Economics of Commercial Giant Clam Mariculture

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The Australian Centre for International Agricultural Research

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Acronyms and Abbreviations

ACIAR
Australian Centre for International Agricultural Research

CITES
Convention on International Trade in Endangered Species

CTSA
Center of Tropical and Subtropical Aquaculture

DPHSS
Department of Public Health and Social Services (Guam)

FDA
Federal Drug Administration (USA)

GATT
General Agreement on Tariffs and Trade

IUCN
International Union for Conservation of Nature

MMDC
Micronesia Mariculture Demonstration Centre

NMA
National Marketing Authority (Fiji)

SITC
United Nations Standard International Trade Classification

USDA
United States Department of Agriculture

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Contents

Preface

This monograph is based upon the results of research undertaken mainly in the period 1989–1993. Financial support for a part of this research was obtained from the Australian Centre for International Agricultural Research (ACIAR) through its Research Project No. 8823, 'Economics of Giant Clam Mariculture', and for part, especially that relating to marketing of giant clams, from the United States Department of Agriculture through the Center of Tropical and Subtropical Aquaculture (USDA Grant Number 88-38500-3884 and Grant Number 90-38500-5045). Clem Tisdell was the project leader for the ACIAR project and Yung C. Shang for the projects sponsored by the Center of Tropical and Subtropical Aquaculture (CTSA). The ACIAR project was conducted independently from the projects sponsored by CTSA, but Clem Tisdell also participated in both those projects, as did PingSun Leung. Some of the material in this monograph has previously been presented in working papers or reports, but has not been presented elsewhere in its present form. It was felt that it would be beneficial to bring these papers together so as to make the information they contain available to a wider audience than otherwise would have access to it. The results obtained by U.S. and Australian researchers are not specific to their own countries and will be of interest to many countries in the Pacific.

This monograph complements ACIAR monograph No. 18, Giant Clams in the Sustainable Development of the South Pacific: Socioeconomic Issues in Mariculture and Conservation, which concentrated on socioeconomic aspects of giant clams and prospects for farming them in the Pacific islands. It took account of the special institutional arrangements prevailing there and the development status of the countries concerned.

This new monograph focuses on exploration of markets for, and attempts at commercial production of, giant clams in more developed countries. The markets for giant clam products in more developed countries are of considerable interest to less developed countries in the Pacific, many of which hope to farm and export giant clams. Also, information on production costs and the economics of production techniques adopted for mariculture in more developed countries will be of interest to less developed island countries considering the commencement of giant clam mariculture, though it may need to be modified to suit their particular circumstances

In these papers, we discuss various aspects of markets for giant clams, including the difficulty of determining what the markets are. Coverage is given to markets for giant clams as food, as aquarium specimens, and for shells. In addition, consideration is given to business strategies of producers of giant clam and the economics of producing giant clams by mariculture.

Clem Tisdell expresses his gratitude to Dr John Lucas, leader of ACIAR Project No. 8873, 'The culture of the giant clam (Tridacnidae) for food and re-stocking of tropical reefs', a project associated with ACIAR Project No. 8823, for his encouragement and research cooperation. Also, we thank all those who have contributed directly or indirectly to this volume, for their support for our research. We are grateful to our sponsors for their financial assistance and for their encouragement of our projects, to ACIAR for agreeing to produce this publication, and to the CTSA for its cooperation. We appreciate the editorial contribution of Peter Lynch and the ACIAR team. We thank Ms Susan Riley for the typing and presentation of the complete manuscript on which this monograph is based.

Clem Tisdell

Yung C. Shang

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Part 1

Background on the Industry

1 Development of Giant Clam Mariculture and the Need for a Review of Commercial Prospects

Clem Tisdell

Yung C. Shang

PingSun Leung

Kenneth M. Menz

Background

Giant clams (Tridacnids) are marine bivalve molluscs and the members of one species, *Tridacna gigas*, grow to be the largest bivalve molluscs in the world—a fully grown specimen may be around 1.4 metres long and 230 kg in weight in its shell. They occur naturally in sunlit tropical and subtropical waters not subject to substantial freshwater intrusions. While their natural distribution is confined to the Western Pacific Ocean and to the Indian Ocean, some species, e.g. *Hippopus porcellanus*, have a relatively limited distribution within this area (Lucas 1988).

In virtually all areas where they occur naturally, giant clams have been eaten by indigenous people. Due to harvesting pressures, they have become largely extinct in a number of areas and IUCN (International Union for the Conservation of Nature) in the 1980s considered that a number of species of giant clam were endangered. This subsequently resulted in giant clams (tridacnids) being listed as endangered species under CITES (Convention on International Trade in Endangered Species) in the 1980s. All species were listed, even though it was arguable whether some species, e.g. *T. maxima* and *T. vidacra crocea*, were endangered. One of the reasons given for listing all species was the difficulties that inspectors would be likely to have in distinguishing between them. In any case, it is clear that, before the application of CITES, many wild stocks of giant clams were being unsustainably exploited to satisfy international trade, e.g. the natural stocks of the Philippines and Indonesia. Substantial international trade in shells of giant clams existed along with meat exports to Taiwan and southern Japan. Furthermore, increases in local human populations and the availability of improved techniques for gaining access to giant clams, e.g. the increasing availability of motorised boats, resulted in mounting harvesting pressures on local stocks. In this deteriorating conservation situation, methods to culture giant clams were to be welcomed.

Methods of culturing giant clams were pioneered by the Micronesian Mariculture Demonstration Center (MMDC), Palau, concentrating on *T. derasa*, the second largest species. While *T. derasa* was being cultured at MMDC by the end of the 1970s, it was only after 1982 and a substantial injection of United States funds that output expanded substantially (Heslinga and Fitt 1989, p. 336). In the mid-1980s the mariculture of *T. gigas* was developed principally in Australia at James Cook University as a result of funding from the Australian Centre for International Agricultural Research--ACIAR (Braley 1989).

In Japan the culture of *T. crocea* was developed at about the same time (Murakoshi 1991). Before the end of the 1980s all the then known species of giant clams had been bred in captivity, including the relatively rare species *H. porcellanus* in the Philippines. The technological and biological possibility of mariculturing (farming) giant clams had been fully established by the end of the 1980s. Furthermore, there appeared to be no major impediment to establishing a closed breeding cycle for most or all species of giant clams; that is, relying on farmed stock to provide successive generations of clams. By the early 1990s MMDC had obtained three generations of *T. derasa* relying solely on broodstock obtained from cultured specimens. Such a closed system means that the continuation of an industry culturing giant clams would not be dependent upon the capture of broodstock from the wild. This is a positive benefit from the point of view of conserving wild stock.

A variety of techniques was developed for culturing giant clams. These ranged from those in which the farmed giant clams spend a substantial part, or even all, of their development for commercial purposes in land-based tanks as raceways to which saltwater is pumped from the nearby ocean, to those in which most of the culture is conducted in the ocean itself, e.g. using floating cages for the initial stages of giant clam development with subsequent growout on platforms under the sea or on the sea floor. The most common techniques are described broadly in Chapter 18.

While giant clams appear to be largely (but not completely) autotrophic (Lucas 1988, p. 31) because of their symbiotic relationship with algae or zooxanthellae located in their mantle, their growth does respond to nutrient enrichment of their surrounding waters. The addition of fertiliser, especially ammonium nitrate, has been found to enhance growth of giant clams (cf. Onate and Naguit 1989). Most commercial farmers add fertiliser to land-based tanks in which giant clams are being grown. Addition of fertiliser may also enhance the colour of the mantle, an important consideration when giant clams are being sold for the aquarium market (see Chapter 14). Furthermore, experiments in the Philippines at Silliman University indicate that shell colour can be influenced by chemical additions to the media in which giant clams are grown and by selection of breeding stock. Since the culture of giant clams is still in its early stages, considerable further development in techniques and methods of husbandry of these bivalves can be expected in the future, especially if this culture proves to be economically viable.

Species of giant clams and their use by humans

There are several species of giant clams, each with its own characteristics, ecological requirements and economic values. If the relatively recently identified species T. *trevoroa* is included, there are eight known species. However, *T. trevoroa* is rare and appears to be confined to relatively deep waters between Fiji and Tonga. Also *H. porcellanus* is rare with a small natural distribution located in some of the waters around the Philippines and Indonesia (Lucas 1988, p. 28). Furthermore, the natural abundance of the larger species of clams as listed in Table 1.1 has been greatly reduced.

Table 1.1 lists the known species of giant clams, provides some information on the comparative size of fully grown specimens and indicates what human uses are made of them. Virtually all parts of the giant clam, all of the meat (except the kidney) and the shell, can be used by humans. The principal recent or current uses include the use of the meat of giant clams for food, the shells for decoration and as containers, and the whole animal as specimens for saltwater aquariums. The value of the different species for these alternative uses varies as indicated roughly in Table 1.1.

Table 1.1 Species of giant clams (Tridacnids), comparative size and main economic uses

Species	Approximate length fully grown	Economic uses[a]		
		Meat	Shells	Aquarium specimens
Tridacna gigas	up to 140 cm	Adductor muscle highly valued. Remainder of meat of lower value but consumed particularly by Pacific islanders[3]	Large shells highly valued for decoration and containers[2]	Some demand but not as great as for most other species[3]
Tridacna derasa	50–60 cm	As for *T. gigas*[3]	Of little commercial value for decoration but may be improved by machining[1]	Exported by MMDC for this trade. Appearance can be improved by fertiliser additions[2]

Table 1.1 (contd.) Species of giant clams (Tridacnids), comparative size and main economic uses

Species	Approximate length fully grown	Economic uses[a]		
		Meat	Shells	Aquarium specimens
Tridacna squamosa	About 40 cm	Not widely traded for meat but a meat preferred by some Pacific islanders[7]	Are decorative and colourful. Was a significant item in the shell trade[3]	Not as yet used to any extent in the aquarium trade[1]
Tridacna maxima	30–35 cm	Highly valued by the southern Japanese for sushi and sashimi. Widely considered to be a tasty species[3]	Of limited value for the shell market[1]	Highly sought after as aquarium specimens[2]
Tridacna crocea	up to 15 cm	Highly valued in southern Japan for sushi and sashimi[3]	Shells of extremely limited use[1]	Sought after as aquarium specimens[3]
Hippopus hippopus	30–40 cm	Eaten but not so highly valued by most consumers[3]	Highly valued for the shell trade on account of their decorative appearance and utility as containers. In the past this was the clam shell traded in greatest volume[1]	Not used as yet to any extent for the aquarium trade[3]
Hippopus porcellanus	Up to about 40 cm	Meat value uncertain. Rare species	Highly valued for the shell trade but rare[3]	Not yet used for aquarium trade
Tridacna trevoroa[b]		Can be used for meat. It is unlikely to be very suitable for widespread mariculture. It has only recently been identified.	Not yet used for shells.	Not yet used for aquarium trade

[a]Numbers in brackets indicate relative importance of use indicated—3, very important; 2, moderately important; 1, of little or no importance.
[b]Located in relatively deep water.

Of course a larger range of uses exist for products of giant clams than those indicated in Table 1.1, but this table highlights the main areas being considered for the marketing of giant clam products. The market for giant clams is further discussed in the next chapter, so as to provide a broad overview after which the results of more specific market studies are given.

The economics of cultivating any species depends not only on the market for it or the products derived from it, but also on the costs of culturing the species. The concluding chapters of this monograph concentrate on the costs of culturing giant clams and the economics of their supply.

The need for a review of prospects for commercial giant clam mariculture

Broadly speaking, scientific and technical research on the aquaculture of giant clams predates research into the economic prospects for such culture. By the late 1970s culture of giant clams at MMDC was established even though the main expansion in this culture did not occur until 1983 onwards (Heslinga and Fitt 1987, p. 334). In 1984, *Hippopus hippopus*, *Tridacna gigas* and *T. derasa* were reared for the first time in Australia from a spawning and in that year also the ACIAR commenced major funding for scientific and technical research into giant clam mariculture based primarily at James Cook University's Orpheus Island Research Station and headed by Dr John Lucas (Braley 1989, pp. 7 and 8). This project involved collaboration with researchers in a number of other countries, e.g. the Philippines and Fiji and did much to advance culture techniques, particularly for *T. gigas*. This ACIAR-sponsored project and its closely related successor continued until the end of 1991.

Apart from a rather perfunctory desk-type survey undertaken by a consulting company on exports of giant clams (Carleton 1984), little in-depth economic research into markets and the economics of giant clam mariculture was undertaken before the end of the 1980s. However, in 1986, Dawson (1986) completed a survey for the Forum Fisheries Agency, Honiara, of the market for giant clam products in Taiwan, Japan, Hong Kong and Singapore (see also Dawson and Philipson 1989). In 1986, Tisdell was asked to provide an initial overview for ACIAR of the socioeconomics of giant clam mariculture (Tisdell 1986).

In 1989, ACIAR began funding major research into the economics of giant clam mariculture. The project was directed by Clem Tisdell in the Department of Economics at the University of Queensland, and was intended to complement the scientific and technical research being undertaken by researchers at James Cook University in collaboration with overseas associates, that is to complement ACIAR Project 8873, 'The Culture of the Giant Clam (*Tridacnidae*) for Food and the Restocking of Tropical Reefs' of which Dr John Lucas was the team leader.

The main aims of this economics research project were to provide information about: (i) market prospects for giant clams; (ii) the production economics and supply factors involved in giant clam mariculture; (iii) marine property rights, as these affect the economics of giant clam mariculture; and (iv) the possible value of giant clam mariculture development in less developed countries of the Indo-Pacific region, especially South Pacific nations. Results in relation to objectives (iii) and (iv) have been substantially published in Tisdell (1992). This new monograph will contain most of the material bearing on objectives (i) and (ii), as well as results from related American research. ACIAR funding for this Australian research officially ceased at the end of 1992 but some follow-up research continued into 1993 (Tisdell 1993).

At about the same time as ACIAR began funding major research on the economics of giant clam mariculture, the United States Department of Agriculture (USDA) began to provide funds for economic research initially for investigating markets for giant clam products and later other economic aspects of this culture; e.g. the comparative costs of production of giant clams using different available techniques for their aquaculture. These funds were distributed through the Center for Tropical and Subtropical Aquaculture, Hawaii, with Professor Y.C. Shang of the Department of Agricultural and Research Economics, The University of Hawaii as the research leader. This research complemented the ACIAR-sponsored economic research which tended to concentrate on Australia and the South Pacific. The prime focus of the U.S. economic research was in relation to American-associated territories in the Pacific. It soon became clear that the research supported by different sponsors would be of interest to all nations in the Pacific who might become involved in giant clam mariculture. There was some scope for cooperative research and some joint research on marketing of giant clam products was undertaken between Yung C. Shang, PingSun Leung and Clem Tisdell. Thus, it was sensible to produce a jointly edited volume such as this one.

Initially, one of the main motivating forces behind the development of giant clam mariculture, particularly that funded by ACIAR, was the possibility of it being used to help restock reefs on tropical islands with giant clams, and so to provide islanders with food to satisfy their subsistence needs. However, giant clam mariculture has not as yet been widely used for this purpose and, in fact, it seems that villagers in the Pacific islands are more interested in the commercial potential of the activity (Tisdell 1992). The governments of many Pacific island developing countries are interested in the prospects of their countries being able to farm giant clams to earn export income. The aim of most villagers in the Pacific islands is to find means of earning greater amounts of cash income from economic activities conducted within their village rather than to supplement their subsistence needs.

Commercial farming of giant clams, though much of it is exploratory, has shown greater development than the culture of tridacnids for subsistence. For this reason and those given earlier, a review of commercial prospects for giant clam mariculture is likely to be of immediate value as a guide. The results of this study should be of value both to less developed maritime countries in tropical and subtropical areas and to more developed ones with a potential to engage in giant clam mariculture. This monograph, after providing some general background on markets for giant clams, specifically examines the markets for tridacnids for food, as aquarium specimens and for their shells, before considering business strategies adopted by some entrepreneurs culturing giant clams and examining specific aspects of the economics of aquaculture of giant clams.

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2 Problems and Methods of Determining the Demand for Giant Clam Products and the Economics of Their Supply

Clem Tisdell

Abstract

General problems involved in determining the demand and markets for cultured giant clams and cost and supply conditions for such clams, are discussed. On the demand side, attention is paid to markets for giant clams for food, as shell and aquarium specimens, and for seed and broodstock. Some special market outlets are noted and possible non-market economic values are mentioned. Because of lack of data and deficiencies in their quality, traditional econometric techniques cannot be used to estimate demand relationships in these markets. Furthermore, it is doubtful whether market demands based on the use of captured wild stock would adequately indicate those for cultured giant clams. Therefore, alternative methods of estimation, such as taste-testing, need to be employed.

Data problems also exist on the supply side. Techniques for marine culture of giant clams are still developing and new information is being gathered. Only limited economic data have been generated by the use of techniques for farming giant clams. Hence, estimation of cost and supply relationships cannot be done by using traditional econometric methods, and alternatives have had to be employed in this study.

Introduction

Although techniques for the aquaculture of giant clams were well established by the beginning of the 1990s, in the sense that a number of working techniques existed, the economics of giant clam production is not yet fully determined. This is because markets are still being studied and developed, techniques of production continue to evolve and those in the industry are continuing to learn about these new techniques for giant clam production and development. The industry is an embryonic one which has hardly begun its product-life cycle. Worldwide in 1993 there was only a handful of firms involved in giant clam production.

The economics of production of giant clams by means of aquaculture depends on demand and supply factors. In turn, the latter depend on the costs of production, distribution and marketing of giant clam products, and these are, in turn, influenced by the prices and productivity of inputs. In order to determine the economics, profitability or commercial viability of giant clam farming, it is necessary to have estimates of, or information on, demand and supply variables such as types of clam products demanded, in what quantities and at what prices, techniques for giant clam production, productivities, and prices of inputs available for use in giant clam production.

The research reported in this monograph yields information about the market and the economics of production of giant clams. In so doing, it provides guidance for the commercial development of giant clam mariculture. It also provides useful information for producers in less developed countries who may need to market their giant clam products in more developed ones.

It should be noted in advance that traditional econometric methods based upon time-series and cross-sectional data could not be used in this study because of the lack or unreliability of such data (cf. Tisdell 1989). In the case of markets, this has meant that data have had to be collected by surveys and by direct market testing. In the case of production economics, it has been necessary to use data from individual suppliers and make use of information supplied by natural scientists about the growth rates of clams, probable mortality rates of giant clams, and so on, to draw conclusions. Information is not available from a wide range of producers using similar techniques. Because no such set of producers exists, cross-sectional analysis cannot be used. Nor are substantial time-series available for production economics variables for conditions involving continuous use of the same techniques. Therefore, the possibilities for using time-series analysis to estimate production economics relationships are limited. Let us examine more closely the estimation of demand and supply relationships in the light of the above.

Estimating demand and determining the nature of markets for giant clam products

Background

When the research reported in this monograph began in 1989, little was known about the demand for giant clam products. Such market data as existed were derived from the exploitation of wild clam stocks to satisfy the market. However, there was little or no systematic collection of these data. For example, data collected on international trade in giant clam products were entirely inadequate (see Chapter 3) because, for instance, giant clam products were not adequately differentiated from other shellfish and much of the trade was unrecorded.

Given this situation, one option for this research might have been to collect more data from markets relying on wild clam stocks. However, these markets were already collapsing in 1989 as wild stocks of giant clams became increasingly depleted. From then also, the Convention on International Trade in Endangered Species (CITES) began to have an increasing impact on international trade in giant clam products. Giant clams were listed under CITES with the effect that international trade in giant clam products obtained from wild stocks of giant clams was prohibited between signatories to the convention. However, trade in farmed giant clams (appropriately certified) is allowed.

Despite the collapsing market based on wild giant clam stocks, it was possible to collect some market data relying on the use of these stocks. This, however, raised the question of whether a market reliant mostly on supply of giant clams from farms would be the same as that based on wild stocks. It is probable that the nature of the market when aquacultured clams are the main source of supply could be somewhat different. For example, farmed clams can be grown so as to be more uniform and to incorporate particular characteristics. Furthermore, given discount and risk factors, farmers have an incentive to harvest their crop as early as possible. Clams will be grown to a very large size only if a substantial price premium exists for very large clams. In addition, market development and promotion for farmed clams may take a different form to that established for marketing of wild stock.

While data based on fish markets utilising natural stock have some value for determining demand for aquacultured supplies, this value can be easily exaggerated. Lack of recent availability of supplies of giant clams, for example, in a number of previous markets for giant clam products, especially for food, means that many potential consumers in these markets now have little knowledge and no experience with the product, e.g. in Taiwan. Consequently the market needs to be redeveloped. Furthermore, there are potential markets amongst consumers in countries or geographical areas where giant clams have not been traditionally consumed, e.g. mainland Japan, and it may be worth while developing these as outlets for the farmed product.

Markets exist and can be further developed for giant clams for food, shells, as aquarium specimens, for seedstock and for broodstock. Let us briefly consider markets for each of these end-purposes.

Food

Since the earliest of times, giant clams have been used by indigenous people in geographical areas where giant clams have occurred naturally, namely in the tropical and subtropical waters of the Pacific and Indian oceans, with the exception of the Western Pacific. They are still widely consumed by Pacific islanders, although natural supplies are much more limited than in the past (Tisdell 1992). The Chinese—along the east coast of China, in Taiwan, and Hong Kong—and the people of the Ryukyus in Japan, all had access to significant local natural stocks of giant clams in the past, which they utilised for food. As local stocks became inadequate and transportation improved, the Taiwanese began to import giant clam or exploit distant water stocks. Some but limited exploitation in the Ryukyus also occurred, and limited trade occurred within the other Pacific islands.

As pointed out in Chapter 4, the main Taiwanese market was (is) for the adductor muscle of the giant clam—a speciality item or delicacy. However, the Japanese market is mainly for the whole meat (minus the kidney) of giant clams for use in sushi and sashimi. The first market would be best served by older clams and those species, e.g. *T. gigas* and *T. derasa*, which grow to larger sizes. However, these species may not be suitable for the Japanese market because of the texture of the meat. *T. crocea* and *T. maxima* seem more suitable for the Japanese market and a younger rather than an older clam seems to be more suitable. The muscles in such clams will be relatively small. Pacific islanders seem to be less discriminating in their meat requirements. They consume all the meat (except the kidney) and appear to find the meat from all species quite acceptable. Information of this type can and has been collected during surveys.

In numerous cases, however, potential consumers have never tasted giant clam meat in any of its many possible forms. In such cases, taste-testing is necessary to get some indication of whether the product is acceptable and likely to be an item purchased if suitably priced and promoted. Results of taste-testing in Micronesia, Hawaii and Australia are reported in this monograph.

Taste-testing does of course have its limitations but provided these are kept in mind it can provide useful information. Some limitations of the method are: (1) samples of tasters tend to be small, so there is always the problem of how representative they are of a wider population; (2) results are likely to be influenced by the method of preparation and presentation (and these can vary widely) of the product; and (3) the amount of product tried and the duration of time for which it is available is usually short because the researchers have a limited budget. Consequently, results may not fully represent likely demand in the longer term. Also, in the longer term with learning and experience, new methods of preparation and presentation of the food item may evolve. Furthermore, in the case of giant clams, the quality of the meat may vary according to the species and its age, and thus influence results from taste-testing.

Shells

Since early times, the shells of giant clams have been used for both decorative and utilitarian purposes. The early Babylonian and Assyrian civilisations used the inner portion of large giant clam shells for scrimshaw, and fine examples of this are to be found at the London Museum, e.g. depicting warriors on their chariots. In parts of the Pacific islands where stone was not available, such as some of the Cook Islands, these shells were used to make adzes and digging implements. Giant clam shells have been used since the earliest times as food and water containers in regions where they occurred naturally.

In recent times, there has been extensive international trade in the shells of giant clams but such trade is now restricted. Such shells were widely offered for sale at gift and souvenir shops mostly located at or near seaside resorts. Exports to more developed countries such as Japan, USA and Australia, as well as European and other countries occurred in significant volume, with the Philippines being the most important single source of such exports.

While a significant international trade in giant clam shells still existed in 1989, this trade has now virtually ceased. This is because international trade in giant clam shells obtained from the wild is illegal amongst signatories of CITES, and available wild stocks are seriously depleted, especially in the Philippines and Indonesia. Little supply as yet is available from farmed stocks and the most popular species of giant clams for the shell trade have not yet been farmed to any great extent.

Information about the shell market provided in this monograph is based mostly on surveys of gift and souvenir shops undertaken before CITES had a substantial impact on trade in giant clam shells.

Aquarium specimens

The global market for fish as aquarium species is a very large one but it is principally for freshwater species. However, saltwater aquariums are becoming more popular. Stock for such aquariums is usually captured in the wild. Prior to the culture of tridacnid clams, the aquarium trade relied on captured wild stock.

The mariculture of giant clams has provided a new source of supply. It has made for a more regular supply and eliminated the need to use wild stocks to supply the aquarium trade, so potentially favouring conservation of wild stock. This trade provides a significant commercial outlet for the clam production of the Micronesia Mariculture Development and Demonstration Center in Palau, and for Reefarm Pty Ltd, an Australian commercial giant clam farm. Both have found it relatively easy to tap existing market networks for marketing and distributing aquarium specimens.

Information is provided on the market for giant clams as aquarium specimens in this monograph by making use of surveys and the sale of trial samples of clams through retail outlets.

By quantity of clams used, the market for shells of giant clams far exceeded that of giant clams for aquariums. Both markets were (are) geographically more widespread than that of clams for food. There are no reliable statistics on the numbers of clams used for food, but potentially this is a large market.

Seedstock and broodstock

A market for giant clam seed and for broodstock has developed as a result of the development of giant clam culture. Seed may be used for supplementing wild stock or for growing for subsequent commercial sale. Demand for broodstock comes mainly from organisations planning to establish hatcheries and nurseries. The demand for seedstock and broodstock is, in the end, a derived demand. It derives from the demand for the products obtained from clams—meat, shells and aquarium specimens. However, not all economic values of giant clams are marketable.

Special markets and values of giant clams

Apart from the above markets, small-scale commercial sales of giant clams to universities and scientific institutions are possible. Such specimens may be used for demonstration and experimental purposes. There has also been some demand from tourist resorts in suitable areas, e.g. Fiji, for farmed tridacnid clams to stock or restock waters near the resorts so as to make them more attractive to visitors.

In addition, and particularly in countries which have had a traditional association with giant clams, giant clams can have existence, option and bequest values. However, these values cannot as a rule, be marketed.

Estimating supply and cost relationships

Originally the supply of giant clams was entirely dependent on captive supply. There is, however, little chance of estimating the supply curve for captive supplies because of the lack of reliable past data. Furthermore, especially in the last few decades, advances in harvesting technology and its wider availability, e.g. diving equipment, refrigeration systems and motorised boats, have meant that the supply curve has been shifting. Therefore, even if more data were available, an identification problem would exist. Furthermore, availability of supply from mariculture and the possibilities for expansion of these supplies means that a new supply situation exists. In addition, because giant clams are listed under CITES, little legal international supply from captive sources exists.

The main concern in this monograph as far as supply and cost relationships are concerned is with farmed giant clams. Farms are likely to be the almost exclusive source for any (legal) international trade in giant clam products in the future and, in countries such as Australia where the harvesting of wild clams is prohibited, the only legal source of supply.

It is, however, very difficult to estimate cost of production and supply relationships for farmed clams because of changing and evolving techniques, the presence of learning and the fact that the diffusion of new technologies takes time. Because the situation is dynamic rather than static this makes it difficult to use traditional econometric techniques to estimate supply and cost functions. Once again, as on the demand side, identification problems and data limitations constrain empirical analysis.

Nevertheless, cost and production relationships have been estimated by drawing on available scientific observations, the experience of marine experimental stations involved in giant clam culture and pilot commercial undertakings. These relationships will undoubtedly change with the passage of time but they are based upon the best evidence currently available. Cost of production estimates are reported in this monograph from United States-associated territories in the Pacific and for Australia. Some estimates have been reported elsewhere for Fiji (Tacconi and Tisdell 1992).

Insufficient data are available to provide reliable estimates of market supply functions for farmed giant clams. However, the availability of ecologically suitable sites is likely to provide an upper constraint on supply. The economics of operating a particular site and gaining access to markets will further limit supply. In fact, the latter may be influenced by the mixture of factors of production needed for commercial supply. For example, if labour is a high component of production costs then, other things equal, this will favour production in low-wage countries. Nevertheless, in practice it is quite possible to have supplies of the same product coming from low and high-income countries because of differences in efficiency, technology and perception of the quality of the product, e.g. Australia produces and exports sugar from sugar cane as do many less developed countries.

The first commercial supplies of farmed giant clams are coming from areas within their natural distribution. This is not surprising because the basic ecological conditions are known to be suitable in such areas. This means that most cultured production or planned production of tridacnids is from the tropical waters of the western Pacific. It may of course be possible to produce giant clams in areas outside their natural range, for example in Hawaii or in the Caribbean. Furthermore, land-based aquarium production of giant clams could extend the geographical range of their production considerably, particularly if heating of aquarium water happens to be available at low cost in cooler climates, e.g. in southern Japan during the winter. However, the economics of such operations are as yet uncertain.

In a period of 10 years or less, the supply of aquacultured giant clams can be increased manifold. All species of giant clams are sexually mature before 10 years of age so if the availability of broodstock is the main limitation on expansion of production, this constraint can be overcome in a relatively short time. The smaller the size of the adults of a giant clam species, the younger the age at which they reach sexual maturity. *T. crocea* has the smallest size for adults and reaches full sexual maturity (hermaphroditism) at approximately 5-6 years of age. Giant clams have an extremely high fecundity. Murakoshi (1991, p. 261) reports that *T. crocea* of approximately 8-9 cm shell length produce 3-4 million eggs. It is therefore clear that even with relatively high mortality rates, tridacnid populations can be rapidly increased by artificial breeding and culture programs. Furthermore, suitable hatchery/nurseries can be built and extended within a relatively short time, so supplies of giant clan can be expanded greatly in a 10-20 year period. This can be expected to occur if economic conditions are favourable to such expansion.

Future supplies of giant clams are, however, not likely to be homogeneous. Different species may be cultivated for different end-products and for differing lengths of time to meet varied demands. The species chosen for cultivation may also be influenced by local ecological and sociological conditions. Therefore there are many different aspects and complexities to consider in relation to supply of cultured giant clams.

Concluding comments

When a new commercial industry is establishing itself it is always difficult to estimate its demand and supply relationships. Although an industry based upon captured giant clams existed in the past (and some remnants of it remain), for the reasons indicated, market data based on this source are of limited value in determining the potential market for farmed giant clams. Of course, supply data based on use of captured stocks are of no value in determining likely supplies from aquacultured stocks.

Compared to the capture fishery, aquaculture is capable of providing a more regular and uniform (standardised) supply. Giant clams can be bred, selected and husbanded to meet particular needs. This is likely to have a favourable impact on demand. Furthermore, private suppliers of farmed giant clams have a stronger motivation to promote use of their product than those relying on the capture fishery and to introduce the product to new consumers. It is therefore possible that supply obtained from aquaculture can raise the demand for the product (cf. Tisdell 1991, Ch. 6). This adds to the argument that demand based upon supplies from capture fisheries may be an imperfect indicator of demand for a similar product obtained by aquaculture. Let us now consider the specific results obtained as a result of this research.

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3 Evaluation of International Trade Statistics and the Demand for Substitutes as Indicators of the Market for Giant Clam Meat

John Stanton

Abstract

This chapter examines whether international trade statistics can be used to provide a useful estimate of the extent of trade in, and the potential market for, giant clam meat. It evaluates the contribution of two reports which assessed potential export markets for giant clam meat. It also discusses the value of investigating the potential export market demand for giant clam meat using possible substitutes as a guide.

International trade statistics are found to be insufficiently disaggregated to draw any conclusions as to the volume of trade in giant clam meat. In addition, even if the commodity could be distinguished, assessment of any country's potential market demand for giant clam meat would require an accompanying in-depth market analysis. The two previous studies of the potential export market demand for giant clam meat used differing methodologies and reached different conclusions. At one extreme, Compass suggested a very large potential export market to many countries based on a diverse range of clam meat uses. At the other extreme, Dawson conducted a market analysis in only four countries which focused on identifying a narrow range of existing and potential uses.

This study examines the use of giant clam adductor muscle as a possible substitute for other seafood products using a characteristics approach and a review of studies of own-price, cross-price and income demand elasticities for seafoods. Substitution possibilities exist, but the review suggests that market expansion, based on securing market share from adjacent commodities in characteristics space, may be difficult. Aggressive pricing to establish a market is likely to be counter-productive.

Introduction

Giant clam is the common name applied to a family of marine bivalve molluscs of which there are seven species. Five belong to members of the genus *Tridacna* and two to the genus *Hippopus*. References to their distribution, growth characteristics and their present status as a mariculture can be found in Dawson (1986) and Tisdell (1989). Although listed by the Convention for International Trade in Endangered Species (CITES) as an endangered species, the likelihood of successful giant clam commercial farming requires an assessment of their potential export markets.

All parts of the animal except the kidney are used; that is, the adductor muscle, mantle, gonads, other internal organs, and the shell. The adductor muscle is the meat which has been most traded internationally and the most valuable portion. The mantle is also consumed by some indigenous groups but there appears to have been little international trade in this product.

This chapter:

1. examines the usefulness of international trade statistics in giving an indication of the extent of the trade in, and the potential market for, giant clam meat;
2. evaluates the contribution of previous studies in assessing the potential market for giant clam meat; and
3. discusses the value of investigating the potential market demand for giant clam meat using possible substitutes as a guide.

Evaluation of international trade statistics

Marketing analysts often use the value of imports of a particular commodity group as an indicator of the potential market size available for a commodity that appears to be similar and for which they wish to apprise export potential. The use of such import statistics alone will be an inadequate indicator of the market potential for giant clam meat.

Any assessment of the export market opportunities for giant clam meat using import statistics must take into account the past, current and trend quantities and values of imports of it and apparently similar commodities; and the past, current and trend quantities and values of production of these commodities in the importing and potential importing countries. The types and effects of trade barriers on current imports and any likely effects with increased market penetration should also be assessed. Business practices existing in the target countries which can create barriers to import entry, such as the integration of wholesaling and retailing activities, will also need to be examined. These are only the broad demand elements and a complete appraisal of the potential market for giant clam meat would also require an assessment of supply and its determinants. One study which has attempted such an assessment of market opportunities in seafoods is Combs (1978). Observing trade flows can be only a partial guide to clam market opportunities and only if the level of commodity disaggregation is sufficient to distinguish commodities that are close substitutes for each other.

Existing international trade data are inadequate in providing any guidance as to the potential markets for giant clam meat. There are five basic characteristics of international trade statistics: coverage, commodity classification, valuation, exchange conversion and country designation.

All compilations of trade statistics provide information on the international movement of goods, but exactly what goods are included and what goods are excluded (the coverage of the statistics) depend on the particular practices followed. All countries show details of the different types of commodities moving in international trade, but how the detail is presented depends on the principles followed in establishing the system of commodity classification used in the compilation (Allen and Ely 1953, p. 4).

The treatment of clam meat trade in international trade statistics suffers from a restricted coverage and an excessively broad commodity classification.

Foreign trade statistics are usually compiled from copies of export and import documents prepared by exporters, importers, or their brokers or agents at the time goods enter or leave the country. Clam fishing raises the problem that illegal fishing will go unrecorded because of the lack of documentation. In addition, coverage may also be affected by the conventions covering the recording of merchandise trade. Specifically,

Fish and salvage sold abroad or to foreign vessels off national vessels, and fish and salvage landed from foreign vessels in national ports should be excluded from merchandise trade statistics, but, where important, should be recorded and published separately (United Nations 1977, p. XII).

Classification is covered by the general principles of the United Nations Standard International Trade Classification (SITC). The classification problems consist of providing sufficient detail to distinguish the commodity in question. In general, most countries subscribe to the SITC classification system. The current system provides for a different code for exports and imports.

The Australian Harmonized Export Commodity Classification (Australian Bureau of Statistics 1987b, 1988), which follows the SITC Revision 2, is:

0307: Molluscs, whether in shell or not, live, fresh, chilled, frozen, dried, salted or in brine; aquatic invertebrates other than crustaceans and molluscs, live, fresh, chilled, frozen, dried, salted or in brine.

0307.9: Other after excluding oysters, scallops, mussels, cuttlefish, octopus, snails. 'Other' thus covers abalone and other residuals.

0307.91: Other dissected according to preparation—live, fresh or chilled.

0307.91.90: Other.

0307.99.90: Other than abalone, otherwise treated as in 0307.91.

Even if this level of disaggregation were available for all countries' import and export data, identification of clam meat trade would still not be a simple task. The eight-digit class is often a residual item which needs to be examined for each country in order to identify the products. However, neither the six nor eight disaggregation levels provide a consistent basis for considering the products included in them as being close substitutes. While the classification is based on an apparent similarity of physical characteristics, a multi-product class is unlikely to be consistent with a designated market because there is no consideration whether products are potential substitutes in terms of offering a similar quantity, quality, mix and value of characteristics. The import classification (Australian Bureau of Statistics 1987a) is similar. For example:

037: Fish, crustaceans and molluscs, prepared or preserved, NES
037.20: Crustaceans and molluscs
037.20.29: Other

Again, the statistics tend to be excessively aggregated.

Published international trade statistics surveyed at the international organisation level such as United Nations International Trade Statistics, and FAO Fishery Statistics, present their trade flows for this commodity group at the four and three-digit levels respectively. Thus, FAO (1988) presents trade data for the commodity group 'Crustaceans and molluscs, fresh, frozen, dried, salted, etc.' Although production data in this source are separated according to several groups, of which the most relevant is 'clam meat, frozen', the production of only five countries is reported and the term covers a very wide range of marine animals with no indication of their uses or substitutability, while problems of coverage arising from the monitoring of production and illegal trade remain. With these caveats Table 3.1 presents the production statistics for these leading clam producers for the years 1982–1986. The large volume suggests that giant clam farming may not add significantly to world clam production for many years. However, the impact on trading prices and quantities may be much greater for products close to it in the hierarchy of substitution if uses of giant clams are confined to a small sub-market.

Table 3.1 Production of clam meat, frozen 1982–1986 (t)

Country	1982	1983	1984	1985	1986
Canada	1139	790	957	1224	822
Chile	84	213	465	568	663
China	9843	10769	10339	10752	10276
Korean republic	2248	2231	2197	1375	2311
USA	46082	47960	54275	53641	52465

Source: FAO (1982, p.122).

A study of the trade and production statistics published by each country that might be involved in the giant clam trade (exporters and importers) would be more costly, yet it is doubtful whether it would yield results which define the trade in giant clams. For example, Fiji Fisheries Division (1988) provides fish export data at the six-digit level by volume, value and destination. However the relevant commodity groups are:

036.010: Crustaceans and molluscs live; and
036.020: Crustaceans and molluscs, chilled, frozen, salted, etc.

Products in this group range from lobsters, crabs and prawns to bivalves, gastropods and echinoderms. Even within the bivalve family there is a diverse product range of which giant clams constitute only one part. Substitutability between crustaceans and molluscs is likely to be very poor, while within the mollusc family the diversity of culinary uses is also likely to restrict substitutability. The basic problem is that published international trade commodity data are largely a response to its importance to individual countries and the magnitude of trade flows. It is not a response to expected growth. One would expect to find trade statistics for giant clams in the molluscs NES (not elsewhere specified) commodity group, even at the eight-digit level, for importing countries.

A general picture of world trade flows and restrictions to trade for the three-digit commodity group, 'crustaceans and molluscs, fresh, frozen, etc.', can be drawn using U.N. published trade data as well as relatively recent OECD reports (1985, 1989) on the fish trade. Three economies dominate the importation of shellfish: Japan, USA and France. Table 3.2 provides an indication of the size and value of this market.

Table 3.2 Imports of SITC group crustaceans and molluscs, selected countries,1986

Country	Quantity ('000 t)	Value (U.S.$ million)
USA	263	2249
Japan	608	3197
France	132	454

Source: OECD (1989, Table 1).

Table 3.3 provides the main components of shellfish imports for the three major importers. While clam imports into Japan may be a small percentage of its total shellfish trade their value is still large. Yet the value is not an indication of potential market opportunities because it is not evident that the many clam species are all substitutable for each other in this or other large shellfish markets.

The problems of establishing giant clams in the clam market, outside existing culinary uses, can be noted from the OECD (1985) general observation of demand for shellfish:

> Apart from the different species consumed, each of the major OECD markets portray special characteristics of consumer orientations. The products, the channels of distribution and the methods of buying, selling and transportation are often different. Regulations regarding standardisation and grading reflect the nature of the market and where the end products are consumed: and government laws and regulations affect the market environment (including competition) and are a determinant of pricing policy (p. 299).

Table 3.3 Shellfish[a] imports by Japan, USA and France according to major species, 1981

	¥ million	U.S.$/¥	U.S.$ million	%
Japan, total	431459	0.004552	1964	100
Spiny lobster	5404		25	1
Shrimp	161725		736	37
Crabs	31039		141	7
Squid	68776		313	16
Octopus	100450		457	24
Abalone	1896		9	
Clams	18148		83	4
Scallops	1270		6	
Other	42751		194	1
United States			1244	100
Crabmeat, fresh or frozen			23	2
Scallops			113	9
American lobster			53	4
Spiny lobster			256	21
Shrimps			715	57
Other			84	7
	FF	U.S.$/FF		
France, total	1580	0.184753	292	100
Oysters	11		2	1
Squid, octopus	105		19	7
Mussels, scallops, etc.	201		37	12
Other mussels and crustaceans	23		4	1
Lobster and Norway lobster	279		52	18
Crabs	56		10	3
Shrimp	692		128	44
Other crustaceans	76		14	5
Other	137		26	9

[a]Excludes preserves ($84 million).
Source: OECD (1985, p. 301).

Tariffs applying to imports of shellfish, including clams, in selected OECD countries are listed in Table 3.4.

In two major potential markets for giant clam meat, Japan and the USA, tariff measures are unlikely to restrict any trade. In the former, tariffs for shellfish vary from 3–15%. In the latter, the relevant category is duty free. Taiwan, a known major consumer of giant clam meat, has significantly higher restrictions which could impede legal trade (Combs 1978, p. 39; Dawson 1986, p. 26).

Table 3.4 Tariffs and preferences—crustaceans and molluscs (CCCN 03.03)

Australia	Free/expt., Bex, OP
New Zealand	0–25% & $NZ 0–7.50/100 kg, Bex, GSP, OP
Canada	Free/expt., 8%, B, GSP, OP
United States	0–18.1%, Bex, GSP, Free/expt. B
Japan	3.0–15%, Bex, GSPex
EEC	0–25%, Bex, Iqex, GSPex, Opex
Norway	0–1NKr/kg
Sweden	Skr 0–120/100 kg, Bex, GSPex, Opex
Iceland	Free/expt., Bex
Finland	Free/expt., B
Turkey	25%
Austria	15%, Sch 2 000/100 kg Bex, GSPex, Opex
Switzerland	Free/expt., Bex, GSP, OP

B= Bound in GATT.
GSP = General system of preference.
OP = Other preference.
Source: OECD (1989, p. 26).

The contribution of previous studies

Two studies in the mid-1980s have surveyed the market for giant clams. Their assessment techniques and conclusions differed. The 'Compass report' (Compass Consulting Services 1986) was primarily based on responses to a postal questionnaire sent to Australian Trade Commissioners representing 17 countries in the Indo-Pacific area expected to be either exporters and/or importers of clam meat. The 'Dawson report' (September 1986) was the culmination of an in-depth market survey of four potential giant clam markets (Taiwan, Japan, Hong Kong and Singapore) which apparently involved visits and assessments in these countries. Differing budgetary considerations may have determined the appropriate market survey techniques and also imposed constraints on their application.

