 0, ..., J$$

Under the above assumption, the probability distribution between any two alternatives will not be affected by the presence or omission of another alternative, which is known as independent and irrelevant alternatives (IIA) (Greene 2002a; 2002b; Hensher *et al.* 2005).

Application

The main steps of a CM are the selection of attributes and levels, experimental design, questionnaire design, and survey design and implementation.

Attribute selection

The attributes selected should be related to the policy concerns, as well as being meaningful to the respondents (Bennett and Adamowicz 2001). After consultation with fishery scientists and through an internet preliminary survey with Hong Kong consumers, four attributes were selected for this CM application: fish species, wild-caught or cultured source, environmental impact and price. Details of the attributes, levels, and their interpretations are provided in Table 1.

Table 1: Attribute information sheet

Attribute	Level
Species	 Humpback Grouper (*Cromiletus altivelis*)  Leopard Coralgrouper (*Plectropomus leopardus*)  Tiger Grouper (*Epinephelus fuscoguttatus*)  Humphead Wrasse (*Ceilinus undulatus*) Humphead Wrasse is an endangered species because it is vulnerable to overfishing, slow growth and late maturation.
Sources	***Wild:*** - Wild LRFF are caught from coral reef and then transported to Hong Kong ***Cultured:*** - Cultured LRFF are reef fish reared in fish farm in any time of its life cycle
Environmental impact	***(Environmentally friendly) Sustainable fishing or cultured method:*** - Sustainable fishing or cultured methods will not have negative impacts to future long term supply of LRFF. For example, using hook-and-line is environmentally captured method while hatchery-based aquaculture is environmentally cultured method. ***(Non-environmentally friendly) Unsustainable fishing or cultured method:*** - Unsustainable fishing or cultured method will lead to overfishing or damage to marine habitat and affect the long term supply of LRFF. For example, cyanide fishing, targeting spawning aggregation, targeting juvenile fish are unsustainable method.
Price	***Price in Hong Kong dollar per tael*** Price range for Humphead Wrasse (HK$17, 25, 33, 42) Price range for Humpback Grouper (HK$18, 26, 33, 41) Price range for Leopard Coral Grouper (HK$9, 14, 18, 23) Price range for Tiger Grouper (HK$10, 12, 14, 17)

Note: 1 US$ = 7.8 HK$, 1 tael = 37.5 g, 1kg = 26.5 taels

Four LRFF species were selected. Humphead Wrasse (*Ceilinus undulatus*) (HHW), Humpback Grouper (*Cromiletus altivelis*) (HBG), Leopard Coralgrouper (*Plectropomus leopardus*) (LCG) and Tiger Grouper (*Epinephelus fuscoguttatus*) (TG). HHW and HBG are very high-value species while LCG and TG are medium to high-value species. HHW is an 'endangered' species and is listed in CITIES Appendix II (Baillie and Groombridge 1996; ICUN 2005) but its juveniles are still commonly sold in retail stores or restaurants. HBG is becoming popular and hatchery-based aquaculture production is emerging in Indonesia (Rimmer *et al.* 2005). LCG is the most popular species. Because its red colour symbolises fortune, it is commonly served in wedding banquets and celebrations. TG is the third most popular species after Green Grouper (*Epinephelus coioides*) (GG). There are increasing supplies of aquaculture-produced of TG. GG was not included in this CM design for two reasons.

First, it is a low-valued species and 90 per cent of it is produced from aquaculture (Sadovy *et al.* 2003). Second, malachite green, a carcinogenic chemical, was reported in cultured GG in September, 2005 (FEHD 2005). It was excluded from the survey because of possible consumer bias against the species.

Experimental design

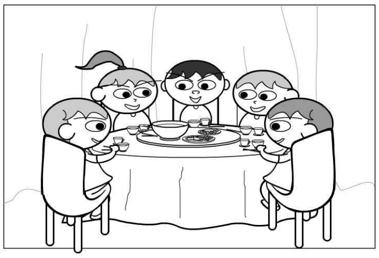
In CM, an experimental design is used to formulate a combination of the levels taken by the different attributes to form different choice sets for testing the hypothesis of interest (Louviere *et al.* 2000:84). This CM used a design with the four LRFF species set as labelled options. There are four choice alternatives, with two two-levelled attributes (source and environmental impacts) and one four-levelled attribute (price). The complete factorial of combinations is $L^{MA} = 4^{4\times 2} = 65536$. A 'main effect' orthogonal design is applied to ensure there is an efficient estimation of the parameters in a linear model (Louviere *et al.* 2000:94) with no multicollinearity between attribute levels. Using the statistical software package SPSS, an orthogonal design involving 32 choice sets as generated. The choice sets were randomly sorted into eight blocks so that each questionnaire had four choice sets.

Questionnaire design

The questionnaire for the CM survey (written in Cantonese) involved four sections. The first section included questions asking respondents about their LRFF consumption behaviour. The second section included a framing statement, presented as a comic (Figure 2), to introduce a hypothetical situation of purchasing LRFF in a restaurant. Respondents were reminded to read the attribute descriptions before proceeding to answer the four choice set questions in the next section. To add realism, consumers could choose not to purchase any fish for dinner if they did not like any of the four fish alternatives in the choice set (Figure 3). We assume that it is possible to have LRFF supplied from sustainable captured fishery (wild and sustainable) or unsustainable aquaculture production (cultured and unsustainable) as explained in the information sheet (Table 1). The last section involved question on the socio-demographics of respondents.