The Compass report

A questionnaire was sent to Australian Trade Commissioners representing Burma (Myanmar), China, Fiji, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, New Zealand, Papua New Guinea, Philippines, Singapore, Solomon Islands, Thailand, USA and Vanuatu. No response or information was apparently received in relation to five countries by the time of publication. These were Myanmar (Burma), Korea, Fiji, New Zealand and Solomon Islands.

The study sought to identify existing or potential markets for giant clam meat by identifying the volume and value of exports, imports, production and consumption of 'clam meat'. This term can and does include other molluscs and it is not possible to say whether these have a close substitutability with uses of giant clam. As a copy of the survey document is not included in the report, it is not possible to assess if the responses cover only giant clam meat. However, given the geographic distribution of the giant clam, it is fairly obvious that the production statistics for the USA include species that are not giant clams. Again the question which must then be addressed is whether a giant clam market has been identified by the process of identifying trade, production and consumption of a wider product range.

The Compass report identifies major Asian importers of 'clam meat' as Japan, Malaysia and Singapore. Taiwan and Thailand are major consumers but measured imports are small. In the former case, this may arise from a high level of illegal imports. The USA is also recognised as a major importer and producer of 'clam meat'.

The sources for country data are generally mollusc production and trade, a category which includes not only octopus and squid but also all forms of bivalves. The relevant commodity market should encompass only products which consumers consider are close or potentially close substitutes in terms of characteristics and prices. An approximate assessment of market demand can then be obtained by summing domestic production and imports, less exports. To assume substitutability in consumption among the diverse range of molluscs produced and traded is a heroic assumption. In summary, the Compass report does not provide a useful guide to the potential market for giant clam meat.

The Dawson report

Dawson (1986) adopted a market survey approach. He was able to visit four countries (Taiwan, Japan, Singapore and Hong Kong) and conduct wide-ranging discussions with trading companies, restaurants and fishermen. His approach identifies the market for giant clam meat in terms of an expansion of its existing use.

Dawson's report first outlines the tridacnid family of giant clams, their growth characteristics, their geographical distribution in the Indo-Pacific region, utilisation of the animal in terms of the meat, souvenir items and craftware, and natural stock levels in the Forum Fisheries Area. He then describes the development of mariculture, the international giant clam mariculture project, and foreign (especially Taiwanese) fishing activity. Finally he reports on surveys of the market for giant clam meat in each of the four countries.

For Taiwan, Dawson examines the supply of giant clams, the pattern of distribution, the product and price structure, importation requirements, market entry and future development (demand). For the other countries the markets are less identifiable so the study is concerned with identifying market opportunities in these in terms of potential buyers and importation requirements. The study identifies Taiwan as the only country where there is an established market for giant clam meat. There was difficulty in establishing the size of this market because illegal fishing operations and importation of giant clam meat render official statistics useless. However, Dawson assesses the giant clam adductor muscle market (based on restaurant trade) at approximately 100 t/year. He assesses the other countries as not having a significant giant clam meat market, and opines that, in countries such as Japan, demand arises primarily from Chinese ethnic groups. A very large mollusc adductor muscle market exists in Japan using scallop, pen shell and other clam species but not apparently the giant clam. While domestic production of some molluscs is large and growing, Japanese adductor muscle imports declined from 2172 t in 1982 to 900 t in 1984, possibly due to import replacement. The major exporters to Japan were Korea, China, Philippines, Chile and New Zealand, countries not noted for giant clam stocks.

The off-the-boat price of adductor muscle varies according to species, size and colour. In Taiwan, 'In January 1986, the base price for the lowest grade muscle was U.S.$7.50/kg and the highest grade price range from U.S.$21.25' (Dawson 1986, Summary page). Frozen adductor muscle was the main form of supply. Dawson notes an interest by restaurateurs in the fresh/chilled product, but no enthusiasm for the dried or processed form.

The high-quality restaurant market for giant clam adductor muscle was assessed as not having significant growth potential. However, only by a lower product price can the market be widened to lower price restaurants and retail outlets. Dawson's assessment that the 1986 market for giant clam adductor muscle was 100 t/year places it as a very small part of the Taiwanese bivalve market demand which in 1984 apparently consumed 25 853 t of hard and freshwater clams (Compass Consulting Services 1986, p. 20)

Dawson could not find an existing market in Japan for giant clam meat, although he argued that the sushi restaurant trade offered the prospects of a market. In Hong Kong, bivalve non-giant clam adductor muscle use also exists; that is, any trade in giant clam meat is apparently negligible. However, the possibility of development of a fresh/frozen market exists in both countries although the potential scope is not specified other than at 'total levels of several 100 tonnes per annum' (Dawson 1986, Summary page).

Similarly, Singapore, Malaysia and Thailand also consume adductor muscle, although not apparently from the giant clam family. If there is close similarity in characteristics among adductor muscles and a comparable cost and price structure then a potential market exists. Dawson estimates 50 t/year of giant clam adductor muscle as the potential market for these three countries. To secure new markets, the price level for giant clam adductor muscle (1986) would need to be approximately U.S.$10.00/kg delivered. The possibility of it being used as a substitute for scallop (a major product) would also be poor, in his view.

Dawson's study provides useful information on the giant clam trade and the consumption possibilities and helps to define the existing market for the product. His most detailed information is for Taiwan.

As with other countries, Taiwan's statistics do not distinguish the various species of shellfish as molluscs such as snails, trochus and abalone are included. Dawson outlines the pattern of supply of giant clam and, in particular, the illegal operation of Taiwanese fishing boats. His information suggests that clam poaching activity peaked in 1976, and there was a view that wild clam stocks which were accessible and safe could be exhausted in 'two to three years' (Dawson 1986, p. 24).

Fresh/frozen adductor muscle is the only form of the product which appears to have an established market. The dried or processed form does not appear to be attractive to the restaurant trade in the four countries directly surveyed, although Hong Kong sources 'thought that there might be considerable market for a dried/ processed product in the People's Republic of China' (Dawson and Philipson 1989, p. 91).

Given the trade data deficiencies, the product and price information which Dawson provides is a useful basis for considering the potential for product substitution among molluscs. There were three grades of giant clam adductor muscle recognised in Taiwan with prices to the suppliers (trawlers supplying muscle) as at February, 1986 varying by grade as follows (Dawson 1986, p. 25):

Grade	Price/kg (U.S.$)
First	from 21.25
Second	from 17.50
Third	from 7.50

Grading was apparently based on species, muscle size, whiteness and texture, with size and species closely interrelated. Prices also varied between various ports of entry. As there is a wholesale network, restaurant purchase prices must be significantly higher than the above.

Taiwanese clamming activity was largely illegal so considerable doubt attaches to whether prices would be maintained if trade were to become legal and regular, so probably increasing supply of the product. Dawson believes that the exotic nature of the product is a major determinant of its consumption and that if it were supplied legally the price might fall by as much as 50% (Dawson 1986, p. 26). The extent of any price fall can only be conjectured given the lack of information on projected supply changes which might result from mariculture activities. It is more useful to note that one could expect both snob and bandwagon effects with any legislation and increased regularity of supply, as well as income and substitution effects from any changes in price. But since the amount of expenditure on clams as a proportion of total expenditure is likely to be low, the income effect is likely to be small.

While Japan's trade in giant clam meat is apparently non-existent or negligible (Dawson 1986, p. 28) at least one North Queensland project is targeting the sushi/ sashimi restaurant market for adductor muscle. Dawson notes that 'kaibashira' is the Japanese term referring to adductor muscle from any mollusc prepared in either fresh, frozen, boiled, boiled and dried, or canned forms (Dawson 1986, p. 30) and that its production, imports and consumption are very large. Increasing domestic production of scallop appears to have dampened imports. Against a background of increasing domestic production and lower domestic prices, Dawson suggests that the use of giant clam as a substitute for scallop adductor muscle may be poor. Again, a lot will depend on the delivered prices of the farmed giant clam and its characteristics. The substantial Japanese scallop export markets in the USA, Hong Kong and elsewhere may be easier to penetrate.

In Hong Kong and Singapore no established market demand for giant clam meat could be found. Dawson believes that transhipments may be involved from these countries to Taiwan. In both countries a potential market is seen to exist in Chinese cuisine restaurants using bivalve adductor muscle.

Summary and comments on the two reports

Both reports confirm the view that international trade data on giant clams are difficult to obtain and those that can be obtained are also likely to be unreliable. The extent and value of the trade is unknown. Use of aggregate mollusc or bivalve commodity groups cannot provide an indication of market size for giant clam meat because there is very little information to indicate the extent of substitutability. Additionally, it is the adductor muscle which is the part of the giant clam which is mainly traded. By-product uses, especially of the mantle, have not been explored.

Dawson's country surveys show that there are entrepreneurs willing to explore market opportunities but at present the existing giant clam meat market is shown to be very narrow and based primarily on Taiwan. In this and other countries there may be problems in widening usage beyond the high-quality, restaurant niche.

Both studies have problems in identifying the current supply and disposition of giant clam meat with any degree of accuracy. Provided the clam adductor muscle is not an inferior commodity, one could expect, with rising per capita incomes and populations, the potential market for adductor muscle alone to increase. Because there are no reliable estimates of existing demand, with prices inflated by the illegality of a large part of the trade, projections are difficult.

The Compass report assesses market potential in a broad sense because it does not address whether there is close substitutability in consumption between all forms of bivalve molluscs. The study implies there is a single market in the sense that, providing there is price competitiveness, giant clam meat could meet the needs of existing consumers of 'clam chowder' and many other kinds of shellfish in different countries. If price competitiveness cannot be attained then the giant clam market will be confined to a small niche. There are underlying assumptions that taste differences are minimal; and that other characteristics such as texture and colour are relatively unimportant. If they are important, then there is no basis for examining the aggregate market for clam meat.

On the other hand, Dawson's study may be an unnecessarily restrictive assessment of potential market size. The focus on giant clam adductor muscle in the restaurant trade identifies an existing market based on higher price Chinese cuisine and the possibility of use in higher class Japanese sushi restaurants. Expansion of this trade requires close characteristics substitutability and price competitiveness with other more widely used mollusc adductor muscles such as those of scallops and penshells. However, there is the perverse possibility that, if there is a snob effect, greater accessibility of the product may reduce the value of potential trade.

The difference in the scope of each market study is important. Compass envisages a growth in demand for giant clam meat over time based on its substitution for other marine bivalve molluscs, as well as a growth in demand from existing culinary uses. Dawson examines existing Chinese and Japanese culinary uses for the giant clam. The potential growth in demand is investigated from this viewpoint and from the possibility of substituting it for other adductor muscles in similar culinary uses. (Editor's note: It is also true that some of Dawson's hypotheses need to be modified in the light of later findings, such as those outlined in Chapter 4 and in Part II.)

The market for substitutes as a guide to potential market demand for giant clam meat

It may seem a paradox but, although the giant clam is restricted in international trade as an endangered species, in order to examine its potential market it is necessary to treat it as an underutilised species. The rationale is an apparent lack of trade in the product at the present time although it may have been traded on a larger scale in the past; an apparent lack of familiarity with this species in mainland Japan and in other countries outside of Taiwan and, in Taiwan, its apparent confinement to higher-priced restaurants; and the likelihood that greater familiarity with giant clam edibility characteristics will have to be established in potential importing countries.

The meat of bivalve molluscs differ in terms of size, texture, colour, by species and age. According to Tisdell (1989, p. 5) harvest of farmed giant clams may be optimal from 2–3 years of ocean growout to not more than 5 years. Such clams would be approximately 4–6 years old and not more than 8 years old. But these are early tentative estimates for *T. gigas*. Over its period of growth its edibility characteristics may alter, increasing its substitutability with some species and reducing it with others. While the meat may be a potential substitute for differing bivalves depending on when it is harvested, at any instant the harvested animal can occupy only one area of characteristics space.

Edibility characteristics will determine the potential market opportunities. For example, if a 2-year-old clam is similar in edibility characteristics to an oyster, depending on price competitiveness, a very large potential market is possible. The identification of markets for an underutilised species such as the giant clam can probably only be achieved by assessing the potential for substitution with species which are marketed. Combs (1978, p. 78) uses classification of edibility characteristics in assessing export market opportunities for underutilised seafoods. Edibility characteristics that can be used to classify seafood are flavour intensity, fat content, odour, colour, flakiness, firmness, coarseness and moisture. Flavour is often associated with colour and fat content, while flakiness, firmness and coarseness are aspects which can be covered by the term texture. These two characteristics are used in Figure 3.1 to examine some of the issues involved in assessing the potential giant clam meat market.

The characteristics approach (Lancaster 1966, 1971) argues that the classification and relationship of products are aided by distinguishing between the product itself and the various characteristics or attributes a potential consumer perceives that it offers. In the context of fresh or chilled shellfish meat, assume that it is possible to objectively measure the key edibility characteristics of flavour (0 for no flavour, 100 for perfect) and texture (0 for very poor, 100 for perfect). The use of flavour to encompass several characteristics and the assumption that it can be measured without inconsistency is a simplification for heuristic purposes.

From the viewpoint of the consumer, if products offer precisely the same mix and quantities of the characteristics per unit of each product then the products are perfectly physical substitutes. If products offer the same characteristics but in different proportions and/or different amounts of each characteristic per unit of the product then they are imperfect physical substitutes. Whether products that are perfect or imperfect physical substitutes will be close substitutes in the market—that is, whether their cross elasticities of demand will be high and positive—will depend on whether their prices are in a range that make them feasible substitutes.

Table 3.5 assigns arbitrary characteristic values for a range of products. Each product could be considered a specific type of bivalve meat, such as Pacific oyster, razor clam, abalone, scallop and pen shell. The ratios of the characteristics mix for each product are plotted in Figure 3.1. Each ray is labelled in small letters. Given the wide range of shellfish species marketed and consumed worldwide, many products could have similar mixes and values such that characteristics space is likely to be very crowded.

Table 3.5 Characteristics of alternative products and prices—hypothetical data

Product	Price/kg ($)	Characteristic rating Flavour	Texture	Mix ratio	Price/character unit
A	10	80	20	4:1	$0.10
B	10	75	50	1.5:1	0.08
C	10	60	60	1:1	0.083
D	10	30	80	1:2.67	0.09
E	10	20	80	1:4	0.10

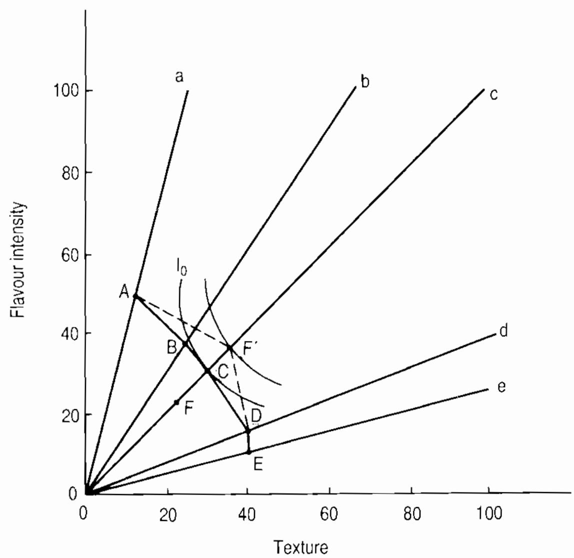

Figure 3.1 Ratios of the characteristics mix (labelled a–e) for each product

Each product could be plotted as a point on its relevant ray depicting its physical qualities of each characteristic. However, it is more fruitful to take into account the effects of prices on consumer choice. Price per unit of characteristic is highest for products A and E and lowest for B. Assuming perfect product divisibility, a consumer with a seafood budget of, say, $5 would obtain lower total consumption of both characteristics by purchasing A or E. Prices and the consumer's budget define the maximum attainable combination of characteristic from each product. These points are labelled in capital letters. Joining these points gives the consumer's 'efficiency frontier'. If the consumer's preference pattern is given by the indifference curve, the tangency of the curve with the frontier indicates the optimum consumption point.

Assume that farmed giant clam meat, approximately 3 years old, now comes on the market (product F). Its characteristics ratings are 50:50, giving it the same ray as product C, but with less total flavour and texture. If its initial price is poorly set, for example $12/kg, for the same budget constraint its maximum potential consumption point is point F and the substitution of product F for C is unlikely to occur. If the price of F is reduced to less than $8 it displaces C on the efficiency frontier. Its substitution for other products with adjacent characteristic mixes is also likely to occur if the price of F is further reduced. The consumer's frontier and consumption moves out to the point F' when F is reduced in price to $7. This excludes adjacent product B, as well as product C.

This analysis can be used to draw some useful conclusions on the question of market potential. The approach assumes that consumer preferences exist for all parts of characteristics space. However, finding and holding a market will be easier if the product characteristics ray is occupied by only one product and adjacent product rays are distant. Positioning the product in terms of both characteristics and price will thus determine the market potential. There may be insufficient data on the edibility characteristics of giant clams at various stages and their feasible prices to select this position at present. When it is positioned in the market it may substitute for other species with similar characteristics, for different qualities of the same species or for a different form of processing.

Empirical evidence on substitutability

Studies of own-price demand elasticities and substitution patterns among other forms of seafood may provide limited guidance on the extent to which giant clam meat is likely to be a substitute for other forms of molluscs.

The own-price elasticity of demand (n_{ii}) measures the percentage change in quantity demanded of i, resulting from a small percentage change in its price. If own-price elasticity of demand is inelastic (less than unity) then market size (total sales revenue) may decrease if mariculture leads to an increase in supply of giant clam. Cross-price elasticity of demand (n_{ij}) is defined as the percentage or proportionate change in quantity demanded of product i, divided by the percentage or proportionate change in the price of product j, all other variables in the demand functions of both products remaining unchanged. The main purpose of measuring the cross-price elasticity is to assess whether consumers view the two products as related, how they are related, and the strength of the relationship. A positive value is an indication of substitutability, with the higher the coefficient value, the greater the substitutability.

If there is a high degree of substitutability the values of the cross-price elasticities in both directions will be high, such that if any small price fall occurs, the product whose prices is held constant will suffer a severe fall in sales. No particular value of can be advanced as the crucial dividing line for market separation. There will be a chain of cross-price elasticities among seafood products. A low positive cross-price elasticity between two products indicates limited or poor substitutability.

The value of the own-price elasticity of demand will be influenced by the positioning of substitutes. If giant clam adductor muscle is a very close substitute for scallop adductor muscle, and the price of the former falls, we would expect to see a large proportional increase in the quantity demanded of clam; that is, an own-price elasticity for clams greater than unity. If scallop is the only close substitute we would also expect that the value of the coefficient for the cross-price elasticity of demand for scallop with respect to clam prices to be positive and high. However, because of the large number of possible substitute relationships the strength of this predictive relationship may be highly variable for any pair of commodities.

The income elasticity of demand (n_{iy}) measures the percentage change in the quantity of commodity i demanded resulting from a one per cent change in income, y. Positive values for n_{iy} would strengthen the argument for a demand growth for giant clam meat over time given the rising per capita income of existing consuming nations such as Taiwan, and in potential consuming nations such as Japan, Hong Kong and Singapore, where adductor muscle in fresh and frozen forms is already widely used in Chinese cuisine according to Dawson (1986). Other countries, such as the USA, with high and still rising per capita incomes and a large Chinese and Japanese cuisine following, could also be potential markets. However, except in Taiwan, what may be required is a change in tastes if the attributes of existing adductor muscle used in cooking differ significantly from that of the potential substitute, giant clam. Increases in income may be expected to increase the demand for giant clam meat in the exclusive Chinese restaurant trade, but market growth at a more rapid level may require taste as well as income changes.

In 1987 a Japanese cuisine restaurant in Sydney was supplied with 2 and 3-year-old clams for the preparation of seven experimental dishes for tasting by a consumer panel. The mantle meat was considered to have an odour of seaweed. Nevertheless, the panel favoured two mantle meat dishes over those including adductor muscle. Potential customers were thought to be gourmet Chinese and Japanese restaurants. Despite the size similarity of the 2-year-old clams to oysters and mussels, the panel did not consider clams competed directly with these products mainly because of the extra preparation required for the giant clam. Rather, clams were seen as 'similar to abalone' (Cowan 1988, p. 256).

While there is a growing body of studies estimating own-price, cross-price and income elasticities for a range of commodities, very little appears in relation to fish and products such as beef, pork and poultry. These cross-price elasticities may provide general guidance as to the way consumers view substitutability among white and red meats, but this is of no help in considering whether consumers view various shellfish as substitutes.

Cheng and Capps (1988) focus on the lack of studies of the demand for seafood products using disaggregated fish species data. Their study uses a 1981 Seafood Consumption Survey conducted for the National Marine Fisheries Service, USA. The survey investigates only at-home seafood consumption expenditure in the USA drawing on information from 9422 households. As away-from-home outlets accounted for approximately 60% of total seafood consumption the study conclusions cannot be used as a generalised explanation of fish demand determinants. Being based on a household expenditure survey, the study examined socio-demographic influences such as occupation, household income, age, race and religion, on the consumption pattern. Of the 200 or more seafood species currently marketed in the USA only the most important were analysed. Price variables for red meat and poultry were included in order to examine substitution effects between fish products and these two types of meat. Unfortunately, cross-elasticities among the various fish species were not analysed.

The relevant elasticity estimates are presented in Table 3.6. The values indicate that, excepting oysters, fresh and frozen shell and finfish demand tends to be price inelastic. Cross-price inelasticities of the main species of shellfish with poultry and beef are positive but very low, implying a very weak substitution relationship. The income elasticity of demand for shellfish is also positive but low, with the results statistically significant for only two of the three species.

Table 3.6 Recent seafood demand elasticity estimates, USA

Fresh & frozen products	Own-price elasticity	Cross-price elasticity poultry	Cross-price elasticity red meat	Income elasticity
Shellfish				
Crabs	−0.7713*	0.1212	0.0314	0.4610*
Oysters	−1.1320*	0.3105	0.1991*	0.1769*
Shrimps	−0.6956*	0.3437	0.0257	0.0365
Total shellfish	−0.8850*	0.9642*	0.0265	0.1114
Finfish				
Cod	−0.5358*	0.6051*	0.1710*	0.0632
Founder/sole	−0.4500*	−0.5501	−0.0574	0.0368
Haddock	−0.5557*	−0.4033	0.0096	−0.0062
Perch	−0.7039*	0.3157	−0.1035	0.0172
Snapper	−0.9720*	−1.7752*	0.1568*	−0.1087
Total finfish	−0.6746*	0.0382	0.0184	0.1405*

*Significant at 0.10 level.
Source: Based on Cheng and Capps (1988, p.540).

Estimates by other researchers of demand elasticities for fish products are provided in Table 3.7. These studies mainly relate to the USA. Cheng and Capps (1988) observe that their estimates of own-price elasticities for cod, perch and flounder compare favourably with estimates given by Tsoa et al. (1982). Considerable differences among U.S. estimates could be expected, being the result of differing data sources and the significant regional and socio-demographic differences to be found in the USA. *A fortiori*, such differences could be expected to apply to estimates for different countries, reducing the validity of using one country's coefficients in estimating the market for a single seafood product such as giant clam.

Table 3.7 Estimated demand elasticities for fish products—various studies

Product	Country	Own-price	Cross	Income	Primary researchers
Atlantic Groundfish	USA	−1.000			Anderson (1973)
Cod		−0.405[a] −0.460[b]		+1.847	Tsoa et al. (1982)
Fillet/ steaked fish				+0.082 to +0.134	Perry (1981)
Finfish				+0.192	Keithly (1985)
Flounder & Sole		−0.549[a] −1.040[b]		+1.813	Tsoa et al. (1982)
Fresh seafood				+0.467	Keithly (1985)
Frozen seafood				+0.303	
Halibut		−1.000			Anderson (1973)
Ocean Perch		−0.606[a] −0.702[b]			Tsoa et al. (1982)
Salmon—Canadian—all types					
	France			+3.1	Devoretz (1985)
	UK			+3.9	
	Italy			+3.3	
	Sweden			+1.0	
	W. Germany			−0.52	
Chinhook	France			+1.4	
	UK			+3.8	
	Italy			+3.5	
	Sweden			+0.41	
	W. Germany			+0.64	
Chum	France			+1.10	
	UK			+2.30	
	Italy			+1.01	
	Sweden			+1.00	
	W. Germany			−0.006	
Sardines	USA	−0.9837			Anderson (1973)

Table 3.7 (contd.) Estimated demand elasticities for fish products—various studies

Product	Country	Own-price	Cross	Income	Primary researchers
Tuna		−0.8632			
Total seafood				+0.239 +0.165	Keithly (1985) Capps (1982)
Canned fish				+0.062 to +0.175	Perry (1981)
Canned seafood				+0.303	Keithly (1985)
Canned Canadian salmon—all species					
	France			+0.058	Devoretz (1982)
	U.K.			+0.023	
	Italy			+1.70	
Sockeye	Canadian	−13.8	9.2		
Pinks	Exports	−0.73	1.4		
Chum		−12.9	10.4		
Crabs	USA	−0.1487			Anderson (1973)
Clams		−0.6047			
Northern Lobster		−0.5995			
Oysters		−0.6724			
Sea scallops		−0.6337			
Shellfish				+0.543	Keithly (1985)
				+0.069 to +0.344	Perry (1981)
Shrimp		−0.63		+1.12	Doll (1972)
		−0.3099			Anderson (1973)

[a]Short run elasticity. [b]Long run elasticity.
Source: Compiled from Cheng and Capp (1985); Shaw and Muir (1987); Staniford (1988); Tsoa et al. (1982). They cite the primary sources listed in column 6. See references.

Tables 3.6 and 3.7 make clear the lack of demand elasticity studies for shellfish and the general lack of cross-price elasticity estimates among seafoods. The own-price elasticity estimates for nearly all forms of fresh seafood, including most shellfish species, suggest that these are price inelastic while the remaining estimates hover close to unit elasticity. The implication of the inelastic cases is that increases in the supply of a species is likely to cause large falls in its price and a decline in market size (total revenue). Cross-price elasticity estimates among fresh seafoods are notably absent. However, if giant clam is similar to most other shellfish species (Cheng and Capps' oyster result appears anomalous) the low own-price elasticities suggest limited substitution possibilities for clam meat using pricing strategies. A small price reduction in giant clam meat will bring forth only a small quantity response and a likely fall in total revenue.

Income elasticities vary widely, and tend to be high and positive for some fresh food species but are weak for the shellfish listed. The fresh salmon income elasticities vary widely according to type and country, emphasising the importance of consumer perceptions in treating some outwardly similar products (chinhook salmon) as being superior and thus resulting in a high income elasticity. Marketing of a limited quantity product such as giant clam may be able to establish it in this category. The very high own-price and cross-price elasticities for the various types of Canadian canned salmon provide a warning that consumer perceptions that products are similar can cause large swings in demand with considerable substitution occurring.

Summary

This chapter has investigated some of the issues involved in assessing the potential market for giant clam meat. Assessment using international trade data faces many obstacles. Assuming that suitable disaggregated commodity data exist, current imports into a country cannot by themselves provide an adequate indicator of potential export opportunities. Trade barriers, business practices, trends in production and trade all require examination. In the case of giant clam meat the first hurdle was insurmountable: the commodity data are excessively aggregated and, due to illegal catching and trading, perhaps inaccurate.

The Compass and Dawson reports have both addressed the question of the potential market for giant clam meat. The former uses trade data that are probably too aggregated to distinguish those imported commodities where giant clam meat could possibly be used as a feasible substitute. The potential market recognised is too wide. The latter study focuses primarily on the existing import market demand for giant clam meat, and its potential growth. As there is always the possibility of substitution between adjacent commodities in characteristics space, and the edibility characteristics of giant clam can alter with age, the assessment of market potential is perhaps too restricted.

Substitution possibilities exist but a review of the evidence on demand elasticities for various seafoods suggests that market expansion based on securing market share from adjacent commodities may be difficult. Considerable marketing effort will be needed to find the best location in characteristics space and then establishing the product in this position. If own-price elasticity of giant clam meat is low, as seems likely, aggressive pricing to establish a market is likely to be counterproductive. Non-price marketing strategies are likely to be more rewarding. It also follows that both demand and supply will need to be closely monitored and controlled as excessive supply increases are likely to cause large price falls over time. In spite of rising incomes in many potential consuming nations, income elasticities for shellfish may not be high enough to obviate a close monitoring of supply growth.

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4 Markets for Giant Clam Products in Selected Countries: an Initial Overview Concentrating on East Asia, Australia and the United States

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Abstract

The natural stocks of giant clams have been seriously depleted, due mainly to over-harvesting, to the extent that most species are now listed as threatened. The recent advances in culture techniques make giant clam farming possible. With the anticipated expansion in giant clam production, marketing information is urgently needed. The lack of published trade data on giant clam products made it necessary to collect basic market information by field interviews.

The purpose of this study was to evaluate the existing market for giant clam products in Japan, Taiwan, Hong Kong, Australia and the United States. Most of the information for this study was obtained through interviews of seafood importers/distributors, restaurant owners, aquarium species distributors and shell distributors who have had experience in handling giant clam products. The interviews were conducted during the latter part of 1989 and early 1990.

The preliminary market surveys ascertained that markets exist for five types of giant clam products: food, aquarium specimens, seedstock, broodstock and shell. The largest potential market for giant clam products appears to be as food.

There are markets for giant clams as food in Okinawa, Taiwan and the Pacific islands. The food market in Okinawa may absorb up to 500 t of giant clams in-shell — mainly for use as sashimi and sushi dishes. People in Okinawa prefer *Tridacna crocea*. Whether other giant clam species could penetrate the Okinawa market would depend on the price and taste of the product. If *Tridacna derasa* were to be imported, the import price for a 2-year-old clam would have to be much lower than *T. crocea's* current price of U.S. $1.43–$2.38 in order to be feasible.

In Taiwan, a market for fresh or frozen giant clam adductor muscle exists with a potential of about 240 t annually. The economic feasibility of producing the large-size clam muscles at competitive prices needs to be studied further.

In Australia, a market exists for giant clams among immigrants from Pacific islands and their descendants. Giant clams are unknown species for food in mainland Japan, Hong Kong and the United States; the market potential should be explored.

A limited market potential exists for giant clams as aquarium specimens in Japan, Australia and the United States. The market for giant clam shells appears good. A limited market also exists for giant clams as seedstock and broodstock in the Pacific islands.

Giant clams are treated as threatened species, and trade in naturally caught giant clam products is restricted between the signatories of the Convention on International Trade in Endangered Species (CITES). Although cultured giant clam products are not restricted for trade, it is difficult to distinguish between the naturally bred and cultured species. Therefore, certification that the giant clam products were cultured may be necessary, and an import permit is required to ship giant clam products to the member countries of CITES.

Introduction

Giant clams of the family Tridacnidae are confined to the shallow, sunlit waters of Indo-Pacific coral reefs. The largest clams are *Tridacna gigas* and *Tridacna derasa*, which reach a maximum shell length of approximately 100 and 50 cm, respectively. The likely maximum shell lengths of other species in the region are as follows: *Tridacna squamosa*, 40 cm; *Hippopus hippopus*, 40 cm; and *Tridacna maxima*, 30 cm. *Tridacna crocea*, the burrowing clam, is much smaller, averaging 15 cm.

Pacific giant clams are popular as food and for other purposes within the Pacific Rim countries. Their high value and easy accessibility have threatened their populations in many parts of the tropical Pacific Ocean, and the ineffective protective regulations have not been able to prevent poachers from continuing their decimation. Today, giant clams are listed by the International Union for the Conservation of Nature as threatened species, and the harvest and export of naturally caught giant clam products are restricted among the signatories of the Convention on International Trade in Endangered Species (CITES). As with many other popular and valuable marine food species, mariculture has belatedly been recognised as an important long-term solution to their continued supply.

With the limited land and freshwater resources in the Pacific islands, the development of mariculture has considerable potential to diversify their narrowly based economies, to provide food and employment for small-scale farmers and fishers, and to earn foreign exchange. The development of giant clam farming is of particular interest because:

- giant clams are autotrophic, requiring no artificial feeding;
- the ocean growout phase appears technically simple and requires little capital investment;
- giant clams are well adapted to the sunlit waters of coral reef areas low in nutrients; and
- the breeding and rearing techniques are relatively simple.

Research efforts in giant clam culture are a recent development and are still evolving. Research conducted mainly at the Micronesian Mariculture Demonstration Center (MMDC) in Palau and James Cook University in Australia has developed breeding and rearing methods that make giant clam farming technically possible. Pilot operations in giant clam culture now exist in American Samoa, Micronesia, the Marshall Islands, Solomon Islands, the Philippines and Australia. Most of the pilot operations have concentrated on the two largest species, *T. gigas* and *T. derasa*. Envisioning large-scale commercial farming in the Pacific by the end of the next decade is not unrealistic.

The key to the success of the giant clam industry, like that of any other industry, is coordination of the production and marketing operations. With future expansion in the production of giant clams possible, information on market and product development is urgently needed. Marketing information on giant clam products is very limited.

Tisdell (1986) made a theoretically based review of the market supply and demand for giant clam meat and shells. The markets for giant clam muscle in southern Asia and Japan were explored by Dawson (1986). These two studies, while useful, are regarded as insufficient due to their limited scope. Existing international trade data are inadequate in providing any guidance to the potential markets for giant clam products (Stanton 1990). The treatment of giant clam products in international trade statistics suffers from restricted coverage and an excessively broad commodity classification. Because giant clam fishing is regarded as illegal, and international trade of giant clam products is restricted, trade statistics for giant clam products are not available. In addition, published international trade statistics usually include giant clam in a broad commodity category such as crustaceans and molluscs, or as clam meat. Even the clam meat category includes a diverse product range, of which giant clam constitutes only one segment.

The lack of published trade data on giant clam products made it necessary to collect basic market information by interviewing key seafood brokers in selected potential markets in Japan, Taiwan, Hong Kong, Australia and the United States. Personal interviews were conducted in Japan, Taiwan, Hong Kong and Australia, while mail surveys were conducted in the United States. In consideration of the limited resources available for this study, identified key persons with marketing experience in giant clam products were interviewed where possible. The survey was conducted in the latter part of 1989 and early 1990. The existing market for giant clam products in each selected country will be evaluated in the following sections.

Markets in Japan

Giant clam products can be classified into three major categories in Japan: food, aquarium specimens and shells. Between 27 July and 10 August 1989, 30 people in Japan were interviewed.

Food market

Although the giant clam is a popular food item in Okinawa, it is unknown on most of mainland Japan. Let us consider the Okinawa market and then the mainland Japanese market.

Okinawa market

The main supply of giant clams in Okinawa is from the domestic catch in nearby waters. The most important species is *T. crocea*, followed by *T. squamosa* and *H. hippopus*. The total catch of giant clams reached its highest level of 578 t in 1975, declining to 91 t in 1987, due primarily to overfishing (Table 4.1). The declining catches resulted in higher prices for clams. To prevent further decline in natural stocks, several measures have been taken by the local government, as follows:

- The months of June–August are a closed season during which catches of giant clams are prohibited;
- The minimum legal size of catch was set at 8 cm or larger. However, based on catch statistics, the most frequent size in the catch is 5–6 cm;
- A hatchery producing giant clam seed, established by the government on Ishigaki Island, provides about 200000 one-year-old seed clams annually to fishers' cooperatives at no cost. These seed clams are then released into the waters around Okinawa by the cooperatives.

In Okinawa, giant clams are consumed in two forms: raw and processed.

Table 4.1 Catches of giant clam in Okinawa, 1975–1987

Year	Quantity (t)	Value (¥m)	Average price (¥/kg)[a]
1975	578	232	401
1976	227	96	423
1977	215	101	470
1978	222	107	482
1979	187	99	529
1980	187	107	582
1981	92	58	630
1982	112	61	545
1983	116	67	578
1984	154	68	442
1985	172	96	558
1986	154	103	669
1987	91	70	769

[a]This chapter used the conversion ratio of US$1=¥140 throughout.
Source: Fisheries Statistics of Okinawa.

Raw food

Most of the sushi bars in Okinawa prepare the giant clam as sushi and sashimi. The preferred species is *T. crocea* in live or fresh form and from 5–6 cm size in-shell. Frozen clams are not considered desirable due to the change in meat colour and flavour.

The catches of giant clam are distributed through auction and direct contact with intermediaries. Sushi bars usually obtain their supplies from wholesalers. The auction price ranges from about ¥400–¥1500 (U.S. $2.86–$10.71)/kg in-shell. The difference in price is primarily due to three factors: size of clam, season and species. The smaller clams have more tender meat and thus fetch a higher price. The price is also relatively high during the winter and typhoon seasons when supply is low. *T. crocea* commands a higher price than *T. squamosa* and other species (Table 4.2).

Table 4.2 Wholesale price of giant clam meat in Okinawa

Species	Price/kg (muscle and mantle only)
Tridacna crocea	¥8000–¥10000 (US$57.14–$71.43)
Tridacna squamosa	¥3000–¥4000 (US$21.43–$28.57)
Hippopus hippopus	¥8000–¥10000 (US$17.86–$21.43)

Currently (1989–90) sushi bars pay ¥1200–¥2000 (U.S.$8.57–$14.29)/kg for *T. crocea* in-shells compared with ¥700 to ¥1000/kg for *T. squamosa*. One 5–6 cm *T. crocea* weighs about 180 grams; 5–6 clams make one kg. If *T. crocea* can be cultured locally, and if producers can sell directly to sushi bars, production costs must be less than ¥200–¥333 (U.S.$1.43–$2.38)/clam in-shell in order to make a profit.

To test whether *T. derasa* would be acceptable to sushi bars, a local shrimp farm in Okinawa imported 400 2-year-old *T. derasa* from Palau, supplying them to five sushi bars at the time of this study. All of them indicated that the meat of *T. derasa* is too soft compared with that of *T. crocea*. Four of the five sushi bars expressed a willingness to buy *T. derasa* at a lower price than *T. crocea*, while the other had a negative impression about the species and may be willing to buy only during the off-season at a lower price.

Thus, if *T. derasa* were to be imported, the import price would probably have to be much less than ¥200–¥333 (U.S. $1.43–$2.38) for a 2-year-old clam in order to be feasible. Alternatively, older clams—perhaps 3-year-old *T. derasa*—might provide firmer meat, which is more suitable for sushi dishes, and these clams may command a higher market price.

A local fish market at Naha sells live *T. squamosa* supplied by a fish dealer. The clams usually range from 1–2 kg in-shells and retail at ¥800 (U.S. $5.71) /kg. This market often sells live *T. crocea* at ¥1200/kg (U.S. $8.57/ kg) for 5-cm clams.

A fish auction in Naha sells fresh clam muscle and mantle meat at ¥4000–¥4500 (U.S. $28.57–$32.14)/kg. Identification of the species was difficult. The buyers are wholesalers/intermediaries.

Processed food

A local fish-processing factory produced giant clam pickles in jars using clam meat and muscle imported from the Philippines and from local catches. The two types of products—salted and sweetened—are packed in three different sized bottles that retail at different prices (Table 4.3).

Table 4.3 Retail prices of pickled giant clams, Okinawa 1989

100 g bottle	¥ 500 (U.S. $3.57)
200 g bottle	¥ 1000 (U.S. $7.14)
440 g bottle	¥ 2000 (U.S. $14.29)

Retail stores in the local market indicated that 1kg bottles of salted pickles are the preferred size. The processor uses an estimated 2400 kg of clam meat annually and is promoting his products in some of the marine product exhibitions on mainland Japan.

As for the market potential of giant clam as a food item in Okinawa, the local market's absorption of 578 t of locally caught clams in 1975 seems to be a good indication of the size of the local market, provided the supply is available and the price is reasonable.

The Japanese mainland market

There is no indication that giant clam products are consumed in either raw or processed form on mainland Japan. Interviews with sushi restaurants in Tokyo revealed that they have not as yet tried the giant clam for sushi and sashimi. All of the sushi restaurants interviewed indicated interest in the giant clam but declined to make any decision until they had a chance to taste the clam samples. One company that owns about 100 sushi bars in and out of Japan suggested that if the giant clam has potential as a raw food item, the size preferences and price range could be similar to the hen clam. The preferred size for the hen clam in Japan is about 120 g, and the wholesale price was about ¥1300 (U.S. $9.29)/kg in-shell in 1989.

Interviews with fishery trading companies, processing firms and wholesalers in Tokyo revealed that they were not familiar with giant clams. Many of those interviewed were interested in obtaining clam samples. One large fish-processing company suggested that if the giant clam has the potential to be processed as a food item, the wholesale price should be less than ¥2000 (U.S. $14.29)/kg of meat.

The consensus is that if there is a potential market for giant clam on the mainland, the most likely prospects would be in the sushi restaurant trade. However, several people said that the mainland Japanese, unlike Okinawans, are very conservative and will not readily try new foods, especially exotic foods such as the giant clam. But a sushi bar chef in Okinawa mentioned that some tourists from mainland Japan considered giant clam sushi and sashimi, 'OK', after tasting the dishes. This could be an indication that promoting the giant clam as a raw food item on mainland Japan may be feasible.

Based on interviews with private enterprises, it is doubtful that giant clam adductor muscle can penetrate the scallop market. Scallop production in Japan is rising, with frozen and processed scallops being exported to Hong Kong and other countries. In Tokyo, the retail price of fresh scallop meat is about ¥3600 (U.S.$25.71/kg).

Aquarium market

Interviews held with aquarium dealers and shops in Tokyo indicated that only one aquarium shop handled giant clams. The wholesaler obtained two sizes of giant clams from Okinawa.

The price mark-ups are high—from 100-200%—between each trading level (Table 4.4). The preferred size is 10-15 cm. This wholesaler can sell about 50 clams/month. With proper promotion, sales could increase.

Table 4.4 Prices for giant clams as aquarium specimens, Tokyo 1989-90

Size (cm)	Price paid	Wholesale price	Retail price
10-15	¥500 (US$3.57)	¥1500 (US$10.71)	¥3000 (US$21.43)
30	¥3000 (US$21.43)	¥9000 (US$64.29)	¥18000 (US$128.57)

The aquarium shop had limited experience in selling giant clams. The owner obtained his giant clams from the Philippines at U.S. $1/10 cm clam and sold them at ¥2000-¥3000 (U.S. $14.29-$24.43) per piece. He believes he can sell about 20-30 clams/month if the supply is regular.

The limited interviews indicated that Japan has a small market for giant clams as aquarium specimens.

Shell market

It appears that Japan has a market for giant clam shells. Giant clam shells are used in sushi bars as serving dishes, in flower shops as vases, in furniture stores as decorator items, in hotels and souvenir shops as gift items and in rental stores as dishes. Stores rent or sell giant clam shells at very high prices, as indicated in Table 4.5.

The NBK Corporation has business connections with the giant clam farm in the Marshall Islands. The corporation recently imported some giant clam shells for test marketing. However, according to the CITES ruling, giant clams are among the threatened species and naturally caught giant clam products are restricted for trade among member countries. Although cultured giant clam products are not included in the treaty, it is difficult to distinguish between the naturally bred and cultured clams. Consequently, the imported shells were not cleared by the Customs Department in Japan during the fall of 1989.

In 1987, Japan imported a variety of shells for processing and for other purposes (Table 4.6). It is difficult to determine at this stage the extent to which giant clam shells can penetrate the shell market in Japan.

In summary, Okinawa has a potential market for giant clams as food, but the price must be competitive. The market for giant clams as food in mainland Japan awaits testing and promotion. A limited market exists for giant clams as aquarium specimens in Japan. The market for giant clam shells appears good.

Table 4.5 Retail prices and annual rental prices of giant clam shells in Japan, 1989–90

Size of shell (cm)	Rental price	Sale price
20	¥400 (U.S.$2.86)	¥1680 (U.S.$12.00)
25	¥600 (U.S.$4.29)	¥2380 (U.S.$17.00)
30	¥1000 (U.S.$7.14)	¥4130 (U.S.$29.50)
90	¥5000 (U.S.$35.71)	¥26.250 (U.S.$187.50)

Table 4.6 Imported shells in 1988[a]

Types of shells	Quantity (t)	Value (¥m)
Bottom shells	1440	667
White shells	153	93
Black shells	651	749
Standing shells	1619	826
Other shells	9503	2970

[a]Source: Japanese Imports of Marine Products, 1988.