Figure 2: Framing statement

Suppose you and your family is about to have dinner in a Chinese seafood restaurant to celebrate a birthday or Chinese festival.



You are about to order a reef fish as one of the main dishes.

Suppose the restaurant only provides 4 kinds of fish, weighted between 0.5 catty to 3 catties*. Which one will you choose for dinner?

We would like to understand your choice in more detail. Each fish will be described in 4 attributes: species, source, sustainable (environmentally friendly) and price. Details of the attributes can be found in the information in the inner front cover. Please read carefully before answering the following questions (Q6 - Q9).

The information about source and sustainability is not usually provided. Some species do not even have cultured fish provided yet. However, we assume aquaculture technology will be improved and environmental labelling will be provided in the future. When you make a choice, please also consider your income and expenditure.

Note: translated from Cantonese.

*1Catty=604.79 grams

Figure 3: Sample choice set

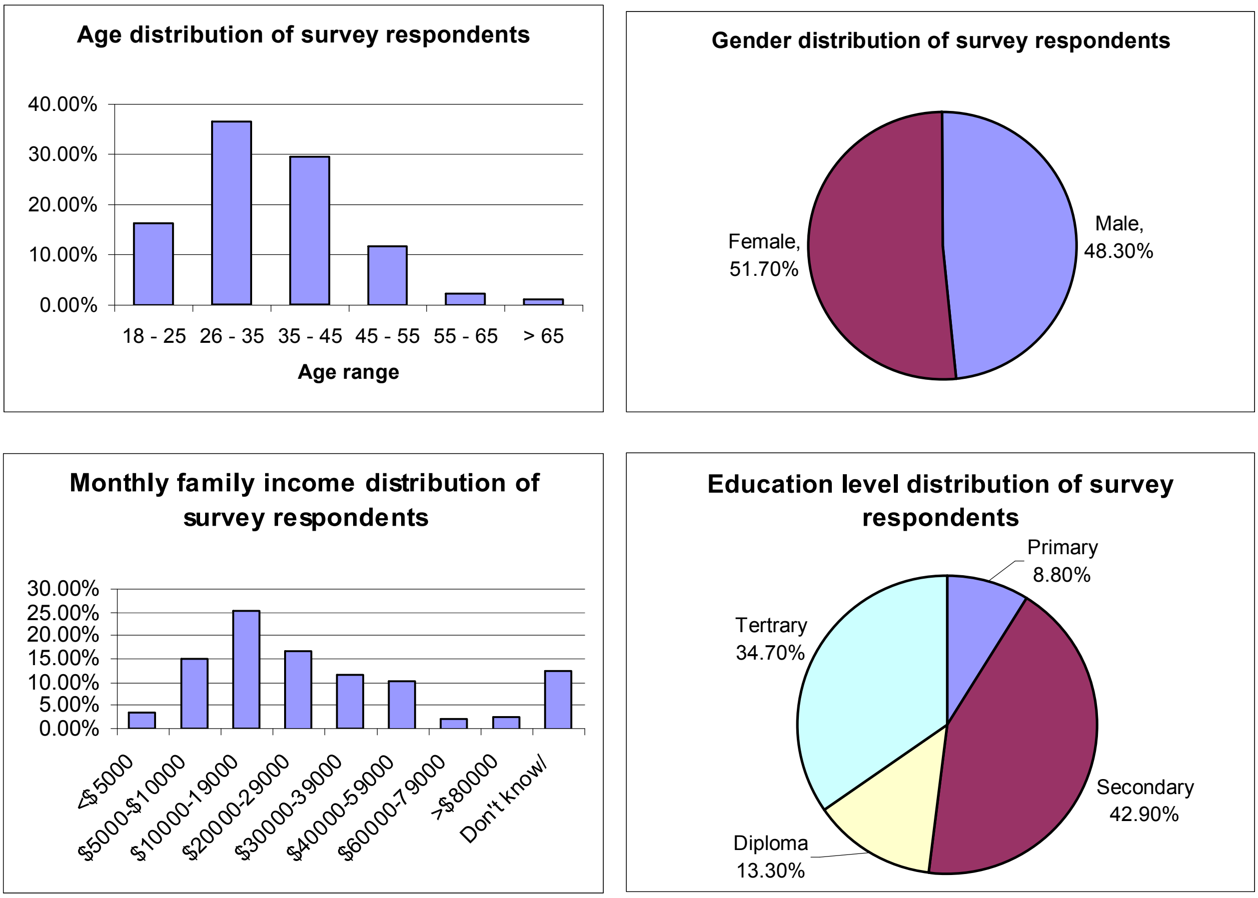
Of the following four fish, which ONE will you choose, or would you decide not to order any fish for dinner?

A2	Humphead Wrasse	Humpback Grouper	Leopard Coral Trout	Tiger Grouper	No fish
Reef fish species					I won't choose any fish for dinner
Souce	Cultured	Wild	Cultured	Cultured	
Sustainable fish/cultured method	sustainable	non-sustainable	sustainable	non-sustainable	
Price (per tael)	HK$28	HK$35	HK$17	HK$12	
I will choose	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

Survey design and implementation

The target respondents for this CM survey were LRFF consumers in Hong Kong restaurants. In September 2005, about 650 Chinese seafood restaurants were registered in the Yellow Pages telephone directory. Eleven restaurants were randomly selected to participate in the survey. Consumers over 18 years old were invited by the restaurant managers or the researcher to take part in the survey during December 2005 to January 2006. Respondents answered the questionnaire without assistance. In all, 343 completed questionnaires were collected. The socio-demographic statistics of the survey respondents are shown in Figure 4.