Markets in Taiwan

Interviews with 25 people were conducted in Taiwan during 12–23 August 1989. In Taiwan, a well-established market exists for frozen giant clam adductor muscle. This market is confined to the exclusive restaurant trade, particularly those restaurants specialising in seafoods. Supplies of giant clam adductor muscle in Taiwan come mainly from two sources: catches of Taiwanese clam boats in foreign waters, and imports.

The catches of Taiwanese clam boats in foreign waters are illegal, with clam boats usually ignoring requests to fish only in certain areas and seasons. Since the early 1970s, clam poaching activities by Taiwanese fishing boats have threatened the natural population of giant clams in the tropical Pacific Ocean and also seriously damaged Taiwan's reputation throughout the region. The Taiwanese Government now rejects all requests for clam fishing activities.

Because clam fishing is illegal, the supply of giant clam adductor muscle in Taiwan has come from imports during the past few years. The main sources of supply are Indonesia, Papua New Guinea, Australia and Fiji. Quantifying imported giant clam adductor muscle is difficult because official statistics categorise giant clam muscle and molluscs together as Ganbei. Of the total imports of fresh and frozen Ganbei (Table 4.7), at least 31 t in 1987 and 40 t in 1988 were estimated to have been giant clam adductor muscle. The only limitation on importation of fresh, frozen or dried Ganbei is that it be procured from cholera-free areas.

Table 4.7 Imports (t) of Ganbei in Taiwan

Year	Live	Fresh/frozen	Dried	Canned
1987	0.50	208.6	121.3	5.3
1988	0.04	386.5	229.0	–

Source: Taiwan Customs Office 1988.

Based on interviews with former giant clam boat owners and market distributors, the market potential for fresh and frozen giant clam muscle in Taiwan is an estimated 20 t/month or 240 t/year. The preferred size is 400 g or more per muscle. Market potential would be much less for smaller muscles.

In Taiwan, giant clam muscles are classified into 5 categories (Table 4.8) by size, with larger muscles commanding higher prices. Most preferred size are 1 kg muscles, but in recent times, muscles of this size have been rare. The price mark-up between wholesale and retail is about 10%.

Table 4.8 Wholesale price of giant clam muscle by size (weight) in Taiwan, 1989

Size[a]	Wholesale price
Less than 100 g	NT$200+/kg (US$7.69)
100–200 g	NT$300–$400/kg (US$11.54–$15.39)
200–300 g	NT$400–$500/kg (US$15.39–$19.23)
300–400 g	NT$600–$700/kg (US$23.08–$26.92)
More than 400 g	NT$700–$800/kg (US$26.92–$30.77)

[a]The weight per muscle varies with the species and age of clam as shown in Table 4.9.
Source: Personal interviews.

Table 4.9 Weight of muscle by species and age of giant clam

Species	Age (years)	Muscle weight (g)
T. derasa	7	81
T. gigas	5	290
T. gigas	7	470
T. gigas	10	730

Former clam boat owners indicated that species seem to be preferred in the following descending order: *T. gigas*, *T. derasa*, *H. hippopus*, *T. squamosa* and *T. crocea*. This preference is somewhat related to the size of muscle produced by different species.

In addition to size, whiter muscles are considered higher quality and command higher prices. Freshness—always an important consideration for the quality of fishery products— also affects price.

No dried, canned or other processed giant clam products are available in Taiwan, and no market currently exists for giant clam mantle meat (but see Chapter 7 for more recent information). A limited market may be developed for giant clams as aquarium specimens and for giant clam shells if they are available.

Markets in Hong Kong

Interviews with seafood import/export companies, seafood restaurants and government officials conducted in December 1989, showed that no market exists for giant clam products in Hong Kong. Very few people were aware of the giant clam, but all those contacted were eager to obtain samples. It appears that live giant clams may not be competitive at the current farm price of $3 per 2-year-old *T. derasa*. The cost of packing and transporting live clams is high. As for dried giant clam meat, the price has to be low to compete with dried seafood such as sea snail, which is wholesaled at U.S.$16.40/kg. If giant clam adductor muscle can be dried in a way similar to scallops, it would probably have a better chance of capturing a Hong Kong market. Dried scallops wholesale for about U.S.$95, $115, and $133/kg for small, medium and large sizes, respectively. However, there is a lack of knowledge on whether dried giant clam muscle is a close competitor to dried scallop.

No conclusions can be drawn until those surveyed in Hong Kong have a chance to evaluate giant clam products. However, the fact that per capita consumption of live and dried crustaceans and molluscs is increasing in Hong Kong (Table 4.10) should encourage further effort in developing the giant clam market there.

Table 4.10 Consumption various forms of crustaceans and molluscs in Hong Kong

	Live, chilled, frozen		Salted, dried, smoked		Canned, preserved		Total	
Year	Weight (t)	Per capita (kg/year)	Weight (t)	Per capita (kg/year)	Weight (t)	Per capita (kg/year)	Weight (t)	Per capita (kg/year)
1980	33869	6.72	6320	1.25	1777	0.35	41966	8.33
1985	42427	7.82	8470	1.56	2166	0.40	53063	9.78
1986	51210	9.26	8507	1.54	2205	0.40	61922	11.19
1987	59370	10.58	8084	1.44	2702	0.48	70156	12.50
1988	53962	9.50	12115	2.13	1932	0.34	68009	11.97

Source: Agriculture and Fishery Department, Hong Kong Government.

Markets in Australia

The market for giant clam products in Australia was evaluated in three categories: food, aquarium specimen and shell.

Food market

The giant clam has been a traditional source of food among Pacific Islanders. Thus, islander immigrants and their descendants living in Australia might still want to consume giant clams. Members of the Tongan community in Brisbane were interviewed in December 1989, and January 1990, in order to gather evidence bearing on this hypothesis. Information was collected on the size of Australia's Tongan community, the quantities of clam meat that Tongans are prepared to buy and the types of product and the prices they are looking for.

Although the Tongan community in Australia numbers only about 10000–15000 persons, it could represent a substantial market because of the quantities of clam meat Tongan families plan to purchase —1–4 kg/week/family—even at relatively high prices of A$5–A$12/kg (U.S.$3.85–U.S.$9.24/kg). Tongans prefer the meat of the whole clam rather than the adductor muscle. Tongans, in combination with other Pacific Islanders who have similar consumption patterns, could be a potential market for the giant clam industry in Australia.

In 1987, a limited taste test was conducted in Australia (Cowan 1988). A total of twenty 2- and 3-year-old clams were prepared in seven Japanese dishes that were tasted by a panel. The panel indicated that the mantle meat has a seaweed-like smell. A sushi expert felt that the meat of the 2-year-old was too thin, soft and watery for sushi, but he added that 3-year-old and possibly older clams might provide thicker and firmer meat more suitable for this dish.

Aquarium market

In 1989, 10 saltwater aquarium retailers in southeastern Queensland were surveyed to obtain some indication of the likely demand for giant clams as aquarium specimens in the region and more broadly in Australia. None of the aquarium retailers in the sample was selling live giant clams at the time of the survey. The two main reasons cited were the lack of availability of supply, and the lack of adequate demand. Although five of those interviewed had sold giant clams in the past, none of them had sold more than three clams each in the previous six years. Past supplies of giant clams—most of which were *T. maxima*—had come mostly from divers collecting wild stocks in the region. Giant clams are protected species now, and importing live giant clams to Australia is illegal. The supply problem is understandable because supplies have not been available from domestic giant clam farms.

The survey results indicated that the Australian market for giant clams as aquarium specimens is likely to be small, possibly absorbing about 5000 clams/year, but it seems that these will need to be sold to retailers at a price of less than A$10 each (U.S.$7.70) for 5–10 cm clams. The demand for giant clams may fall below this level once the market is saturated. However, the number of saltwater aquariums is increasing, so this may help to maintain demand. The current market is so small that supplying it would be a sideline for a clam farm. Whether Australia could compete in the export market needs further study.

Shell market

Results of 1989 interviews with 14 shell wholesalers and souvenir/gift shop owners in Queensland and New South Wales showed that the most commonly traded shell was that of *H. hippopus* (Table 4.11).

The shell of *H. hippopus* has a number of characteristics that meet the varied market demand. It is an attractive, clean shell that is usually sparkling white with decorative, symmetrical, reddish markings on the outside. It has a generous bowl-like cavity, can be machined on the outside so that it stands firmly as a bowl, is quite sturdy and can be used in conventional and microwave ovens. The preferred size appears to be 15–20 cm. It is widely used for ashtrays, soap holders and general purpose holders. The average wholesale and retail prices are listed in Table 4.12. Larger shells command higher prices. The mark-up between wholesale and retail ranges from 100% to more than 500%.

The second most widely sold shell is that of *T. squamosa*. Although usually a dull ivory-white colour, the shell also comes in attractive colours ranging from yellow or orange to pink and can have a ceramic-like sheen. These attractive colours and the shell's unusual fingernail-like form make it appealing as a decorative item. *T. squamosa* shells, most popular in sizes ranging from 15–25 cm, are usually traded in pairs at a wholesale price of A$2.50 (U.S.$1.93) for a 15-cm shell.

Table 4.11 Number of outlets selling giant clam shells by species, features and most popular sizes of shells in Australia, 1989

Species	Most popular size (cm)	Features	Number of outlets selling
H. hippopus	15–20	Versatile (ashtrays, soap holders and general purpose holders); attractive markings on back of shell; not easy to break.	14
T. squamosa	15–25	Attractive appearance (with fingernails); used in bathroom or for decorative purposes.	7
H. porcellanus	25–30	Attractive appearance: resembles china (decorative).	4
T. gigas	The larger, the better	Landscaping and interior design use.	3
T. crocea	–	–	5
T. maxima	–	–	1
T. derasa	–	–	0

Table 4.12 Average price of *H. hippopus* shells by size in Australia

	10–15 cm	15–20 cm	20–25 cm	25–30 cm	30–35 cm
Wholesale price[a]	A$0.59	A$1.55	A$3.40	–	A$3.98
Retail price[a]	A$2.04	A$3.22	A$9.32	A$14.50	A$23.31

[a]A$1 = US$0.77.

T. crocea shells ranging in size from 7.6–10.2 cm were available in souvenir shops. Demand for these shells appears limited because of their small size and the rough, concrete-like appearance of the outside.

The shells of *Hippopus porcellanus*, popularly called the china clam, are thin and almost translucent with a pure white colour. Sizes available appear to range between 25 and 50 cm, with a wholesale price some 4–5 times higher than that of *H. hippopus*.

The shells of *T. gigas*, the largest clam species, are in great demand, but supply is inadequate due to eradication of much of the natural stock and the effect of the CITES ruling. The shells of this species are used both for indoor decoration and outdoor landscaping. The demand and price increase with the size of the shell. The retail price was quoted as A$40 (US$31) for a 61 cm shell and A$80 (US$62) for shells 91-120 cm.

Shells of the second largest of the clam species, *T. derasa*, were not sold by any of the outlets interviewed. Only one shop had handled *T. maxima* shells.

Thus, it can be ascertained that the shells of only four species of giant clams, *H. hippopus*, *T. squamosa*, *H. porcellanus* and *T. gigas*, seem to be in real demand for the shell trade in Australia. The Australian market potential is estimated to be 100000-120000 giant clam shells per year. Practically all clam shells were imported from the Philippines, but supplies are becoming scarce as CITES takes effect and natural stocks become exhausted.

Tourists possibly account for 60-70% of clam shell sales, but only 10% of sales are to overseas tourists because of baggage weight problems. Restaurants and households appear to purchase a reasonably high proportion of clam shells. Practically all shell outlets interviewed expressed interest in obtaining clam shells from clam farms when they are available.

Markets in the United States

Selected seafood distributors and aquarium species distributors on the U.S. mainland were surveyed by mail in early 1990. They were supplied with a picture of giant clams and literature about the different species of giant clam and uses of giant clam products. Response to the mail survey was minimal. Many respondents shared the view that they know so little about giant clams that they have difficulty expressing any opinions before seeing and tasting the clams.

Food market

Of 160 seafood wholesalers, distributors and importers surveyed on the U.S. mainland, only 15 responded, and not all of those provided complete answers.

Respondents indicated that the giant clam flesh may fit into either the exotic or luxury market. Giant clam muscle may compete with scallops, and giant clam mantle meat may compete with squid and other chopped clams. Respondents also indicated that they would prefer clam muscle and mantle in frozen form, followed by fresh and live forms, and that they would prefer whole in-shell clams fresh, followed by frozen and live forms. Several respondents indicated that the price of small, whole giant clams should be competitive with that of Manila or cherrystone clams. Honolulu's retail price was about U.S.$9.44/kg for Manila clams and about U.S.$5.04 for cherrystone clams at the time of the survey.

Additional seafood brokers in the San Diego and Los Angeles areas, and seafood retailers in Honolulu, were contacted to determine their interest in test marketing giant clams. Most of them expressed interest. Some seafood retailers in

Honolulu suggested selling frozen or processed clams to avoid the difficulties in obtaining an import permit for live animals.

Aquarium market

In early 1990, selected aquarium species distributors/retailers on the U.S. mainland were surveyed by mail. They were supplied with descriptions of the different species of giant clams. Of the 88 selected aquarium species distributors/retailers surveyed, 18 responded. All respondents indicated a willingness to handle the giant clam as aquarium species if supplies were available. Some of them are already familiar with *T. derasa*, having received shipments from Palau.

The preferred sizes, prices and volumes that could be handled are summarised in Table 4.13. An in-shell length of 5–10 cm ranked highest, followed by 10–15 cm and 15–20 cm. While respondents indicated they would pay higher prices for larger animals, those prices ranged widely in each size category.

As regards species, 10 respondents ranked *T. gigas*, *T. derasa*, and *T. crocea* equally, followed by *T. squamosa*, *T. maxima* and *H. hippopus* (Table 4.14).

Table 4.13 Preferred size and price of giant clams as aquarium specimens in the United States

Preferred size	5–10 cm	10–15 cm	15–20 cm
Number of respondents	16	9	5
Wholesale price willing to pay/clam (U.S.$)	3–6	5–10	9–15
Retail price willing to pay/clam (U.S.$)	5–12	10–18	15–25
Volume respondent could handle	2–500/month	2–400/month	2–400 /month

Table 4.14 Species preferred by U.S. aquarium specimen distributors

Species	Number of respondents
T. gigas	10
T. derasa	10
T. crocea	10
T. squamosa	9
T. maxima	6
H. hippopus	5

Additional aquarium species distributors and retailers in Honolulu were interviewed about giant clams' virtues and problems as aquarium animals. Those interviewed rated giant clams' colourful mantles as their most desirable characteristic. Respondents also rated the following characteristics as desirable: the clams require no feeding; they remove nitrate from the water; they are exotic; and they are unique species. The difficulty in obtaining permits from the State government to market giant clams as aquarium specimens is regarded as the major problem in Hawaii. The extra lighting required to keep giant clams in aquariums was also considered a problem. Lastly, the Hawaii market for giant clams as aquarium specimens is small — estimated to be only about 500–1000 clams annually — and thus could be flooded quickly. Nationally, the number of mini-reef aquariums is increasing, and thus demand for giant clams as aquarium specimens is likely to increase. The estimated national market potential for giant clams as aquarium specimens ranges from 5000–50000 clams annually, depending on price.

Shell market

Selected giant clam shell distributors in Honolulu were surveyed by mail in early 1990. Of 40 selected shell distributors and gift shops surveyed, nine responded. Seven of them had sold giant clams shells in the past. The shell of *H. hippopus* appeared to be a top seller, followed by *T. squamosa*, *T. gigas*, *T. crocea* and *T. maxima*. The most popular sizes, uses and prices for each species are summarised in Table 4.15. Most respondents indicated a shortage of giant clam shells coupled with an increased price. The mark-up between wholesale and retail prices is at least 100%.

Table 4.15 Species, sizes, uses and prices of giant clam shells marketed in Honolulu

Species	Most popular size (cm)	Uses	Number of pairs sold annually	Wholesale price/pair (U.S.$)	Retail price/pair (U.S.$)
H. hippopus	7–12	Soap dish, ashtray, dish, collection	500–2000	1.50–2	3–4
T. squamosa	7–15	Decoration, aquarium use, collection	200–1000	2–3	4–7
T. gigas	23–30 63–89	Dish decoration	1000	5–10	10–20
T. maxima	10–13	Gift, collection	800	1.50–2	3–4
T. crocea	7–10	Gift	1000	0.50–1	1–2

Markets for giant clams as seedstock and broodstock

In addition to being marketed as food, aquarium specimens and shells, giant clams can also be marketed as seedstock and broodstock to pilot operations in the Pacific islands, and to conduct research. The MMDC in Palau is the only centre in the world selling *T. derasa* as seedstock and broodstock. It charges the prices (free on board) shown in Table 4.16.

Table 4.16 Price (f.o.b.) for *T. derasa* seedstock and broodstock from MMDC, 1990

Age in years	Minimum size (cm)	Unit cost (U.S.$)	Minimum order
1.0	5	1.00	1000
1.0+	6	1.25	1000
1.5	7	1.50	400
1.5+	8	2.00	350
2.0	9	3.00	300
2.0+	10	4.00	150
2.5	12	6.00	100
5.0+[a]	27	50.00	20

[a]Broodstock.

The market for giant clams as seedstock and broodstock appears to be short-run oriented. Once the initial stock survives and local hatcheries are established, the demand for this purpose is likely to decline.

Summary and conclusion

The preliminary market survey indicated three types of end markets for giant clam products: for food, aquarium specimens and shells. The largest potential market for giant clam products appears to be as food.

There is a market for giant clams as food in Okinawa, Taiwan, Australia and the Pacific islands. The food markets in Okinawa may absorb up to 500 t of giant clams in-shell to be used primarily for sashimi and sushi dishes. The most popular species there is *T. crocea*. Whether other giant clam species, such as *T. derasa* and *T. gigas*, could penetrate the Okinawa market would depend on the price and taste. Based on the limited taste test in Okinawa, the meat of 2-year-old *T. derasa* is too soft in comparison to that of *T. crocea*; most of the sushi bars surveyed therefore said they may be willing to buy *T. derasa* at a lower price than *T. crocea*. If *T. derasa* imports were to be feasible, a 2-year-old clam would need to cost much less than *T. crocea*'s current price of U.S.$1.43–2.38. In this case, the farmgate price of a 2-year-old *T. derasa* might have to be half the price quoted above. Whether a 2-year-old *T. derasa* could be produced at a competitive price with existing technology needs further study.

In Taiwan, a market exists for giant clam adductor muscle in fresh or frozen form. The market potential is estimated at 240 t annually. Large size muscles are preferred, with demand limited for muscles from clams less than 5 years old. The economic feasibility of producing large clam muscles at competitive prices needs to be studied. No market currently exists for giant clam mantle meat in Taiwan (but see Chapter 7).

In Australia, a market exists for giant clams among Pacific island immigrants and their descendants. Giant clams are unknown as food items in mainland Japan, Hong Kong and the United States; the market potential awaits exploration.

A limited market potential exists for giant clams as aquarium specimens in Japan, Australia and the United States. With the increase in the number of mini-reef aquariums, the demand for giant clams is likely to increase. The important attributes of giant clams as aquarium specimens are their colourful mantles, the fact that the animals require no feeding and remove nitrate from the water, and that they are exotic and unique species. The major problems with giant clams as aquarium species are the difficulties involved in obtaining import permits in some countries, and the extra lighting required.

The market appears favourable for giant clam shells, which are usually used as soap holders, ashtrays, dishes, flower vases, decorations, landscaping, etc. Supplies of giant clam shells are becoming scarce as the CITES ruling takes effect and natural stocks become exhausted. The value of shells is often higher than that of meat.

A market also exists for giant clams as seedstock and broodstock. However, this market appears to be short-run oriented. Once the initial stock survives and local hatcheries are established, the demand for this purpose is likely to decline.

Giant clams are considered a threatened species, and naturally caught giant clam products are restricted for trade among signatories of CITES. Although cultured giant clam products are not restricted for trade, distinguishing between naturally bred and cultured clams is difficult. Consequently, certification that giant clam products were cultured may be necessary and an import permit is required to ship giant clam products to the member countries of CITES.

Since giant clams are relatively new to many markets, numerous people contacted said that they know little about the animals and that they would have difficulty expressing their opinions before having seen and tasted the clams. Therefore, test marketing of giant clam products in new markets must be done to evaluate consumer acceptance and to identify consumer preferences. This is especially true for maricultured young giant clams, which may be somewhat different from larger, older clams harvested from the wild in the past. Test marketing of giant clam products—especially of young clams—in selected markets is the objective of the second phase of this study, results of which are reported in later chapters of this monograph.

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Part II

Markets for Giant Clams as Food

5 Test Marketing of Giant Clams for Food in Honolulu, Guam and Saipan and Observations in Okinawa and Taiwan

Yung C. Shang

PingSun Leung

John Brown

Abstract

The purpose of the study on which this chapter reports was to evaluate the market demand for giant clams as food. Since there was lack of marketing information for giant clam products and most people were not familiar with them outside of its production regions, direct test marketing was deemed to be the most appropriate means of evaluating potential demand for giant clam (*Tridacna derasa*). The test marketing of giant clam as food was conducted in Honolulu, Guam and Saipan.

The acceptance rate of giant clam was measured by an index of average rating in a scale of 1 (poor) to 5 (excellent). Based on the results of test marketing of *T. derasa* as a food item, the average rating by customers was 3.26, 4.07 and 3.51 in Honolulu, Guam and Saipan, respectively. The relatively higher acceptance rate in Guam was due primarily to the fact that local residents were familiar with giant clams. Nevertheless, a majority of the respondents in Honolulu and Saipan indicated that they would like to order giant clam dishes again. This implied that some market potential exists in these two markets with adequate promotional efforts. Most of the participating restaurants preferred larger size (more than 2-year-old) clams. Some market survey results are also reported for Okinawa and Taiwan.

Introduction

The biological and technical feasibility of giant clam farming is now well established through research undertaken mainly by the Micronesian Mariculture Demonstration Center (MMDC) in Palau and the James Cook University in Australia, and through pilot operations in Micronesia, the Marshall Islands, Solomon Islands, American Samoa, the Philippines and elsewhere. However, the key to the success of giant clam farming, like any other industry, is economic viability. There are two major factors affecting the economic viability of giant clam farming: market potential and production costs. With future expansion in giant clam production possible, there is an urgent need for information on market demand. This chapter deals with market demand for giant clam products as food.

Several traditional approaches for estimating demand are found to be inadequate in the case of giant clams. These include analyses of time-series or cross-sectional data, international trade statistics and possible competing products. Since giant clam is a relatively new product outside Pacific island countries, there are no time-series or cross-sectional data available for demand estimation. Existing international trade data are inadequate to provide any guidance as to the market potential for giant clam products (Stanton 1990). Since giant clam fishing is regarded as illegal, and international trade in giant clam products is restricted, there is a lack of available trade statistics for giant clam products. In addition, the published international trade statistics usually include giant clam in a broad commodity category, such as crustaceans and molluscs, or as clam meat. Even within the clam meat category there is a diverse product range of which giant clam constitutes only one segment. In addition, the lack of familiarity with giant clam in potential markets makes it difficult to estimate the market demand for this product by comparing it with possible competing products. For these reasons a marketing survey involving direct test sales of giant clam was deemed to be the most appropriate means of estimating demand for clams as a food item.

Test marketing of giant clam (*Tridacna derasa*) as a food item was originally carried out in Honolulu and Guam. These markets have substantial numbers of Japanese, American and other tourists. Testing in these islands avoids the complication of dealing with intermediaries and complex marketing procedures that would result from direct test marketing in foreign countries.

Before the test marketing in Honolulu, all the necessary permit requirements were met, i.e., permits from the State Plant Quarantine Division, State Health Department and the Federal Drug Administration (FDA). Unfortunately, the FDA suddenly changed its position at the middle of test marketing, claiming that giant clams are filter-feeders (an assessment due to lack of scientific evidence). For filter-feeders, certain procedures must be complied with (such as water monitoring procedures at the production sites) before the organism can be approved for human consumption. Several requests for clearance made to the FDA were denied. Thus, test marketing could not be continued in Honolulu. In Guam, the test marketing also encountered problems because the Guam Public Health Laboratory found salmonella in the clams. Although the salmonella problem was solved after much delay, no additional test marketing was permitted. Further test marketing was therefore conducted in Saipan targeting Japanese tourists (and with the clearance of Saipan authorities). The results of test marketing in these three places, as well as of market surveys in Okinawa and Taiwan, are reported in the following sections.

Test marketing in Honolulu

Two-year-old *T. derasa* were purchased from MMDC in Palau for test marketing in Honolulu. The first shipment of 500 clams arrived on 27 June 1990 and was held in a holding tank at the Agricultural Engineering Laboratory of the University of

Hawaii. These clams were then distributed live to three randomly selected Chinese restaurants, eight Japanese restaurants and two American restaurants that had agreed to participate in the test marketing. They were supplied with live giant clams free of charge. In return, they were asked to distribute and collect the survey forms from their customers. As a promotional measure, table tents were distributed to the participating restaurants. The food section of the *Honolulu Star Bulletin* also published an article on the clam marketing test.

Since sashimi/sushi was the dish selected for testing in Japanese restaurants and steamed-whole-clam as the main dish in Chinese restaurants, the preparations of these two dishes were quite standardised without much variation among the respective restaurants. The major instruction to the participating restaurants was to remove the viscera of clams before serving them.

Customers who ordered giant clam dishes and restaurant chefs who prepared giant clam dishes were asked to rank the following taste characteristics: appearance, taste, aroma, texture, thickness/size of meat, watery consistency and freshness. Rankings used in the survey ranged from 1 (poor) to 5 (excellent). During test marketing of the first shipment of giant clams, 31 customers and 10 restaurant chefs completed the survey questionnaires.

The detailed pattern of customer responses is given in Table 5.1. For each attribute, an average rating was derived. There was no significant difference in average rating among attributes except thickness/size of meat and freshness. Customers rated the lowest for thickness/size of meat and the highest for freshness. The average rating of giant clam as food for all attributes in Honolulu was 3.26.

Table 5.1 Results of test marketing in Honolulu, 1990 (Q3, Appendix 1)

Attribute	Excellent	Very good	Good	Fair	Poor	N[a]	Average rating[b]
Appearance	6	8	8	6	3	31	3.26
Taste	6	8	5	9	2	30	3.23
Aroma	4	5	11	6	2	28	3.11
Texture	3	14	7	7	2	30	3.60
Thickness/ size of meat	0	4	13	5	9	31	2.39
Freshness	12	8	10	0	0	30	4.01
Watery consistency	2	8	10	6	0	26	3.23
Average							3.26

[a]N = number of respondents.
[b]On a scale of 1 (poor) to 5 (excellent).

The customer respondents can be divided into three ethnic groups: Chinese, Japanese and others (based on information provided in the questionnaires). It is useful to know the preference patterns among these ethnic groups. Chinese and Japanese rated giant clam much lower than the other ethnic group (Table 5.2). Again, thickness/size of meat received the lowest rating and freshness the highest rating for all ethnic groups.

When asked what are the possible competing species for giant clam as seafood, Manila clam was indicated as the leading competitor followed by king clam, scallop, oyster, mussels, octopus and stone clam (Table 5.3).

Compared with the possible competing species, giant clam was rated the lowest and far behind king clam, oyster and scallop (Fig. 5.1).

Table 5.2 Ratings of giant clam by ethnic groups in Honolulu (Q3 and Q8, Appendix 1)

	Chinese (N=15)[a]	Japanese (N=7)[a]	Others (N=9)[a]
Appearance	3.01	2.57	4.00
Taste	3.07	2.29	4.22
Aroma	2.86	2.14	4.00
Texture	2.87	3.14	3.88
Thickness/size of meat	2.07	2.14	3.11
Freshness	3.64	4.29	4.50
Watery consistency	2.58	3.33	4.13
Average	2.87	2.84	3.98

[a]N = number of respondents.

Table 5.3 Possible competitors to giant clam (Q5, Appendix 1)

Species	N[a]
Manila clam	9
King clam	8
Scallop	6
Oyster	5
Mussels	3
Octopus	2
Stone clam	1

[a]N = number of respondents.

During the test marketing, two types of giant clam dishes were prepared: raw and cooked. Raw dishes were served in Japanese restaurants as sushi/sashimi, and cooked dishes mainly in Chinese restaurants. There was no significant difference between the average rating for raw and cooked dishes by restaurant chefs for all attributes except taste (Fig. 5.2). For raw dishes, thickness/size of meat again received the lowest rating, followed by appearance and watery consistency, while taste, thickness/size of meat, and appearance received the lowest ratings for cooked dishes. The average rating for all attributes by restaurant chefs (2.8) was lower than that of customers (3.26).

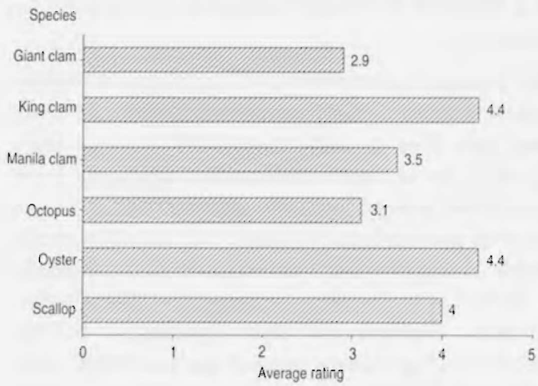

Figure 5.1 Ratings of giant clam and its possible competing species in Honolulu

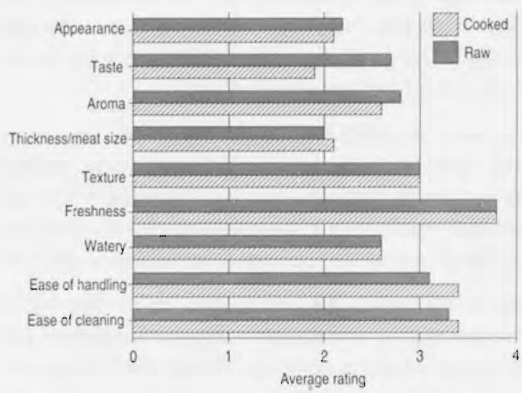

Figure 5.2 Ratings of raw and cooked giant clam dishes by restaurant chefs in Honolulu

The acceptance of the giant clams by the customers and restaurant chefs in Honolulu was not high. This may be partially due to the unfamiliarity with giant clam by local residents. Some restaurants chefs indicated concern about the small meat size of the 2-year-old clams. On the positive side, a majority (69%) of the customers who tasted giant clam indicated willingness to order it again. There appears to be some market potential for giant clams, especially the larger ones, in Chinese and Japanese restaurants in Hawaii, if they are competitively priced. However, since the FDA considers giant clams as filter-feeders, live clams cannot be imported as food from areas without a shellfish sanitation program recognised by the FDA. Therefore, it is not possible at this time to import live giant clams from Palau and Micronesia into Hawaii as food.

Test marketing in Guam

The test marketing of giant clams was conducted by Dr John Brown, School of Agricultural and Life Science, University of Guam. The Guam Department of Public Health and Social Services (DPHSS) permitted the importation of live giant clams from Palau for test marketing under two conditions: (1) the clams should be held in clean water for depuration for a period of one week; and (2) after depuration, the DPHSS would sample the clams and would permit their distribution as a food product if the bacterial screening were negative. These conditions were applied by DPHSS because Palau does not have a shellfish sanitation program recognised by the Interstate Shellfish Sanitation Compact.

Arrangements were made with the Guam Department of Commerce's Fadian Hatchery to hold the clams and seven hundred (700) 2-year-old *T. derasa* were purchased and shipped to Guam from late May to early July 1990 in four shipments. Salmonella bacteria were found in the second and fourth shipments from the sample tests and the test marketing was placed on hold due to public health concerns. Water quality tests were done at the Fadian Hatchery, but no salmonella bacteria were found. It was not possible to determine if the source of salmonella bacteria was in Palau or in Guam. Water sources were rerouted at the Fadian Hatchery and depuration was continued. Subsequent tests conducted by the DPHSS found no salmonella and test marketing was permitted on condition that: (1) the participating restaurants be informed of the testing history of the clams; (2) the participating restaurants be notified that the Government of Guam was not liable if customers became ill; (3) a record of all persons eating the clams be maintained; and (4) no additional clams be imported for test marketing.

Six restaurants participated in the test marketing, including two Japanese restaurants, one Chamorro restaurant, one Italian restaurant, and one neighbourhood bar and grill. Test marketing ran from early November to mid-December 1990. After initial trials, the two Japanese restaurants discontinued with the test marketing because they felt the 2-year-old clams were too small for sashimi dishes.

The same questionnaires and table tents were used in Guam as in Honolulu. During the test marketing, 105 customers and 4 restaurant chefs completed the survey questionnaires. The customers sampled showed a significant preference for all the attributes (Table 5.4). In particular, customers rated taste and freshness the highest and thickness/size of meat and watery consistency the lowest. The average rating by customers for all attributes was 4.07 on the 1–5 scale.

The customer respondents can be classified into residents and tourists. Based on the information provided in the questionnaires, residents can be grouped as those of unknown ethnicity, Pacific islanders, Caucasians, and Japanese. Tourists can be grouped as tourists in general (no ethnic information is provided) and Japanese tourists. It is useful to know the ratings of giant clam by ethnic groups (Table 5.5). Residents, except the Japanese residents, rated giant clam higher (4.1–4.2) than tourists (3.9). Japanese residents rated giant clam the lowest (3.3), followed by Japanese tourists (3.8). Among the attributes, thickness/size of meat and watery consistency received the lowest ratings, especially by the Japanese.

Table 5.4 Results of test marketing in Guam, 1990 (Q3, Appendix 1)

Attribute	Excellent	Very good	Good	Fair	Poor	N[a]	Average rating[b]
Appearance	34	46	23	1	1	105	4.06
Taste	49	42	11	2	1	105	4.30
Aroma	31	36	20	2	0	89	4.08
Texture	27	52	17	2	0	98	4.06
Thickness/ size of meat	28	41	23	8	0	100	3.89
Freshness	42	43	15	1	0	101	4.25
Watery consistency	16	33	16	5	1	71	3.82
							4.07

[a]N = number of respondents.
[b]On a scale of 1 (poor) to 5 (excellent).

Table 5.5 Ratings of giant clam by ethnic groups in Guam (Q3 and Q8, Appendix 1)

	Residents unknown (N[a]=43)	Residents Pacific islander (N[a]=31)	Residents Caucasian (N[a]=15)	Residents Japanese (N[a]=3)	Tourist (N[a]=7)	Tourist Japanese (N[a]=6)
Appearance	4.1	4.2	4.0	3.0	4.3	3.5
Taste	4.3	4.4	4.5	3.3	4.0	4.4
Aroma	4.0	4.0	4.5	4.0	4.4	3.8
Texture	4.1	4.2	4.2	3.7	3.3	4.0
Thickness/ size of meat	4.0	4.0	4.0	2.5	3.4	3.5
Freshness	4.2	4.3	4.4	4.0	4.1	4.0
Watery consistency	3.8	3.6	4.1	2.6	3.5	3.2
	4.1	4.1	4.2	3.3	3.9	3.8

[a]N = number of respondents.

Compared with other possible competing species, giant clam was rated the highest, followed by oyster, king clam, octopus, scallop and Manila clam (Figure 5.3).

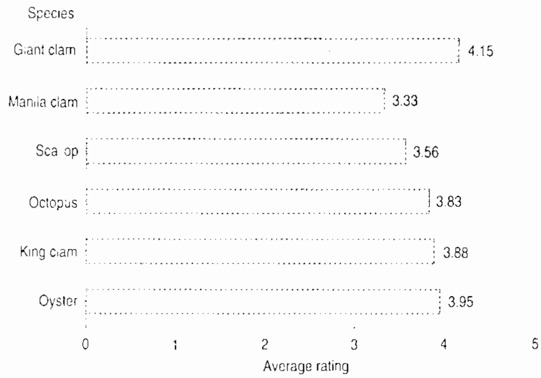

Figure 5.3 Ratings of giant clam and its possible competing species in Guam

During the test marketing, giant clam were prepared raw for sashimi or cooked in coconut milk, or fried. Restaurant chefs who prepared giant clam dishes were asked to rate each attribute for raw and cooked dishes. The overall rating for raw dishes for all attributes was 4.0, compared with 4.1 for cooked dishes. Three chefs indicated that the preferred clam size would be 12.7 cm and that a reasonable wholesale price at that size would be $2.00–3.50 per pound in shell.

Among the 105 people who tasted giant clam dishes, only one would not order it again. Over 70% of the respondents would like to consume giant clam at least twice a month.

In summary, the response of customers to the giant clams was generally very favourable. This was particularly true for the local population which made up the vast majority of the sample after the two tourist-oriented, Japanese restaurants withdrew. Additionally, there was considerable interest expressed in consuming giant clams on a regular basis due to familiarity with giant clams as a local food. It appears that giant clam would also have an excellent acceptance as a fiesta food, that is, foods served at Chamorro social functions. Clams are considered a part of the cultural heritage and to serve them makes the function truly Chamorro.

Concerns expressed by the restaurant managers centred around three related issues. The first was the size of clams. The two Japanese restaurants indicated that the small size of the 2-year-old clams was their primary reason for not participating in the test marketing. It was felt that the 2-year-old clams are too small to shuck and clean economically. In addition, the adductor muscle was too small to make a good sushi serving. These Japanese restaurants were not interested in other parts of the clam.

The second concern was shrinkage, especially after cooking. Some managers were also concerned about the small ratio between shell size and the quantity of meat.

The third concern was that of price, both implicit and explicit. The implicit price concern was centred around the labour necessary to shuck and clean the smaller clams. Once the chefs learned that the clams could be opened easily by steaming them in a shallow pan of water, the concern about labour requirements lessened somewhat for those restaurants which planned to cook the clams. The explicit price concern centred around the meat weights and the small adductor muscles. The two Japanese restaurants indicated that they would be willing to serve their customers larger clams.

Of the four restaurants who continued with the test marketing, two strongly emphasised the local character of the giant clams and rated them highly, but due to the nature of their businesses they felt that price would be an important determinant in their purchasing the clams in the future. The other two restaurants did not emphasise the local nature of the clams to the same degree and did not rate them quite as highly.

Finally, before Guam can be developed as a market for the giant clam, an institutional arrangement must be established to allow for the importation of clams from the islands of Micronesia. Currently, giant clams could be imported from Australia, but not from Palau or the Federated States of Micronesia. This is because Australia has a shellfish sanitation program. If Guam is to be considered as a market for Micronesian giant clams, then work must be begun on establishing the institutional mechanisms necessary to control the public health risks and concerns associated with filter-feeding bivalves.

Test marketing in Saipan

Giant clams were served mainly as sashimi/sushi dishes. The test marketing experiences in Honolulu and Guam indicated that Japanese restaurants prefer larger clams. Therefore, 300 3-year-old clams (instead of 2-year-old *T. derasa*) were purchased from the MMDC. The test marketing was conducted in late May and early June 1991 by Dr Lolita N. Ragus of the School of Agriculture and Life Science, Northern Marianas College, and Dr John Gourley of the Fish and Wildlife Division. Six restaurants participated in the test marketing. The same questionnaires and table tents were used in Saipan as in Honolulu and Guam. During the test marketing, 98 customers and 15 restaurants chefs completed the survey questionnaire. The average rating by customers for all attributes was 3.51 (Table 5.6) on the 1–5 scale used in this study. Freshness received the highest rating.

Based on the information provided in the returned questionnaires, customer respondents were grouped as 'Japanese tourists', 'other tourists' and 'residents'. The average rating of giant clam was the highest by residents (3.70), followed by other tourists (3.66) and Japanese tourists (3.46) (Table 5.7).

Considering all competing species, Japanese tourists rated scallop the highest and giant clam the lowest, while the 'other tourists' rated Manila clam the highest followed by giant clam and oyster. Residents rated oyster highest and giant clam lowest.

Table 5.6 Results of test marketing of giant clam in Saipan (Q3, Appendix 1)

		Rating—frequency					
Attribute	No. of respondents	Excellent	Very good	Good	Fair	Poor	Average rating[a]
Appearance	98	15	34	39	8	1	3.52
Taste	98	10	33	44	9	1	3.43
Aroma	95	10	24	48	11	1	3.33
Texture	94	12	39	38	3	2	3.60
Thickness/ size of meat	97	7	38	38	12	1	3.39
Freshness	98	20	39	35	3	0	3.79
Watery consistency	85	8	35	35	5	1	3.52
							3.51

[a]In a scale of 1 (poor) to 5 (excellent).

Table 5.7 Ratings of giant clam by ethnic groups in Saipan (Q3 and Q8, Appendix 1)

	Japanese tourists		Other tourists		Residents	
	N[a]	Average rating	N[a]	Average rating	N[a]	Average rating
Appearance	72	3.40	8	3.88	18	4.00
Taste	73	3.36	8	3.50	17	3.71
Aroma	72	3.24	6	3.67	17	3.59
Texture	73	3.58	7	3.57	14	3.93
Thickness/ size of meat	73	3.37	7	3.43	17	3.47
Freshness	72	3.79	8	3.88	18	3.67
Watery consistency	63	3.51	6	3.67	16	3.50
		3.46		3.66		3.70

[a]N = number of respondents.

There was no significant difference in average ratings for raw and cooked dishes, based on the responses from restaurant chefs who tasted and/or cooked giant clams. The average rating of giant clams by restaurant chefs (3.30–3.35) was a little lower than that of customers, but the difference was insignificant.

Four restaurant chefs indicated their preferred size of giant clam and suggested reasonable wholesale prices. The preferred size was in the range 17–25 cm with reasonable wholesale price range centred on $10 per clam.

To compare the preference of the restaurant chefs for 3 or 2-year-old clams, 100 2-year-old clams were purchased and distributed to the same restaurants participating in the test marketing. Eleven indicated their preferred size and reasons. Two of them preferred both 2 and 3-year-old clams, seven preferred 3-year-old clams mainly because of thicker meat and firmer texture, and two preferred 4–5-year-old clams for their thicker meat.

Just over 82% of the 98 people who tasted giant clam dishes would like to eat it again, and 50% of them would like to eat it at least twice a month (Table 5.8).

Giant clam was more acceptable in Saipan than in Honolulu, but less so than in Guam. Because most of the respondents were tourists, many were not familiar with giant clam. Most restaurant chefs preferred larger giant clams, more than 2 years old.

Table 5.8 Frequency of consumption in Saipan (Q4, Appendix 1)

Consume giant clam again?	
Yes	80
No	18
Frequency of consumption	
Once/week	20
Twice/month	30
Once/month	17
Once/4 months	1
Once/year	12

Comparison of *T. derasa* and *T. crocea* in Okinawa

Okinawa is the main market for giant clam in Japan. Live or fresh *T. crocea* 5–6 cm in shell are preferred. The main supply of *T. crocea* is from domestic fishing in nearby waters. The total catch of *T. crocea* reached its highest level of 578 t in 1975, declining to 42 t in 1989 due primarily to overfishing. To test whether *T. derasa* would be acceptable to restaurants/sushi bars, 50 2-year-old *T. derasa* were imported from Palau and distributed to 21 restaurants and sashimi shops. This study was assisted by Mr. Shigeo Watanabe of the University of Okinawa during the summer of 1991. Restaurant chefs were asked to compare *T. derasa* with *T. crocea* on attributes such as appearance, taste, aroma, thickness/size of meat, texture, watery consistency and salt. The survey results are summarised in Table 5.9. The restaurant chefs rated *T. crocea* much higher than *T. derasa* for all attributes. Seven of the restaurant chefs surveyed indicated their preferred sizes and the prices they would be willing to pay for *T. derasa* (Table 5.10). Restaurant

Table 5.9 Comparison of *T. derasa* and *T. crocea* by restaurant chefs in Okinawa, 1991

	Rating —frequency						
	Excellent	Very good	Good	Fair	Poor	N[a]	Average rating
Appearance							
T. derasa	–	5	12	4	–	21	3.05
T. crocea	–	14	7	–	–	21	3.67
Taste							
T. derasa	–	10	5	5	1	21	3.14
T. crocea	1	14	6	–	–	21	3.76
Aroma							
T. derasa	–	4	7	6	4	21	2.52
T. crocea	–	15	6	–	–	21	3.71
Thickness of meat							
T. derasa	–	1	4	10	4	19	2.52
T. crocea	1	13	5	–	–	19	3.79
Texture							
T. derasa	–	4	7	6	4	21	2.52
T. crocea	–	12	8	–	–	20	3.60
Watery consistency							
T. derasa	–	1	11	1	3	16	2.63
T. crocea	–	4	11	–	–	15	3.27
Saltiness							
T. derasa	–	4	8	7	2	21	2.67
T. crocea	–	7	14	–	–	21	3.33

[a]N = number of respondents.