Figure 4. Socio-demographic statistics of survey respondents.



Results

Multinomial-logit (MNL) model estimation

In this CM application, a respondent can choose one of the four LRFF species in the choice sets or they can choice not to purchase any fish for dinner ("choose no fish option"). It is assumed that the 'choose no fish' option is the 'status quo' and is assigned a zero utilty in the indirect utility function. The indirect utility function for the four LRFF is assumed additive:

$$U(\text{FISH}_j) = ASC_j + \sum \beta_j a_j + \sum \gamma_i ASC_j \times s_i$$

$$U(\text{NONE}) = 0$$

Since a labelled option design was used, the alternative-specific constant (ASCs) in each indirect utility function represents the difference between the utility of choosing a specific fish species alternative and that of the base case (choosing no fish option). Therefore, each indirect utility function indicates the marginal utility of choosing that particular species of LRFF relative to not purchasing any fish for dinner. Table 2 shows the codes used for each attribute level and socio-demographic characteristic (Si) for the MNL model estimation. Models were estimated using LIMDEP and missing Si data were replaced by the means of the characteristics of overall sampled respondents.

Model 1: generic attribute and Si parameters. The first MNL model is estimated with generic attributes and Si parameters. All the parameters for the four utility functions are the same except the ASCs. Socio-demographic characteristics parameters are interacted with the ASCs of each utility function. The estimated MNL model is set out in Table 3.

The coefficients of the attribute parameters are all significant at the one per cent level and their signs are consistent with expectations. The *price* is negative, *wild* and *env* are positive. These indicate that, if the price of fish increases, the probability of choosing the fish decreases; if the fish is known to be wild-caught, the probability of choosing this fish is higher than choosing a cultured fish; if the fish is known to come from a sustainable source, the probability of choosing this fish is higher than choosing a fish come from unsustainable source.

Table 2: Coding of attribute levels and SDCs in model estimation

Attribute	Variable name	Level	Effect Code
Species		Humphead Wrasse (HHW)	1 if HHW, 0 otherwise
		Humpback Grouper (HBG)	1 if HBG, 0 otherwise
		Leopard Coral Grouper (LCG)	1 if LCG, 0 otherwise
		Tiger Grouper (TG)	1 if TG, 0 otherwise
		No fish (None)	0
Source	*Wild*	Wild-caught	1 if wild,
		Cultured	0 if cultured
Environmental concern	*Env*	Sustainable source	1 if sustainable,
		Non-sustainable source	0 if non-sustainable
Price (HK$ per tael)	*Price*	Price range of HHW	17, 25, 33, 42
		Price range of HBG	18, 26, 33, 41
		Price range of LCG	9, 14, 18, 23
		Price range of TG	10, 12, 14, 17

Socio-demographic characteristics	Variable name	
Have eaten that species before	*Eatbf*	
Estimated annual frequency of consuming LRFF	*Freq*	
The usual number of family members to celebrate festival dinner in Chinese restaurant	*tab*	
Age (mean of age range chosen)	*Age*	
Sex	*sex*	1 if male, 0 if female
Have children or not	*Child*	1 if have children, 0 otherwise
Highest education level attained (Primary, Secondary, Diploma, Teritiary)	*Prim, sec, dip, ter*	1 if dummy variable, 0 otherwise
Annual family income (HK$'0,000, mean of income range chosen)	*inc*	

The coefficients of the Si coefficients are all significant at the five per cent level and are signed as expected *a priori*. The signs of *freq, eatbf, tab* and *sex* are positive but negative for *ter*. These imply that the more often the respondent eats LRFF, the higher the probability of choosing the LRFF for their dinner; if the respondent states that they have eaten that particular fish species before, the higher the probability of choosing that particular fish species; the larger the family size (family members sharing the meals in restaurant), the higher the probability of ordering LRFF for restaurant dinner; a male respondent has a higher probability of choosing LRFF for dinner than a female; and finally, a respondent with a tertiary education has a lower probability of choosing LRFF.

Table 3: Estimation and comparison of choice models.

	Model 1		Model 2*g*	
	Coeff.	**Std.Err.**	**Coeff.**	**Std.Err.**
ASChhw	-1.318	0.279*	-1.392	0.275*
ASChbg	-1.339	0.282*	-1.248	0.272*
ASClcg	-0.753	0.240*	-0.971	0.234*
ASCtg	-1.293	0.237*	-1.594	0.312*
price_all	-0.031	0.006*	-0.031	0.006*
wild_all	0.395	0.072*		
env_all	0.796	0.075*		
wild_hhw			0.385	0.173**
wild_hbg			0.468	0.177*
wild_lcg			0.281	0.120**
wild_tg			0.509	0.143*
env_hhw			1.064	0.185*
env_hbg			0.530	0.177*
env_lcg			0.711	0.120*
env_tg			0.924	0.146*
freq_all	0.107	0.017*	0.108	0.017*
eatbf_all	0.598	0.085*	0.579	0.086*
tab_all	0.036	0.018**		
sex_all	0.356	0.162**		
ter_all	-0.290	0.162***		
inc (hhw, hbg, lcg)			0.111	0.037*
sec (hbg, lcg)			0.315	0.122**
tab (lcg)			0.032	0.013**
age (tg)			0.015	0.007**
No. of observations	1304		1304	
Log likelihood	-1792.71		-1783.56	
McFadden R-square	0.08904		0.09369	
No. of parameters	12		19	
Likelihood ratio	18.292			
Degree of freedom	7			
Critical value of chi-square	14.06			
Conclusion: Model 2 is better				

*: coefficient significant at the 1 per cent level, **: coefficient significant at the 5 per cent level
***: coefficient significant at the 10 per cent level

Model 2: Alternative-specific attribute but generic Si parameters. The second MNL model is estimated initially without restricting any parameters apart from *price* to be the same across the four utility functions. The reason for restricting the *price* coefficient is that we expect the utility of one dollar to be the same for any situation.