Table 5.10 Responses of restaurant chefs to preferred size and price of *T. derasa* in Okinawa, 1991

Preferred size (cm)	No. of respondents	Price willing to pay (¥/clam)
5	1	100
7–8	3	100
10	1	150
12	2	150

chefs were willing to pay much less for *T. derasa* than for *T. crocea*. Several chefs indicated that they would be willing to buy *T. derasa* only when there was no local supply of *T. crocea*.

Market survey of giant clam adductor muscles in Taiwan

In Taiwan, a well established market exists for foreign giant clam adductor muscles. This market is confined to the exclusive restaurant trade. To estimate the market potential for giant clam adductor muscles, 17 distributors were surveyed, only 10 of whom provided useful information. This survey was conducted during the summer of 1991 by Professor Chaur-Shyan Lee and his assistants at the Research Institute of Agricultural Economics, National Chung Hsing University, Taichung, Taiwan.

Market potential in Taiwan was estimated for five sizes of adductor muscles (Table 5.11). The larger muscles command higher prices. The estimated total demand for adductor muscles in Taiwan is about 300 t annually. The survey result indicated that a muscle size of 200–300 g (per muscle) has the highest market potential followed by the muscles of 100–200 g. Abalone would be the product competing with frozen giant clam adductor muscle.

Table 5.11 Market survey of giant clam adductor muscles in Taiwan, 1991

Size (g)	Wholesale price/kg	Estimated demand/year (t)
Less than 100	NT$382 (US$14.69)	35
100–200	NT$497 (US$19.15)	79
200–300	NT$533 (US$20.50)	89
300–400	NT$676 (US$26.00)	56
More than 400	NT$770 (US$29.62)	44
Total		303

Summary and conclusion

The lack of marketing information and unfamiliarity with giant clam outside of its production regions create problems for estimating demand for giant clam products. Consequently, direct test marketing was conducted to estimate demand for giant clams as food and aquarium specimens. The test marketing of giant clam as food was conducted in Honolulu, Guam and Saipan.

Based on the results of test marketing of giant clam (*T. derasa*) as a food item, the acceptance rate was measured by an index of average rating in a scale of 1 (poor) to 5 (excellent). The average rating by customers was 3.26, 4.07 and 3.51 in Honolulu, Guam and Saipan, respectively. The high acceptance rate in Guam was due primarily to the fact that the respondents there, mainly local residents, were familiar with giant clams. In fact, giant clams are favoured species for local residents in Guam. In Honolulu and Saipan, on the other hand, the unfamiliarity of giant clams resulted in a lower acceptance rate. Nevertheless, a majority of the respondents in these two markets indicated that they would like to order giant clam dishes again. This implies that some market potential exists in these two markets and could be developed with an adequate promotional effort.

Among different attributes of giant clams (appearance, taste, aroma, texture, thickness/size of meat, freshness and watery consistency), thickness/size of meat received the lowest rating while freshness received the highest rating. Several Japanese restaurants withdrew from the test marketing after an initial trial due to the small quantity of the meat available from the 2-year-old *T. derasa*. Most of the participating restaurants preferred larger sized clams. Both 2 and 3-year-old *T. derasa* were test-marketed in Saipan. A majority of the participating restaurants there preferred *T. derasa* at least 3 years old.

The test marketing in all three markets was restricted to two major types of dishes: raw and cooked. Raw dishes were served as sashimi/sushi in Japanese restaurants while cooked dishes were served mainly steamed or cooked with coconut milk. There was no significant difference in average rating between raw and cooked dishes.

In this study, because of its ready availability *T. derasa* was the only species test marketed. Customers will not be able to distinguish various giant clam species in either raw or cooked forms. To compare *T. derasa* with other giant clam species, it would be necessary to test-market the various species in the same place and at the same time to enable customers or restaurant chefs to compare and rate them for each attribute. To arrange such a market test for two (or more) giant clam species produced in different countries to arrive in the selected market(s) at the same time would not be an easy task.

In addition to customer preference for each attribute, price is another important factor determining the market demand for giant clam. During the test marketing, restaurants charged various prices, e.g., $1.20–2.88 per clam (2-year-old) in

Honolulu and Guam, and $7–10/clam (3-year-old) in Saipan. Many customers indicated that the prices charged should be 10–20% lower to be competitive with comparable seafoods. Whether the giant clam producers can raise giant clam at a cost significantly below restaurant prices (less shipping and packing costs) is a question to be answered during the next phase of this study.

Giant clams are considered threatened species, and naturally caught giant clam products are restricted for trade among signatories of the Convention on International Trade in Endangered Species (CITES). Although cultured giant clam products are not restricted for trade, distinguishing between wild and cultured clams is difficult. Consequently, certification that giant clam products were cultured is necessary and an import permit is required to ship giant clam products to the member countries of CITES. In addition, since giant clams are considered as filter-feeders, living clams cannot be imported into the U.S. and Guam as food from areas without a shellfish sanitation program recognised by the FDA.

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This chapter is based upon an edited version of a portion of Yung C. Shang, PingSun Leung and John Brown, Test Marketing of Giant Clams for Food and Aquarium Specimens in Selected Markets, The Center for Tropical and Subtropical Aquaculture, Hawaii.

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Reference

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Appendix 1

University of Hawaii seafood market study of giant clams as seafood

Survey of customers

1\. Have you tasted giant clam before?
Yes/No

Where/when did you taste it?

2\. What kind of giant clam dish did you just have? Sushi/sashimi Cooked

3\. How did you like the giant clam dish you just had?

Attributes	Ranking					Comments
	Excellent	Very good	Good	Not very good	Poor	
Appearance (colour)						
Taste (flavour)						
Aroma (fishy smell)						
Texture (firmness)						
Thickness of meat						
Freshness						
Watery						
Other (specify)						

4\. Would you consume giant clam again? Yes/No

If yes, how often would you consume it?

Once a week

Once a month

Twice a month

Number of times per year

5\. In your opinion, what are the close substitutable species for the giant clam as seafood?

Manila clam

Scallop

Mussels

Oyster

Octopus

King clam

Other (specify)

6\. How would you rank the giant clam and its substitutable species?

	Ranking					Comments
	Excellent	Very good	Good	Not very good	Poor	
Giant clam						
Manila clam						
Scallop						
Octopus (tako)						
King clam						
Oyster						
Other (specify)						

7. What would you consider as a reasonable price for the giant clam dish that you just ordered?

10% less than what you paid

10% more that what you paid

20% less

20% more

Over 20% less

Over 20% more

8. Customers background

Local resident	Ethnic group	Sex	Age
Tourist	From	Sex	Age
	(State/ Country)		

Annual family income

Less than \$20000

\$20000–\$39000

\$40000–\$59000

\$60000 or more

Thank you for your cooperation

Appendix 2

Survey of restaurant chefs

1. How do you like the giant clam as sushi/sashimi and/or as a cooked dish?

As Sushi/Sashimi

	Ranking					Comments
	Excellent	Very good	Good	Not very good	Poor	
Appearance (colour)						
Taste (flavour)						
Aroma (fishy smell)						
Texture (firmness)						
Thickness of meat						
Freshness						
Watery consistency						
Ease of handling						
Ease of cleaning						
Other (specify)						

As cooked dish						
Appearance (colour)						
Taste (flavour)						
Aroma (fishy smell)						
Texture (firmness)						
Thickness of meat						
Freshness						
Watery consistency						
Ease of handling						
Ease of cleaning						
Other (specify)						

2.1 In your opinion, what are the cost substitutable species for the giant clam as seafood?

For two year old clam	
For clam muscle	

3. How would you rank the giant clam and its substitutable identified above?

	Ranking					Comments
	Excellent	Very good	Good	Not very good	Poor	
Two year old clam						
Clam muscle						

4. What would be your preferred size of clam and what wholesale price would you regard as reasonable?

	Preferred size	Reasonable wholesale price ($/clam)
Whole clam (inches)		
Clam muscle (gm)		

5. What would be your preferred type of clam?

	Whole clam	Muscle
Live		
Fresh/chilled		
Frozen		

Thank you for your time and cooperation.

6 Knowledge and Attitudes of Asian Restaurateurs in Australia to the Use of Giant Clam Meat

Clem Tisdell

Abstract

A survey of Asian restaurants (East Asian only) was undertaken in Brisbane and the Gold Coast, Australia, in June and July 1992 to determine the extent of the knowledge of owners/managers and chefs of these restaurants about giant clam meat and their interest in using it. This chapter reports on the results. It was found that owners/managers and chefs of such restaurants lack knowledge about giant clam meat and methods of preparing it, and that the contrary view commonly held by Europeans is a myth. The chapter also reports the relationships found between interest of the restaurants surveyed in using giant clam meat and (1) the ethnic background of the restaurant, (2) the geographical location of the restaurant (Brisbane versus the Gold Coast), (3) the extent of its dependence for custom on overseas tourists, (4) the racial nature of its customers (European or non-European) and (5) the income level of its customers. In addition, the results of a follow-up survey of all Japanese restaurants in Brisbane is reported. This survey was undertaken so as to target specifically the interest of Japanese restaurants in using giant clam meat, and their knowledge of it.

Introduction

There is a widespread view in the South Pacific that Asian restaurateurs know giant clam meat and are eager to use it when it is available. For example, a venture to farm giant clams in the northwest of Western Australia specifically mentioned in its prospectus that sales to Asian restaurants in Australia would constitute an important market outlet for its product. A reviewer for the *Journal of Pacific Studies* published from the University of the South Pacific in Fiji specifically mentioned in relation to an article on the potential market for giant clam meat in New Zealand submitted by Tisdell and Wittenberg that demand by Asian restaurants could be an important market outlet (Vanessa Griffen, pers. comm., June 1991). However, no empirical evidence bearing on this matter appears to have been collected in Australia or New Zealand. The purpose of this paper is to provide such evidence, obtained from a survey of Asian restaurants in Brisbane and the nearby Gold Coast. In all, 49 restaurants were surveyed in June and July 1992 using the questionnaire reproduced as Appendix 1. A complete list of the restaurants surveyed is available in Tisdell (1992, Appendix B).

The sample

The sample of 49 restaurants was drawn from Brisbane (38, i.e. 78%) with 11 restaurants being surveyed on the Gold Coast. In Brisbane most of the restaurants surveyed were in Fortitude Valley (Chinatown, a central suburb of Brisbane), in Brisbane City or suburbs close to the Central Business District of Brisbane. The restaurants were located by means of the Yellow Pages of the Telephone Directory and contacted in advance by telephone. Face-to-face interviews were conducted by Mr Haishun Sun and Mr Ziqi Liao. An attempt was made to survey all Asian restaurants in Fortitude Valley and Brisbane City, and a selection of Asian restaurants in suburbs close to Brisbane City. Partially this was determined by ease of access. The Gold Coast was included because it is relatively close to Brisbane and attracts large numbers of foreign tourists, particularly Japanese. The composition of the sample is weighted towards Chinese restaurants which contribute 61% of the sample. Other ethnic groups included are Thai (13%), Japanese (10%), Korean (8%), Malaysian (4%) and Vietnamese (2%). Chinese restaurants are the most common Asian restaurants in Australia, so up to a point, the preponderance of Chinese restaurants in this East Asian sample is not inappropriate. Details of the location and ethnic background of the restaurants surveyed are summarised in Table 6.1.

Table 6.1 The location and ethnic composition of Asian restaurants surveyed

Restaurants	Fortitude Valley	City	Gold Coast	Other	All
Chinese	10	3	6	11	30
Thai	4	1	0	1	6
Japanese	0	0	5	0	5
Korean	4	0	0	0	4
Singapore	1	0	0	0	1
Malaysian	0	0	0	2	2
Vietnamese	1	0	0	0	1
Total	20	4	11	14	49

Use of seafood by Asian restaurants, knowledge of giant clam meat as a food item, interest in using it

Seafood is an important item on the menus of Asian restaurants. Of the 49 restaurants surveyed, 46 served seafood. Ninety per cent of these restaurants believed that seafood was an important (even essential) component of their food selection. The types of seafood most commonly used are prawns, fish, scallops, oysters, crabs and lobsters. The extent of their use in the sample surveyed is shown in Table 6.2.

Table 6.2 Number of Asian restaurants surveyed, indicating use of each type of seafood

Restaurant by ethnic type	Chinese	Japanese	Korean	Thai	Other	All
Prawns	24	5	4	4	3	40
Fish	25	4	2	4	4	39
Scallops	22	3	2	0	3	29
Oysters	14	0	0	0	0	14
Crabs	11	1	1	0	0	12
Lobster	9	2	0	1	0	12

None of the restaurants surveyed was using giant clam meat and it was not well known by them. Some 60% of the respondents to the survey did not know of giant clams. Furthermore, 93% of restaurants surveyed have had no experience in cooking or using giant clams for food. Thus, the general hypothesis that Asian restaurants are, on the whole, very familiar with giant clam meat as a food item was not supported.

Most respondents did not know how to cook or prepare giant clam for food. They imagined that giant clam could be cooked by boiling, steaming, or frying with some special sauces. Some did know that some Japanese like to eat raw giant clam meat, and that giant clam can also be used in soup.

Respondents were asked (Question 9) if they thought giant clam meat was well known to Asian food caterers as a food item. Thirty-eight restaurants (78%) believed that giant clam meat was not well known to Asian food caterers. Only seven respondents thought Asian food caterers had considerable knowledge of giant clam meat and four restaurants were uncertain about this matter. This further emphasises the general unfamiliarity of Asian restaurants in Australia with giant clam meat.

Nevertheless, many respondents expressed interest in using giant clam meat in future if it should become available. Thirty-three restaurants (70%) answered yes to the question (Question 7) of whether they would like to use giant clam in future. About 30% of respondents would not be prepared to use giant clam in future even if it were available, because either giant clam meat is considered unsuitable for their ethnic food dishes (e.g. Thai food), or they were not confident about selling cooked or prepared giant clam meat to their customers.

Furthermore, many respondents thought that Asian food caterers would have considerable interest in the availability of giant clam meat. Of the 49 respondents 25 restaurants (50%) thought Asian food caterers would have considerable interest in the availability of giant clam meat and 14 (28%) thought that those caterers would have moderate interest in giant clam. The remainder thought that Asian food caterers would have little or no interest in the availability of giant clam meat as a food item. The results are summarised in Table 6.3.

Table 6.3 Likely interest of Asian restaurants in using giant clam if available as estimated by respondents (Question 10)

Answer	Interest in usisng		
	Considerable	Moderate	Little/No
Number of restaurants	25	14	10
Percentage	50	28	22

Table 6.4 summarises the binary answers to questions 5–9 by respondents according to their ethnic background. The questions were designed to determine the following:

Q5. Whether giant clams were known by respondents.
Q6. Whether they had been or were being used by respondents for their meat.
Q7. Whether the respondent would be interested in the possibility of using giant clam meat in the future.
Q8. Whether the respondent knew of any recipes for preparing giant clams as food.
Q9. Whether or not respondents believed that the meat of giant clams was well known to Asian food caterers in Australia.

Some interesting observations can be made from Table 6.4. Firstly, the majority of Asian restaurants sampled did not know of giant clams and, surprisingly perhaps, Chinese restaurant operators were least knowledgeable about giant clams. Furthermore, extremely few Asian restaurant operators had ever used giant clam meat. Only staff in two Chinese, one Japanese and one Malaysian restaurant had used it. However, interest was expressed by all ethnic groups in using giant clam meat if it were to become available. Overall, about two-thirds of Asian restaurants indicated that they would be interested in the possibility of using giant clam meat. Most interest existed amongst the Korean group, followed by Japanese and Chinese, with Thai restaurants being least interested. The majority of Thai restaurants indicated that they would not use giant clam meat even if it were readily available.

Question 8 was designed to provide additional information about the knowledge of Asian food caterers of giant clam meat as a food item. Only 20% of all respondents indicated that they knew a recipe or recipes for the preparation of giant clams as a food item. The Japanese caterers were least knowledgeable in that respect and Chinese restaurants were below the average in relation to such knowledge. In general, knowledge about how to prepare giant clam meat as a food item is very limited amongst Asian food caterers.

Table 6.4 Asian restaurants' response to Questions 5 to 9

Ethnic background	Total number of responses	Q5				Q6				Q7				Q8				Q9			
		Yes		No		Yes		No		Yes		No		Yes		No		Yes		No	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Chinese	30	8	27	22	73	2	7	28	93	21	70	9	30	4	13	26	87	3	10	27	90
Japanese	5	5	100			1	20	4	80	3	60	2	40			5	100	2	40	3	60
Thai	6	3	50	3	50			6	100	2	33	4	67	1	17	5	83	1	17	5	83
Korean	4	2	50	2	50			4	100	4	100			1	25	3	75			4	100
Malaysian	2	2	100			1	50	1	50	1	50	1	50	2	100			1	50	1	50
Singaporean	1			1	100			1	100			1	100	1	100					1	100
Vietnamese	1	1	100					1	100	1	100			1	100					1	100
Total	49	21	43	28	57	4	8	45	92	32	65	17	35	10	20	39	80	7	14	42	86

Further confirmation of the paucity of knowledge of Asian food caterers in Australia about giant clam meat was obtained from Question 9. The vast majority of respondents (86%) indicated that, in their view, it was not well known amongst such caterers. The Chinese group of respondents believed that this knowledge was less prevalent than did the Japanese respondents but all were agreed about the lack of such knowledge.

The view that Asian food caterers in Australia provide a ready market for the sale of giant clam meat must be discounted. While most caterers would be prepared to try such meat if it became readily available, virtually all lack experience with it and knowledge about its preparation. Thus, in Australia, it would seem necessary for sellers of giant clam meat to make available information (recipes) for its preparation and use in Asian-style cuisine.

Location of restaurants and socioeconomic characteristics of their customers related to the interest of restaurants in using giant clam meat

As mentioned earlier, of the 49 restaurants surveyed, 38 were located in Brisbane and 11 on the Gold Coast. As specified in Table 6.5, a higher proportion (88%) of the Gold Coast restaurants were interested in using or trying giant clam meat than in Brisbane where 66% expressed such an interest. Greater interest on the Gold Coast might reflect the high proportion of overseas tourists there.

Table 6.5 Comparison of the distribution of those surveyed restaurants interested (and not interested) in using giant clam meat in Brisbane and on the Gold Coast

		Interest[a]		No interest[b]	
All	Total	Number	%	Number	%
Total	49	34	70	15	30
Brisbane	38	25	66	13	34
Gold Coast	11	9	82	2	18

[a]Answered 'Yes' to Question 7.
[b]Answered 'No' to Question 7.

The majority of restaurants surveyed obtain most of their business from Australian customers, mainly locals. Sixty-five per cent of restaurants surveyed indicated that 80% or more of their customers were Australian residents. Nevertheless, 30% of the sample stated that half or more of their customers were overseas visitors. The distribution of the dependence of the restaurants on overseas tourists and on Australian customers is indicated in Table 6.6.

It is worthwhile considering whether there is any relationship between the interest of the restaurant managers in using giant clam meat in the future (answers to Question 7) and the dependence of the restaurants on overseas customers for business. From Table 6.7, it can be seen that restaurants which draw half or more of their customers from overseas visitors had slightly greater interest in trying clams then the remaining restaurants. Yet, if one considers restaurants which draw 70% or more of their customers from overseas visitors, they are, on the whole, more eager to try giant clam meat than the remaining restaurants. Nevertheless, even those restaurants in which Australian customers predominate have considerable interest in trying giant clam meat.

Table 6.6 Distribution of restaurants surveyed in terms of their percentage dependence on overseas and Australian customers

Australian customers (%)								
Over 80–100	Over 70–80	Over 60–70	Over 50–60	Over 40–50	Over 30–40	Over 20–30	Over 10–20	0 –10
Overseas customers (%)								
0–20	20–under 30	30–under 40	40–under 50	50–under 60	60–under 70	70–under 80	80–under 90	90–100
Number of restaurants								
22	10	1	1	7	2	3	2	1
Percentage of total restaurants								
45%	20%	2%	2%	14%	4%	6%	4%	2%

Table 6.7 Relationship between the dependence of restaurants on overseas tourist customers and their interest in using giant clam meat

Origin of customers		Interest[a]		No interest[b]	
	Total	Number of restaurants	%	Number of restaurants	%
50% and over from overseas	15	11	73	4	27
49% and less from overseas	34	23	68	11	32
70% and over from overseas	6	5	83	1	17
69% and less from overseas	43	29	67	14	33

[a]Answered 'Yes' to Question 7.
[b]Answered 'No' to Question 7.

Restaurants were asked to indicate the relative proportions of Europeans and non-Europeans among their customers. Europeans were predominant in most of the restaurants. As Table 6.8 indicates, there was slightly less interest in trying clam meat amongst restaurateurs with predominantly European customers. However, even for restaurants in which European customers were in the majority, most respondents were interested in trying giant clam meat. This indicates that use of clam meat is not dependent on Asian or other non-European customers.

Asian restaurateurs were asked the income group to which most of their customers belonged (Question 14). They were asked whether they belonged mostly to the high, middle or low income groups. The intention was to see if there was any connection between the levels of income of customers served by restaurants and their interest in using giant clam meat. The responses and the relationship is indicated in Table 6.9. Most restaurants said that they were catering for middle and middle-to-high income groups, with the next largest group catering for low and low-to-middle income groups. The smallest number of restaurants catered for either high or low income groups exclusively.

From Table 6.9, it can be seen that the group in which the highest percentage of restaurants expressed interest in using giant clam meat cater for middle and middle-to-high-income customers. The next greatest level of interest was among those restaurants catering jointly for low and middle income customers. Least interest was expressed by those restaurants catering exclusively for high income earners and those concentrating only on low income earners.

Table 6.8 Relationship between the racial background of the majority of their customers and the interest of restaurants in using giant clam meat

Racial type of most customers	Total number of restaurants	Interest[a] Number	%	No interest[b] Number	%
All races	49	34	70	15	30
European	34	22	65	12	35
Non-European	7	5	71	2	29
European and Non-European[c]	8	7	88	1	12

[a]Answered 'Yes' to Question 7.
[b]Answered 'No' to Question 7.
[c]No clear majority of either Europeans or non-Europeans.

Table 6.9 Relationship between the income levels of the majority of their customers and the interest of restaurants in using giant clam meat

Dominant income group of customers	Total	Interest[a]		No interest[b]	
		Number of restaurants	%	Number of restaurants	%
All groups	49	34	70	15	30
High income	2			2	100
Middle income	30	22	73	8	27
Low income	1			1	100
H + M[c]	7	6	85	1	15
M + L[d]	8	5	63	3	37
H + M + L[e]	1	1	100		

[a]Answered 'Yes' to Question 7.
[b]Answered 'No' to Question 7.
[c]Middle and high income customers the majority.
[d]Middle and low income customers the majority.
[e]Customers drawn from all income levels.

Concluding comments on the above survey

Although the sample on which these observations are drawn is relatively small, it indicates the following.

- Asian restaurants in Australia have little or no knowledge of clam meat, including methods of preparing it for food.
- The majority of such restaurants, however, would be interested in trying it if it became available.
- This interest does not depend solely on the reliance of restaurants on overseas customers, even though those with the greatest proportion of overseas tourist customers show the greatest interest.
- This interest is not to any great extent a function of the racial composition of the customers of such restaurants. It does not depend to any great extent on whether customers are European or non-European, although interest seems to be *slightly* higher in cases where non-European customers predominate.
- Restaurants catering for middle and middle-to-high income groups expressed the greatest interest in trying clam meat, with those depending almost exclusively on high income customers or low income ones expressing the least interest.

The results from the sample indicate that a market is likely to exist amongst Asian restaurants for giant clam meat but it needs to be developed. In particular if giant clam meat were to become available, restaurants would benefit from advice on its preparation, though many would be willing to experiment with its preparation on their own. Suitable preparation and presentation of the product would be extremely important in gaining its acceptability and building a suitable image for it, especially since in the beginning it would be regarded as an exotic speciality. Price would also influence long-term use but it may not be the most important consideration in the period of early introduction of the product.

Follow-up survey of Japanese restaurants in Brisbane

Because no Japanese restaurants in Brisbane were included in the earlier survey, it was decided to survey all 12 such restaurants in Brisbane. This was done in October 1993 by Dr Yoshihiro Kuronuma, by direct interview, using a modified form of the questionnaire shown in Appendix 1. The detailed results and details of the survey are given in Tisdell and Kuronuma (1992) and only the main findings are reported here. These results are consistent with those for the broader Asian survey.

The main findings were as follows.

- Japanese restaurants in Brisbane have relatively little practical knowledge of clam meat, including exact methods of preparing it for food. However, their suggested methods of cooking it for Japanese menus differ according to the ethnic background of the chefs.
- The majority of chefs in such restaurants would be interested in trying giant clam meat if it becomes readily available.
- Their interest would depend on its market price, its taste, and its yield for cooking. Australian (local and interstate) customers would play a crucial role in the continuing acceptability of giant clam meat by Japanese restaurants in Brisbane.
- Interest in trying giant clam meat is not to any great extent a function of the racial composition of the customers of such restaurants. It does not depend to any great extent on whether customers are European or non-European.
- All Japanese restaurants in Brisbane cater for middle-to-high and high income groups and all expressed a strong interest in trying clam meat.

The results from the sample indicate that, as for other Asian style restaurants, a potential market is likely to exist amongst Japanese restaurants in Brisbane for giant clam meat but that it will need to be developed. As before, price and stable supply of giant clam would also influence long-term use but price may not be the most important consideration in the period of early introduction of the product, particularly if it is regarded as a specialty item. For example, crocodile meat sells for $A34 per small plate as an appetiser at a Japanese restaurant in Brisbane. Presumably because it is a speciality item its high price is not a deterrent.

Acknowledgments

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Appendix 1

Survey of Asian food restaurants in Brisbane about their knowledge of giant clam meat and interest in using it

Confidential

	Name of respondent and position	
	Name of restaurant ; Address; Telephone	
1.	Ethnic background of owners or of effective operators of the business e.g. Chinese (Cantonese).	
2.	What type of ethnic food do you sell? List in descending order of importance (e.g. (1) Chinese-Cantonese, (2) Australian).	
3.	Is seafood included in your menu? If yes, is it an important part of your menu? What types of seafood do you mostly use?	Yes/No Yes/No
4.	Do you use shellfish (scallops, prawns, oysters, clams and so on) on your menu?Yes/No Is shellfish an important item in your menu?	 Yes/No
	Which types of shellfish do you mostly use?	
5.	Do you know of giant clams? [This is the shell of one. Please see photographs].	Yes/No
6.	The shells of the giant clam cover the meat inside. The meat of young clams can be eaten whole after discarding the kidneys, but the meat of older clams is usually divided into two parts—the muscle (which is firm and whitish in colour) and the mantle. Both parts may be eaten but are usually prepared differently by those that eat it. Sometimes only the muscle is eaten, e.g. this is usually the case in Taiwan. Have you used giant clam meat for eating or for any of your recipes? Please explain. If yes, indicate the recipes or ways in which you used it.	Yes/No
7.	Do you think that you might use giant clam meat in your cooking or food preparation in the future if it were available? Please explain. If you might use it, would you please indicate how you might like to use it?	Yes/No
8.	Do you know of any recipes or ways (not mentioned earlier) in which giant clam meat can be used? If yes, would you kindly provide some information about these.	Yes/No
9.	Do you think that giant clam meat is well known to Asia food caterers in Australia? Please explain.	Yes/No
10.	Do you think that Asian food caterers in Australia would have: considerable; moderate; little; or no interest in the availability of giant clam meat? Please explain.	
11.	What percentage of your customers would be people resident in Brisbane?	%
12.	What percentage of your customers would be overseas tourists? From what country or countries do they mostly come?	%
13.	Of your Australian customers, are they mostly European or non-European? What is the main ethnic background of your non-European Australian customers?	

14.	What socio-economic groups do most of your customers belong to? High income Middle income Low income	
15.	What short statement best describes the nature (characteristics) of your customers or custom?	
16.	Any other comments?	

Thank you for your co-operation and time. Your answers will remain confidential.

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Would you like a free copy of our report when it is available?Yes/No

7 Notes on the Use of Giant Clam Meat for Food in Taiwan

Clem Tisdell

Cheng-Ho Chen

Abstract

There have been two major studies of the use of giant clam meat for food in Taiwan (Dawson and Philipson 1989; Shang et al. 1991). The purpose of this paper is to provide some additional information about the demand for and use of giant clam meat for food in Taiwan, especially given the changing supply situation. It also gives specific recipes used in Taiwan for preparing dishes using giant clam meat. These are of twofold interest:

1. A survey of Asian restaurants in Australia found that they were interested in using giant clam meat in their cuisine but had no recipes and little knowledge of how to prepare it.
2. The range of recipes indicates that although Taiwanese prefer clam adductor muscle, they do have dishes which use clam mantle and dried clam meat.

It was also found that a considerable Taiwanese market may exist for the raw meat of young clams. These findings have favourable implications for farmed giant clams for which there is likely to be an economic advantage in harvesting them at a young age.

Introduction

Many people in the South Pacific have traditionally considered giant clam meat to be in considerable demand in Taiwan. This image was partly built up because of reputed poaching by Taiwanese fishing vessels on reef areas of the South Pacific in the 1970s and into the 1980s (Dawson and Philipson 1989, pp. 112–114). Products collected on such expeditions included giant clam muscle. This was collected not only in the northern waters of Australia, including the Great Barrier Reef, but in the Pacific islands. Apart from such activities, Taiwan was also one of the main outlets for large exports of giant clam muscle from the South Pacific. But with depletion of natural stocks of tridacnid clams and the advent of the Convention on International Trade in Endangered Species (CITES), this trade has virtually stopped. Taiwan's imports of giant clam meat seem now to be very limited and have been for at least the last five years.

Some scientists (e.g. Munro and Heslinga 1982) suggested that in the 1980s, very high prices were paid for giant clam adductor muscle in Taiwan and that

Taiwan could be an important market for the meat of cultivated giant clams. However, later in-depth studies indicated that the Taiwanese market was not as large as it was earlier reported to be and also the prices which Taiwanese were willing to pay for giant clam meat were lower than earlier casual reports indicated (Dawson and Philipson 1989; Shang et al. 1991).

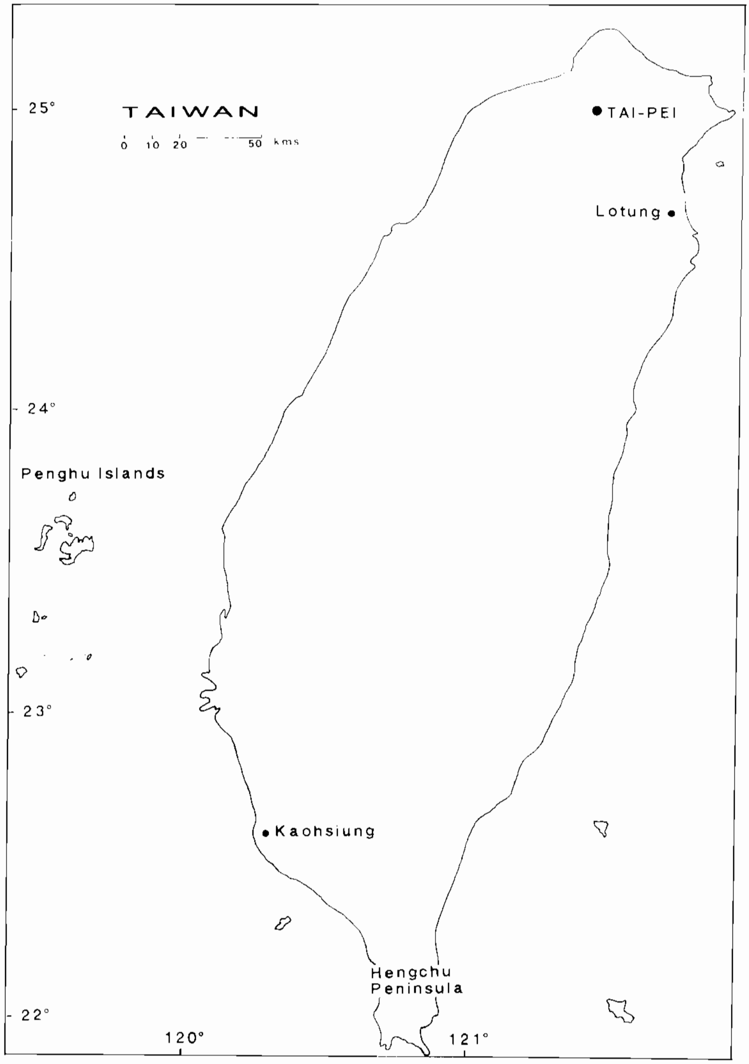
This chapter provides some additional information on the use of giant clam meat for food in Taiwan. Giant clam meat is now very difficult to obtain in Taiwan so the market situation is changing. Another important aspect of this chapter is to present some recipes used in Taiwan for preparation of giant clam meat. A recent survey of Asian restaurants in Brisbane and the Gold Coast found that while most were interested in the possibility of using giant clam meat in their cuisine, very few knew of any recipes for preparing dishes using the meat (Tisdell 1992 or Chapter 16). Successful marketing of giant clam meat might therefore depend on the dissemination of suitable methods for preparing giant clam meat for eating. Lack of knowledge about this hinders sales of giant clams to the restaurant trade in Australia according to the experience of personnel of Reefarm Pty Ltd, a commercial producer of giant clams near Cairns (Jeremy Barker and Bruce Stevens, pers. comm., October 1992).

Material used in this chapter was collected in Taiwan in the period June–September 1992, mainly as a result of contacts by Mr. Cheng-Ho Chen, a graduate of the National Kaohsiung Institute of Marine Technology and now a postgraduate student at the University of Queensland. He arranged for ten Taiwanese restaurants to be surveyed using the survey form attached as Appendix 1 to this chapter.

Present status of giant clams in Taiwan and import of tridacnid clam meat

Taiwan lies within the natural distribution of most species of tridacnid clams, including within the natural range of *Tridacna gigas*. However, *T. gigas* has disappeared from Taiwanese waters, presumably because of its overexploitation for human use. *Tridacna maxima* continues to exist and occurs around most of the Taiwanese coast. *Hippopus hippopus* occurs only on the Penghu Islands and the Hengchun Peninsula (See Map 7.1). It is also possible that *Tridacna crocea* continues to occur in Taiwan since it occurs in the nearby Nansei Islands of Japan. Because of the poor state of local stocks of giant clams, virtually all tridacnid clam meat has to be imported to Taiwan.

The Taiwan Customs Office includes imports of giant clam meat under the category 'ganbei' which includes a range of marine molluscs. This means that it is difficult to obtain any detailed statistics on imports which relate only to tridacnid clams. Table 7.1 lists imports by quantity and value of 'ganbei' into Taiwan for the period 1977–1988. In the past, giant clam meat has been imported in fresh/frozen, dried and canned forms. Presently, import of fresh or frozen giant clam meat to



Map 7.1 Map of Taiwan

Taiwan is prohibited but canned meat and dried meat is available. Illegal import of fresh or frozen meat does occur (cf. Dawson and Philipson 1989).

Knowledge of Taiwanese consumers of giant clam meat

Taiwanese awareness of giant clam meat varies. Interviews with proprietors of ten Taiwanese seafood restaurants and some Taiwanese fishermen indicated that persons younger than 20 years of age have little knowledge of giant clam meat.

Table 7.1 Imports of ganbei to Taiwan

Year	Quantity (t)	Value (N.T. $'000)
1977	9	662
1978	34	23985
1979	33	42397
1980	46	72461
1981	16	29930
1982	9	14618
1983	0	137
1984	0	12
1985	3	698
1986	76	13728
1987	336	126662
1988	621	274008

Source: Taiwan Fisheries Year Book 1988.

This is partly a result of its recent very short supply, its high price, and the fewer opportunities available to younger people than older people to try clam dishes.

Giant clam meat is rare and expensive and is considered a luxury. It is sold only in large restaurants or can be found at wedding parties. Furthermore, people in urban areas appear to be more aware of clam meat than those who live in rural areas, because most large seafood restaurants are located in urban areas. People who live in areas near fishing ports appear to have more understanding of giant clam meat than people who live farther away, because some fishing vessels harvested giant clams before they were considered an endangered species, and consequently protected.

Use of tridacnid clams for meat in Taiwan

Although all portions of the meat of tridacnid clams except the kidney can be consumed by humans, people in Taiwan prefer to eat only the muscle of the giant clam, and not the mantle. The main demand is for the adductor muscle of the giant clam. The mantle of the giant clam was used in the past as feed for livestock or poultry. However, there is some demand for the mantle for dishes for human use as indicated by some items in the list of recipes given later. Furthermore, there could be a demand for tridacnid clams for sashimi (see later).

A few former clam processing factories are located at Lotung in the north-east of Taiwan and in Kaohsiung in the south-west of Taiwan (see Map 7.1). They imported and canned the fresh/frozen muscle of clams and supplied it to the domestic market. They are multipurpose seafood processing factories.

In Taiwan, people have been consuming raw seafood, or sashimi for a long time. The owner of the East Coast Seafood Restaurant stated that about 60% of his customers order raw seafood. The owner of the King of Dragon Seafood Restaurant said that about 40% of his customers eat raw seafood. Furthermore, the owner of the Changtayen Seafood Restaurant claims that approximately 70% of his customers eat raw seafood. It would appear then, that a large proportion of people in Taiwan like to eat raw seafood. However, although young clams may be eaten raw, it is extremely difficult to find raw giant clam meat in Taiwan, because of lack of supply from natural sources. A number of restaurateurs believe that raw clam meat would be an attractive ingredient for them to use in their dishes if the supply of young clam meat was plentiful. A significant potential market seems to exist for the supply of meat from young clams for the sashimi-style market in Taiwan.

One of the Taiwanese clam traders interviewed pointed out that there is still market potential and demand for giant clam meat in Taiwan, even though the tariff on imported ganbei or compoy, which would include clam meat is high (approximately 50%). He also stated that people in Taiwan prefer fresh or frozen clam meat which has a better taste than dried or tinned clam meat. Since the giant clam became an endangered species, scallop meat has been imported by Taiwanese traders as a substitute for the adductor muscle of giant clams in the Taiwanese market.

Some general comments received from interviewees about demand for giant clam meat in Taiwan

- The price of giant clam meat in Taiwan is relatively high. It would be difficult to expand the market for clam meat and maintain such a high price.
- Some people are concerned about eating large quantities of clam meat as the general belief is that it contains high levels of cholesterol and albumen, even though this belief may have no scientific foundation.
- Giant clam meat does not seem to be any more nutritious than other seafood. Therefore the incentive to spend money on clam meat could be low from a nutritional point of view, it is expensive in comparison with other types of seafood, especially fish.
- A possible reason for the high demand for clam meat in Taiwan despite its cost is that it is rare. This rarity plus its 'priciness' means that there is social influence on demand.[1] Nevertheless, some people do not wish to consume

[1] This social influence may partly involve a 'snob effect' and a 'Veblen-effect' or another effect, the desire to treat a guest to something very special and costly as a gesture of social significance (cf. Leibenstein 1980; Tisdell 1972, pp. 117–180).

giant clam meat because they have never seen the meat of the giant clam, and are afraid of eating unfamiliar items.

Possibly the main reason why giant clam meat is both well-known and very popular in Taiwan is that people feel that it is delicious.

Chinese Taiwanese recipes for clam meat

There are a variety of ways to prepare giant clam meat. Generally, it can be cooked with vegetables, used in soup or fried. The following recipes were provided by seafood restaurants in Taiwan, and seem quite delicious. Most involve use of muscle but some use mantle or dried clam meat.

Recipe 1.

Muscle meat is covered with cornstarch before deep frying. Fried muscle meat is put on butter lettuce and accompanied by salt and monosodium glutamate (MSG) mixed spice.

Recipe 2.

Muscle meat is dipped for a few seconds in boiling water. The meat is then placed on a dish and surrounded by garnishes of ginger, garlic and lemon and dressed with mayonnaise, soy sauce, vinegar and oil.

Recipe 3.

Muscle meat is covered lightly with cornstarch before dipping it in boiling water. It is then cooked with ginger, garlic and leeks.

Recipe 4.

Muscle meat is cooked with ginger, garlic, parsley and leeks.

Recipe 5.

Muscle meat is cooked with snow peas, mushrooms, garlic, white garlic and bamboo shoots which are mixed with cornstarch and topped with a sprinkle of pepper.

Recipe 6.

Muscle meat is cooked with oyster mushrooms, bamboo shoots, parsley, prawns, fish balls and squid, and topped with oyster sauce, leeks and fish stock.

Recipe 7.

Muscle meat is covered with cornstarch and cooked with fish balls, sea cucumber and broccoli.

Recipe 8.

Muscle meat is cooked with a dry mushroom-based soup and leeks.

Recipe 9.

Muscle meat is cooked with asparagus-based soup, and topped with chopped parsley.

Recipe 10

Muscle meat is cooked with a scallion (e.g. shallot/leek) based soup.

Recipe 11.

Raw clam meat with soy sauce and mustard mixed accompaniment.

Recipe 12.

Chilli slice, rice wine, ginger slice and oyster sauce mixed combination with boiled clam meat.

Recipe 13.

Stewed clam mantle with brown sauce.

Recipe 14.

Clam mantle with bean paste.

Recipe 15.

Steamed clam mantle with a mixture of soy sauce, ginger and chilli slice, vinegar and sesame oil.

Additional combinations involving the use of clam meat are shown in Figures 7.1–7.6 (taken by Mr Yu Ko-Chien for this project). These are:

1. Stir-fried chilli with clam meat (muscle) pieces, asparagus and shallot.
2. Mixture of clam meat, mullet eggs and calamari.
3. Combination of clam meat, mullet eggs and seafood roll.
4. Chinese vegetables topped with clam meat, crab meat and jellyfish.
5. Deep-fried clam mantle with seasoned pepper, salt.
6. Stir-fried Chinese vegetables, mushrooms with dried clam meat.

In addition, as noted earlier, there is considerable scope in Taiwan for using fresh young clams raw as well as raw adductor muscle.

The above indicates that giant clam meat can be used in Taiwanese Chinese cooking in a variety of ways. In this cooking, use exists for:

1. the adductor muscle;
2. the mantle; and
3. dried clam meat.

Concluding comments

Taiwan remains a promising market for giant clam meat but amongst the younger generation knowledge of giant clam meat is beginning to disappear for the reasons outlined above. In the past, Taiwan relied mostly on import of giant clam adductor muscle from natural stocks to satisfy its demand for giant clam meat. But imports have been curtailed as a result of the depletion of natural stocks and the endangered status of these stocks.

While Taiwanese prefer the adductor muscle of the giant clam, it is clear that potential and actual Taiwanese demand is not limited to the adductor muscle.[2] Several recipes use giant clam mantle and a number use dried giant clam meat. Furthermore, if a regular supply of fresh young clams happened to be available, it seems that there would be considerable demand for their use raw, that is, sashimi–style.