Parameters which are insignificant at the 10 per cent level are dropped from the model in sequence. The alternative-specific model (Model 2*a*) is presented in Table 4.

Table 4: MNL model estimation of Model 2a

	U(HHW)		U(HBG)		U(LCG)		U(TG)	
	Coeff.	Std.Err.	Coeff.	Std.Err.	Coeff.	Std.Err.	Coeff.	Std.Err.
ASC	-1.553	0.306*	-1.548	0.323*	-0.935	0.248*	-1.672	0.317*
price	-0.031	0.006*	-0.031	0.006*	-0.031	0.006*	-0.031	0.006*
wild	0.357	0.175**	0.457	0.179**	0.284	0.120**	0.524	0.144*
env	1.060	0.186*	0.532	0.178*	0.709	0.120*	0.932	0.146*
freq	0.104	0.017*	0.107	0.017*	0.106	0.017*	0.108	0.017*
eatbf	0.575	0.180*	0.878	0.182*	0.463	0.133*	0.533	0.148*
tab					0.034	0.013*		
sex	0.320	0.184***			0.230	0.128***		
inc	0.188	0.053*	0.132	0.058**	0.098	0.043**		
age							0.017	0.007**
sec			0.593	0.197*	0.257	0.138***		
ter	-0.393	0.200**						

Log likelihood function = -1774.7
Number of observations = 1304
McFadden R-square = .098
No. of parameters = 31

*: coefficient significant at the 1 per cent level, **: coefficient significant at the 5 per cent level
***: coefficient significant at the 10 per cent level

The above model has 31 parameters. A good model should be parsimonious having as few parameters as possible to capture any desired features (Wooldridge 2006:210, 867). In order to develop a model which economises on parameters, a likelihood ratio (LR) test was used to compare whether the SDC parameters of the above model should be restricted to be the same. The LR test $[2\times(LL_{\text{larger model}} - LL_{\text{smaller model}})]$ is to compare the log likelihoods of two models to the chi-squared critical value with the degree of freedom equals to the number of restrictions. The null hypothesis is that the unrestricted (larger) model is no better than the restricted (smaller) model. If the LR is greater than the five per cent chi-squared critical value, the null hypothesis is rejected. Table 5 shows the LR tests results of different intermediate models after restricting certain parameters or dropping certain statistically insignificant variables.

Table 5: Comparison of intermediate models by LR test

Null hypothesis: The larger model (with more parameters) is not better than the smaller model in improving the log likelihood

Model	change of model	# of parameters	Log likelihood	d.f.	Likelihood ratio	χ^2	Reject null ?
2a		31	-1774.73				
2b	restricting *freq* parameters	28	-1775.80	3	2.14	7.81	no
2c	dropping insignificant *sex* parameter in U(hhw)	26	-1777.86	2	4.13	5.99	no
2d	restricting *eatbf* parameters	23	-1779.66	3	3.60	7.81	no
2e	restricting *inc* parameters	21	-1781.25	2	3.16	5.99	no
2f	restricting *sec* parameters	20	-1782.22	1	1.95	3.84	no
2g	dropping insignificant *ter* parameter in U(hhw)	19	-1783.56	1	2.68	3.84	no
Comparing model 2a and Model 2g				12	17.66	21.03	No

Model 2*g,* which has 19 parameters, includes all the Si parameters being restricted to be the same across alternatives, is shown in Table 3.

In Model 2*g*, the coefficients of all the attribute parameters (*price*, *wild*, *env*) are significant at the five per cent level and signs are consistent with expectations. The interpretation is the same as the previous model. However, there are differences in the interpretation of individual Si parameters among the four fish utility functions. Only variables *freq* and *eatbf* are positive and significant in the four fish utility functions. Monthly household income (*inc*) is significant and positive in choosing all fish except Tiger Grouper. Respondents with a secondary school education (*sec*) have a higher probability of choosing Humpback Grouper and Leopard Coral Grouper than respondents with a primary, diploma or tertiary education. Moreover, the larger the family size or number of family members sharing a meal in a restaurant (*tab*), the higher the probability of choosing Leopard Coral Grouper. On the other hand, the older a respondent (*age*), the higher the probability of choosing Tiger Grouper.

Comparison between Model 1 and Model 2*g*. Table 3 shows the comparison of the significant parameters and their coefficients between Model 1 (generic model) and Model 2*g* (alternative specific - AS - model). The signs of significant parameters are consistent in both models. The *price* coefficient (-0.031) and its standard error (0.006) are the same for both models. The *wild* coefficient is 0.395 for the generic model, while it ranges from 0.281 to 0.509 in the AS model. The impact of the *wild* coefficient is greatest for Tiger Grouper and smallest for Leopard Coral Grouper. Similarly, the *env* coefficient is 0.796 in the generic model, and it ranges from 0.530 to 1.064 in the AS model. For the Si parameters, the coefficients for *freq* and *eatbf* are similar in both models. The *sex* and *ter* parameters are significant in the generic model but not in the AS model; while the *inc*, *se* and *age* is significant in choosing certain fish in the AS model but they are absent in the generic model.

The two models are compared with the application of a LR test. The LR is 18.292 [$2\times(-1783.56-(-1792.71))$]. The critical value of chi-square with 7 degrees of freedom and 5 per cent level is 14.06. The LR is greater than the chi-square critical value and so the null hypothesis is rejected. This indicates that Model 2g, with its more flexible Si parameters, is better at explaining the LRFF choice probability of respondents.

Implicit prices

The implicit prices of attributes can be calculated using the formula.

$$\text{Implicit price} = -\frac{\beta_{\text{attribute}}}{\beta_{price}}$$

In the generic model (Model 1), the calculated implicit price of the *wild* attribute is HK$12.76 per tael (US$43.28 per kg) and that of the *env* attribute is HK$25.69 per tael (US$87.12 per kg). These imply that, for a LRFF known to be wild-caught, the WTP is HK$12.76 per tael higher than that for a fish known to come from aquaculture. Similarly, for a LRFF known to come from a sustainable captured or cultured method, the WTP is HK$25.69 per tael higher than that for a LRFF known to come from an unsustainable captured or cultured method.

Table 6: Calculated implicit prices

		HK$ per tael	HK$ per kg	US$ per kg	relative to market price
Model 1					
	wild	12.76	337.57	43.28	57.7%
	env	25.69	679.55	87.12	120.8%
Average price in 2002 = HK$22.1 / tael = US$75.1 / kg					
Model 2g					
HHW	wild	12.38	327.63	42.00	42.1%
	env	34.26	906.44	116.21	116.5%
Average price in 2002 = HK$29.4 / tael = US$99.9 / kg					
HBG	wild	15.06	398.54	51.10	51.1%
	env	17.07	451.47	57.88	57.9%
Average price in 2002 = HK$29.5 / tael = US$100.2 / kg					

LCG	wild	9.05	239.39	30.69	56.2%
	env	22.90	605.77	77.66	142.2%
Average price in 2002 = HK$16.1 / tael = US$54.7 /kg					
TG	wild	16.40	433.83	55.62	123.3%
	env	29.75	787.06	100.90	223.7%
Average price in 2002 = HK$13.3 / tael = US$45.2 / kg					
Note:		1 kg = 26.5 tael;		1 US$ = 7.8 HK$	

In the AS model (Model 2g), the calculated implicit prices of *wild* and *env* attributes are different for different LRFF species. The implicit price difference between the wild fish and cultured fish is lowest for Leopard Coral Grouper (HK$9.05 per tael or US$30.69 per kg) and highest for Tiger Grouper (HK$16.40 per tael or US$55.62 per kg); while that of Humphead Wrasse and Humpback Grouper are HK$12.38 per tael (US$42 per kg) and HK$15.06 per tael (US$51.1 per kg) respectively. However, the implicit price difference between the sustainable source and unsustainable source of fish supply information is highest for Humphead Wrasse (HK$34.26 per tael or US$116.21 per kg) and lowest for Humpback Grouper (HK$17.07 per tael or US$57.88 per kg); while that of Leopard Coral Grouper and Tiger Grouper are HK$22.90 per tael (US$77.66 per kg) and HK$29.75 per tael (US$100.9 per kg) respectively.

Discussion

After calculating the implicit prices of the *wild* and *env* attributes, we can further compare the consumer WTP for LRFF from difference sources. Table 7 presents four different cases.

Table 7: Difference in consumer WTP for LRFF coming from different sources

Case 1:		Price (wild, sustainable) - Price (cultured, sustainable)			
	OR	Price (wild, unsustainable) - Price (cultured, unsustainable)			
		HK$ per tael	HK$ per kg	US$ per kg	Relative to market price
Model 2g	HHW	12.38	327.63	42.00	42%
	HBG	15.06	398.54	51.10	51%
	LCG	9.05	239.39	30.69	56%
	TG	16.40	433.83	55.62	123%
Model 1	Average LRFF	12.76	337.57	43.28	58%
Case 2:		Price (sustainable, wild) - Price (unsustainable, wild)			
	OR	Price (sustainable, cultured) - Price (unsustainable, cultured)			
		HK$ per tael	HK$ per kg	US$ per kg	
Model 2g	HHW	34.26	906.44	116.21	117%

	HBG	17.07	451.47	57.88	58%
	LCG	22.90	605.77	77.66	142%
	TG	29.75	787.06	100.90	224%
Model 1	Average LRFF	25.69	679.55	87.12	116%

Case 3:		Price (sustainable, cultured) - Price (unsustainable, wild)			
		HK$ per tael	HK$ per kg	US$ per kg	
Model 2g	HHW	21.88	578.80	74.21	74%
	HBG	2.00	52.93	6.79	7%
	LCG	13.85	366.38	46.97	86%
	TG	13.35	353.23	45.29	100%
Model 1	Average LRFF	12.93	341.98	43.84	58%

Case 4:		Price (sustainable, wild) - Price (unsustainable, cultured)			
		HK$ per tael	HK$ per kg	US$ per kg	
Model 2g	HHW	46.65	1234.07	158.21	159%
	HBG	32.13	850.02	108.98	109%
	LCG	31.95	845.15	108.35	198%
	TG	46.15	1220.89	156.52	347%
Model 1	Average LRFF	38.45	1017.12	130.40	174%

The findings provide information on incentives for the development of a sustainable LRFF industry. First, the consumer WTP for environmentally friendly (sustainable) labeled fish is on average HK$12.76 per tael higher than an environmentally harmful (unusustainable) fish of the same species and from the same wild or cultured source. Second, the difference in WTP for environmentally friendly fish is higher than the difference in WTP for wild and cultured fish (case 3). This indicates a potential economic incentive for LRFF stakeholders to develop eco-labelling in both the wild and cultured sectors.