[2]This view is somewhat at variance with the conclusion of Dawson and Philipson (1989).

Figure 7.1 Stir-fried chili with clam meat, asparagus and shallot

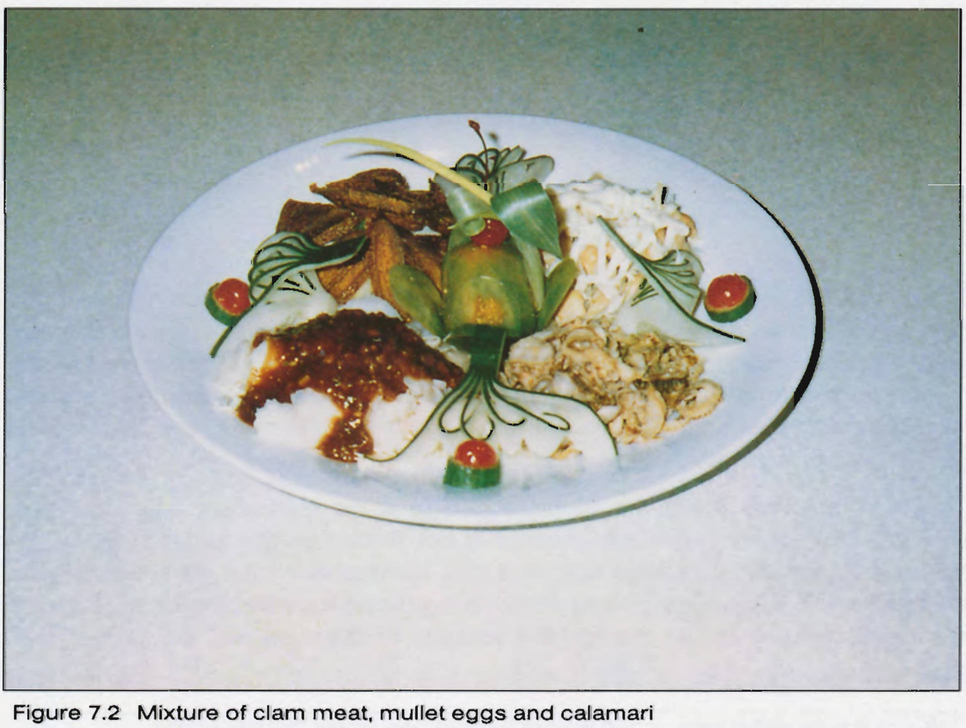


Figure 7.2 Mixture of clam meat, mullet eggs and calamari

Figure 7.3 Combination of clam meat, mullet eggs and seafood roll

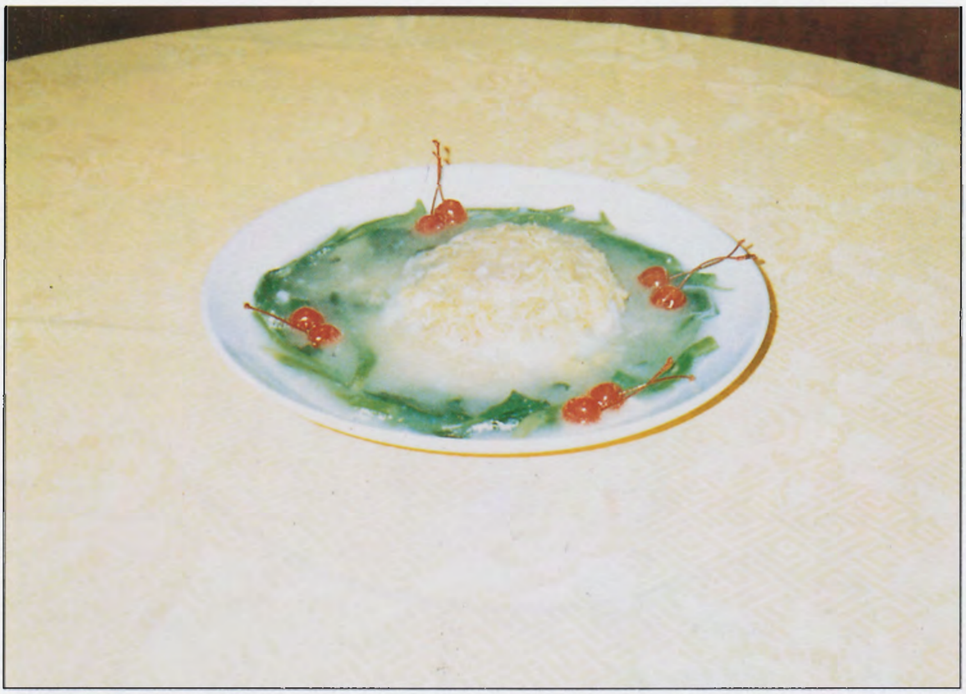


Figure 7.4 Chinese vegetables, topped with clam meat, crab meat and jelly fish

Figure 7.5 Deep-fried clam mantle with seasoned pepper and salt

Figure 7.6 Stir-fried Chinese vegetables, mushrooms with dried clam meat

This market would presumably be one that could be tapped by those engaging in land-based cultivation of tridacnid clams e.g. *T. crocea* or *T. maxima*. Such clams might be sold to satisfy this market when they are 2–3 years of age. This may prove to be more profitable for many clam farmers than holding clams longer in ocean growout conditions to satisfy the traditional adductor-muscle market in Taiwan. However, it is possible that there is room for both types of operations, for example, land-based aquaculture operations to supply tridacnid clams for the Taiwanese raw seafood market, and ocean growout to supply adductor muscle and some mantle fresh or dried for the Taiwanese market.

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Appendix 1

Use of giant clam meat in Taiwan for food

Set of questions		
1.	What use is made of the muscle of the giant clam for food? Indicate ways in which it is used or was used.	
2.	Please give some Chinese (Taiwanese) recipes (general recipes) for the use of giant clam muscle as food.	
3.	Do those who know giant clam muscle for food rate it highly?	Yes/No
	What evidence do you have for this?	
4.	What use if any is made of the mantle of the giant clam in Taiwan?	
5.	I understand that dried clam has been used in Taiwan. What is it used for?	
6.	Is the dried mantle used?	Yes/No
	Is the dried muscle used?	Yes/No
	Is the whole dried clam used?	Yes/No
	What are the above used for?	
7.	Do people in Taiwan like to eat raw seafood, that is, seafood sashimi style?	Yes/No
8.	Young clams may be eaten raw. Have people in Taiwan eaten them raw?	Yes/No
	Would they be interested in eating young clams raw?	Yes/No
9.	Giant clams may now be farmed. Is there likely to be much interest in Taiwan in importing the meat of such clams for food?	Yes/No

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8 Trials of Giant Clam Meat by Japanese Restaurants in Australia and the Use of Giant Clams for Food in Okinawa, Japan

Clem Tisdell

Yoshihiro Kuronuma

Abstract

This chapter reports the responses of both chefs and tasters to trials of giant clam meat for food in two Japanese restaurants in the city of Brisbane, Queensland, Australia. The trials were conducted in mid-December 1992 (summer in Australia) in order to determine the potential for using giant clam meat for food in Japanese restaurants in Brisbane. The Japanese chefs were able to use giant clam meat effectively in Japanese cuisine, although they had no previous experience in preparing and using it. The tasters (three Australians and four Japanese) were supportive of all tested recipes (e.g. sunomono, sushi and grilled giant clam with salt) prepared by the two participating Japanese restaurants. The results indicate that, with suitable preparation and presentation, giant clam meat can gain acceptability as an 'exotic' speciality item in Japanese cuisine. Procedures followed and the cost of these trials are stated and inferences are drawn about the economics of using giant clam meat in Japanese dishes. Some of the selected recipes for using giant clam meat from the Ryukyus are given. The market for giant clam meat in the Ryukyus (Okinawa prefecture) is also considered and there is some discussion of whether Australian suppliers could economically supply that market.

Introduction

There is a widespread view in the South Pacific that Asian restaurateurs know giant clam meat and would be eager to use it. To investigate this view, two surveys of Asian restaurants in Queensland and one of Japanese restaurants in Brisbane were undertaken. The results were summarised in two reports (Tisdell 1992; Tisdell and Kuronuma 1992) and in the previous chapter. Although most Asian and Japanese restaurants in Queensland were interested in using giant clam meat in their cuisine, few knew of recipes for using giant clam meat and most had little knowledge of how to prepare it. Moreover, it was found from the sample of Japanese restaurants that while a potential market exists amongst those restaurants in Brisbane for giant clam meat, this market needs to be developed (Tisdell and Kuronuma 1992).

This chapter provides information on the results of trials using giant clam meat for dishes in Japanese restaurants in Brisbane. These trials were conducted in two Japanese restaurants (the Oshin and the Sennari) in Brisbane city in mid-December 1992. These accounted for 20% of the Japanese restaurants in Brisbane.[1] Chefs and tasters were asked to fill out the survey forms using the survey questionnaires reproduced in the Appendix to this chapter. Two species of live giant clams (*Tridacna crocea, Tridacna maxima*) were ordered from a commercial grower of giant clams on Fitzroy Island near Cairns (Reefarm Pty Ltd). Two batches each consisting of half a dozen of each species were air freighted from Cairns to Brisbane on two separate occasions.

The next section describes the trials of giant clam meat in dishes in Japanese restaurants in Brisbane and the cost involved. It also assesses the suitability of giant clams for such dishes. Selected recipes used for preparing giant clam meat in the Ryukyus (Nansei Islands), the only part of Japan where giant clam occur naturally and are traditionally used for food, are provided as additional information. Aspects of the market for giant clam meat in Okinawa are also outlined. Okinawa is a potential export market for farmed clam meat from Australia.

Trials of giant clam meat for food in Japanese restaurants in Brisbane

Description of the trials

The two batches of clams obtained for these trials were supplied from the land–based hatchery/nursery facility at Fitzroy Island, operated by Reefarm Pty Ltd. They were grown entirely by mariculture in land-based tanks (cf. Tisdell and Menz 1992). Each clam was placed in a separate plastic bag containing saltwater and each bag was secured by a tie (see Figure 8.1). Each batch was then placed in a styrofoam container (see Figure 8.2) before shipping. Each batch was packed in the afternoon, transported by ferry to Cairns and from there by road to Cairns airport, and freighted to Brisbane overnight and collected from the Brisbane domestic air cargo terminal of Ansett Airlines at about 9.15 am. They were transported to the University of Queensland and held for about 3–4 hours before being taken to the restaurant for the trial. This was necessary because a suitable time had to be arranged with the restaurant. Around 2 pm was most suitable because most lunch-time customers had finished their meal by then. Thus, the clams were packed for approximately 20 hours before the trials began. All the clams remained in excellent condition.

Costs

The cost of deliveries of small batches is generally higher per unit than large batches. We decided to purchase two small batches since the trials were to be held

[1] As of December, 1992, ten Japanese restaurants existed in Brisbane. One take-away shop is excluded from this figure.

Figure 8.1 Each tridacnid clam has been packed individually in its own plastic bag with seawater before being placed in the styrofoam container for transport.

Figure 8.2 The first batch of clams arrive at the University of Queensland in a styrofoam container held by Dr Y. Kuronuma.

on different days and we wanted to ensure that the live clams were in good condition when used. A dozen clams were used in each trial, and a half of these were *T. crocea* and the remainder, *T. maxima*. These were the species most easily available from the supplier who was growing them mainly to supply the aquarium trade. Furthermore, they were also known to be the two most popular species for eating in the Ryukyus.

T. crocea cost A$4.50 each and *T. maxima* A$5.50 each at the farmgate. These prices were determined by prices in the market for these species as aquarium specimens. The supplier arranged for the clams to be delivered to Cairns airport free of charge to us, but the styrofoam container had to be purchased at A$4.00/delivery (see Figure 8.2). Air freight from Cairns to Brisbane was A$20.00/delivery. A restaurant would also have the cost of delivery from Brisbane airport to its restaurant. Such a delivery in Brisbane by taxi truck would be about A$5.00/delivery. Thus the total cost of each batch of a dozen delivered to a Brisbane restaurant is as set out in Table 8.1. In this case, the shipping cost per clam was $2.33 each, so the total landed cost for *T. crocea* was A$6.83 each and for *T. maxima* A$7.88 each. Shipping costs per clam would be considerably lower for larger-sized batches. On regular orders, the supplier may be prepared to give a discount on the clams. Furthermore, there is a potential for the price of clams at the farmgate to come down if demand rises because considerable economies of scale are possible in land-based aquaculture facilities for growing clams.

It might be noted that although the cost of each *T. maxima* was higher than that for *T. crocea*, the cost of *T. maxima* per gram of wet weight meat yield is much lower for *T. maxima* (see notes to Table 8.1).

Table 8.1 Costs of delivery for a batch of 12 giant clams from Cairns to a Brisbane restaurant

Farmgate cost	**A$**	**A$**
6 × *T. crocea*[a] at A$4.50 each		27.00
6 × *T. maxima*[b] at $5.50 each		33.00
Shipping costs		
Styrofoam container	3.00	
Air freight	20.00	
Taxi truck delivery from Brisbane airport	5.00	
Total shipping costs	28.00	28.00
Total cost per batch		88.00

[a] All the *T. crocea* shipped from Cairns were about 2 years old. Their shell length ranged from 3–5 cm each with a length of around 3 cm. Their weight in the shell was 15–20 gm each and the wet weight of the meat of each was 2–3 gm.

[b] The *T. maxima* shipped from Cairns were also approximately 2–3 years old. The length of their shell was 5–7 cm each and their length 4–5 cm. Their weight in the shell was 20–30 gm each and the meat of each weighed 4–6 gm wet.

The two trials and evaluation of results

First trial (Sunomono): held on December 10 1992 at Japanese restaurant A

The chef of the restaurant decided to prepare sunomono (a vinegared dish) because the giant clams supplied were not very large[2] (around 6 cm) and very little meat was available (see Figure 8.3). Firstly, the chef opened each bag (Figure 8.4) and each shell and separated the meat from the shell (Figure 8.5). Then, the kidney of each giant clam was removed (Figure 8.6). Salt was rubbed into the clam meat to sterilise it. Then, the clam meat was washed in fresh water (Figure 8.7). Finally, the clam meat was squeezed to press out the water and placed onto a dish with some sliced vegetables (e.g. white radish, carrot) and lemon. Dressing was also placed in the same plate. This dressing is basically made from mirin (sweetened sake), salt, rice vinegar, dashi etc. The sunomono dish is shown in Figure 8.8.

The chef of this Japanese restaurant was able to use giant clam meat to prepare sunomono although he had not used giant clam meat before. The chef was asked to fill out the questionnaire which is reproduced in the Appendix to this chapter. According to the chef, giant clam meat is suitable for sunomono and with larger-sized clams he felt that the effort in preparing it from this source would not be greater than for alternatives (Question 6). However, he would not be interested in using giant clam meat for this dish again (Question 7) if giant clams were as small as those supplied. This is mainly because the yield of meat from small shells is low in relation to effort in preparing this dish if the meat is supplied with shells (Question 9). Effort and time is required to remove the meat from the shell. However, he would like to use giant clams for this dish and other dishes (e.g. sashimi) if giant clams of a larger size (size around 15–20 cm or more) were supplied. He also thought that the restaurant could use one giant clam of 15–20 cm shell width to prepare two sashimi side-dishes or entrees. The chef would modify his methods of preparing sunomono if giant clams were used (Question 8). According to the chef, it would be desirable for the giant clam meat to be either salted or vinegared and stored in a refrigerator for several days before being used to prepare sunomono. This would eliminate its strong sea flavour, especially that of *T. crocea*.[3] The chef thought that a very small serve of this trial dish would retail at around A$5 per customer (Question 10). He mentioned that this giant clam sunomono side dish could be introduced as a new or special item on their menu.

The restaurant owner (who is also the chef) was concerned about storage of giant clams. He mentioned that a Tasmanian company had supplied cold water systems for storing Tasmanian live seafood, such as abalone, in their restaurant. Giant clams cannot be stored in this cold water tank. This restaurant also has a warm water tank containing crabs. Clams could be kept in this water tank for a

[2] However, as a result of a telephone contact to the commercial producer in Cairns after this first trial, the producer mentioned that these are the preferred sizes in Okinawa for *T. crocea* for food.

[3] This suggests that it would be most economical to do this at or close to the farm site e.g. in this case in Cairns. This would cut down on freight costs and the salt or vinegar would act as a preservative. Also other species of clams such as *T. gigas* may be more economical to use in sunomono.

Figure 8.3 The clams supplied were relatively small in size —about 5 cm in width.

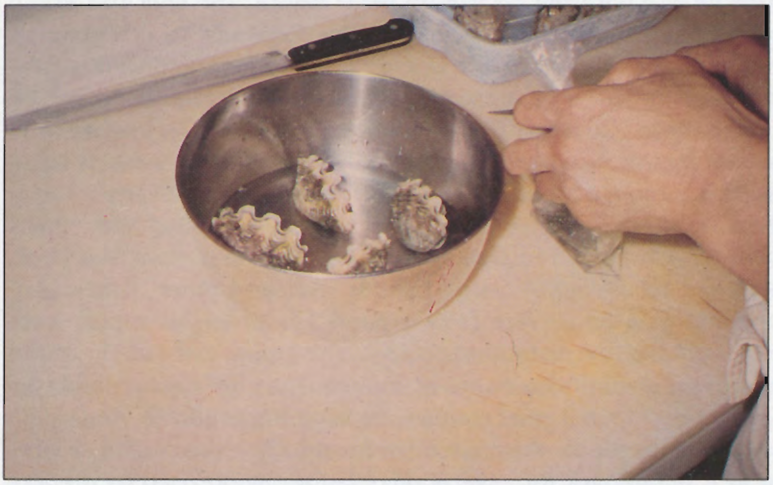


Figure 8.4 The chef removing clams from their individual plastic bags.

Figure 8.5 Clams being opened by the chef of restaurant A.

Figure 8.6 Kidney being removed from clams by the chef.

Figure 8.7 The chef washing the clam meat.

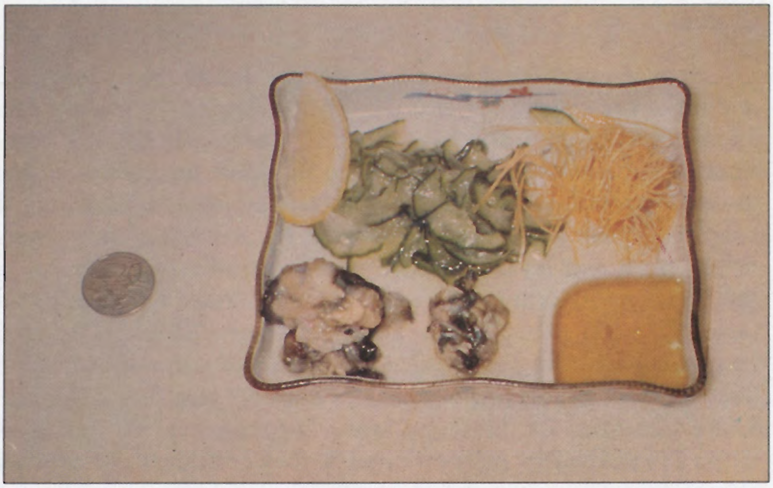


Figure 8.8 The sunomono dish prepared by restaurant A.

limited time if protected from the crabs. From the owner's perspective, a small serve of this *sunomono* dish would sell retail at A$12–A$15 and probably two to three dishes could be prepared from a giant clam 15–20 cm in size.

Using the method of preparation adopted, sunomono in this case, only enough meat was obtained from the dozen clams used for a small side dish or entree for around three to four people. If this were to retail at around A$12/serve, this would mean a total of A$36–A$48 in receipts. This would not cover the basic cost of the clams. However, if the approach suggested in footnote 3 is followed and say older specimens of *T. gigas* are used, the price of the meat could be much lower.

As a result of telephone contact with the producer of the giant clams in Cairns, the producer suggested that four giant clams in the shell might sell as a sashimi side dish or entree for A$18. This would still require the price of giant clams ex hatchery to be much lower than at present for the restaurant to recover costs.

Five persons tested the dish and were asked to fill out the questionnaire which is reproduced in the Appendix to this chapter. All tasters were very familiar with seafood cuisine including Japanese seafood dishes. Table 8.2 summarises the binary answers to Questions 6 to 13 except Question 10 by all tasters. The questions were designed to determine the following:

Q6 Whether the tasters liked the dish.

Q7 How the tasters would rate the dish for eating on special occasions.

Q8 Whether the tasters would like to try the dish again in the future.

Q9 Whether the tasters would be prepared to buy the dish as a speciality item.

Q11 What the tasters thought about the texture of the clam meat in this dish.

Q12 The opinion of the tasters about the flavour of the giant clam meat in this dish.

Q13 The views of tasters about the colour/appearance of the giant clam meat in this dish.

Some interesting observations can be made from Table 8.2. Firstly, all the Japanese tasters did not like this dish (Question 6) mainly because it tasted to strongly of the sea and had a bitter after taste. On the contrary, one of the Australian tasters (taster A) did like this dish because it is unusual. Almost all tasters (four out of five tasters) rated this sunomono as a poor dish for eating on special occasions (Question 7) because the amount of meat was too small, it had a 'bitter' taste and an unattractive mantle/meat colour. Several tasters mentioned that the quantity of this dish was too little to judge accurately on this matter. Only taster A rated the dish as acceptable for eating on special occasions and commented that he would probably try it if this dish were available and if he had an overseas visitor. All tasters except one were interested to try this dish again in the future (Question 8). Although taster D (Japanese) did not show any interest in trying this dish again, he mentioned he may consider it if the clams were larger than in the trial. Larger-sized giant clams were preferred by all other tasters. All tasters showed their interest in buying this particular dish as an entree if the size of giant clams were larger (Question 9). Three tasters (two Australian and one Japanese) indicated that a maximum reasonable price for a small serve of this trial dish (sunomono) would be A$10–12/head. The owners of the restaurant thought that such a serve would sell at between A$12–15/dish as a special item.

Table 8.2 Responses to Questions 6 to 13 (except Q10) by tasters: first trial (sunomono)

	Q6	Q7	Q8	Q9	Q11	Q12	Q13
Taster A[a]	Yes	Acceptable	Yes	Maybe	Poor	Not a problem	Poor
Taster B	Undecided	Poor	Yes	Yes	Not a problem	Good	Poor
Taster C	No	Poor	Yes	Yes	Poor	Not a problem	Very poor
Taster D	No	Poor	No	Yes	Poor	Poor	Poor
Taster E	No	Poor	Yes	Yes	Poor	Not a problem	Poor

[a]Taster A: Australian male, age 50s; Taster B: Australian female, age 30s; Taster C: Japanese male, age 30s; Taster D & E: Japanese males, age 40s.

Tasters were asked if they had any suggestions about how this particular dish might be improved (Question 10). Four of the five tasters indicated that the dish would probably be more acceptable to the customers if giant clams of larger size were used. One Japanese taster mentioned that the dish might be improved if the strong sea flavour was removed, especially in *T. crocea*. An Australian female taster provided possible alternative recipes to sunomono. The suggested recipe was Kokoda (Fijian dish of Escabeche) style cuisine based on lime juice and coconut milk and using only the muscle. However, larger sized clams would be needed for the preparation of this dish. The texture of the clam meat in this sunomono dish was rated as poor by all tasters except one who rated it as no problem (Question 11). Four of the tasters indicated that it was too chewy to eat.

Questions 12 and 13 were designed to provide information about how tasters rated the flavour (Question 12) and the colour/appearance of the clam meat in this dish (Question 13). Three of the tasters answered 'Not a problem' in relation to the flavour of giant clam meat. The chef, however, who also tasted this dish found the flavour to be poor because of its strong fresh sea flavour and its after taste, especially for *T. crocea*. On the other hand, the Australian female taster rated this dish as 'good' because of its fresh sea flavour. All tasters rated the colour/appearance of this dish to be 'poor' (Q13). Taster C (Japanese) even indicated 'very poor' for the colour/appearance of the clam meat in this dish. This was mainly because the mantle, which is a black/dark colour, was included with the muscle which although creamy, was very small in size. Thus this dish appeared to be unattractive in colour/appearance. General comments on the first trial and this sunomono dish were mainly as follows: there was little meat for one dish; it may have potential for other recipes (e.g. soup) if giant clams of this size are used.

Second trial: held on December 11 1992 at Japanese restaurant B

Following the experience of the first trial, a chef of restaurant B was asked to prepare three different dishes including sushi (Figure 8.9), sunomono (Figure 8.10), and grilled giant clam with salt (Figure 8.11) using *T. crocea* and *T. maxima* of the same size as in the first trial. As can be observed from these photographs, the chef used the shells of the giant clams to serve each dish. The method of preliminary preparation was exactly the same as for the first trial (Figures 8.4–8.7). The chef then used both *T. crocea* and *T. maxima* to prepare the three different dishes.

The chef of this Japanese restaurant was able to prepare giant clam meat for sushi, sunomono and grilled giant clam with salt although he had no previous experience in using giant clam meat in Japanese cuisine. According to him, the difficulty of using giant clam for sushi, sunomono and grilled giant clam with salt would only be about the same as for alternative material if giant clam meat could be provided shucked and either fresh or chilled (Question 6). Although this chef did not take as much preparation time as the chef of the first trial, he mentioned that it takes time to prepare if clams are in the shells because the process shown in Figures 8.4–8.7 is required. The chef of this Japanese restaurant would be interested in using giant clams for these dishes again (Question 7) if the size of the giant clams were at least two to three times larger than those supplied. These comments mirror those of the chef at the first trial. This indicates that giant clams 15–20 cm long, which occur at around 4–6 years old for these species, would have more potential for use in Japanese cuisine. The chef of this second trial also mentioned that he would like to try giant clams for sashimi (raw sliced clam meat in this case), grilled with butter, and also with macaroni and cheese.

Using giant clams as a material for preparing sushi, sunomono and grilled clam with salt, the chef would not modify his method of preparation except that he would prefer to use larger-sized clams. He would expect a small serve of these trial dishes to sell retail at around A$5 for sushi (two sushi), A$8–10 for sunomono, and A$10 for grilled giant clam (Question 10). The chef thought that these dishes would probably be only prepared as special entrees and not for main courses. He commented that these giant clam dishes can be introduced as a special item on their menu and this would be an advantage of these dishes. The chef in the first trial made a similar comment. The chef in the second trial also indicated that he has some worries about food poisoning. This was partially because giant clam meat was unknown to him and he was not confident of the standard of handling in Australian seafood markets. Generally the chef thought that the size of the clams was not suitable for these trial dishes (Question 9) but that these dishes had good potential as special items in the restaurant's menu if the size of the giant clams were larger.

Figure 8.9
Sushi prepared by the chef of restaurant B.

Figure 8.10
Sunomono prepared by the chef of restaurant B.

Figure 8.11
Grilled clam meat prepared by the chef of restaurant B.

Four tasters (two Japanese and two Australians) were also asked to fill out a questionnaire for each of these trial dishes. The questionnaire is reproduced in the Appendix to this chapter. Tables 8.3, 8.4 and 8.5 summarise the binary answers to question 6 to 13 (except Question 10) of each of the tasters.

Some interesting observations can be made from the three tables (Tables 8.3–8.5). Firstly, all tasters (both Australian and Japanese) liked all three trial dishes (Question 6) including the sunomono dish which was disliked by most in the first trial at restaurant A. This may partially be because of the excellent presentation made by the chef on the second trial, although this is subjective. All tasters commented that they preferred *T. maxima* to *T. crocea* for most of the dishes. This is because *T. maxima* has a very soft and smooth texture and a milder sea flavour. By contrast, *T. crocea* has a strong sea flavour and a (fibrous) chewy texture. The following summarises the responses of each of the tasters to the trial dishes.

Sushi (Figure 8.9)

All testers rated sushi as 'acceptable' to 'excellent' (Question 7). The two Australian tasters and a Japanese rated this dish as excellent, particularly *T. maxima*. The chef (also a taster) rated this dish as 'acceptable'. All tasters showed their interest in trying this dish again in the future (Question 8) and buying this dish as a special item (Question 9). Two Australian tasters indicated that a maximum reasonable price for a small serve of this trial dish sushi would be around A$10–12 per serve, three sushi in one dish in this trial. Two Japanese tasters indicated that a price of around A$4–6 per serve (two sushi per serve) as reasonable.[4]

Tasters were asked to make any suggestions about how a particular sushi dish might be improved (Question 10). Three tasters indicated that they had no suggestions. This indicates that the three tasters are most likely satisfied with this dish. A Japanese taster suggested that it would be better if more clam meat was used but other than that this sushi had good potential as a special item. The texture of the clam meat in this sushi dish was rated from 'very good' to 'poor'. The two Australians rated the texture of this dish as 'very good' although one of them rated *T. crocea* as only 'good'. A Japanese taster rated this dish as 'good' for *T. maxima* and 'no problem' for *T. crocea*. However, the Japanese chef rated this dish as 'poor' mainly because its dark mantle colour on the white vinegared rice gave a negative impression of this dish.

All tasters rated this sushi dish as 'good' or better in relation to its flavour (Question12). Both Australians and one Japanese taster indicated that the flavour of *T. maxima* was better than that of *T. crocea*. However, the chef preferred the flavour of *T. crocea* to *T. maxima* because of its fresh sea food flavour. Three out of four tasters rated the colour/appearance of this sushi dish as 'good' (Question 13). This includes the chef although he indicated 'poor' in response to Question 11. One Australian taster (not so familiar with seafood) rated this sushi dish as 'very good'. This indicates that this sushi dish would be attractive to customers, probably as an

[4] In the case of sushi in Japanese cuisine, two sushi per serve is the standard serve.

Table 8.3 Responses to Questions 6 to 13 (except Q10) by tasters: second trial (sushi)

	Species	Q6	Q7	Q8	Q9	Q11	Q12	Q13
Taster A	Both	Yes	Very good	Yes	Yes	Very good	Good	Very good
Taster B	*T. maxima*	Yes	Excellent	Yes	Yes	Very good	Good	Good
	T. crocea	Yes	Excellent	Yes	Yes	Good	Good	Good
Taster C	*T. maxima*	Yes	Excellent	Yes	Yes	Good	Very good	Good
	T. crocea	Yes	Very good	Yes	Yes	Not a problem	Good	Good
Taster D	Both	Yes	Acceptable	Yes	Yes	Poor	Good	Good

Taster A: Australian female, age 30s; Taster B: Australian male, age 50s; Taster C: Japanese male, age 30s; Taster D: Japanese male, age 40s.

Table 8.4 Responses to Questions 6 to 13 (except Q10) by tasters: second trial (sunomono)

	Species	Q6	Q7	Q8	Q9	Q11	Q12	Q13
Taster A	Both	Yes	Excellent	Yes	Yes	Very good	Very good	Very good
Taster B	Both	Yes	Excellent	Yes	Yes	Good	Very good	Good
Taster C	Both	Yes	Excellent	Yes	Yes	Very good	Very good	Good
Taster D	Both	Yes	Very good	Yes	Yes	Good	Good	Good

Taster A: Australian female, age 30s; Taster B: Australian male, age 50s; Taster C: Japanese male, age 30s; Taster D: Japanese male, age 40s.

Table 8.5 Responses to Questions 6 to 13 (except Q10) by tasters: second trial (grilled clam with salt)

	Species	Q6	Q7	Q8	Q9	Q11	Q12	Q13
Taster A	Both	Yes	Very good	Yes	Yes	Very good	Good	Very good
Taster B	Both	Yes	Very good	Yes	Yes	Not so good	Good	Not a problem
Taster C	*T. maxima*	Yes	Very good	Yes	Yes	Very good	Very good	Very good
Taster D	*T. crocea*	Yes	Accepta ble	Yes	Yes	Very good	Good	Very good
Taster D	Both	Yes	Very good	Yes	Yes	Good	Good	Very good

Taster A: Australian female, age 30s; Taster B: Australian male, age 50s; Taster C: Japanese male, age 30s; Taster D: Japanese male, age 40s.

entree. General comments on this sushi dish were as follows: although *T. crocea* has a slightly stronger sea flavour, this dish was excellent and the presentation made by the chef was excellent. This dish might have been better if more meat was available from each clam. The dish has excellent potential as a speciality item for Japanese restaurants.

Sunomono (Figure 8.10).

The second dish tried was sunomono. This was rated as 'excellent' by three tasters and as 'very good' by one taster (Question 7). The chef (also a taster) commented that if the customer likes fresh clam meat, this dish might have good potential as an entree. The other Japanese taster indicated that the taste of this sunomono dish was 'good' in its vinegar dressing. The fact too that the dish was presented in individual clam shells added an exotic character to it. All tasters said that they would be interested to try this dish again in the future (Question 8) and all indicated that they would be prepared to buy this sunomono dish as a specialty item (Question 9). Although a maximum reasonable price for a small serve of this dish varies, the two Australian tasters indicated its price as A$12–15, and a Japanese taster suggested around A$5–10, depending upon the amount of clam meat in the dish. The chef indicated A$7–8 per serve as reasonable if the amount of meat in this trial was used and A$10–15 if about 50% more clam meat was used.

Tasters were asked that if they had any suggestions about how this particular dish might be improved (Question 10). Three tasters did not make any suggestion. This possibly indicates that the tasters were satisfied by the sunomono dish in this second trial. These results contrast with those in the first trial for the same dish. The other Japanese taster commented that presentation was excellent with seaweed and cucumber, and he suggested that it would probably be better if more clam meat was served in each dish. The texture of the clam meat in this sunomono dish was rated as 'very good' by two tasters and as good by the other two tasters (Question 11). The flavour of this sunomono dish was rated as 'very good' by three tasters and good by the chef (Question 12). Three tasters preferred the flavour of *T. maxima* to *T. crocea* because of its less pronounced sea flavour. The chef preferred *T. crocea* because of its strong sea flavour. Three tasters rated the colour/appearance of the clam meat in this sunomono dish as 'good' and the Australian female taster rated it as 'very good'. Although the same species and sizes of giant clams were used in both the first and the second trial, the responses of the tasters were quite different on the different occasions. This may be partially because of differences in the presentation and the type of sweet vinegar dressing used. Overall, comments on the second trial sunomono dish were: enjoyed the sweet taste; good potential as a side dish; very tasty served with seaweed, cucumber and chilli, as in this trial.

Grilled giant clam with salt (Figure 8.11)

As can be observed from Table 8.5, grilled giant clams (*T. crocea*, *T. maxima*) was rated as a 'very good' dish for eating on special occasions (Question 7) by all tasters except one Japanese who rated grilled *T. crocea* only as acceptable. The chef commented that this dish may suit Japanese customers because it is similar to a top shell (*Turbo* [*Batillus*] *cornutus*) cooked in its own shell with sake and soy sauce (tsuboyaki in Japanese). All tasters were interested to try grilled giant clam with salt again in the future (Question 8) although two tasters mentioned that they would prefer bigger pieces of giant clam meat. All tasters indicated that they would buy this dish as a special item. Three tasters (one Australian and two Japanese) indicated that a maximum reasonable price for this trial dish (grilled giant clam with salt) as an entree would be around $10 and the other Australian taster indicated that a reasonable price for an entree would be around $6.

Tasters were asked if they had any suggestions about how this particular dish might be improved (Question 10). Two tasters including the chef mentioned that larger pieces of giant clam meat would be needed for this dish (about three times larger than the size of the giant clams provided for this trial). One taster mentioned that he would like to try giant clam grilled meat prepared in different ways, e.g. grilled with butter, grilled in its own shell with soy sauce and sake (i.e. tsuboyaki). The texture of the clam meat in this grilled dish was rated by different testers from 'very good' to 'not so good' (Question 11). Two tasters indicated 'very good', one answered 'good' and the other rated it as 'not so good'. The taster who said 'not so good' mentioned that there is a small problem because of a slightly stringy texture. This probably came from the mantle of the giant clam.

Two tasters rated the flavour of this dish as 'good', and one said it was 'very good'. Another rated the flavour as 'very good' for *T. maxima* and as good for *T. crocea* (Question 12). Three tasters indicated the colour/appearance of the clam meat in this dish to be 'very good' and one said that it was 'not a problem'. One taster commented that its brownish colour indicated that it was well grilled. General comments about this dish were: beautifully presented; preferred *T. maxima* to *T. crocea* (all tasters); good potential as a side dish.

Observations from the two trials

The first trial was less successful than the second one. On the basis of the sunomono prepared on the first trial, the prospects for using giant clam meat did not appear to be very promising. However, the second trial gave a much more favourable impression of the prospects of using giant clam meat in Japanese cuisine. The results indicated that it can be successfully used in sushi, sunomono and also in grilled form.

There was a general view that the clams supplied were too small for the dishes prepared. Opinion seemed to be that clams of two to three times larger would be preferable. Overall, *T. maxima* was preferred to *T. crocea*. This is interesting because per unit of meat it is cheaper.

Both chefs commented on the amount of labour involved in separating the clam meat from the shells. In small clams the meat yield in relation to effort is low. A similar observation was made by Shang, Leung and Brown from their restaurant trials with giant clams (poster at the 7th International Coral Reef Symposium, Guam 1992 and also Chapter 5). For some of the dishes, e.g. sunomono, it may be preferable to complete the initial process at or near the giant clam farm and freight the chilled meat. Chilled or frozen meat should also be suitable for the grilled dishes. Aesthetically, it does seem desirable to serve giant clam dishes in clam shells. For this purpose, however, a restaurant could reuse its stocks of clam shell. For some dishes, e.g. sunomono, species of clam such as *T. derasa* and *T. gigas*, which grow larger and more quickly than *T. maxima* and *T. crocea*, may be suitable especially if the meat is chilled at or near the farm. Taste tests with these species would be desirable for comparative purposes. In the light of the above, it is useful to consider the use of giant clams in the Ryukyus for food recipes used there, for their preparation and the local trade in giant clam meat.

Use of giant clams for food in the Ryukyus and selected Ryukyuan recipes for giant clam meat

According to Murakoshi (1991), both mantle lobes and adductor muscles of *T. crocea* and *T. maxima* are eaten raw (i.e. sushi, sashimi) in the Ryukyus (Okinawa prefecture). Raw adductor muscles of *H. hippopus* and *T. squamosa* are also eaten raw while the mantle lobes are salted for processing. Murakoshi (1991) also mentions that frozen mantles of large species such as *T. gigas* and *T. derasa* have been imported from the Philippines because the materials for salted giant clam meat are in short supply in Okinawa.[5] According to Mr. Tamaki, Research Associate of Okinawa Prefectural Sea Farming Center, giant clams are generally used in a form of sushi, sashimi and sunomono in Okinawa. However, in some areas of Nansei Shoto such as the Yaeyama Group including Ishigaki Island, the meat of *T. crocea* and *T. squamosa* are used in ordinary home cooking in Chanpulu (meaning 'to fry' in the Ryukyuan language). This meat is fried with white radish, onion and other vegetables. This method is similar to that used in some Taiwanese recipes reported in Tisdell and Chen (1992 or see Chapter 7). Shell ligaments (muscles) of *T. squamosa* and *H. hippopus* are used for Agemono (a deep-fried dish with flour/cornflour) as a special item in Chinese cuisine in the Ryukyus. On Ishagaki Island, giant clam meat is used as an addition to miso-soup. According to Tamaki, the consumption of giant clam meat is closely related to local availability of giant clams and they are therefore mostly consumed in the Yaeyama Group and on Miyako Island, and in the northern part of the main island of Okinawa. Traditionally, giant clams are not used for food in the central and southern parts of the main island of Okinawa. However, salted giant clam meat is produced mainly for consumption in the prefecture, especially on Ishigaki Island.

The following are some of the selected recipes for Ajike (general term for giant clam in the Okinawan language) which are provided by Mr Tamaki, Research Associate of Okinawa Prefectural Sea Farming Centre.

[5] According to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), these two species are listed as endangered species and can only be traded if it is authorised in exceptional circumstances (CITES, article II).

Recipe 1. Sunomono

Ingredients: Giant clam meat (all parts) 300g; Japanese cucumber (2-3)

Dressing: rice vinegar—90 ml (6 tablespoons); *dashi*-soup—60 ml (4 tablespoons); soy sauce—30 ml (2 tablespoons); chilli—1

Method: a)wash giant clam meat in fresh water

b) dice the clam meat

c) pour a little bit of rice vinegar over the meat and take off the moisture

d) rub salt into the cucumber then wash it with fresh water

e) slice the washed cucumber

f) place the diced giant clam meat on top of the sliced cucumber

g) combine ingredients for dressing

Recipe 2. Misoae (giant clam meat with *miso* dressing)

Ingredients: Giant clam meat—300g; kidney of giant clam—(one kidney); rice vinegar—proper quantity; *miso*—proper quantity; sweetened *sake*—a little

Method: a)wash giant clam meat under fresh water

b) separate the kidney from the giant clam

c) dice the giant clam

d) place the kidney in a *suribachi* (an earthenware mortar) and grind it with rice vinegar and *miso*, then add the clam meat

e) garlic and ginger can be added depending upon preference

Recipe 3. Ajike-nashimun (Tsukemono dish)

Ingredients: Giant clam meat—6 kg; salt—300 g; crystal sugar—1 kg; red chilli—10-15; *Awamori* (Ryukyu spirits) proper quantity

Method: a)remove kidney from the giant clam

b) wash the giant clam meat under fresh water

c) dice the clam meat

d) rub salt into the clam meat and leave it in a refrigerator for around two days

e) mix giant clam meat with crystal sugar and the red chilli in an appropriate container

f) store in a cool, dark place

g) when bubbles appear, add an appropriate amount of *Awamori*

h)store for around six months

Trade and availability of giant clam meat in the Ryukyus

According to Murakoshi (1991), most giant clams in the Ryukyus are sold directly from fishers to consumers without being auctioned through a fisheries cooperative association because the volume of giant clams harvested has declined drastically since the early 1970s. Hence it is difficult to estimate harvest levels of giant clams in Olinawa for recent years. Murakoshi (1991) provides estimates of catches of giant clams in Okinawa during the period 1973-1982 and Shang et al. (1991, p. 6) those for 1975-1987. The figures using both sources are shown in Table 8.6.

Murakoshi (1985) indicated that in the Yaeyama Group, six species of giant clams can be found: *T. crocea*, *T. squamosa*, *H. hippopus*, *T. maxima*, *T. derasa* and *T. gigas*. However, as Murakoshi (1985) points out, the harvest other than for *T. crocea* is very low. Thus, the figures shown in Table 8.6 are mainly for *T. crocea*.

Table 8.7 is reproduced from Murakoshi (1985, 1991) which shows the price of giant clams at Ishigaki Island in the Yaeyama Group in April 1985. As can be observed from Table 8.7, the price of *T. crocea* in Naha is 20–30% higher than in Yaeyama (Ishigaki Island) in 1985. This pattern was still the case when Tisdell visited Okinawa in 1991.

Table 8.6 Catches of giant clam in Okinawa, 1973–1987[a]

Year	Quantity (t)	Value (¥ million)	Average price (¥/kg)
1973	481	40	83
1974	432	94	218
1975	578	232	401
1976	227	96	423
1977	215	101	470
1978	222	107	482
1979	187	99	529
1980	187	107	572
1981	92	58	630
1982	112	61	545
1983	116	67	578
1984	154	68	442
1985	172	96	558
1986	154	103	669
1987	91	70	769

[a]Catches from January to October are shown for 1973 and 1979, and figures for 1974 and 1980 include catches in November and December in the previous year.
Source: *Agriculture, Forestry and Fisheries Statistics*, Okinawa General Bureau, Okinawa Development Agency.

Shang et al. (1991, p.6) reported that the wholesale price per kilogram in Okinawa of giant clam meat from the various species was as set out in Table 8.8. These are the same prices as reported by Murakoshi for April 1985.