Development of certification or eco-labelling.

One of the limitations of this research is that consumers are assumed to have full information about the sources of the LRFF they purchase. This rarely is the case in real life.

The research results indicate that on average, Hong Kong people are WTP HK$25.69 per tael more for LRFF that comes from sustainable rather than unsustainable sources of supply. One method to provide information on supply source to customers in order for producers to be able to capture some of this WTP as a return to investing in sustainable practices is through certification or an eco-labelling scheme.

Eco-labelling or certification is not new in international traded seafood products. Dolphin-free tuna, turtle-free shrimp, and numerous fishery products certified by the Marine Stewardship Council (MSC) (Gardiner and Viswanathan 2004) are examples. In addition to captured fisheries, certification and labeling schemes are growing in importance in the marine aquarium trade and in aquaculture. One successful case is the certification of ornamental fish, invertebrates and corals by Marine Aquarium Council (MAC) (Alencastro *et al.* 2005). The MAC certification covers the chain of supply, ranging from the ornamental companies in the US, Europe and Japan as well as the collection areas in developing countries such as the Philippines, Indonesia and Fiji (Gardiner and Viswanathan 2004:23-24). In the aquaculture sector, there are also examples of certification of shrimp and salmon production (Gardiner and Viswanathan 2004:25-26).

Recently, both importing and exporting countries have shown concern about the sustainability of the LRFF trade. In 2004, an International Standard for the Trade in Live Reef Food Fish (Anon 2004) was developed. This aimed to promote best practices in the captured and the cultured LRFF industries. Whilst it is difficult to implement certification on small-scale community fisheries, such as LRFF fisheries, relative to large-scaled fisheries, such as tuna and salmon fisheries (Gardiner and Viswanathan 2004:14-15), Muldoon and Scott (2005) comment that a certification program to implement the International Standard might be both possible and an important step towards the sustainable management of the LRFF trade and coral reef ecosystem.

Certification in the wild LRFF fishery sector.

Wild fish is favoured over cultured fish. Consumers are WTP more, averaging HK$12.76 per tael, for a wild-caught LRFF over a cultured LRFF (Table 7: case 1). Although there are costs of compliance in a certification program, the WTP, averaging HK$25.69 per tael, for sustainable source LRFF (Table 7: case 2), shows a positive incentive to develop certification system in the wild LRFF industry.

Australia is the fourth largest supplier of captured LRFF, and the largest supplier of Leopard Coral Grouper (Sadovy *et al.* 2003:27). Muldoon and Scott (2005) suggest that Australia should find it relatively easy and economically viable to comply with the requirements of the certification of wild LRFF industry. At present, most of the Leopard Coral Grouper depends on wild captured fishery supply. The results reported here show that consumer's WTP for sustainable sourced wild Leopard Coral Grouper is HK$22.90 per tael compared to an unsustainable source of supply, such as using cyanide fishing in certain parts of the Philippines and Indonesia. Therefore, Leopard Coral Grouper supplied from Australia could be the first trial of a certification scheme.

Certification in the cultured LRFF sector.

An increasing proportion of LRFF is supplied from aquaculture sources. Until recently, most of the grouper aquaculture production relied on the nurturing of captured juvenile fish that are fed with low value or bycatch fish (Sadovy *et al.* 2003:98). However, with technology improvement, an increasing number of LRFF species are being successfully bred from hatchery-based aquaculture production. Together with the improvement of pellet-feed to replace by-catch, more LRFF can be produced from sustainable aquaculture techniques.

Muldoon and Scott (2005) recommend that the market structure of the LRFF aquaculture industry appears to be more favourable to the implementation of a certification scheme compared to the captured LRFF sector. Even if the WTP for cultured LRFF is lower than wild-caught LRFF (on average, HK$12.76 per tael) WTP of consumers for sustainable sources of supply (on average, HK$25.69 per tael) indicates that it may be profitable to develop an ecolabelling scheme on the sustainable cultured LRFF sector. The WTP for a sustainable cultured LRFF is on average HK$12.93 per tael higher than an unsustainable wild LRFF of the same species (Table 7: case 3). Recently, Tiger Grouper and Humpback Grouper have been raised successfully and are economically viable from hatchery-based aquaculture production (Rimmer *et al.* 2005). If the profit can be transferred back through the market chain through a fair trade scheme, these results imply that there can be economic incentives to developing certification for the responsible management of sustainable aquaculture for LRFF production.

Education campaign.

Over the last few years, a number of education campaigns have been established in Hong Kong aimed at the conservation and awareness of live reef fish, especially the 'endangered' Humphead Wrasse (WWF 2006). This research has helped to reflect the impact of environmental education campaigns towards consumer WTP. Before respondents proceeded to answer the choice modeling question, they were asked to read the information about LRFF and the attribute explanations. Conservation information about Humphead Wrasse was also included.