As mentioned earlier, nearly all of the local trade in the Ryukyus is in *T. crocea*. It is therefore interesting to consider the size of *T. crocea* traded. Trading at Naha fish market in *T. crocea* provides a guide. On 29 February 1988, the size distribution of *T. crocea* at this market was as indicated in Figure 8.12. As can be seen, the majority of the *T. crocea* for sale had a shell length of 45–55 mm. This meant that they were about the same size as those provided by the Cairns farm for our

Table 8.7 Prices (¥/kg) of giant clams at Ishagaki Island in the Yaeyama Group in April, 1985

		T. crocea	*T. squamosa*	*T. maxima*	*H. hippopus*
For food					
Within Yaeyama Group					
Wholesale price		6000–7000	(1500–2000)[a]	3500–4000	ca. 1000[a]
Retail price		7000–8000	–	–	1500–2000
Shipped to Okinawa I.					
Wholesale price		8000–10000	(3000–4000)[b]	–	(2500–3000)[b]
For other uses					
Within Yaeyama Group					
Live shell		–	2000	–	1500
Shell valves	(Small)	–	500	–	–
	(Large)	–	250	–	–

[a]Small quantity is landed.
[b]High prices at the time of typhoon.

Table 8.8 Wholesale price of giant clam meat in Okinawa

Species	Price/kg (muscle and mantle only)
Tridacna crocea	¥8000–¥10000
	(US$57.14 –$71.43)[a]
Tridacna squamosa	¥3000–¥4000
	(US$21.43–$28.57)
Hippopus hippopus	¥8000–¥10000
	(US$57.14–$71.43)

[a]Exchange rate of US$1 = ¥140.

trials. It is also true that most *T. crocea* traded at the Naha market were below the legal limit of 80 mm shell length. It is reported that most of the *T. crocea* of around 50 mm traded in the Naha market are used for sushi (pers. comm. by Mr. Tamaki, Jan. 1993). Giant clam meat appears to be able to be used very economically in sushi and the strong (fresh) sea-flavour taste of *T. crocea* may be an advantage rather than a disadvantage for this dish. Our taste tests in Brisbane indicated that all tasters particularly liked giant clam served in sushi.

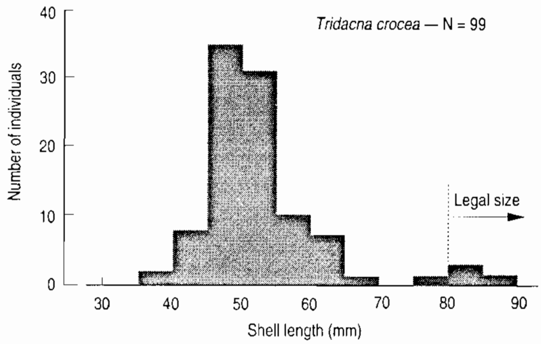


Figure 8.12 Size distribution of *T. crocea* at Naha markets on 29 February, 1988.

The *T. crocea* supplied by Reefarm for our Brisbane taste tests were clearly comparable in size to most of those traded in the Naha markets (at the most, they might have been slightly smaller on average).

Mr. Tamaki of the Okinawa Prefectural Sea Farming Center informed us that in Okinawa, *T. crocea* takes 3–5 years to reach a shell length size of around 5 cm. Under culture at Fitzroy Island near Cairns, *T. crocea* reaches a similar size when about two years old. This may be due to the advantages of land-based aquaculture at Fitzroy Island and a more suitable temperature regime for the growth of this species, than in Okinawa. From an economic point of view, such speedy growth would be an advantage.

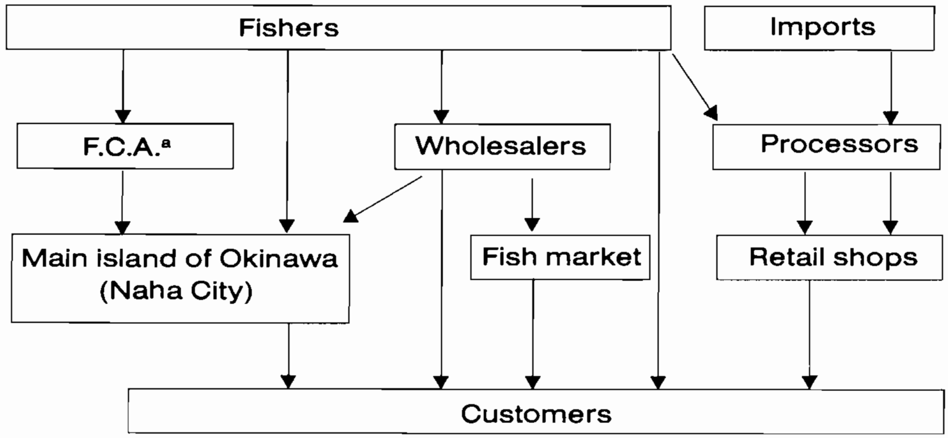
As mentioned earlier, most harvested giant clams are now supplied directly to customers by harvesters. Figure 8.13 shows channels used for marketing giant clams in Okinawa and is adapted from Murakoshi (1985). Note that imports do not usually go through the same marketing channels as local clams. Furthermore, it can be very difficult for foreign firms to get access to distribution channels (see Anderson and Riethmuller 1992).

Concluding comments

The trials undertaken at Japanese restaurants in Brisbane indicate that giant clam meat has definite potential in Japanese cuisine. Indeed, responses to the second trial involving the serving of giant clams in sushi, sunomono and grilled are very encouraging. It is clear that presentation and method of preparation would be very important in using these shellfish in the Japanese restaurant trade.

While Brisbane tasters thought that the small size of the clams was a problem, this was probably less of a problem for sushi than for other dishes tested. In the case of sushi, vinegared rice makes up a substantial component of the dish. Furthermore, when sunomono is served with seaweed, chilli and other ingredients as on the second trial, use of the meat 'can be extended'.

From an economic point of view, the cost of farmed clams in Australia is a problem. If a serve of sushi (using two small clams) were to sell at A$12–15, this would just repay the cost of the landed clams. However, if the farmgate price of



[a]Fisheries Cooperative Association

Figure 8.13 Marketing channels in Okinawa for giant clam meat.

these clams could be halved (and if distribution costs could be reduced), the use of such clams could be worthwhile from a restaurant's point of view. Farmgate prices of clams can be reduced substantially with increases in volume throughout because strong economies of scale in production exist.

At the present time, most of the production of giant clam farms is used to supply specimens for the aquarium trade. However, if sales to restaurants could be achieved on a regular basis and in volume, scope exists for substantially reducing farmgate prices.

On the two trials conducted in Brisbane, both chefs pointed out that considerable effort is involved in preparing clam meat when clams are supplied in the shell, and that meat yield in relation to effort is low when the giant clams are small. Larger-sized clams would have an advantage from this point of view. It may be that ingredients for some of these dishes could be supplied by other species of clams which grow more quickly to a larger size than *T. crocea*. In the Brisbane trials, *T. maxima* was found to give greater meat yield than *T. crocea* and on the whole to be preferred by tasters. There was no opportunity to test other species e.g. *T. gigas*. It seems likely that different species would be appropriate for different types of dishes, e.g. the larger-sized species of clams might be more suitable for grilling.

It is also clear that it may be unnecessary to ship giant clams alive to supply meat suitable for Japanese cuisine. Chilled meat can be suitable for sushi. In the case of sunomono the meat may actually 'improve' if it is salted or vinegared and chilled and held for a couple of days. A clam farm or facilities associated with it could do the necessary initial processing thereby reducing transport costs and possibly obtaining some scale economies. There needs to be liaison between clam producers and Japanese restaurants to ensure that this is done correctly. Such a situation could be attractive to a large Japanese restaurant chain which might find backward integration worthwhile with clam production. However, it should be pointed out that most Japanese are not familiar with giant clams. On the whole familiarity is limited to the far south of Japan in the Ryukyus. Nevertheless, given the suitability of giant clam meat for inclusion in Japanese cuisine, sales of giant clam meat could be extended to Japanese restaurants generally both in Japan and abroad, if adequate promotion and supply of giant clam meat were forthcoming. There seems to be a good prospect of this happening as a speciality item in relation to Japanese cuisine.

The question might be asked if there would be a market for Australian farmed giant clams for meat in Japan. Clearly a market exists in Okinawa but as yet there are not direct flights from Cairns to Naha. Also, the Ryukyu market is rather small, according to Shang et al. (1992 or see Chapter 4). But actual consumption of giant clam meat exceeds this figure since a large quantity of giant clams are sold directly by fishers to customers in the Ryukyus. Other than in the Ryukyus, no ready market exists in Japan but a potential would appear to exist for development of the use of giant clams in Japanese restaurant cuisine in other parts of Japan. As pointed out by Riethmuller (1993), Japanese are consuming an increasing proportion of their food outside their homes.

In order for Australian producers to supply the Okinawa market, the farmgate price of their clams would have to be much lower than at present. In 1989, for example, sushi bars in Okinawa paid about A$2.10–3.60 for each 5–6 cm *T. crocea* in the shell. (cf. Shang et al. 1991, p. 6). The Australian farmgate price for such clams was A$4.50 each. It seems that this price would have to be at least halved if sales were to be realised in Okinawa, especially because shipment costs have to be added to the farmgate price. It is feasible because of economies of scale (cf. Tisdell et al. 1990, 1993) for production costs to be halved for *T. crocea* if volume of production can be substantially raised on clam farms, but the possibility of doing so involves a 'chicken-and-egg' problem in that expansion of production depends on expanded demand which in turn may hinge on enhanced levels of production.

Acknowledgments

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Appendix 1

Questionnaires for chefs and for tasters of giant clam meat used in Japanese cuisine, Brisbane 1992

Questions for chefs: Information sheet re potential for giant clam meat in cuisine

1.	Date	
2.	Restaurant	
3.	Respondent	
4.	Dish	
5.	Species of giant clam used	
6.	Have you prepared this dish before using seafood other than giant clam? If yes, what other seafood did you use? Was it: Harder Easier About the same: to prepare this dish using giant clam? Comment	Yes/No
7.	Would you be interested to use giant clams for this dish again? Comment	Yes/No
8.	If you were to use giant clams to prepare this dish again, would you modify its ingredients or method of preparation? Comment	Yes/No
9.	Was the size of the clam suitable for this dish? Please explain	Yes/No
10.	What would you expect a small serve of this dish to sell at retail? Number of persons likely to be involved in eating a small serve? Do you have in mind a main course, subsidiary course, e.g. entrée, accompaniment?	$
11.	Please indicate the advantages and disadvantages of using giant clams for this dish from your viewpoint. Advantages Disadvantages	

Questions for tasters: Information sheet re potential for giant clam meat in cuisine

1.	Date	
2.	Restaurant	
3.	Respondent	
4.	Dish	
5.	Species of giant clam used	
6.	Did you like this dish?	Yes/No/Undecided
7.	How would you rate this dish for eating on special occasions? 1. Excellent 2. Very good 3. Acceptable 4. Poor 5. Unacceptable Comment	
8.	Would you like to try it again in the future?	Yes/No/Not sure
9.	Would you be prepared to buy it as a specialty item? If yes, what do you think would be a maximum reasonable price for a small serve?	Yes/No $
10.	Do you have any suggestions about how this dish might be improved?	
11.	Is the texture of the clam meat in this dish Very good/Good/No problem/Poor Please explain	
12.	Is the flavour of the clam meat in this dish Very good/Good/Not a problem/Poor Please explain	
13.	Is the colour/appearance of the clam meat in this dish Very good/Good/Not a problem/Poor Please explain	
14.	Any other comments on the dish.	

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9 A View of the Market from a South Pacific Island Nation —Fiji

Vina Ram

Abstract

In the period August-November 1991, the municipal markets in Suva were surveyed to determine the quantity of trade in giant clam meat and other characteristics of the trade. The results are reported here. In addition, supermarkets, international restaurants and butcher shops in Suva were surveyed by direct interviews in order to gather information about their involvement in and potential interest in trading or using giant clam meat. Furthermore, interviews were undertaken with 80 persons in Suva to obtain information about their consumption patterns as far as giant clam meat is concerned.

In the past, Fiji has had a substantial export market in giant clam meat, mostly muscle. Exporters of bêche-de-mer and of fresh fish were interviewed, and this included all previous major exporters of giant clam meat. The data are presented to illustrate some implications for future trade. Some difficulties in relying on aquacultured clams for export purposes are noted e.g. muscle size may be small. Furthermore, sociological problems that could arise in village-based mariculture of giant clams in Fiji are pointed out. It is considered that while urban demand for giant clam meat does exist in Fiji, this demand might be appropriately developed by market promotion and advertising because many potential consumers in urban Fiji are not knowledgeable about clam meat.

Background

Among a variety of shellfish and sea molluscs, giant clams (*Tridacna* spp.) have provided an important source of food to the people of the maritime islands of the South Pacific. However, as a result of increased harvesting, stocks have declined rapidly with some species (such as *Tridacna gigas*) almost becoming extinct in certain parts of the Western Pacific Ocean and others being endangered. With the possible threat of their becoming extinct, international trade in giant clams has been banned by many countries, including Fiji.

On the other hand efforts have been made to mariculture giant clam in the hope of restocking some of the heavily exploited areas, and also to introduce clams to new areas in order to provide a continued subsistence supply and also possibly to establish commercial farming.

Successful implementation of commercial clam culture will depend greatly on the effective demand for the product in the domestic and international market. Studies have been carried out in various countries including Australia, New Zealand, Taiwan, Japan and USA on the market prospects for giant clams (Shang et al. 1991 or see Chapter 4). This study focuses on the current status and the future prospects for the market for giant clams in Fiji.

Methodology

The study was primarily carried out in Suva from mid-August to mid-November 1991. Structured questionnaires were used to interview consumers at the Suva Municipal Market and beside the Nabukalou Creek where most of the fish and fisheries products are sold. These questionnaires are set out in Appendix I of Ram (1992).

It was envisaged that consumers would be selected in different towns throughout Fiji but due to time and budget constraints this was not possible. Instead, consumers buying or enquiring about giant clams, fish and other marine products were chosen as the target group within the allotted time. The survey was conducted on Saturdays from 9.30 am to 11.30 am, this being the peak period for sale of giant clams, fish and other fisheries products at the market. Informal discussions were held at the market with women selling giant clam meat. Market survey data and reports by the Fisheries Department were also consulted.

Furthermore, supermarkets, restaurants and butcher shops were studied using an interview schedule.

With regard to the export market, interviews were carried out with former giant clam exporters and current exporters of fresh fish and bêche-de-mer, to get an indication of their possible interest in international trade in giant clam.

A major constraint during interviews was that some respondents had to recall their past experience. As a result it was difficult to gather any documentary evidence from them e.g. from exporters, supermarkets, and butcher shops where giant clam trade did not represent a major part of their business.

Results of the survey

Municipal market area

Both men and women vendors were selling giant clams at the Municipal Market, the majority being women vendors. Women sold clam meat with other food items such as root crops and vegetables, whereas men sold whole clam meat inside the shell, together with fish.

During the three month period in which interviews were conducted, the majority of the sellers (80%) were from Verata area, in particular from Ucunivanua and Burewai villages which are on the eastern coast of Viti Levu. The vendors from the area claimed that giant clams, mostly *Tridacna derasa* commonly known as *Vasua dina*, are still abundant in the area and to a lesser extent *Tridacna squamosa* (cega) is also found. On average there were about 8–10 vendors each week from the Verata area selling approximately 12–15 pieces of clam meat each. Giant clams are also an important part of their subsistence diet.

The area unfortunately did not fall in the Giant Clam Project Field Survey of the Fiji Fisheries Division. The Fisheries Reports do not report any sale of *T. squamosa* at the market. However, it seems that the rate of exploitation in Verata is quite high, it being the largest domestic supplier to the Suva market on a regular basis.

Collecting clams is part of the normal daily activities of villagers if weather is good. Clams are collected for the market while gathering subsistence foods, and kept near the coast until the market day (mostly Saturdays). Before the clams are brought to the market, meat is taken out of the shells and put inside a bucket of water. This saves women carrying bulky shells in hired containers to the market. Shells are kept either near the shore or brought home for terracing the garden. Sometimes shells are also discarded on the reef.

A small shell market does exist in Fiji and purchasers are generally tourists, hotel and restaurant operators. The latter mostly utilise the shells as serving dishes, ash trays or for ornamental purposes.

From the survey at the market, the majority of male vendors were fishermen from Beqa who not only sold clams but also fish. Most of them brought the fish and live clams in their outboard motor punts to the Nabukalou Creek and sold them as live clams. It was observed that the number of people interested in live clams was much higher than in clam meat already taken out of the shell.

Oriental people preferred to buy live clams and supplies of live clam sold much faster than clam meat already de-shelled, which gives an indication of consumer awareness of quality and freshness. Table 9.1. gives the results of the survey at the market as far as quantity of trading is concerned.

The length of clam meat pieces ranged from 12 cm to about 30 cm, with the majority of meat pieces being around 20 cm. Prices[1] ranged from $3–$8 per piece of meat, with weight generally ranging from 0.5–1 kg. The dominant species sold was *T. derasa* and only twice was *T. squamosa* also noticed. There was no *T. maxima* sold during the entire period of the survey.

[1]All prices in this chapter are in Fijian dollars.

Table 9.1 Results of the survey at the Suva municipal market and the Nabukalou Creek area

Date	Total no. of vendors observed	Total no. of shells or pieces of clam meat sold
17–8–91	10	60
24–8–91	7	62
31–8–91	12	58
07–9–91	5	30
14–9–91	8	50
21–9–91	10	35
28–9–91	12	60
5–10–91	14	110
12–10–91	8	60
19–10–91	7	95
26–10–91	12	85
02–11–91	10	90
09–11–91	7	60
16–11–91	10	68

The Fiji Fisheries Division Market Survey estimates of domestic sale of giant clam meat over the years 1978–1990 by quantity is given in Table 9.2. The results indicate an increase in sales of clam meat in the early 1980s when the documented export industry took off. In 1984 and 1985 the domestic sales declined through the Municipal Market because most clams would have been sold to the exporters.

However, in 1986 local market supply again increased and then dropped in 1987 and 1988. This latter decline may have been a result of political instability in the country.

On the other hand, in 1989 and 1990 the municipal market supply increased again. This could be explained as the result of the ban on exports. Those villagers who became dependent on the giant clams as a source of income probably had to re-direct their supply to the domestic market.

Supermarkets

Representatives of the five largest supermarkets in Suva were interviewed:

- Apteds Ltd
- Bajpai's Supermarket

Table 9.2 Municipal market sales of giant clams in Fiji

Year	Total sales (kg)
1978	8000
1979	6800
1980	13830
1981	13410
1982	11960
1983	12700
1984	8350
1985	8410
1986	12360
1987	7980
1988	8970
1989	13540
1990	10780

Source: Fiji Fisheries Division, Annual Reports 1987–1990.

- B. Kumar Supermarket
- Morris Hedstrom Ltd
- R.B. Patel Centerpoint Supermarket

Results indicated that R.B. Patel, Bajpai's and B. Kumar Supermarket generally have mainly Indian customers who do not have any notable demand for giant clams. In 1988, R.B. Patel Centerpoint in Laucala Beach Estate had sold clam meat (mantle) only once on a trial basis. According to the manager interviewed, 10 kg of mantle was supplied by Feeders Fiji Ltd at $2.00/kg and retailed at $3.50/kg. The demand for frozen mantle was quite low and over 5 kg was thrown away because of spoilage.

Bajpai's Supermarket in Nabua and B. Kumar Supermarket in Raiwasa never sold giant clam meat, claiming that their supermarkets cater generally for Indian consumers.

On the other hand, the Morris Hedstrom Food Hall in downtown Suva and the Apteds Supermarket in Flagstaff were the major retailers in clam meat from 1986–1988. Clam meat consisting of mantle was supplied to Morris Hedstrom by Feeders Ltd at prices ranging from $2.00–2.50/kg and sold for $4.00–4.50/kg.

According to the food hall manager of Morris Hedstrom Ltd, total sales over the entire period were about 60 kg. With regard to demand, the manager indicated that in comparison with other seafoods, the demand for their clam meat was quite low as people did not like frozen clam meat and the quality of the product supplied was not good.

Apteds Ltd based at Flagstaff specialises in selling fresh and chilled seafoods. Their supply was mostly from Savusavu but some clam meat was also bought from the National Marketing Authority. The buying price for mantle ranged from $1–1.50/kg and the selling price was around $3. Muscle was bought at $5/kg and sold at around $10–12/kg.

Interviews at Apteds indicated that local Fijians preferred whole giant clam rather than separated parts, whereas other customers, predominantly expatriates of Asian origin including Taiwanese and Japanese, bought muscle only. Sometimes, the excess mantle was used by the Old Mill Cottage Restaurant (owned by Apteds) as clam meat in coconut cream or 'Vasua ni lolo'. Over the entire period from 1986 to early 1989, Apteds sold over 150 kg of giant clam meat.

With regard to interest in marketing of giant clam if it became available again, Apteds Ltd indicated that they still have interest in selling fresh and chilled giant clam meat. According to the supervisor-in-charge of seafoods, the buying price preferred for muscle was around $5/kg and mantle was $2/kg, whereas at Morris Hedstrom Ltd, the buying price preferred for whole clam including muscle was $2–3/kg. The manager of Morris Hedstrom indicated that this level of price would enable the selling (retail) price to be around $4–5/kg after packaging. This is the average price of the fish foods and other meat sold at the supermarket. The manager thought that a comparable price to this average price would be necessary to entice customers to purchase giant clam meat. However, it is difficult to determine the real substitutability of these commodities.

R.B. Centerpoint indicated that in future if the quality of supply improved, the supermarket would give giant clam meat another try. Bajpai's and B. Kumar indicated that if consumers show an interest or enquire about giant clam meat, they would be willing to sell it.

Restaurants

Restaurants in Suva specialising in seafoods were interviewed. Tiko's Floating Restaurant, which basically sells a variety of seafoods, indicated that giant clam is either bought from the Suva Market or supplied by fishers directly to the restaurant from their punts. The restaurant had a preference for bigger clams which have a large muscle, as they only use the muscle. This is served raw in lemon juice as an appetizer or entree dish. Prices ranged from $5-$8/clam. Mantle is discarded as there is no demand for it.

At the Travelodge Hotel Suva, which operates two large restaurants, an interview with the head Chef indicated that giant clam has never been used in any food preparation. The Old Mill Cottage Restaurant in Carnavon Street however used to sell giant clam mantle cooked in coconut milk. As mentioned earlier, clam meat was supplied to the restaurant by Apteds Ltd, the parent company. The restaurant has not used clam meat for some time now because it is not readily available. According to the interview, the demand for 'Vasua ni lolo' was moderate as only people familiar with the dish ordered it as the main course.

Most Chinese restaurants in Suva selling bêche-de-mer dishes indicated that giant clam meat would be a new food for them to introduce to their restaurants. They were of the opinion that the muscle would definitely have a demand, but since it has been an expensive commodity and not readily available, it did not appear on their menu.

Interviews of three restaurants (the Ming Palace, Sichuan Pavilion and the Great Wok of China) indicated their interest in using giant clam muscle if it became readily available. One of the managers said that with an increase in the number of Oriental tourists and expatriates over the last three years, there would be a definite demand for food preparations using the muscle.

Butcher shops

All four butcher shops in the city (the Whaleys Butchery, Tebara Halal Meats, Nausori Meat Co. and Leylands Ltd) were interviewed. Except for Leylands, none of the butcher shops had sold giant clam meat.

According to the assistant manager of Leylands, giant clam meat was sold from 1986–1988. The supply over the entire period was on an irregular basis with approximately 20 kg being sold per week.

Over the three year period a total of about 3 t of clam meat consisting largely of mantle was sold, at a price ranging for $2.5–3/kg. The mantle was mostly supplied by the National Marketing Authority and Feeders Fiji Ltd. Some supply of clam meat, including muscle, also came from Savusavu.

Prices paid for clam meat ranged from $1.5–$2/kg, according to the interview at Leylands in town. The assistant manager stated that there was considerable demand for the clam meat. Clam meat was sold both frozen and chilled. The majority of the customers were Fijians and Pacific Islanders. When the ban on exports of clam meat was imposed in early 1989, supply from the National Marketing Authority and Feeders Fiji Ltd ceased.

The assistant manager of Leylands indicated that Leylands would have a definite interest in selling giant clam meat if it became readily available provided the buying price for whole clam meat including the muscle was between $2–3/kg for medium sized clams. He added that giant clam meat prices depended a lot on the availability of other seafoods such as squid, mussels and octopus in his shop. This suggests considerable substitutability with these items.

Domestic consumption pattern

Using a structured questionnaire (available in Ram 1992) the consumption pattern of people living in the Suva area was determined. Although the sample size is too small to be used as a representative sample of the entire population of clam eaters in Suva, it gives an indication of the current trend in demand for clam meat in the domestic market.

Eighty people were interviewed of whom 55 were females and 25 males. Ethnically, 65 were Fijians and the rest, part-European, Pacific Islanders and Chinese. Twenty Indians were asked whether they ate giant clams or not. Out of the 20 Indians interviewed only one indicated that he had tried it after hearing from a friend and reading about it in the newspaper. On the other hand, in an informal discussion with Indian people involved in the giant clam industry or having sufficient knowledge about it, the majority of them indicated that they had tried eating giant clam cooked in coconut cream and the taste was good. They did not buy it from the market because they were not sure about the quality of the product. However, they had occasionally consumed clam meat if it was available otherwise, such as from the supermarket and village suppliers.

Most of the Fijians interviewed originally came from the outer Islands. Only 37% indicated that Viti Levu was their island of origin.

The following are some of the findings from the survey based on the questionnaire.

When asked about the regularity of consumption of giant clams, the majority of the respondents indicated that they ate clam meat whenever it was available. Since it did not appear as a regular food item, most of them indicated when they had last eaten clam meat in a period ranging from last year to last week.

Very few of the respondents could recall or estimate the weight of the clam meat because meat from the market is not sold by weight and also clams gathered by friends and relatives are not usually weighed. Sizes of clams ranged from small (referring to either *T. maxima* (katavatu) or small *T. derasa* (vasua dina) less than 15 cm), to medium (15–25 cm) to big (over 30 cm). Most people indicated that they usually bought one to two medium-sized clams and this was sufficient for their family's immediate consumption.

All people interviewed ate both the adductor muscle and the mantle. Although they all preferred the muscle, they liked the mantle too because it provided the bulk of the clam meat. Some indicated that the gonads were also eaten raw with lemon juice and salt.

Eighty percent of the people interviewed could not indicate their order of preference for the different species that are available because they have not had a chance to try all the different species. Twenty percent indicated preference for *T. maxima* (katavatu) because it is 'sweet' and has tender meat compared with other species. However, during the survey no *T. maxima* was sighted, but most people had eaten it some time back or on the Western side of Viti Levu, for example in Nadi and Lautoka, where it is more readily available. Most people knew about *T. derasa* (vasua dina) and only a few knew of *T. squamosa* (cega).

In terms of preference, both *T. derasa* and *T. maxima* species seemed to be equally liked. Generally speaking, it was found that the younger urban consumers did not know the difference between the various species. All they said was that they knew of giant clams as just one kind of shellfish or bivalve.

It was obvious that *T. derasa* had the highest consumption rate because it was the most readily available species at the market during the interview.

Responses varied when respondents were asked how long ago they had last consumed clam meat. Some of the responses were: 'last week', '3 months ago', 'during last visit to the islands', 'last Easter', 'last Christmas', and 'a few years back'. It seems obvious that the diversity of species available in the giant clam population has declined and that people do not get the chance to know about a range of species because of their lack of availability.

With regard to source of supply, 60% of the respondents indicated that they buy from the market, about 6% collected giant clams themselves if they went to their island village and about 15% indicated that friends and relatives send clams to them. Of the people interviewed only about 8% had ever bought clam meat from Apteds or Leylands.

The majority of the consumers indicated that the prices they paid per clam or for the meat of a whole clam ranged from $2–7. Most medium-sized pieces of clam meat sold at the market during the survey fetched either $4 or $5/piece. People generally do not go to the market to seek clam meat specifically because it is not regularly available. Most, however, indicated that they buy clam only when they visit the market for other things. This suggests that there is not major reliance on clam as a regular food source. In the urban areas, clam meat is eaten as a delicacy usually for lunch on Sundays after church.

Most people interviewed indicated that fish is their preferred seafood. When comparing clams to other marine foods apart from fish, 40% of those interviewed indicated that their first preference is for giant clams.

The majority of the people who consumed giant clam said that they usually made 'kokoda', that is raw clam meat marinated in coconut cream and lemon juice, or ate raw meat sprinkled with salt and lemon juice. Clam meat cooked in coconut cream 'lolo' was also a very popular method of preparing clam meat.

Those interviewed were asked how their future consumption of clam meat would change if clam meat became more readily available in the market. Most said that they would consume it 'more often than at present', 'once a week' or 'once a month'. On the other hand 15% responded that they would collect their own giant clams rather than buy them. If clam meat became available again, the quantity of clam meat people would buy would increase. The average quantity respondents said they would buy on each occasion ranged from 1–3 clams of medium size. This is enough for a family meal.

Prices which respondents said they would be willing to pay varied from $1/clam to $6/clam of medium size. This would amount to approximately 1 kg weight of clam meat. This price level is, however, much lower than the initial cost estimates from the Makogai Clam Project (Fiji Fisheries Department) of producing 1 kg of clam meat by aquaculture. According to the clam officer at the Fiji Fisheries Department, a 30 cm shell size clam (1 kg) would cost around $8–10 to produce.

On the other hand it is difficult at this stage to gauge the price level people would be really willing to pay. With the rate of exploitation of natural production being so high, the clam population would rapidly decline. Therefore prices are likely to increase further for clam meat in the near future.

If supply increased gradually from mariculture production, it is likely that higher prices may be maintained for some time in the local market. Such prices might help cover the high set-up cost and other overheads involved in an aquaculture project. However, as the supply of clams would increase through time, prices are also likely to go down accompanied by lower costs of production. A more thorough study could be done to forecast the optimal price level and supply and demand pattern to make the giant clam mariculture a viable industry in the Fijian domestic market.

Furthermore, clam meat would need to be compared to other marine foods such as mud crabs, prawns and other bivalves to determine the degree of substitution. For example mud crabs are another commodity which is heavily exploited. The excess demand indicated by rising prices for mud crabs, as for giant clams, suggests that mud crabs could sooner or later become a locally endangered species. Will giant clams obtained from mariculture be used to substitute the mud crabs at any stage?

Currently mud crabs fetch a price of between $12–15/kg at the local market and are considered to be a high-value commodity. However, if supply was greatly reduced, consumers would look for an alternative as a substitute. The closest substitutes are crustaceans like prawns and lobsters but these commodities are only available in very limited quantities at the municipal markets. Most of the supply is consumed by the hotels and restaurants catering for tourists.

Nevertheless, looking at the current state of market demand for giant clams and mud crabs, it is evident that they are not substitutes for each other. The demand for mud crabs mostly comes from Indians whereas giant clams are consumed largely by Fijians. On the other hand, if mud crab resources were threatened and ultimately depleted, Indians' choice of marine foods, besides fin fish, would be limited to the fresh water shellfish *Batissa violacea* because they also do not generally consume other fisheries products like octopus, bêche-de-mer, cockles, etc. The closest substitute in such a case would be giant clams. However, one cannot say for certain that such a trend would take place but there is a good chance that it may if the Indian consumers became more aware of the giant clam meat.

Furthermore, the introduction of giant clams through mariculture is most likely to occur at the community or household level. This may mean that there may be some degree of self-sufficiency in clam meat in the rural areas where mariculture grounds would be mostly located. Thus, the market demand for clam meat is likely to be limited to the urban markets only. Based on the nature of operations either commercial or semi-commercial, there would be a need for government assistance in setting up the industry.

Export market

An interview questionnaire (a copy is contained in Ram 1992) was used as a guide to gather information on trade in giant clams, and discussions were held with some current exporters of bêche-de-mer and fresh fish.Trade in giant clams has existed since the colonial days, but there was no documentary evidence available on exports during the survey. It is believed that Asian vessels occasionally poached around for giant clams, as it is a commodity that has long been sought in Asian markets. The Fisheries Department records on giant clam exports are given in Table 9.3.

Table 9.3 Exports of giant clam meat by weight from Fiji

Year	Kg
1982	0
1983	0
1984	7276.5
1985	20794.7
1986	11379.0
1987	na
1988	na

na = not available.
Source: Fiji Fisheries Division *Annual Report* 1987. p.24.

There was no direct regulation on exploitation of giant clams until the early 1980s, when giant clams were declared internationally to be an endangered species. As a result, direct regulations on giant clam exports were laid down by the Fijian government. Export licences were issued and export guidelines on the exploitation of giant clams in relation to size and quantity were established.

By the mid-1980s, most other giant clam exporting countries had also banned exports of giant clam. Therefore exports from Fiji increased tremendously. The industry had some set-backs in 1987 and 1988 following the military coup because of trade bans and strikes. However by early 1989, Fiji also became a signatory to the CITES (Convention on International Trade in Endangered Species) and imposed a total ban on export of giant clams.

The National Marketing Authority (NMA), Feeders Fiji Ltd, Wasawasa Fishing Co., Fiji Co-operative Association and Seafoods South Pacific Co. were amongst the giant clam exporters interviewed.

The former marketing manager of the NMA gave an account of exports of giant clams by the NMA, as the current management did not have adequate knowledge about the previous operation of the Authority. The NMA employed a Fisheries Department vessel to collect giant clams from the islands, mostly from the Lau group and Kadavu. The clam meat, both the muscle and mantle, was collected by the villagers who were paid by the NMA officers on board. The vessel also collected clam meat from other NMA centres located in Labasa, Savusavu and Lautoka. Prices paid at the collection sites varied from $1-3/kg. Sometimes the muscle and mantle was separated, and then the mantle fetched a price of $0.5-1/kg and muscle $3-$5/kg.

Statistics on NMA sales were not available due to change in the management of the Authority. However, mantle was largely sold to retail outlets and government institutions, while muscle was exported.

Wasawasa Fishing Co. (now operating as Fresh Fish Ltd) indicated that exports of clam by the company started around 1983 and stopped when the ban on trade in giant clams was imposed. According to its general manager, over the period of six years the company would have exported in excess of 40 t of giant clam meat, mostly consisting of muscle, at an average price of U.S.$20/kg.

Muscles were packed in medium sized cardboard boxes and frozen for export. The manager indicated that about 25% of the catch was supplied by the villagers with price ranging from $5-9/kg for muscle and $0.5-1 kg for mantle. The mantle was sold locally while muscle was exported mainly to Taiwan.

The General Manager of Feeders Fiji Ltd. indicated that his company had engaged in exports of giant clam since 1982 and stopped exporting when the ban was imposed. However, trade had declined after the military coup in 1987. Their supply was obtained from the fishers in the outer islands, and collected by Feeders vessels. According to its general manager, suppliers were paid between $4-6/clam. However, he did not disclose the total quantity exported over the period.

Pacific Seafoods Ltd based in Lautoka was engaged in the giant clam trade from 1985 until the ban in early 1989. According to the manager, the company exported approximately 10 t of giant clam meat per year mostly to Taiwan and Hong Kong.

Some supplies were obtained by the company from Tonga. Likewise, Fiji Co-operative Association was engaged in exports of giant clams from 1986–1988 with supplies coming from co-operative groups around Fiji.

The major markets for all the exporters were Taiwan and Hong Kong followed by Australia, New Zealand and Japan. All exporters indicated a high demand for the muscle.

Two exporters in particular expressed concern about the size of clams anticipated under mariculture production. They indicated a preference for clam muscle to be around 200–250 g in weight in order to fetch the optimal price. This indicates their preference for trade in large-sized clams.

Mixed feelings were expressed about the impact of the ban on exports. Commercially the bans did not have a major impact on exporters because most of them were also engaged in exports of tuna and deepsea snapper. Although the giant clam muscle was a high value and low volume commodity, none of the exporters were forced to shut down as a result of the ban.

All the exporters interviewed still showed an interest in engaging in exports of giant clams if sufficient supplies became available. In addition, South Pacific Seafoods indicated its interest in farming giant clam as well. All exporters indicated that they would target their previous markets again if they were to engage in trade.

Interviews with five current exporters of bêche-de-mer, (Tacko Fiji Ltd, Fishy Affairs Ltd, Yon Tong Co. Ltd, CaCo Fisheries Fiji Ltd, and Pacific Seafood Co. Ltd) indicated that they also have an interest in exporting giant clams as there is a definite market for clams in Hong Kong, Taiwan, and Singapore. All indicated interest because giant clam muscles are high-value products compared to bêche–de-mer.

The main concern of some exporters, however, was about the size and the possible price levels of muscle for export. It was felt that the growing period of giant clams might be short under aquaculture (1 kg of shell meat would take about five years to grow according to exporters), and the muscles of these giant clams would be much smaller than wild stock previously harvested and might be lower priced. The question of possible competition with the scallop market was also raised by some exporters. Therefore in analysing the economic viability of giant clam aquaculture, one would also need to understand the behaviour of the scallop market as well, and to determine the extent of impact, if any, it might have on the clam market.

Discussion

From the analysis of Fijian consumption patterns, it is obvious that giant clam meat is not now a normal part of the staple marine food diet of the majority of urban dwellers in Fiji, because it is not readily available. For urban Fijians it has become a delicacy consumed whenever it is available, which is somewhat irregularly. In the coastal countryside, it is still consumed as a part of the subsistence diet (Vuki et al. 1991). Some inland people interviewed indicated that they had no special preference for clams, because they have not been accustomed to eating clams.

According to the Fiji Fisheries Division stock assessment survey, there has been a definite decline in the giant clam population of Fiji, thus eventually leading to a reduction in supply for human consumption. Some of the younger people interviewed indicated that they could not distinguish the various species except *T. maxima* (katavatu), which is generally smaller in size and found among the rocks.

The reduction in supply has increased the prices of giant clams from \$0.5-1/shell (of meat) to \$5-8 within a five-year period. Some people also said that with prices of clam being high, they now prefer to buy fish which has a similar price and which can provide a meal, whereas a piece of clam meat may not be sufficient for a meal.

In comparison to other seafood such as crabs, prawns, lobsters and fresh water shellfish, trading in giant clam was not a major commodity domestically. Partly due to the difficulty of transporting bulky shells, it often did not appear at the market place. It was seen basically as a commodity consumed at the subsistence level. However, with an increase in urban migration of island people, the demand for giant clams together with other sea foods like sea urchins, spider shells, chiton, etc. has risen and so have supplies to urban areas. While Fijian stock assessment surveys indicate a decline in giant clam resources, supply to the domestic market (refer to Table 9.2) does not actually reflect the decline. Instead, it shows a somewhat steady supply with only some minor fluctuations. This can be by increased effort in exploitation as a result of the increase in the market value of the clams.

Discussions also indicated that although some people favoured giant clams they did not buy them because they were too expensive. Sometimes relatives brought giant clams from their villages and one family made a point of eating clams when visiting their island village.

For Fijians, the preferred forms of preparation of clam meat has been 'kokoda', clam meat marinated in lemon juice and coconut cream, or just eaten raw with lemon juice. Both of these forms of preparation require the meat to be fresh and of good quality. Previously clam meat, mostly consisting of mantle, was available at the retail outlets. It was frozen and generally had been poorly handled resulting in a low quality product and higher spoilage. Exporters were mostly interested in the muscle which had a high value compared to the mantle, which was around \$0.5-1/kg only.

With regard to the Indian consumers, 95% of the people interviewed did not eat giant clam, simply because they had never tried it, or because they do not know much about it or the look of it does not appeal to them. Some being vegetarian simply would not eat clams at all. However, for non-vegetarian Indians, there is no 'taboo' or religious prohibition. Most people are simply not aware because they do not have a history of giant clam consumption. Those who had tried had giant clam meat had a very favourable response. With awareness and good post-harvest handling and packaging, this product can attract more Indian consumers than at present.

The giant clam may present a similar case to that of tilapia. Originally when tilapia was introduced to Fiji it was not considered to be a high-value product. Demand was limited because of lack of knowledge about the commodity. However, now that the culture of tilapia is established, tilapia has become an accepted fish which fetches a price almost equal to that of reef fish species.

Supply of giant clam meat by retail outlets such as hotels, supermarkets and restaurants relied much on the export trade. Increased export of clam muscle meant increased sale of mantle to some of these outlets. Therefore if trade in giant clam resumes, these outlets may provide adequate demand for clam meat even when the quality is poor. As the economy expands and with an increasing number of Asian expatriates and tourists in Fiji, demand for clam meat is likely to expand sufficiently for clam meat to appear on the regular menu of some Fijian restaurants, particularly those specialising in seafoods.

Analysis of the export market resulted in interesting responses. The majority of the exporters enjoyed open free-trade in giant clams during the early years of trade. However, they are reluctant to disclose the nature of their past experience. Most had collected large giant clams e.g. *T. gigas,* which had large muscles weighing between 200–300 g. Records on prices paid to the islanders is also sparse. It is only after the early 1980s when giant clam trade was regulated by Government that information became more readily available on the export trade. In the 1980s, Fiji was one of the few countries exporting giant clams. Therefore Fijian exports fetched the highest prices possible.

The lack of data from individual exporters also limits study of the economics of a possible cultured clam industry. However, some inferences can be drawn from the above mentioned survey. Firstly, one cannot expect the nature of the giant clam trade to be of a similar pattern for mariculture production to that based on wild stocks of giant clams. Supplies of cultured clams are likely to be more constrained by economic factors than those harvesting wild clams. Pricing structures would therefore be different compared with natural production based on open-access.

The level of commercialisation and success of the project to farm giant clams will directly depend upon the government's objectives and intervention. Lessons should be learnt from the past experience of other fisheries and aquaculture development projects based on production at the household level in the islands.

The social attitude and lifestyle, which is basically semi-subsistence in nature, of the target group or community must be taken into account. For example, the Rural Fisheries Development Project has had a limited success because villagers lack motivation to undertake commercial operations. Fishing has been basically a part-time activity among native Fijians, carried out when there is need for food and cash, i.e. as judged by their perceived level of needed income. Thus the demand for cash by native Fijians is limited and fishers are not profit-orientated. Likewise, in the seaweed industry, although the major problem here related to export markets, a semi-processing plant could not be established to maintain the industry because limited local supply fell short of that needed to set up a semi-processing plant economically. The limited availability of supply was mainly a result of local small farmers of seaweed regulating their own production and supply in accordance with their demand for cash. The economic activities of Fijians tend to be part-time in nature and are usually not motivated by profit maximisation.

In establishing a giant clam mariculture industry, one needs to consider these social and cultural factors. A village-based giant clam industry may also exhibit a similar pattern.

An alternative to small-scale household operations is the establishment of a limited number of large-scale enterprises under joint-venture operations with local communities, the number depending on market demand. Again the social and economic impact on the communities and the nature of joint ventures would need to be scrutinised carefully before seeking such an option.

It would be interesting to study the scallop market and its impact on the clam export market as a substitute commodity. Furthermore, for the domestic market a comparative study with other fisheries products such as crabs and lobsters, i.e. commodities that are either threatened or not readily available to majority of the consumers, needs to carried out to see what impact, if any, they would have on the demand pattern for giant clam from mariculture production in Fiji. An analysis of other bivalves would also give an indication of the substitutability. Trends in supply and demand and the status of these particular resources would assist in forecasting the demand for giant clam from mariculture production.

Concluding observations

From a preliminary investigation of the Suva market, the largest urban market in Fiji, it is evident that an unsatisfied demand does exists for giant clams. Therefore their production, using mariculture, could definitely help to meet a demand in urban and export markets. It is difficult to determine exactly what the level of demand would be initially but it is evident from the survey that demand would increase if the giant clam product was promoted carefully.

Current consumption patterns indicate that the majority of the people do not have ready access to clam meat because of the decline in natural stocks of giant clams over the years. However, wherever clam is available, there is increased commercial exploitation of stocks because of its higher market value compared to some years back. For example the local Fijian price of 1 kg clam meat has more than doubled within the last five years.