From market data collected by the International Marine Alliance (IMA) during 2001 and 2003, the retail prices of Humphead Wrasse and Humpback Grouper were similar (McGilvrary and Chan 2003). From our results, the WTP for sustainable sourced Humphead Wrasse, HK$34.26 per tael, is double that of the Humpback Grouper, HK$17.07 per tael. Consequently, a further education campaign regarding the conservation of wild Humphead Wrasse and Giant Grouper, which is a 'vulnerable' species, would be useful to increase the awareness of consumers. If these two LRFF species can be supplied from sustainably managed sources in the near future, and accompanied with an education campaign, our results reply that consumers would have a high WTP for these species. Currently, as Giant Grouper can be successfully produced from hatchery-based aquaculture (Rimmer *et al.* 2005), certification and an education program could be trialed with this species.

Further research.

To reduce the discount on the price of a cultured LRFF product, it could be useful to improve production techniques so as to improve the taste and texture. Previous taste tests conducted by Nature Conservancy showed that consumers prefer cultured over wild Malabar Grouper under a blind taste test situation (OminTrak 1997). In a triangle taste test conducted in Hong Kong (Chan 2006), it was found that almost half of the tasters were unable to identify wild Humpback Grouper from a mixture of wild and cultured Humpback Grouper portions. To remove the perception that the taste and texture of cultured fish is inferior to wild fish, taste demonstrations and advertisements would be useful. Finally, due to the variation in the distribution of costs and profits in both the LRFF fishery and aquaculture sectors in different exporting countries (Muldoon 2006), it would be worthwhile to conduct further research to assess the costs and benefits of developing a certification program for different sectors and stakeholders.

Conclusion

The LRFF trade is an important source of income to many coastal communities in developing countries as well as stakeholders in Hong Kong and mainland China. Over the last decade, the increasing demand of this high valued product has become an enticement to destructive fishing and overfishing in coral reefs in the Asia-Pacific region.

This research applies choice modelling to gain an understanding of consumer preferences for LRFF. Responding consumers were found to be willing to pay an average of HK$12.76 per tael more for wild fish than cultured fish of the same species. This is a 58% premium over the average current market price of the four LRFF fish species. Moreover, if environmental information is available, for example, through eco-labelling, consumers may be willing to pay on average of HK$25.69 per tael more (a 121% premium over the average current market price) for fish that come from sustainable source than a fish of the same species that come from an unsustainable source.

The results of this research imply that Hong Kong consumers have a higher WTP for fish that is sourced from sustainable sources. This can potentially provide an economic incentive for traders and marketers to source future product from fisheries where it can be demonstrated that sustainable fishing and aquaculture is in place. However, before this outcome could be achieved, it is necessary to develop the basic building blocks of sustainable live reef fish fisheries practices in both wild-caught and culture based production and to develop the marketing systems to support them. Key policy initiatives that should be considered are: (1) the development of certification or eco-labelling schemes for both wild-caught and sustainable cultured LRFF industries that have hatchery-based aquaculture production and pellet feed facilities; (2) further consumer education campaigns on the environmental vulnerability of the ecosystems from where live reef fish are sourced and the need to move to sustainable production;

(3) more research on sustainable aquaculture techniques to improve the taste and texture of cultured LRFF products; and (4) taste tests and demonstrations of wild and cultured fish products to improve consumer acceptance of cultured LRFF.

Reference:

Agricultural, Fishery and Conservation Department (AFCD) 2006. 'Monthly wholesale prices for wild cultured live marine fish, website: www.hk-fish.net (01/03/06).

Adamowicz, W., Louviere, J. and Swait, J., 1998. *Introduction to Attribute-Based Stated Choice Methods*, Final Report submitted to Resource Valuation Branch, Damage Assessment Center, National Oceanic and Atmospheric Administration, and US Department of Commerce.

Alencastro, L., Degner, R. and Larkin, S., 2005. 'Hobbyists' preferences for marine ornamental fish: a discrete choice analysis of ecolabeling and selected product attributes', *SPC Live Reef Fish Information Bulletin*, 15:19-22.

Anon, 2004. *The International Standard for the Trade in Live Reef Food Fish*, The Nature Conservancy, Marine Aquarium Council, APEC, McArthur Foundation.

Baillie, J. and Groombridge, B., 1996. *1996 IUCN Red List of Threatened Animals*, IUCN, Gland, Switzerland.

Bennett, J. and Adamowicz, V., 2001. 'Some fundamentals of environmental choice modelling', in J. Bennett and R. Blamey (eds), *The Choice Modelling Approach to Environmental Valuation*, Cheltenham: Edward Elgar:37-69.

Blamey, R. and Bennett J. 2001. 'Yea-saying and validation of a choice model of green product choice', in J. Bennett and R. Blamey (eds), *The Choice Modelling Approach to Environmental Valuation*, Cheltenham: Edward Elgar:179-201.

Cesar, H.S.J., Warren, K.A., Sadovy, Y., Lau, P., Meijer S. ad Ierlad, E.V., 2000. 'Marine market transformation of the live reef fish food trade in Southeast Asia', in H.S.J. Cesar (ed.), *Collected essays on the economics of coral reefs*, Sweden, Cordio: 137-157.

Chan, N.W.W., 2000. *An Integrated Attitude Survey on Live Reef Food Fish Consumption in Hong Kong*, World Wide Fund for Nature Hong Kong, Hong Kong.

Chan, N.W.W. 2006. 'Survey and taste test in Hong Kong', Discussion paper presented in Second Workshop: ACIAR Project – Economics and Market Analysis of the Live Reef Fish Food Trade in the Asia-Pacific, Penang, Malaysia, 14-16 March 2006.