Currently, the commercial supply of clams is largely restricted to the municipal markets, where women and men sell clam meat together with other products. Market days for clams are usually limited to Saturdays, when most people visit the market. This further confirms the lack of availability of clam meat to consumers at large, and those who generally buy their food items from the supermarkets, butcher shops or from other retail outlets.

Results from the survey indicate the lack of adequate knowledge about the commodity. Unless urban people are made aware about the clam, its taste, nutritive value, and so on, it may become a strange commodity to the majority of the people, including those whose ancestors once survived on it as part of their staple diet. Some form of consumer awareness program should be mounted to make the general public more aware of the commodity before it enters the market.

Post-harvest technology also needs to be improved not only for the export market but also for the domestic market, as most people prefer to eat raw clam meat rather than cooked meat. As for exports of clam meat from Fiji, exporters of fish and other marine products are interested in resuming exports. Interest still lies in export of muscle, which is a low volume and high-value commodity. The developed transportation infrastructure for fresh fish exports also provides an adequate transportation system for the export of clam meat, whether fresh, chilled, or frozen.

Several other factors need to be taken into account when considering the economic viability of the mariculture projects in the outer islands. Firstly, the mode of production at the community or household level where production may be on a semi-subsistence basis: Will such a production system provide a steady reliable supply to fulfil the demand at the market place? The impact of the ownership of the farms such as whether it will be self-regulated production or a joint venture, and the degree of government intervention, need to be assessed. This could also assist in determining more realistic production costs and price levels, and further help assessment of the marketability of the product.

On the other hand, if the production is commercially oriented (say based on large-scale commercial enterprises) and aimed at export markets, it is likely that it will be in competition with other exporting countries and with other fisheries products which are close substitutes, like possibly scallop and mussel. Thus the relationship with other exporting countries, the substitutability of clams with other products and possible bottlenecks to the industry will need to be assessed.

Use of parts of the clam other than muscle, such as the shells and mantle needs to be further explored. This is particularly important for production of larger shells as they are quite bulky. Greater use of clam shells could greatly facilitate the economic viability of the giant clam mariculture project in Fiji. Export markets need to be explored on use for Fijian clam shells because currently shells from natural production are only in very limited demand in Fiji. As in many Asian-Pacific countries, shells could be used as serving dishes, as ash trays, for decoration and for various ornamental purposes.[2]

[2] Further information on the market for giant clams in Fiji, for their export from Fiji and for prospects for mariculture can be found in Tacconi and Tisdell (1992, a, b and c) [Editor].

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Part III

The Market for Giant Clams as Aquarium Specimens

10 The United States Market for Giant Clams as Aquarium Specimens

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Abstract

The purpose of this study was to evaluate the demand for giant clams as aquarium specimens, and test marketing was conducted in the U.S. mainland. The acceptance of giant clams as aquarium species was measured by an index of average rating on a scale of 1 (poor) to 5 (excellent). The acceptance rate of giant clams as aquarium specimens was 3.8 by aquarium distributors and 4.2 by aquarium owners. The national market potential was estimated to be roughly 33400 clams per year at a retail price of \$10 for a 5–10 cm clam. (All dollar magnitudes in this chapter are in U.S. dollars.)

Introduction

The keeping of ornamental fish is a worldwide hobby. Conservative estimates suggest that at least 150 million ornamental fish are now sold on a worldwide basis each year. The world aquarium trade is a multi-billion dollar industry. Aquariums are found in about 8% of the estimated 86 million homes in the U.S. (Andrews 1992).

There is a potential aquarium market for giant clams due to the increasing demand for ornamental fish, especially marine reef fish, and the exotic nature of giant clams and their colourful mantles. Due to the lack of marketing data and the lack of familiarity with giant clam as aquarium specimens, test marketing was deemed to be the most appropriate means of evaluating its market potential.

To test the U.S. aquarium market, 350 1.5-year-old *Tridacna derasa* were purchased from the MMDC and shipped to 17 selected marine aquarium fish distributors/shops on the West Coast during the summer of 1990. The selected aquarium fish distributors/shops were provided with live clams free of charge. In return, they were asked to return the survey forms (see appendixes to this chapter) and also to distribute and collect the survey forms from their customers who purchased giant clams as aquarium specimens. Since very little information is available regarding care and handling of giant clams as aquarium animals, some of the essential information on temperatures, salinity, dissolved oxygen, light, and water flows were provided to the distributors.

Results from the survey of distributors/shops

The selected aquarium fish distributors/shops were asked to rank giant clams as aquarium specimens according to a number of attributes, such as colourful mantle, exotic nature, attractiveness of shell, nitrate removal, no feeding, and diversification, on a scale of 1 (poor) to 5 (excellent). An average rating was derived for each attribute. The respondents rated exotic nature of giant clams the highest followed closely by no feeding and colourful mantle. The possibility of giant clam being used as nitrate removers in the aquarium received the lowest rating (Table 10.1). The average rating of giant clams as aquarium specimens for all attributes was 3.83.

Table 10.1 Ratings of giant clam by aquarium distributors in U.S.

		Rating frequency					
Attribute	N[a]	Excellent	Very good	Good	Fair	Poor	Average rating
Colourful mantle	17	3	5	4	–	–	3.92
Exotic	12	4	5	3	–	–	4.08
Beautiful shell	10	2	5	2	1	–	3.80
Nitrate removal	6	2	–	3	1	–	3.50
No feeding	8	3	2	3			4.00
Diversification	3	1	–	2	–	–	3.67
							3.83

[a]N = Number of respondents.

The selected aquarium fish distributors were also asked to express their preference for giant clams by sizes and prices. The most frequently preferred size was 10–15 cm followed closely by 5–10 cm. Clam sizes smaller than 5 cm were not preferred and clam sizes more than 25 cm were preferred only by one distributor. Suggested reasonable wholesale price ranged from $8 for a 5–10 cm clam to $50 for a clam of more than 25 cm (Table 10.2).

The difficulties indicated by distributors in having giant clams in aquariums were the lack of literature followed by the extra lighting needed (Figure 10.1).

The selected aquarium fish distributors were asked to rank the giant clam with possible substitutes as aquarium species. Giant clam was ranked highly but behind anemones and corals. Oyster and scallops were rated poorly as aquarium specimens (Table 10.3). Some distributors indicated that giant clams, anemones and corals may be complements rather than substitutes. If all of them are available, people may buy them all to increase the variety in their aquariums.

Table 10.2 Preferred size and price by aquarium distributors

Size	N	Reasonable wholesale price range	Average reasonable wholesale price
2.5–5 cm	0	–	–
5–10 cm	6	$5–10/clam	$8/clam
10–15 cm	7	$5–15/clam	$12/clam
15–20 cm	4	$10–20/clam	$16/clam
20–25 cm	5	$12–30/clam	$22/clam
Larger than 25 cm	1	$50/clam	$50/clam

Table 10.3 Ratings of giant clam and possible substitutes by aquarium distributors

		Rating frequency					
	N	Excellent	Very good	Good	Fair	Poor	Average rating
Giant clam	12	6	3	3	–	–	4.25
Anemone	11	8	3	–	–	–	4.73
Coral	12	7	3	1	1	–	4.33
Oyster	10	1	3	5	1	–	3.40
Scallop	1	–	–	1	–	–	3.00

The selected aquarium fish distributors were asked how many clams they could sell on a monthly basis. Nine of them responded to the question with a wide range of answers (from 4-75 clams/month). The majority of them indicated they could sell 4-10 clams/month (Figure 10.2).

Results from survey of customers

The survey forms of giant clam buyers were similar to those of distributors. Twenty-nine buyers returned the survey forms. The respondents rated exotic nature of giant clam as the leading attribute (Table 10.4). The average rating of giant clam for all attributes as aquarium specimens was 4.00.

The most frequently preferred giant clam size reported by responding customers was 10-15 cm followed by 15-20 cm (Table 10.5).

The difficulties indicated by customers in having giant clams in aquariums were the lack of literature on giant clams and the extra lighting needed (Figure 10.3).

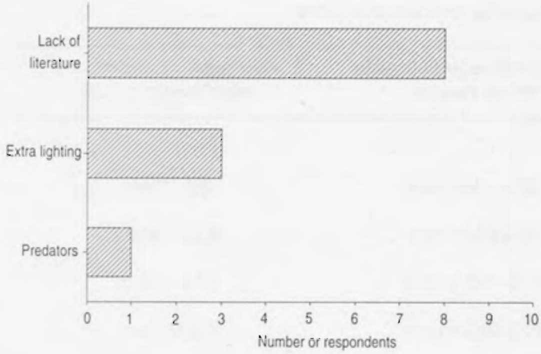

Figure 10.1 Difficulties involved in having giant clam in aquariums for distributors.

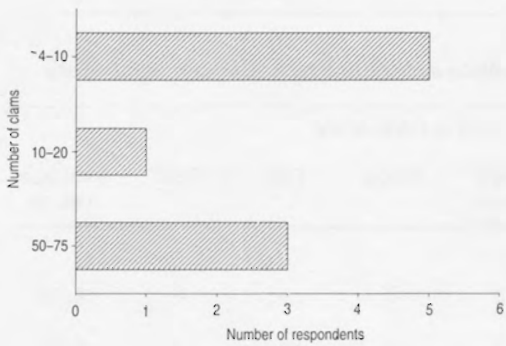

Figure 10.2 Responses to how many clams can be sold monthly.

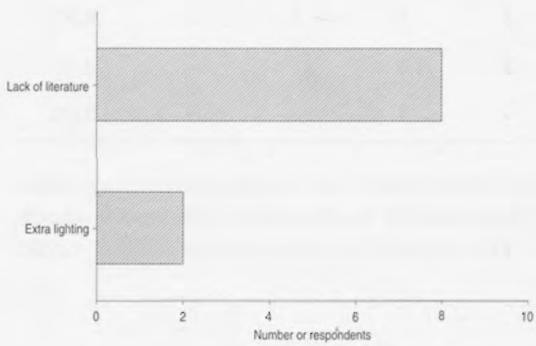

Figure 10.3 Difficulties involved in having giant clam in aquarium for buyers.

The responding customers rated giant clam as good as coral followed closely by anemone as aquarium specimens (Table 10.6).

Summary and conclusion

Test marketing of giant clams (*T. derasa*) as aquarium specimens was conducted in the western U.S. The acceptance rate index was 3.8 by aquarium distributors and 4.2 by aquarium owners. Among different attributes (colourful mantle, exotic nature, beautiful shell, nitrate removal, no feeding and diversification), the exotic nature of giant clams received the highest rating followed by no feeding and

Table 10.4 Ratings of giant clam by aquarium fish buyers

Attribute	N	Rating frequency					
		Excellent	Very good	Good	Fair	Poor	Average rating
Colourful mantle	29	7	14	8	–	–	3.97
Exotic	28	12	11	5	–	–	4.25
Beautiful shell	27	8	6	13	–	–	3.93
Nitrate removal	18	6	2	8	2	–	3.83
No feeding	19	5	9	5	–	–	4.00
							4.00

Table 10.5 Preferred size and retail price by buyers

Preferred size	N	Range of price	Average reasonable retail price
2.5–5 cm	0	–	–
5–10 cm	10	$5–40	$21
10–15 cm	15	$8–50	$27
15–20 cm	8	$30–50	$41
20–25 cm	3	$60–80	$73

Table 10.6 Rating of giant clam and its possible substitutes by buyers

	N	Rating frequency					
		Excellent	Very good	Good	Fair	Poor	Average rating
Giant clam	24	11	6	7	–	–	4.17
Anemone	24	10	8	4	2	–	4.08
Coral	23	7	13	3	–	–	4.17
Oyster	20	7	4	4	5	–	3.65
Scallop	1	–	–	–	1	–	2.00

colourful mantle. In comparing giant clams with possible competing species, giant clams were rated high (4.3), but slightly behind anemone (4.7) and coral (4.3).

It is difficult to estimate the market potential for giant clams as aquarium specimens in the United States based on the limited information available. Only a few aquarium distributors provided a rough estimate of the national market potential for giant clams, ranging from 5000–50 000 clams/year at a retail price of about $10 for a 5–10 cm clam. Another way to approximate the market potential for giant clams is using national data together with some assumptions. Approximately 8% of the estimated 86 million homes in the U.S. keep ornamental fish (Andrews 1992). Assuming 5% of them are marine aquaria, which is about 334 000 marine aquaria, and again assuming 10% of the marine aquaria owners will purchase one clam, this will result in 33 400 clams. Some marine aquaria owners may keep more than one giant clam, and some may not buy giant clams every year. These two factors may balance out. But with the increase in the number of mini-reef aquariums and with an adequate promotional effort, the demand for giant clams as aquarium specimens is likely to increase in the future.

Acknowledgments

Our sincere thanks to participating aquarium distributors/shops and their customers who contributed to the data collection for this study. Test marketing in the U.S. mainland was assisted by Charmaine Price, research assistant on this project. Dr Kevan Main, Director of the Center for Tropical and Subtropical Aquaculture, provided invaluable support throughout the project.

Financial support for this project was provided by a grant from the United States Department of Agriculture through the Center for Tropical and Subtropical Aquaculture.

References

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Appendix 1

Questionnaire to sellers of clams as aquarium specimens

1. Name of distributor

   Address

   Telephone

2. In your opinion, what are the attributes of the giant clam as an aquarium specimen and how do you rank the importance of the attributes?

Attributes	Ranking					Comments
	Excellent	Very good	Good	Not very good	Poor	
Colourful						
Exotic						
Shell						
Nitrate removal						
No feeding						
Others (specify)						

3. What would be your preferred size of clams and what wholesale price would you regard as reasonable?

Preferred size	Reasonable wholesale price ($/clam)
1–2 inches	
2–4 inches	
4–6 inches	
6–8 inches	
8–10 inches	

4. Do you anticipate any difficulties in having giant clams in the aquarium?

   Extra lighting requirement

   Lack of literature

   Others (specify)

5. In your opinion, what are the close substitutable species for the giant clam as an aquarium specimen?

   Anenome

   Oyster

   Coral

   Other (specify)

6.	How would you rank the giant clam and its substitutable species?						
		Ranking					Comments
		Excellent	Very good	Good	Not very good	Poor	
	Giant clam						
	Anemone						
	Coral						
	Oyster						
	Others (specify)						
7.	How many giant clams can you sell on a monthly basis?						

Thank you for your time and co-operation.

Appendix 2

Questionnaire to buyers of clams as aquarium specimens

1.	What kind of marine aquarium do you have? Traditional Mini reef Size of aquarium (gallons)						
2.	In your opinion, what are the attributes of the giant clam as an aquarium specimen and how do you rank the importance of the attributes?						
	Attributes	Ranking					Comments
		Excellent	Very good	Good	Not very good	Poor	
	Colourful						
	Exotic						
	Shell						
	Nitrate removal						
	No feeding						
3.	What would be your preferred size of clams and what price would you regard as reasonable?						
	Preferred size	Reasonable wholesale price ($/clam)					
	1–2 inches						
	2–4 inches						
	4–6 inches						
	6–8 inches						
	8–10 inches						
4.	Do you anticipate any difficulties in having giant clams in the aquarium? Extra lighting requirement Lack of literature Others (specify)						
5.	In your opinion, what are the close substitutable species for the giant clam as an aquarium specimen? Anemone Oyster Coral Other (specify)						

6.	How would you rank the giant clam and its substitutable species?						
		Ranking					Comments
		Excellent	Very good	Good	Not very good	Poor	
	Giant clam						
	Anemone						
	Coral						
	Oyster						
	Others (specify)						
7.	Would you purchase the giant clam again if the price is reasonable?						
	Yes/No						
8.	Buyer's background						
	Ethnic group			Sex	Age		
	State of residency						
	Annual family income						
	Less than $20000						
	$20000–$40000						
	$40000–$60000						
	More than $60000						

Thank you for your time and cooperation. Enjoy your clam.

11 The Australian Market for Giant Clams as Aquarium Specimens — an Initial Survey

Clem Tisdell

Abstract

Retailers of supplies of specimens for saltwater aquariums, in Southeast Queensland, were surveyed in August 1989 with a view to obtaining some indication of the likely demand in this region (and more broadly in Australia) for giant clams as aquarium specimens. Information was gathered on the size of the market, the possible demand in Australia for giant clams from clam farms, prices, and attitudes of aquarium retailers to clam farms. Also, economic prospects for supplies from clam farms, as well as other factors such as the desirability or otherwise of allowing imports of live clams for the aquarium trade were researched. It emerged that the Australian market for giant clams is likely to be small. Possibly it could absorb about 5000 clams/year but it seems that these will need to be sold to retailers at a price of A$10 each or less (possibly A$6 each or less) if a market of this size is to be obtained. The market is so small that to supply it would be a sideline for a clam farm and indeed one farm could more than supply the whole market. At a turnout of say 100 000 clams/year by a farm, it would only require 5% of its production to satisfy the whole Australian market for clams as aquarium specimens.

Introduction

The Micronesia Mariculture Demonstration Center (MMDC), Palau, has reported a substantial demand for giant clams as aquarium specimens. It began marketing 1- and 2-year old *Tridacna derasa* as aquarium specimens in 1987–88.

> 'Exports from the MMDC hatchery are routed to Honolulu, then to the U.S. mainland and Europe (England and West Germany). The potential size of this market is not known but the current demand exceeds the MMDC's available supply. Opportunities exist for other hatcheries in the region to begin supplying aquarium markets' (Heslinga et al. 1988).

In August 1989 there were no exports from Australia for this trade by the three clam farms which existed in northern Queensland. The purpose of this survey was to gather some information about the potential Australian market for giant clams as aquarium specimens.[1]

The survey was limited to Southeast Queensland (Sunshine Coast-Brisbane-Gold Coast) because this was effective from a cost point of view given the location of the researchers. It was also possible to make joint use of journeys undertaken for the purpose of interviewing retailers of giant clam shells. This region also has a relatively large population—about 1.6 million. The general location of the survey is indicated in Map 11.1.

There were 10 retailers in the survey and they were initially contacted by telephone using the Yellow Pages (Trade Directory) and all, except one, were directly interviewed at their shops using the questionnaire attached as Appendix 1. In the case of the New South Wales respondent, the interview was conducted by telephone.[2]

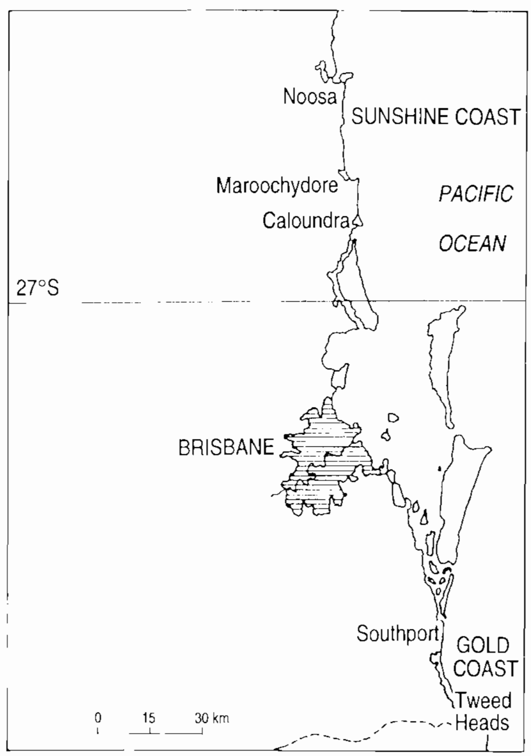
Note that one retailer was from outside the region, namely at North Bondi, Sydney, and is a large supplier of aquarium specimens. Of the respondents, five were located in Brisbane, one in New South Wales, one on the Gold Coast and three at the Sunshine Coast. We contacted all retailers of supplies for saltwater aquariums in the Sunshine Coast-Brisbane-Gold Coast area and completed the interviews in August 1989.

Sales of giant clams for saltwater aquariums

None of the aquarium retailers in the sample were selling live giant clams at the time of the survey. Two main reasons were given, (a) lack of availability of supply, or (b) lack of adequate demand for them. Five of the ten retailers of aquarium supplies had sold clams in the past but only in very small quantities. They appear to have sold not more than three clams each in the past six years or so and supplies appear to have been obtained in response to special requests by customers. It seems that in the past these supplies came from the wild and were collected by divers in the region. It seems likely that they were mostly *Tridacna maxima*. Giant clams being protected species and the import of live giant clams to Australia being illegal, it is understandable that supply is a problem. Up until now supplies have not been available from Australian giant clam farms. However, one retailer, 'Wonderfish Aquarium', said that it had been approached by a giant clam cultivator 'south of Cairns' offering live clams for sale for aquariums. But they were only available in minimum batches of 1000 at a time. This minimum amount is uneconomic for this retailer to purchase since he would expect to sell only a few a week. Ideally he would like to buy in batches of 10–12 at a time.

[1] This survey indicates the situation in Australia prior to giant clams becoming available to the aquarium trade from clam farms.

[2] A list of respondents with their addresses can be found in Tisdell 1989.



Map 11.1 General location of survey

Possible demand in Australia for giant clams from clam farms for the aquarium trade

Retailers were asked (Question 3), 'Do you think that there would be a demand in Australia for supplies of clams from clam farms for the aquarium trade?' and asked to give reasons for their answer and if they said 'Yes', to indicate the extent of the demand. Seven of the ten respondents said that there would be demand in Australia for supplies of clams from clam farms for the aquarium trade.

The owner of the Southern Cross Aquatics shop (North Bondi, NSW), believes that there is a good local demand for clams in the aquarium trade, as he received enquiries constantly, and there is a strong overseas demand for clams in the aquarium trade. He has not been able to sell any clams as it has been illegal to obtain them, either from overseas (because the species is protected under CITES) or domestically. A few months prior to the survey, he was contacted by a clam-farm operator from 'around Townsville' but he has not been supplied with any specimens to date. Thus he is very interested in the development of clam farms. Two of the retailers interviewed (Scott's Aquarium and Clayfield Aquarium) stated that most of the demand for clams in the aquarium trade would come from people keeping special live coral tanks. However, as these are not great in number, current sales would be limited. Nevertheless, it appears that coral tanks are becoming more popular and some individuals with normal saltwater tanks would also be interested in stocking these with live giant clams.

It is worthwhile considering individual answers to Question 3. Of those saying 'Yes', the following responses are of interest:

1. Argonaut Aquarium: '100 saltwater aquarium shops in Australia, 5 in Brisbane and 10 in Southeast Queensland'.

2. Wonderfish Aquarium: 'We could possibly sell 100 giant clams/year'.

3. Scott's Aquarium: 'Demand would only be from individuals having special live coral tanks. These need special lighting and few people have these tanks'.

4. Clayfield Aquarium: 'Yes, but limited sales because the main purchasers would be those stocking live corals and crustaceans in their aquariums. This is not a large group'.

5. Westside Pets: 'Yes, demand for a very small number. Not many invertebrates are stocked in aquariums. Biggest problem is transport because clams are heavy'.

6. Something Fishy: 'Yes, if they would stay alive. It is difficult to keep clams and other shellfish alive'.

7. Southern Cross Aquatics: 'Good local demand. Strong overseas demand. Constantly get enquiries'.

Of those saying 'No', two did not give any reason but Sunshine Aquariums and Pets said, 'Not for this shop but in Brisbane probably hundreds could be sold'.

Question 7 was as follows: ‘Do you have or know of any figures on the number of saltwater aquariums in Australia? How many are there? Are they common? Are they increasing in number?’ This was asked since it was believed that the number of saltwater aquariums would place a limit on the demand for giant clams as aquarium specimens.

Estimates varied considerably by those providing answers. Westside Pets suggested a maximum of 100000 but pointed out that individuals involved in saltwater aquariums usually have more than one aquarium. Wonderfish Aquarium suggested possibly 50000. Another said there were 5000–10000 in Brisbane and a Gold Coast supplier suggested 2000 saltwater aquariums in the Gold Coast area. If there are 100 retailers of saltwater aquarium supplies in Australia this suggests an average of 500–1000 saltwater aquariums/outlet Australia-wide. Many suppliers pointed out that saltwater aquariums are more common in the southern Australian states. The number of such aquariums is increasing as technology improves.

From these figures, it seems likely that the demand for giant clams for aquariums in Australia would not exceed 5000 clams/year. That would involve sales on average of one clam for 5–10% of saltwater aquariums/year, or an average of about 100/retailer. Not all retailers will sell giant clams and not all aquariums will be stocked with the species, but in some aquariums more than one giant clam may be stocked. In reality, of course, this will be virtually a new market. Sales may be slow at first, then take off and subsequently be limited to replacement demand and that associated with expansion of the number of saltwater aquariums. The amount of replacement demand will depend on how long the clams live in private aquariums. However, it is clear that the Australian market for giant clams as aquarium species is small (even if the figure of 5000 is doubled) and would absorb only a small percentage of the expected total annual turnout from a commercial giant clam farm.

Prices

Since the market for giant clams was extremely small, little information was available on the prices of aquarium specimens. Wonderfish Aquarium said that burrowing clams, *Tridacna crocea* in the range of 5–13 cm (2"–5") would sell for approximately A$20 retail, with slight price variation with size. A clam farmer quoted A$10–15/clam delivered to Southern Cross Aquatics. Sunshine Aquarium said that it would expect to sell clams of 5–10 cm (2"–4") in size to customers for about A$10–20. Clearly at these retail prices a price of A$10–15/clam delivered to retailers from clam farms would appear to be too high. This tends to be confirmed by Question 12.

Retailers were asked how many giant clams might they sell annually if a ready supply happened to be available at a ‘reasonable’ price. They were also asked what prices they thought would be reasonable for them to buy at. Answers varied from very few clams (Westside Pets), to 20–100 clams (Sunshine Aquarium) and 100 clams (Argonaut and Wonderfish). Reasonable wholesale prices for giant clams ranged between A$3-6 (Sunshine Aquarium), A$4-6 (Westside Pets), A$5-10 (Argonaut Aquarium), A$10 (Wonderfish Aquarium)/clam. From this one might infer that a price/clam of A$5-10 might be reasonable but A$10-15 'too high'.

Attitudes to clam farms and advice to clam farms

All of the retailers who answered Question 11 (a total of eight respondents) were in favour of the farming of giant clams in Australia. The owner of Westside Pets welcomed the farming of any natural resource, as long as the environment is protected. As well, he welcomed it because it would keep the species alive and it would be of benefit to Australia, if export markets were established. On the other hand, the manager of Clayfield Aquarium believes that clam farming would only have a small impact on sales, as there is little demand for giant clams. The owner of Argonaut Aquarium believed there would be only limited sales as the giant clam is a long-living animal.

Retailers were asked (Question 5), 'If clam farmers are breeding clams for the aquarium trade, are there desirable characteristics that they should try to breed for? Is there some preferred size or species for the trade? Is there any species which you would prefer?' Eight out of the ten respondents answered this question. Most indicated that clam farmers should try to breed for colourful mantles (especially blue–green) and indicated preferred sizes to be in the range 2 inches to 8 inches. No retailer suggested a preferred species.

However, it seems that species of smaller size and brightly coloured mantles would be preferred, presumably more so if they happened to be more robust. It is possible therefore that *Tridacna crocea* would be ideal for the aquarium trade as it reaches a maximum length of only 15 cm and its mantle is usually brightly coloured and includes combinations of green, blue, purple, brown and orange. However, Rosewater (1965), mentions that 'living specimens of one of the smaller species, the *Tridacna maxima* are occasionally on sale in the Washington D.C. area and probably in other cities. These specimens were imported from Singapore several times a year'. The mantle of this species is often brightly coloured and variable in colour and pattern. It is also robust and grows to a larger size than *T. crocea*. One of the retailers in our sample reported sales of *T. crocea* in the past and it seems that others have had sales of *T. maxima* collected in the Moreton Bay area. It is also reasonable to infer that the retailer reporting a sale of giant clams on substrata was selling *T. crocea*. It is clear that large clams are not in demand for most aquariums, and most retailers are looking for clams of less than 15 cm in size.

Question 13 to retailers asked, 'What advice would you want to give to someone planning to breed and grow giant clams to supply the aquarium trade?' The following interesting suggestions were received:

1. 'Find a wholesaler to distribute. Otherwise it will not be economically viable because retailers want to buy in small quantities.'

2. 'Prepare an information sheet which can be handed to the purchaser by the retailer.'

3. 'Grow baby turtles instead. They sell for A$20–30 each. Also explore the export market.'

4. 'Pricing is important if you want to sell clams.'

5. 'Look for overseas markets.'

6.'Growers of clams will go broke if they concentrate on the Australian aquarium market because locals are a bit sceptical about clams. Concentrate on the Asian aquaculture market and have the Australian market as a sideline.'

Transportability of clams, storage and import of giant clams from overseas

Respondents to Question 9 indicated that they have not encountered any difficulty in the transport and storage of clams. They were said to be easy to keep but overcrowding could facilitate the outbreak of disease. 'Wonderfish' indicated that summer heat can cause excessive mortalities.

Out of the seven retailers who answered the question about whether it should be legal to import giant clams from overseas (Question 19), two respondents believed they should not be allowed to be imported into Australia for environmental reasons and because there was no need for such importation. Among the five people replying 'Yes', one person believed that it should be legal to import farmed clams provided Australian bred animals are allowed for sale in Australia. The other four shop-owners believed that imports of giant clams should be legal if they are farmed and as long as there are no problems with disease. They would rather see overseas clam stocks exploited than Australia's. One commented, 'If you can import other marine fish, why not clams as long as they go through quarantine'.

Discussion

One of the problems in carrying out a survey of this nature is that giant clams are protected species in Australia and any supplies which might have been obtained in the past were presumably obtained through private divers and collectors. Retailers might therefore have been reluctant to discuss their trade, if any, in these species. Nevertheless, it is quite clear that the current trade in 1989 was extremely small. None of the aquarium retailers interviewed had received shipments as yet from commercial farmers of giant clams although two retailers had been approached about this possibility. One of the main reasons why those approached appeared not to have taken up the offer of supplies from clam farms was the requirement of purchase of a minimum batch of 1000 clams which is too large a quantity for most retailers.

It seems that the Australian market for giant clams for aquariums is likely to be limited to about 5000 clams/year and may fall below this level once the market is 'saturated'. On the other hand, the number of saltwater aquariums is increasing so this may help to maintain demand. Nevertheless, the market would not be adequate to support a clam farm, assuming that a commercial farm turns out at least 50000 to 100000 clams/year. Not even a small specialist could survive in the market, for the total annual revenue generated, assuming an average price to the grower of A$6/clam, would only be A$30000. So the Australian aquarium market would seem at most only to provide scope as a sideline to other activities or to the supply of clams for other end-uses. Whether or not Australia could compete in the export market (which undoubtedly is a larger market) remains to be explored. The potential world market for aquarium clams probably does not exceed 150000 clams/year (30 times the possible Australian market) and so the whole world demand could be supplied by say two clam farms.

Acknowledgments

I wish to thank René Wittenberg for his research assistance. Financial support for this research was provided by a grant from the United States Department of Agriculture through the Center for Tropical and Subtropical Aquaculture (USDA grant number 88-38500-3884) and through ACIAR Project No. 8823.

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Appendix 1

Questionnaire to suppliers of specimens for saltwater aquariums

Confidential August 1989.

Survey of retail outlets of supplies for saltwater aquariums	
1.	Name, address and telephone number of outlet
2.	Do you sell giant clams for saltwater aquariums? Yes/No If Yes, from where do you get your supplies? Also give some details about the size and type of clam shells, numbers sold and total value of sales. If No, why don't you sell giant clams? Did you sell giant clams in the past and discontinue sales? Yes/No (Please give reasons if you discontinued)
3.	As you may know, it is now possible to farm giant clams. Do you think there would be a demand in Australia for supplies of clams from clam farms for the aquarium trade? Yes/No Please give some reasons for your answer. If Yes, how much demand do you think there would be? The remaining questions need only be answered by retailers who have sold or sell giant clams
4.	How much do giant clams for the saltwater aquarium trade cost the retailer and the customer? Please indicate price variations according to size, quality or type of clam, if possible.
5.	If clam farmers are breeding clams for the aquarium trade, are there desirable characteristics that they should try to breed for? Is there some preferred size or species of giant clam for the trade? Is there any species which you would prefer?
6.	If you are selling or have sold giant clams what are the main difficulties that you have faced in marketing them (that is, in dealing with them)?
7.	Do you have or know of any figures on the number of saltwater aquariums in Australia? How many are there? Are they common? Are they increasing in number?
8.	If you have sold giant clams, what type of customer tends to buy them?
9.	What difficulties, if any, have you encountered with the delivery of giant clams and their storage?
10.	Do you think it should be legal to import giant clams from overseas? Yes/No Please comment
11.	Would you welcome the farming of giant clams in Australia? Yes/No Please comment
12.	If a ready supply of giant clams happened to be available at 'reasonable' prices, how many might you sell annually?
13.	What advice would you want to give to someone planning to breed and grow giant clams to supply the aquarium trade?
14.	Would you like a complimentary copy of the report on this survey? Yes/No

Thank you for your co-operation

12 The Australian Market for Giant Clams as Aquarium Specimens – 1991 Survey

Clem Tisdell

Abstract

This chapter contains the results of research based on the test marketing of giant clams as aquarium specimens in Brisbane, Australia, in the third quarter of 1991. Giant clams were distributed through six cooperating retail aquarium outlets and sold at a reasonable commercial price. This was considered to be A$10–13 for *T. crocea* of 2.5–5 cm (1–2") in size. Clams were supplied free of charge to cooperating retailers. In return they were required to complete survey forms and to try and ensure that purchasers of their clams did likewise, and to take care of the clams in their possession.

The results indicate that giant clams are rated as very good aquarium specimens and in that respect were considered to be about as equally desirable as coral and anemones. The most desired size of clams was considered to be in the range 5–10 cm (2–4") and purchasers on average thought that a price of around A$19 would be reasonable for such clams, even though retailers suggested a slightly lower price.

The margin of mark-up available to retailers in Queensland for sales of giant clam aquarium specimens in the size range 2.5–5 cm seems quite low, particularly given the cost of the permit required from the Queensland Department of Primary Industries. The permit and regulations enforced by the Queensland Department of Primary Industries are a major impediment to the development of the aquarium market for giant clams in Queensland. Apart from the expense involved for the retailer, purchasers are also required to hold permits from this Department. This places a major dampener on sales in Queensland given that permits must be obtained in advance by potential purchasers. Although commercial farming of clams exists in Queensland, farmers find it easier to export their products or sell them interstate rather than to attempt to sell them in Queensland.

This report also provides information about a number of other issues affecting the market for giant clams as aquarium specimens, e.g. availability of information on keeping them in home aquariums, characteristics of purchasers and so on. The results also indicate that the Australian market for giant clams as aquarium specimens is about 5000/year. This is a similar estimate to that made in 1989 on the basis of a different survey (see Chapter 11).

Background

This chapter reports the results of test marketing undertaken in Brisbane, Australia, in the third quarter of 1991 to estimate potential demand for the giant clam as an aquarium specimen and to highlight issues in marketing clams. The survey was conducted by Professor Clem Tisdell of the Economics Department at the University of Queensland with the assistance of Ms Thea Vinnicombe and was intended to complement a similar project being undertaken in the USA by Professor Y.C. Shang and Professor P.S. Leung of the University of Hawaii.

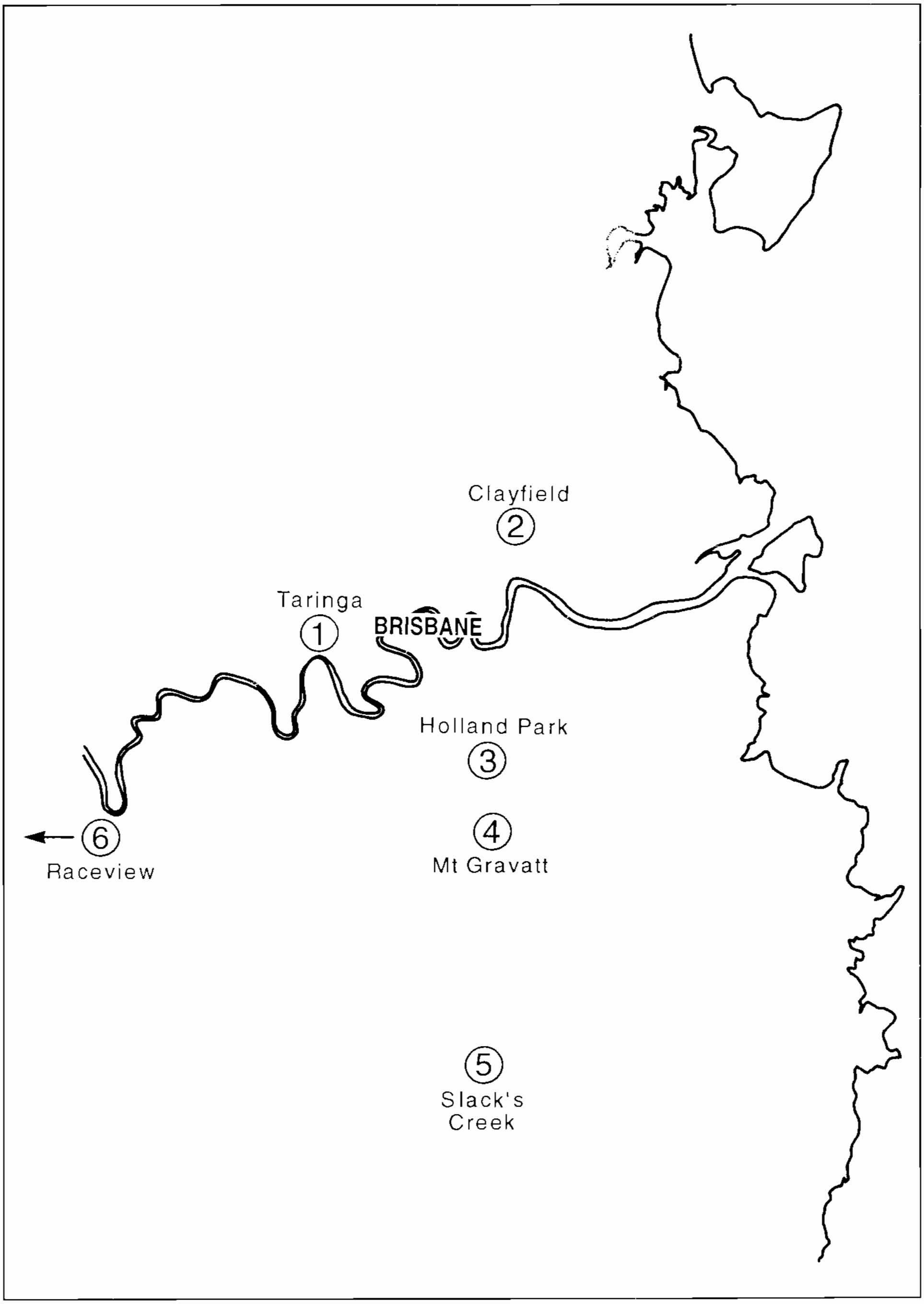
Although limitations of past historical data create problems for estimating demand for all products derived from giant clams, they are perhaps more acute in the case of the market for aquarium specimens because in the past this has involved little trade. The market has been very thin. Consequently a marketing survey involving direct test sales of giant clams was deemed to be the most appropriate means of estimating demand for clams as aquarium specimens and identifying market issues and problems.

The Australian project was intended to take place in the early months of 1991. However, the legal requirements enforced by the Queensland Department of Primary Industries caused considerable delay because of the need to apply for and obtain appropriate permits. The test marketing was planned for the Brisbane area through aquarium outlets. They were asked whether they would be willing to participate and be supplied free of charge with the number of clams requested by them. In return for the supply of these clams, they were asked to collect data, complete survey forms and arrange for customers to complete survey forms. The survey forms were similar to those used in Hawaii by Professor Shang, merely modified for Australian conditions.

Both the principal researcher and the retail outlets were required to have permits and these were paid for from project funds. Outlets could retain any income earned.

The survey was confined to the Brisbane metropolitan area where the researchers were located, largely to minimise problems associated with the transport and distribution of live molluscs. This was also logical given that this was the primary target area of an initial survey conducted by Professor Tisdell and which had established contact with most Brisbane retailers (Tisdell 1989 or see Chapter 11).

Brisbane has a relatively large population (1.13 million in 1989), is a state capital and serves much of the surrounding country region. Map 11.1 indicates the general location of the survey. Of the seven retail outlets in Brisbane known to supply saltwater aquarium specimens, six agreed to participate in the project. Their suburban location is shown in Map 12.1. However, had the exact legal requirements of the Queensland Department of Primary Industries been known from the outset, the survey might have more effectively taken place interstate. The same licensing conditions, fees and regulations do not apply in other Australian states.



Map 12.1 Key to location by suburb of cooperating aquarium retailers. (1) Westfield Pets, Taringa; (2) Clayfield Aquarium, Clayfield; (3) Wonderfish Aquarium, Holland Park; (4) Pet City, Mt Gravatt; (5) Argonaut Aquarium, Slack's Creek; and (6) Oscar's Aquarium and Plants, Raceview.

While it was known that permits could be required in Queensland for the sale and distribution of giant clams, the nature, and in particular, the cost of these permits and procedures were unknown to the project administrator prior to commencement of the project. After a lengthy application period, the Department of Primary Industries determined that regulations currently applying to the sale and distribution of giant clams would apply in this case, despite the non-profit and pure research nature of the project, and its potential benefit to Queensland. Thus, all retail outlets were required to hold a permit at a cost of A$100/outlet (these were paid from project funds) and potential customers were required to apply for and receive 'holding' permits *before* being able to make a purchase. Although customers were not required by the Department of Primary Industries to pay a fee for their permits, the fact that these had to be applied for individually in advance put a 'dampener' on purchases. An earlier survey had estimated *maximum* sales of 100 clams/year/retailer (Tisdell 1989, p.8). But there was a definite possibility of the permit system reducing potential sales of retailers significantly. In addition, customer inconvenience undoubtedly had a detrimental effect on sales. Nevertheless, retailers were prepared to persevere, given that the permits would be paid from the project funds.

Details of project execution

One hundred *Tridacna crocea* clams were delivered by air to Brisbane airport from Cairns on 4 July 1991. The clams were obtained from Reefarm Pty Ltd, a commercial farming venture with a nursery located on Fitzroy Island near Cairns, (and approximately 2000 km from Brisbane). They were packed in small plastic bags filled with saltwater and delivered by Ms Thea Vinnicombe, research assistant for this project, directly to the six participating outlets in Brisbane.[1]

Airfreight of A$126 was an essential part of the cost of the project. The wholesale purchase price for this batch of clams was A$4.50/clam (f.o.b.). The clams were of a small size, between 2.5 and 5 cm. Any increase in size would have involved an increase in price. Retailers had previously stressed excessive size of clams as a disadvantage for aquarium specimens, but it may be that the size delivered erred at the opposite extreme. Delivery from Brisbane airport to retailers was arranged by the project. Note that otherwise delivery would constitute further costs in terms of time and inconvenience for the individual retailer. Retailers were asked to price the clams for sale to customers on a commercial basis. They were allowed to retain any income earned. Their resulting retail prices rangedbetween A$10–13.

Each aquarium owner or manager completed a specific survey form for his or her retail outlet and agreed to provide survey forms to customers and ensure their completion.[2] The purpose of the forms was to gather data about demand and

[1] The names and localities of participating aquariums and numbers of clams requested by each can be found in the original report on which this chapter is based, namely Research Reports and Papers in Economics of Giant Clam Mariculture, No. 26, Department of Economics, University of Queensland, 4072, Australia, Appendix II.

[2] Copies of these questionnaires can be found in Appendix III of Research Reports and Papers in Economics of Giant Clam Mariculture, No. 26, Department of Economics, University of Queensland, 4072, Australia.

provide practical information about marketing giant clams as aquarium specimens. To ensure compatibility with the Hawaiian project, the survey forms used for the Australian project were the same as those used in Hawaii, with only slight modifications.