Food and Environmental Hygiene Department (FEHD), 2005. *Malachite Green Found in One Seawater Fish Sample*, Press Release, http://www.fehd.gov.hk/news/details/le. html9/2/2005 (01/09/2005).

Gardiner, P.R. and Viswanathan, K.K., 2004. *Ecolabelling and Fisheries Management*, WorldFish Centre, Panang.

Grafton, R.Q., Adamowicz, W., Dupont, D., Nelson, H,, Hill, R.J. and Renzetti, S., 2004. *The Economics of the Environment and Natural Resources*, Blackbell Publishing, Oxford.

Graham, T. 2001. *A Collaborative Strategy to Address the Live Reef Food Fish Trade*, Asia Pacific Coastal Marine Program, Report No. 0101. Honolulu: The Nature Conservancy.

Greene, W.H., 2002a. *LIMDEP Version 8.0 Econometric Modeling Guide Volume 2*, Econometric Software Inc., New York.

Greene, W.H., 2002b. *NLOGIT Version 3.0 Reference Guide*, Econometric Software Inc., New York.

Greene, W.H., 2003. *Econometric Analysis* (5th Edn), Prentice Hall.

Habb, T.C. and McConnell, K.E., 2002. *Valuing Environmental and Natural Resources: the econometrics of non-market valuation*, Edward Elgar Publishing, Cheltenham and Northampton.

Hensher, D.A., Rose, J.M. and Greene, W.H., 2005. *Applied Choice Analysis: A primer*, Cambridge University Press, Melbourne.

IUCN, 2005. 'The IUCN Red List of threatened species: species information *Cheilinus undulates*', http://www.redlist.org/search/details.php?species= 4592 (02/06/05).

Johnston, R.J., Wessells, C.R., Donath, H. and Asche, F. 2001. 'A contingent choice analysis of ecolabelled seafood comparing consumer preferences in the United States and Norway', *Journal of Agricultural and Resource Economics*, 26:20-39.

Lancaster, K., 1971. *Consumer Demand: a new approach*, Columbia University Press, New York & London.

Lancaster, K., 1991. *Modern Consumer Theory*, Edward Elgar Publishing, Hants and Vermont.

Lau, P. and Parry-Jones, R., 1999. *The Hong Kong Trade in Live Reef Fish for Food*, TRAFFIC-East Asia and World Wide Fund for Nature Hong Kong, Hong Kong.

Louviere, J.J., Hensher, D.A., Swait, J.D., 2000. *Stated Choice Methods: Analysis and Application*, Cambridge University Press, Cambridge.

Mantel, S.K., Cheung, D., Welford, R. and Sadovy, Y., 2006. *Criteria for Selecting Live Fish in Hong Kong: Pilot Study Results*, Collaborative project between The Centre of Urban Planning & Environmental Management and The Department of Ecology & Biodiversity, Hong Kong.

McGilvrary, F. and Chan, T., 2003. 'Market and industry demand issues in the live reef food fish trade', *SPC Live Reef Fish Information Bulletin*, 11:36-39.

Muldoon, G., Peterson, L. and Johnston, B., 2005. 'Economic and market analysis of the live reef food fish trade in the Asia-Pacific region', *SPC Live Reef Fish Information Bulletin*, 13:35-41.

Muldoon, G.J. and Scott, P.G., 2005. 'The international standard for the trade in live reef food fish: from voluntary code to certification', *SPC Live Reef Fish Information Bulletin*, 15:23-32.

Muldoon, G, 2006. 'Market chain analysis for the trade in live reef food fish' in B. Johnston and B. Yeeting (eds) Proceeding of a workshop in Economic and Marketing of Live Reef Food Fish Trade in Asia-Pacific, ACIAR Working Paper No. 60, Noumea:135-154.

Nicholson, W. 2000. *Microeconomic Theory: Basic principles and extension* (8 th edn), South-Western Thomas Learning.

OmniTrak Group Inc., 1997. Maricultured Grouper Taste Test Study (Summary), Paper prepared for the Nature Conservancy, Project no. 3064.

Rimmer, M.A., Phillips, M.J. and Sim, S.Y., 2005. *Aquaculture of Grouper Species in Asia and the Pacific*, Discussion paper prepared for the SPC/ACIAR workshop *Economics and Marketing of Live Reef Fish for Food*, Noumea, New Caledonia, 1-3 March 2003.

Sadovy, J.Y., Donaldson, T.J., Graham, T.R., McGilvrary F., Muldoon, G.J., Philips, M.J., Rimmer, M.A., Smith, A. and Yeeting, B., 2003. *While Stocks Last: the live reef food fish trade*, Manila, Asia Development Bank.

Sadovy, J.Y. and Vincent, A.C.J., 2002. 'Ecological issues and the trade in live reef fishes', in P.F. Sales (ed.) *Coral Reef Fishes Dynamics and Diversity in a Complex Ecosystem*, Elsevier Science:391-420.

Wessells, C.R., Johnston, R.J. and Donath, H. 1999. 'Assessing consumer preferences for ecolabeled seafood: The influence of species, certifier and household attribute', *American Journal of Agricultural Economics*, 81(5):1084-1089.

Wooldridge, J.M. 2006. *Introductory Econometrics: A modern approach*, 3rd edition, Manson, Thomson South-Western.

World Wide Fund for Nature Hong Kong (WWF), 2005. "WWF Marine Awareness Survey: Seafood consumption", website: http://www.wwf.org.hk/eng/pdf/references/ marine%20awareness%20II%20accomp%20051013_1.pdf (9/03/06).

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