Results from retailers

Introduction

Retailers were asked to rank giant clams as aquarium specimens according to a number of attributes, these were specified as colourfulness, exotic value and attractiveness of their shell. They were also questioned about the size of clams which they would prefer to sell, the price at which they thought it would be reasonable to sell them, and any difficulties which they anticipated in holding giant clams in their aquariums. In addition they were asked about the substitutability of other aquarium specimens for giant clams, how they rated giant clarns in relation to other selected aquarium specimens and how many clams they expected to sell on a monthly basis. Let us consider the responses received from the six cooperating retailers.

Ranking of attributes of giant clams as aquarium specimens

On a scale ranging from 'poor' to 'excellent', most retailers saw giant clams as varying between 'good' and 'excellent' for colourfulness, exotic value and attractiveness of their shell. Giant clams are also a possible source of nitrate removal in the home aquarium. However, the general feeling of respondents was that insufficient time had elapsed to prove their efficiency in this regard.

The detailed pattern of responses is indicated in Table 12.1. Retailers rated colour of the mantle and the exotic nature of giant clams more highly than the

Table 12.9 Ranking by retailers of attributes of giant clams as aquarium specimens—frequency of responses and average rating

Attribute	Ranking-frequency					Average rating	
	Excellent	Very good	Good	Not very good	Poor	(a)	(b)
Colourful	1	2	2	0	0	3.66	2.66
Exotic	1	2	3	0	0	3.66	2.66
Shell	1	1	3	1	0	3.33	2.33
Nitrate removal [c]	0	0	3	0	0	3.00	2.00

(a)Using a linear scale of 1–5 for categories from 'Poor' to 'Excellent'

(b)As above but using a scale of 0 –4

[c]Three respondents said this was not known accurately.

quality of their shell. On the whole, the ability of giant clams to remove nitrate from water was given the lowest rating but three retailers did not rank this attribute and three suggested that the ability of giant clams to remove nitrate was uncertain or unknown. Although retailers could mention any other attributes of importance, none did.

Preferred size and reasonable retail price

All retailers expressed a preference for giant clams not exceeding 15 cm (6") in size with the size 5–10 cm (2"-4") being the size most frequently preferred. But the size 10–15 cm (4"-6") was also popular. The distribution of preferred clam sizes is shown in Table 12.2 together with the range of retail prices considered to be reasonable.

Table 12.2 Sizes of clams preferred by aquarium retailers and range of retail prices for clams thought to be reasonable by them

Size of clam	Number of retailers expressing a preference for this size[a]	Reasonable retail price/clam ($A)
2.5–5 cm (1–2")	2	10–13
5–10 cm (2–4")	5	15–18
10–15 cm (4–6")	4	18–20
15–20 cm (6–8")	0	20–25
20–25 cm (8 –10")	0	25–30

[a]Some retailers expressed a preference for several sizes of clams. One respondent ranked all five sizes. So in this case only the three most desired sizes were included in the above distribution.

Our initial contact with retail outlets had indicated that they were concerned that clams for the home aquarium should not be excessively large. *T. crocea* was favoured because its maximum expected size is only 15 cm. However, those actually tested in the survey were very small, between 2.5 and 5 cm in length. It appears that these may have been too small, with retailers indicating a preference for larger-sized clams of 5–10 cm or even 10–15 cm in length. Suggested reasonable prices for small clams ranged between A$10 and A$15, while a price range of A$15–20 was considered reasonable for those of larger size.

Difficulties anticipated by retailers in having clams in their aquariums

While retailers believed that it would not be difficult to keep giant clams in their aquariums, all but one said they would need extra lighting and all expressed concern about the lack of available literature on the keeping of giant clams in aquariums. In general retailers expected no difficulties. However, as can be seen from Table 12.5, the giant clams in four out of the six retail outlets experienced fatalities. Two retailers lost almost their complete stock due to a ‘toxic-substance’ in the water, one had losses due to the accidental introduction of a predator (a cone shell) and another had losses due to unspecified causes. Overall mortality of clams in the aquarium outlets was high (30–40%). To some extent these losses were due to lack of previous experience in keeping giant clams. With more experience fewer losses might be expected. One outlet experienced no losses.

Substitutable species for giant clams in aquariums and rating of giant clams in comparison to selected other aquarium species

Retailers were asked whether anemones, corals, oysters or any other species could be regarded as a substitute for giant clams as aquarium specimens. There were five responses to the effect that anemones and corals can be regarded as substitutes for giant clams in aquariums but only one response that oysters could be so considered. No other substitutable species were mentioned. But one retailer responded that no other species could be regarded as a substitute for giant clams in aquariums and so did not list any substitutes. An attempt was made in discussions with retailers to assess the degree of substitutability between giant clams and alternative aquarium specimens. It may be that giant clams and other aquarium specimens are actually complements, rather than substitutes. For instance, people with established coral tanks are more likely to purchase a clam than those without these. Retailers described customers as interested in variety in their aquariums, with the main concern being compatibility between species. Clams for instance are vulnerable to attack from a number of other species due to their immobility. Where such incompatibilities do not exist, customers think in terms of extending the range of their specimens, rather than substituting one for another.

Retailers were also asked to rate giant clams, anemones and corals as aquarium species using a ranking from poor to excellent. The distribution of responses is given in Table 12.3 and the average rating is also indicated. Giant clams, anemones and corals were rated highly but oysters were rated poorly as aquarium specimens.

On average, giant clams were rated slightly below anemones and corals as aquarium specimens. Nevertheless they fall into a similar niche. On the other hand oysters were rated as decidedly inferior to all the other aquarium specimens indicated in Table 12.3.

Expected quantity of sales of giant clams as aquarium specimens

Retail aquarium outlets were asked how many clams they could sell monthly. After possible high initial sales due to novelty value, most retailers felt regular monthly sales would be small, generally ranging from four to six clams. Two retailers distinguished between the number they could sell given the prevailing permit situation in Queensland and the numbers they could sell without permits. One claimed monthly sales of between ten and twenty clams without permits as opposed to four clams with these requirements imposed on customers. The responses of retailers are listed in Table 12.4.

From the responses given in Table 12.4, average annual sales for retail outlets of 50 giant clams seems likely in the Brisbane area, given present Queensland Government impediments to sales imposed by the permit system. Without such restrictions, sales seem as though they would be more than doubled. This would give a similar level of potential sales to that estimated from direct interviews with retailers in 1989 (Tisdell 1989). It is clear that government regulations in Queensland are a substantial impediment to sales of giant clams in this state.

Table 12.3 Rating of clams in relation to selected other aquarium species by retailers —frequency of responses and average rating

Attribute	Ranking-frequency					Average rating	
	Excellent	Very good	Good	Not very good	Poor	(a)	(b)
Giant clam	3	2	1	0	0	4.33	3.33
Anemone	4	1	1	0	0	4.50	3.50
Coral	4	1	1	0	0	4.50	3.50
Oyster	0	0	0	2	4	10.133	0.33

(a)Using a linear scale of 1–5 for categories from 'Poor' to 'Excellent'.
(b)As above but using a scale of 0–4.

Table 12.4 Individual responses of retailers to the question 'How many clams can you sell on a monthly basis?'

Respondent	Responses
1	Not many
2	After initial interest about five
3	Not known. Small numbers
4	Plenty. But permits taking too long to come through to move these
5	4–6
6	With paperwork for permits: 4
	Without paperwork and need for permits: 10–20

Experience of retailers with their batches of clams and with completion of survey forms by customers

Table 12.5 indicates the number of giant clams distributed to individual retailers as part of the project. Although only 85 clams were ordered from Reefarm, 100 were sent and the 'extras' were distributed amongst the retailers who co-operated. Several retailers lost clams due to a variety of causes specified in Table 12.5. The exact number of clams lost due to mortality is not known but it was between 30–40.

Customers were requested to complete survey forms but a number failed to do so, either because of their own reluctance and/or because retailers did not press them in this matter. All told 12 survey forms were received from customers but since several purchased a number of clams this accounted for 37 clams. This meant that between 23 and 33 clams taken by customers were not accounted for by survey forms. Nevertheless, the response rate from customers for clams actually sold exceeded 50%.

Results from customers

Introduction

Customer survey forms were similar to those of retailers in format and to some extent in information required, and elicited similar responses. For instance, customers recorded a preference for larger clams particularly in the 5–10 cm and 10–15 cm ranges and similar levels of pricing were indicated but with some differences highlighted later in this chapter. Lack of literature was regarded as the major foreseeable difficulty in keeping clams, with some buyers also mentioning the possibility of changed lighting requirements. Again the question about the degree of substitutability between the giant clam and other products was poorly understood.

Let us consider in turn, characteristics of purchasers of giant clams as aquarium specimens, their rating of selected attributes of giant clams, and any difficulties anticipated by purchasers in keeping giant clams. In addition, let us consider the comparative ratings given to giant clams by purchasers, the number of giant clams that purchasers would like to have in their aquarium, the sizes of clams preferred by them and their views about reasonable retail prices.

Purchasers of giant clams as aquarium species—selected characteristics

Thirteen customers completed survey forms. Most of these had coral reef tanks (11 out of 13) and most had wet-dry trickle filter systems (10 out of 13). Therefore most sales of giant clams as aquarium specimens are likely to be to owners of coral reef tanks. Sizes of tanks of customers varied widely. The minimum size was 57 L and the maximum was 750 L.

Table 12.5 Experience of retailers with their batches of giant clams and with completion of survey forms by customers

Retail outlet	Number of clams delivered to retailers		Number of customers completing survey forms	Number of clams accounted for by customer responses	Comments
	Ordered	Extras			
1	15	2	0	0	Clam fatalities due to the introduction of a toxic substance in a water change. Customer non-cooperation.
2	10	2	0	0	Clam fatalities soon after delivery—unknown toxic element in the aquarium presumed.
3	15	3	5	12	Clam fatalities due to a predator (cone shell) inadvertently introduced into the aquarium. Multiple sales. Customer non-cooperation (approx. 12 clams accounted for).
4	20	3	7	23	Multiple sales. All clams accounted for.
5	10	2	1	2	Customer/retailer non-cooperation. Multiple sales. Two clams accounted for.
6	15	3	0	0	Customer/retailer non-cooperation—clam fatalities due to unspecified reasons.
Totals	85	15	13	37	

Most purchasers described themselves as ethnically Australians (11). In addition, one stated that he was an English-born Australian and another was European. It seems likely that racially all purchasers were Europeans. Their average age was 32. Six were in their 20s, four in their 30s and two in their 40s and the age of one was unknown. Nearly all sales were to persons under 40 years of age, and to males (11 persons). One sale only was made to a female and one sale was made to a couple.

Two purchasers of clams did not reveal the level of their family income but of those indicating their level of family income most had an income of A$40000–A$60000. The number of respondents in each income category was <A$20000 (1); A$20000–A$40000 (3); A$40000–A$60000 (6); >A$60000 (1). Most purchasers had an income well above the Australian median level of income.

Anticipated difficulties in keeping giant clams

While no great difficulties were anticipated by purchasers in keeping clams, most (7/13) said that the absence of literature on the care of clams was a disadvantage. One said that they would need extra lighting in their aquarium. Another found that her long-nosed butterfly fish ate her clams.

Ranking of attributes of giant clams, comparison with other aquarium species, and substitute species

Customers were asked to give their ratings of various attributes of giant clams as aquarium species. The colourful mantle and exotic nature of the giant clam was rated highly, with its shell quality and ability to remove nitrate ranked much lower. But many customers mentioned that they were unsure of the ability of giant clams to remove nitrate from the water. These ratings are similar to those of retailers and are detailed in Table 12.6.

Table 12.6 Ranking of attributes of giant clams by purchasers—frequency of responses and average rating

Attribute[a]	Ranking-frequency					Average rating	
	Excellent	Very good	Good	Not very good	Poor	(b)	(c)
Colourful (13)	4	5	4	0	0	4	3
Exotic (12)	5	2	5	0	0	4	3
Shell(13)	1	1	10	1	0	3.15	2.15
Nitrate(8)[d]	2	1	3	1	1	3.25	2.25

(a)Number of respondents in brackets.
(b)Ranked on a scale of 1 to 5 corresponding to 'Poor' to 'Excellent'.
(c)Ranked on a scale of 0 to 4 corresponding to 'Poor' to 'Excellent'.
[d]A number of respondents stated that they lacked knowledge about the ability of giant clams to remove nitrate.

Comparisons of giant clams, anemones, corals and oysters as aquarium species by customers resulted in giant clams being ranked highest followed by corals and anemones while oysters were ranked much lower and considered to be poor or not very good aquarium specimens. Details of the responses are given in Table 12.7.

Four respondents said that the giant clam was not a substitute for any other aquarium specimen. But five respondents said that it was a substitute for coral, four that it could be regarded as a substitute for oyster and three that it is a substitute for anemone. One respondent mentioned that it could be substituted for pipis (*Plebidonax deltoides*) and another said it could be a substitute for fish. It seems however that giant clam is not a close substitute for any other aquarium species. It therefore fills a different niche to other aquarium specimens.

Table 12.7 Customers' ranking of giant clams and other aquarium species—frequency and average rating

Attribute[a]	Ranking-frequency					Average rating	
	Excellent	Very good	Good	Not very good	Poor	(b)	(c)
Giant clam (8)	6	2	0	0	0	4.75	3.75
Anemone (9)	5	3	2	0	1	3.78	2.78
Coral (10)	3	1	3	0	1	3.90	2.90
Oyster (9)		1	3	3	2	2.33	10.133

[a]Number of customers responding indicated in brackets
(b)Ranked on a scale of 1 to 5 corresponding to 'Poor' to 'Excellent'
(c)Ranked on a scale of 0 to 4 corresponding to 'Poor' to 'Excellent'.

Customers' preferred sizes of clams, views about reasonable retail prices and desired number of clams for their aquariums

Most customers expressed a preference for giant clams of 5–10 cm (2–4") in size but clams slightly smaller or slightly larger were also of interest to most customers. Nevertheless, clams larger than those test marketed (which were in the range 2.5–5 cm) would have been preferred by most customers. Table 12.8 sets out sizes preferred by buyers and the range of prices which they thought to be reasonable. Note that the range of prices suggested is wider than that indicated by retailers. At the bottom of the range, these suggested prices are lower and at the top of the range higher than those suggested by retailers.

Because of the variation in prices suggested as reasonable by customers, it may be useful to set out the array of actual prices suggested by them and estimate the arithmetical average. This has been done in Table 12.9.

Table 12.8 Sizes of clams preferred by customers and range of prices suggested as reasonable by them

Preferred size	Number preferring this size	Retail price range suggested as reasonable (A$/clam)
2.5–5 cm (1–2")	4	5–13
5–10 cm (2–4")	8	9–25
10–15 cm (4–6")	5	15–30
15–20 cm (6–8")	3	15–50
20–25 cm (8 –10")	1	30–80

Table 12.9 Array of prices/clam) suggested as reasonable retail prices by customers

	Size of clam (cm)				
Customer	2.5–5	5–10	10–15	15–20	25–30
1		20–25			
2					
3		20	30	40	
4				15+[a]	
5	13	25			
6	5	10	18	25	30
7		20–30			
8	8–10	10–15			
9	13				
10	5–9	9–15	15–20	25	40–60
11		20–25			
12[b]			30	50	80
Simple average	9.4	19.3	23.9	31.0	53.3

[a]Unsure.
[b]Customer 13 did not suggest any prices.

As for the number of clams which purchasers would like for their aquariums, the most frequently mentioned number was three. Presumably a cluster display was intended. The desired number of clams were as follows: one customer—one clam; three customers—two clams; five customers—three clams; one customer—four clams and two customers—six clams. One customer did not specify a number but merely writes that it all depends on the size of the clams. On the average, sales of about 3 clams/potential customer seem achievable.

Further comment on customers' responses

Questions specific to the customer focused on the size of the home aquarium and consumer income. It was interesting to note a significant number of buyers were located in the relatively high income groups, A$40000–A$60000 and over A$60000. Some retailers had previously suggested a concentration of low income earners amongst aquarium enthusiasts due to the relatively low cost nature of the hobby. Once established, an aquarium may be virtually self supporting and the collector is then able to concentrate on adding to stock as finances allow. However, marine aquariums have comparatively high set-up costs, relative to fresh water tanks. Filtration systems and special lighting requirements intended to reproduce the marine environment are necessary. Enthusiasts can indeed devote considerable time and money to their hobby. Retailers, for example, spoke of regular customers living a considerable distance from Brisbane who nevertheless frequently arrived in search of new specimens. The tanks of buyers varied considerably in size from the relatively modest to a large 750 L aquarium. This may reflect the variation in income of respondents—they varied from one respondent on social security benefits to others in the high income brackets described earlier.

A small number of customers were contacted after having their clams for some weeks. Most reported their animals to be in good health and were very happy with their purchase. Most said they would like to have a number of clams, rather than one, particularly if the clams are of small size. One customer, however, had lost her clam as a result of it being attacked by a cone shell.

Discussion of responses generally

While the responses of customers and retailers to similar questions in their survey forms were broadly similar, there are some differences that are worth mentioning. Retailers, for example, rated anemones and corals ahead of giant clams as aquarium specimens but customers rated giant clams as superior to these species. Both groups thought the colourfulness of giant clams and their exotic nature were very good attributes but the quality of the shell and nitrate removal ability was not rated highly as an attribute. All agreed that the lack of availability of suitable literature on the keeping of giant clams as aquarium specimens was an important problem.[3]

Similar preferences about clam sizes were expressed by both retailers and customers. But customers seemed to be more interested in the availability of bigger sizes of clams than retailers. Also on average they were prepared to pay somewhat more for larger sized clams than considered reasonable by retailers, but for the smallest sized clams they suggested a somewhat lower price to be reasonable in

[3] Advice on keeping giant clams in home aquariums is contained in Appendix IV of Research Reports and Papers in Economics of Giant Clam Mariculture, No. 26, Department of Economics, University of Queensland, 4072, Australia. See Tisdell (1991).

Table 12.10 Comparison of sizes of clams preferred by retailers and customers and of reasonable retail prices suggested by them (A$/clam)

Preferred size (cm)	Retailers		Customers	
	Ranking[a]	Price range	Ranking[a]	Average price
2.5–5	3 (2)	10–13	3 (4)	9.4
5–10	2 (5)	15–18	2 (8)	19.3
10–25	1 (4)	18–20	1 (5)	23.9
15–20	– (0)	20–25	4 (3)	32.0
20–25	– (0)	25–30	5 (11)	53.3

[a]Ranking on the basis of number of respondents indicating that a size is a preferred one. The number of such respondents is shown in brackets.

comparison to that suggested by retailers. These features can be seen from Table 12.10. It seems that clams of 5–10 cm in size could be sold at $20 and that this size of clam might generally be the most suitable for retailers to stock.

While more than 50% of customers purchasing giant clams completed survey forms, many did not. A factor limiting their response rate was a reluctance on the part of some to be involved in an exercise requiring completion of a survey form. This was reported by aquarium owners as being due to a concern regarding confidentiality in the context of the additional permit requirements of the Department of Primary Industry. Some customers were therefore concerned about the amount of information required from 'official bodies'. In some instances, retailers may have been reluctant to enforce the completion of a customer survey form as a requirement of clam purchases, particularly when customers insisted on taking the form home for completion. In many cases, this was simply a means of avoiding completion of the survey form. One retailer spoke of a young buyer whose parents refused to allow him to complete the form. Ensuring a high response rate was difficult for the project organisers who were necessarily removed from this part of the work. In addition, there were quite a number of multiple purchases of clams by the same customer so that one form frequently represented the sale of several clams.

The rate at which clams sold varied markedly between aquarium retailers. It was interesting to note that the outlet showing a particularly slow rate of sales was of a significantly larger scale than the others. While most specialised in aquarium supplies, the larger retailer was a more generalised pet shop. This outlet also appeared to have a comparatively large paid workforce and to generate a high sales turnover. Customer service may therefore have been of a different nature to that occurring in the other outlets. These were characterised by a smaller scale of operation and staff were familiar with many of their customers who were typically described as 'regulars'. This familiarity seems to be particularly common in the saltwater aquarium trade, which is quite specialised and therefore confined to a relatively small number of customers. Saltwater tanks are more expensive and have more complex requirements than freshwater tanks and customers are often quite dedicated to the collection of interesting specimens. Familiarity with customers enabled smaller retailers to advertise through word of mouth, an avenue not as readily available to a larger business. And it was in the smaller outlets that the clams sold quickly and in the largest numbers.

One such retailer had in fact sold almost his entire stock within a week of their being delivered. Regular customers had been kept informed of their impending arrival and were consequently keen to purchase. This shop has since made independent arrangements for additional stocks. Two further outlets sold clams steadily and felt continuing demand would be constant if small. A major concern however was the Department of Primary Industry permit requirements which were seen to significantly diminish sales. The 'red tape' involved raised questions for retailers about the desirability of continuing to stock giant clams.

All retail outlets recorded sales lost due to the permit-requirements. Most claimed that they could sell at least twice the number of clams if these requirements did not exist. Inconvenience arises as customers are required to apply to the Department of Primary Industries for permits *before* being able to make a purchase. Once having made the application, they must then wait some time for its approval and their receipt of the actual permit. They can then return to the shop, show their permit and make the purchase. Often the wish for a clam is insufficiently strong to complete this procedure which adds significantly to transaction costs. Retailers were often understandably reluctant to hold clams when they could not be sure whether the buyer would return. Customers therefore had no guarantee of a clam still being available after receipt of the permit, which naturally affected their incentive to take the necessary trouble to apply.

Observations on economics of retail sales and market size

From the information given above, it seems that the margin available to aquarium retailers on sales of giant clams in the size range 2.5–5 cm is likely to be quite small and that the licence fee payable to the Department of Primary Industries is a major impost. Licensing requirements add considerably to costs of clams and seem likely to seriously reduce sales.

On average, it would seem that each retailer might expect to sell 50 clams annually. If these were purchased in one batch, their cost would be at least that set out in Table 12.11.

Given the basic cost shown in Table 12.11, very little margin is left for retailers if clams sell at a retail price of A$10–13 each. This is the actual range of prices

Table 12.11 Estimated minimum cost of 50 giant clams of size 2.5–5 cm size to Brisbane retailer

Item	Total (A$)	Cost/clam (A$)	%
Air freight	63	1.26	14
Cost of clams at A$5.50 each[a]	275	5.50	60
Department of Primary Industries permit	100	2.00	22
Local delivery charge	20	0.40	4
Total basic cost	458	9.16	100

[a]Includes an extra dollar for a small batch

charged by retailers in the test marketing and is the range of prices they thought to be reasonable. However, the price thought to be reasonable by customers was on average, only A$9.40/clam. This price would leave virtually no margin for retailers.

The profit margin for retailers of giant clams of 5–10 cm in size could be higher. The licence fee for example does not vary by the size of the clam and freight costs would not rise proportionately and on average purchasers thought that a price of A$19.30/clam to be reasonable for clams in this size range.

Clearly, within Queensland, given the marginal nature of the market in giant clams, government regulations and charges are a major impediment to the marketing of *farmed* giant clams as aquarium specimens. Current regulations have been framed to protect wild stocks and have not been adjusted to take account of mariculture developments. It is ironic that Queensland, which stands to gain most amongst the Australian states from giant clam farming, has the most restrictive regulations limiting the marketing of giant clams and that this legislation does not discriminate between farmed and other stock in its general provisions. The legislation seems to be out of step with modern developments, provides considerable bureaucratic discretion and is uncertain therefore in its operation, causes delays and adds to costs in the marketing of giant clams in Queensland.

The above information also enables us to provide an estimate of demand for giant clams as aquarium specimens in Australia. Given current regulations in Queensland, the current demand for giant clams as aquarium specimens in Brisbane has been estimated to be about 50 annually/retail outlet. This is about 300 clams/year in sales for Brisbane, given six outlets selling clams. Brisbane's population is around 1.13 million and that for Queensland 2.9 million. Possibly an additional 300 clams would be sold in the rest of the State thus making annual sales in Queensland of 600 clams as aquarium specimens. The population level in the rest of Australia is about 4.88 times that of Queensland but in other States regulations restricting giant clam sales do not occur. So around twice the *relative* level of demand might be expected there, that is sales of 5856 clams/year. With the Queensland sales added this suggests sales of around 6500/annum for Australia. However, if sales in other Australian States were at similar levels to that estimated for Queensland, given Queensland Department of Primary Industries regulations, for example because of extra air freight costs, annual Australian demand would only be 3600 clams for aquarium specimens. Considering all factors, annual sales of around 5000 giant clams as aquarium specimens seems achievable in Australia. This is not a large number but could provide a useful sideline activity for a clam farm. It is interesting to note that this is the same figure as was suggested in 1989 as a result of interviews (Tisdell 1989 or see Chapter 11). Thus the present survey supports a similar prediction to the earlier one.

Because of government regulations in Queensland, Reefarm Pty Ltd, located near Cairns in Northern Queensland has found it easier to export giant clams as aquarium specimens to the USA and Europe, especially Germany, where a larger market exists, or to sell them interstate rather than in Queensland.

Concluding comments

The viability of a market in products from protected species such as giant clams depends not only on the natural forces of supply and demand but is affected by government regulations. The possibility of over-exploitation of protected species seems to have resulted in the legislation imposed by the Queensland Department of Primary Industries. The actual application of the legislation is to a large extent discretionary. While licences may be issued for up to 12 months, they need not be. In the case of this research, they were only issued for one month and other requirements were stipulated. The time required from the date of initial contact with the Department of Primary Industries by telephone in early January 1991 to the issue of permission for research to proceed was six months. Written letters of consent to cooperation from all participating retail outlets were required by the Department of Primary Industries and customers of retailers also had to obtain permits via the method previously outlined. Six hundred dollars was paid to the Department of Primary Industries from project funds to enable retailers to obtain permits and so make it possible for the research to proceed.

While a market exists for giant clams in Australia as aquarium specimens, it is not a large market. Government restrictions can have a considerable influence on market viability as demonstrated above. Ironically, despite CITES (Convention on International Trade in Endangered Species) which applies to giant clams, it is easier to export giant clams to overseas markets than to sell them in Queensland. Whereas trade in farmed clams in Queensland could provide a springboard for developing overseas markets for giant clam products elsewhere, Queensland Government regulations have restricted opportunities for Australian clam producers to follow such a strategy.

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13 More Information on the Market for Giant Clams as Aquarium Specimens in Australia

Clem Tisdell

Thea Vinnicombe

Abstract

During 1991 research based on the test marketing of giant clams as aquarium specimens in Brisbane, Queensland was completed. The results indicated giant clams to be potentially popular as aquarium specimens, being considered to be on a par with coral and anemones. However, the marketability of giant clams in Queensland was reduced by the requirements of the Queensland Department of Primary Industries, which compelled both retailers and customers to obtain permits to hold clams. Permits for retailers were expensive, being A$100/aquarium, and those for customers required a time–consuming application process.

For comparison with Brisbane results (reported in Chapter 12), a telephone survey was conducted in Sydney and Melbourne, the capital cities of the two most populous states of Australia, New South Wales and Victoria. Insufficient resources were available to adopt test marketing in those cities. The results of these surveys support our earlier conclusions, that a small but viable market exists for giant clams as aquarium specimens throughout Australia. Profit margins for retailing of clams in Sydney and Melbourne seem to be higher than in Queensland, partly due to the absence of Queensland's expensive permit requirements. Other differences are also noted. The economic experience of two retailers in Sydney and Melbourne selling farmed giant clams in large quantities is encouraging.

Introduction

While the technical and biological feasibilities of giant clam mariculture are now well established, corresponding commercial viability still requires consideration. One of the possible market outlets for giant clams is as aquarium specimens. A test marketing survey was conducted in Brisbane in the latter half of 1991 to gauge the commercial potential for the sale of clams as aquarium specimens. This project concentrated on Queensland, and in particular the Brisbane area. Because of resource limitations, it was not possible to do test marketing elsewhere in Australia. However, a follow up telephone survey was then undertaken in December 1991 in Sydney and Melbourne in order to provide material for comparative analysis and provide greater depth in this market research. Sydney and Melbourne are the capital cities of the two most populous states, New South Wales and Victoria, of Australia.

Information gleaned from the initial survey was based on actual clam sales, that is through the distribution of live clams to Brisbane marine aquarium outlets for test marketing. Information was gathered from questionnaires completed by both retailers and customers and details were obtained of such factors as potential demand, market size, price and the overall market prospects for giant claims as aquarium specimens. The results of this survey are reported in Tisdell (1991, see Chapter 12).

Retailers of aquarium products in Sydney and Melbourne who indicated, through their advertising in the Yellow Pages of the Telephone Directory, their participation in marine aquarium sales, were contacted and asked if they would take part in a telephone survey. Fourteen Sydney and 11 Melbourne outlets were willing to cooperate. They are listed in Tisdell and Vinnicombe (1992, Appendix B). In both cities, two aquariums preferred not to take part. The survey took place in December 1991 and the questionnaire used is reproduced in Appendix A of Tisdell and Vinnicombe (1992).

Although the Brisbane project related to actual sales, the interstate telephone survey used a similar questionnaire so as to make worthwhile comparisons possible. A major impediment to the research project in Brisbane and to prospects of a viable market for giant clams as aquarium specimens in Queensland were the permit requirements of the Queensland Department of Primary Industry (see Chapter 12). Governments in other Australian states take a less restrictive approach. In Victoria, there is no legislation restricting the sale or holding of giant clams, provided they are obtained from a licensed commercial venture. Information from the Fisheries Department of N.S.W. indicates that the import of clams from interstate requires a licence. However, under normal circumstances there is no fee for the issue of these licences.

Retailers contacted by telephone were initially asked if they supplied marine specimens and if they would be willing to take part in a telephone survey. Of the 14 Sydney aquarium outlets willing to participate only one currently stocked giant clams, while in Melbourne a proportionally higher percentage of outlets, two out of eleven, held clams. Generally, giant clams were not stocked due to a perceived lack of availability. Retailers were frequently unaware that clams could be obtained from commercial farms in quantities sufficiently small for their requirements. An additional factor, however, was an evident lack of knowledge regarding giant clams, and consequent concern as to their care. While a number of respondents said they did not currently stock clams, most said that they actually had held 'the odd one or two', usually accidentally brought in on a piece of coral.

When asked if they would be interested in buying from clam farms, 11 Sydney retailers responded positively, while two were not interested. One outlet was already purchasing from a farm. A similar response pattern was recorded from Melbourne, where two retailers were not interested, eight were interested and one was already making purchases from a clam farm. Of those expressing an interest, their responses were often qualified by the need for more information regarding giant clams as well as their likely cost.

The impression was gained that most retailers had limited knowledge of giant clams. This was reinforced by the inability of all respondents to identify different species of clams and comment on the suitability of different species as aquarium specimens. However, when asked if they would be interested in stocking *Tridacna gigas*, the largest growing of the giant clam species, often described as the 'true giant clam', approximately 50% of sellers said 'yes'.

Reasonable purchase and retail prices for giant clams by retailers

Retailers were asked to specify the sizes of giant clams that they would prefer to stock, along with the cost and retail prices for each size which they thought appropriate and the corresponding sales to be expected per year. Tables 13.1 and 13.2 summarise the responses of respondents in Sydney and Melbourne respectively about reasonable purchase and retail prices. Giant clams were divided into five possible size-categories for respondents to indicate appropriate purchase and retail prices as well as their expected sales.

Melbourne respondents indicated that an average purchase price of A$9.80 for the clams of 5-10 cm in size was reasonable, while a corresponding retail price of A$27.80 was on average believed to be reasonable. Lower prices were recorded as reasonable by Sydney retailers. They suggested on average that cost price for this size of A$6.20 was reasonable and on average that a retail price of A$18.60 is reasonable. Comparing Tables 13.1 and 13.2, it can be seen that higher purchase and retail prices for clams of all sizes were regarded as reasonable in Melbourne. The cost of clams would, in any case, be higher in Melbourne than Sydney because of extra freight costs. Possibly retail demand would be higher in Melbourne because the clam is regarded as more exotic in Melbourne's colder climate.

Comparisons can be made between suggested Sydney and Melbourne retail prices and those suggested to be reasonable by respondents in the Brisbane survey. Tables 13.3 and 13.4 show retail prices considered reasonable by sellers and customers in the Brisbane study. Comparison of the results indicate that higher prices could be charged in Melbourne and Sydney for giant clams as aquarium specimens than in Brisbane. For instance, the retail price suggested for giant claims of 5-10 cm in size ranged from A$10-28 in Sydney and from A$5-60 in Melbourne. The comparative price range suggested by Brisbane retailers was A$15-18 and by customers A$9-25.

Some retailers in Melbourne and Sydney specified their usual mark-up because they felt unable to give reasonable retail price estimates when the cost-price of giant clams to them was not known. Mark-ups ranging from 100 to as much as 300% on purchase prices were normal. A significant factor said to contribute to the level of the retail price and the size of the mark-up was the rate of turnover of the commodity. Many sellers expressed a preference for low cost goods, for which they would give a corresponding low retail price in order to establish a large volume of sales and get quick turnover. The popularity of clams could therefore be an important factor determining their actual retail price.

Quick turnover for larger sizes of clams, 15–20 and 25–30 cm, was regarded by retailers as impossible. Most said these clams would move slowly and the price mark-up would need to be correspondingly high. While the suggested cost-prices for these sizes was as low as A$10 or A$20 (See Tables 13.1 and 13.2), the corresponding retail prices were as high as A$120 (See Table 13.1).

Table 13.1 Array of purchase and retail prices (italics) for giant clams suggested as reasonable by Sydney retailers (A$/clam)

Customer	Clam size (cm)				
	2.5–5	5–10	10–15	15–20	25–30
1	30				
2		5 *10–15*	7.50 *14–20*		
3	>5				
4		28			
5		28			
6	5 *15*	7 *20*	*up to 45*	*up to 55*	*up to 70*
7	2.50 *7.50*	4 *12.50*	5 *16*	6–8 *20*	10 *25–30*
8	10 *28*				
9	5–6 *10–15*				20–30 *120*
10[a]		6–8 *20–25*	10 *30*		
Simple averages	5.5 *17.2*	6.2 *18.6*	8.1 *25.6*	6–8 *48*	17.5 *72*

[a]Retailers 11–14 did not suggest prices.

Table 13.2 Array of purchase and retail prices (italics) for giant clams suggested as reasonable by Melbourne retailers (A$/clam)

Customer	Clam size (cm)				
	2.5–5	5–10	10–15	15–20	25–30
1	14–15 *29.50*	*60*			
2		8–10 *25–30*	8–10 *25–30*		
3		2.50 *5–10*	4 *8–10*		
4	10 *19.95*	15 *28–30*	20 *30–40*		
5	10–12 *20–25*	15–20 *35*	25 *50*		
6		10–15 *25–30*	15–17.50 *35–40*	20 *45*	
7	5 *14.95*	8 *19.95*	10–12	10–12	
8[a]	2 *8–10*	4 *16*	6 *24*	8 *32*	10 *40*
Simple averages	8.5 *19.2*	9.8 *27.8*	13 *30.5*	13 *38.5*	10 *40*

[a] Retailers 9–11 did not suggest prices.

Table 13.3 Clam size preferred by Brisbane aquarium retailers and the range of retail prices for clams thought to be reasonable

Clam size	Number of retailers expressing a preference for this size[a]	Reasonable retail price/clam ($A)
2.5–5 cm (1–2")	2	10–13
5–10 cm (2–4")	5	15–18
10–15 cm (4–6")	4	18–20
15–20 cm (6–8")	0	20–25
20 –25 cm (8–10")	0	25–30

[a]Some retailers expressed a preference for several sizes of clams. One respondent ranked all 5 sizes. So in this case only the three most desired sizes were included in the above distribution.

Table 13.4 Clam size preferred by Brisbane customers and the range of retail prices suggested by them as reasonable

Clam size	Number of customers expressing a preference for this size	Reasonable retail price/clam ($A)
2.5–5 cm (1–2")	4	5–13
5–10 cm (2–4")	8	9–25
10–15 cm (4–6")	5	15–30
15–20 cm (6–8")	3	15–50
20 –25 cm (8–10")	1	30–80

Expected quantities of sales of giant clams by retailers of aquarium products

Tables 13.5 and 13.6 show, for Sydney and Melbourne respectively, expected quantity of sales of giant clams by size-categories of clams. It is perhaps in this area that retailers' inexperience with clams is most evident. Their sales estimates varied so widely that ignorance appeared to be a problem. For example, Sydney retailers' estimates of annual sales ranged from 12–1000 for clams of a size of 2.5–5 cm. Such a wide variation between aquariums may demonstrate, not only considerable disparity between their markets, but also lack of knowledge of the market. Differences in quantities were particularly evident for clams of smaller sizes, while for the larger clams, most retailers agreed that only a few would be sold each year.

Table 13.5 Size of giant clams saleable by Sydney retailers, purchase and retail prices suggested as reasonable by them and expected quantity of sales/year

Clam size	No. of retailers indicating this size as saleable	Suggested purchase price (A$)	Suggested retail price (A$)	Expected quantity of sales/year (No of clams[a])
2.5–5 cm (1–2")	8	2.50–10.00	10.00–30.00	150–200 300–1000 (150–1000)
5–10 cm (2–4")	11	4.00–8.00	10.00–28.00	12 70–100 150–200 300–1000 1000 (12–1000)
10–15 cm (4–6")	9	5.00–10.00	14.00–45.00	6–8 70–100 150–500 (6–500)

Table 13.5 (contd.) Size of giant clams saleable by Sydney retailers, purchase and retail prices suggested as reasonable by them and expected quantity of sales/year

Clam size	No. of retailers indicating this size as saleable	Suggested purchase price (A$)	Suggested retail price (A$)	Expected quantity of sales/year (No of clams[a])
15–20 cm (6–8")	5	6.00–8.00 20.00–30.00 Only 2 responses to price—the remaining 3 were uncertain	20.00–70.00 Only 2 responses to price—the remaining 3 were uncertain	Approx 3 All uncertain as to sales, but felt there would be few
20–25 cm (8–10")	5	10.00–30.00 uncertain	25.00–120.00	As above

[a] Responses by individual retailers indicated. Not all respondents indicated quantities likely to be sold.

Table 13.6 Size of giant clams saleable by Melbourne retailers, purchase and retail prices suggested as reasonable by them and expected quantity of sales/year

Clam size	No. of retailers indicating this size as saleable	Suggested purchase price (A$)	Suggested retail price (A$)	Expected quantity of sales/year (No of clams[a])
2.5–5 cm (1–2")	5	2.00–15.00	8.00–29.50	12–400 12 12 12 100 300–400
5–10 cm (2–4")	8	2.50–20.00	5.00–60.00 all but one in the range 5.00–35.00	6 12 12 30–40 50–100 300–400 500
10–15 cm (4–6")	7	4.00–50.00	8.00–50.00	12 12 15–20 20 200
15–20 cm (6–8")	3	8.00–20.00	32.00–45.00	12
20–25 cm (8–10")	2	10.00–12.00	40.00	?

[a] Responses by individual retailers indicated. Not all respondents indicated quantities likely to be sold.

However, retailers frequently avoided the question of expected quantity of sales altogether, saying they could not comment on expected sales in a market in which they had had no experience.

The experience of the two Melbourne and one Sydney operators actually selling clams is therefore particularly relevant. Of the two Melbourne outlets, only one was currently supplied from a clam farm. The second did not reveal his source of supply and did not appear to be dealing in significantly large quantities. His expected yearly sales were only 12 giant clams for each size category. The other outlet, however, was quite specific. He currently stocks the two smallest size categories, 2.5–5 cm and 5–10 cm. These are purchased at cost prices of A$5 and A$8, respectively. Corresponding retail prices are A$14.95 and A$19.95. His expected sales were in the range of 300–400 clams/year for each size category, although this prediction was qualified to some extent by the colour of the clams. Those described as being of good colour could be expected to move quickly, with less attractive clams being more difficult to sell.

The Sydney retailer was less forthcoming, perhaps being more pressed for time. He presently stocks only clams in the size range 5–10 cm, selling approximately 20/week at a retail price of A$28. This would result in sales of about 1000 clams /year by this outlet. The corresponding cost price was not made available. It is interesting to note that actual retail prices vary in the opposite direction to the averages for each city suggested as reasonable by respondents. The Sydney price is considerably higher than that for Melbourne, which may reflect higher overhead costs in N.S.W., particularly shop rentals.

Sellers in the Brisbane area also were indecisive as to the size of their market. While some said only a few clams could be sold, one respondent claimed that he could 'move plenty' if it were not for the permit requirements of the Department of Primary Industry. However, from the Brisbane responses, it appears that average annual sales would be approximately 50 clams/year/aquarium retailer. Without the restrictions imposed by the Queensland Department of Primary Industry, twice this level of sales might be expected.

Considerable differences in expected annual sales/aquarium are therefore evident. In particular, the Melbourne and Sydney outlets *currently stocking* clams appear to have a larger market than that evident in Brisbane from the survey. Brisbane is a smaller city, with an evidently smaller and more specialised market for marine aquarium products. Most retailers were well known to each other and appeared to see themselves as sharing as opposed to competing, in the market for marine specimens. In calculating expected sales, the Brisbane estimates made allowance for sales that could be expected to be made by other outlets. Melbourne and Sydney retailers may be more specialised, with perhaps room for only a few outlets to sell large numbers of clams, while others could expect to sell only small numbers or none at all.

Some evidence for this view may be found in that a number of Sydney and Melbourne retailers spoke of not being 'geared up' for giant clams and seemed to consider that additional costs would be involved in them 'gearing up' to stock giant clams. While most Brisbane marine aquarium retailers had existing tanks specifically for coral, with few if any fish, this was not so common in Sydney and Melbourne. In order to stock giant clams, a number of retailers in Sydney and Melbourne would need to establish separate tanks.

Saleable sizes of giant clams

From Tables 13.5 and 13.6, the sizes of clams which are most saleable as aquarium specimens can be seen. Responses of retailers indicate that the most preferred size of clam is 5-10 cm (2-4"), followed by 2.5-5 cm (1-2"). In Sydney, 11, 9 and 8 respondents respectively indicated that they would be able to sell clams of 5-10 cm, 10-15 cm and 2.5-5 cm in size. The corresponding number of responses in Melbourne were 8, 7 and 5.

These results accord with those obtained from responses of retailers in the Brisbane survey. Brisbane retailers said that their preference is to stock clams of size 5-10 cm, with their next preference being for those of 10-15cm in size then 2.5-5 cm in size.

Ranking of attributes of giant clams as aquarium specimens by retailers

The final question asked of the aquarium retailers related to the attributes of giant clams as aquarium specimens. Respondents were asked to rank these on a scale from poor to excellent. The results are recorded in Tables 13.7 and 13.8. In general, the clam's attractiveness in terms of colour of the mantle and exotic value was considered to be very good, but its shell less so. This corresponds with the results of the Brisbane survey, as do the findings with respect to the clam's ability to remove nitrate. While scientific evidence indicates that the clam may be beneficial in removing nitrate from the home aquarium (Lucas 1991), this is not generally evident or known to retailers of marine aquarium products. However, one respondent in this survey had kept a comparatively large clam in an aquarium for some time and reported positive reductions in nitrate levels.

Observations on economics of retail sales and comparative market size

Current cost prices were obtained from Bruce Stevens of Reefarm Pty Ltd, Cairns, the commercial farming venture used in supplying clams to the retailers participating in the Brisbane survey. Reefarm sells two types of clams, *Tridacna gigas* and *Tridacna crocea* for the aquarium trade. The former are priced according to size, being A$1/cm up to a size of 20 cm, and A$2/cm beyond this. The *T. crocea* are priced according to numbers obtained, with current prices as follows:

Batch size	Price
0-500	A$5.50
500-1000	A$4.50
over 1000	A$3.50

At current realistic retail prices of A$28/clam for Sydney and A$14.95-19.95 for Melbourne, compared to a cost price of approximately A$5-10, a considerable margin exists between the basic wholesale and retail price. After freight charges, sufficient margins exist for retailing of giant clams to be profitable.

While some differences exist in freight charges between Cairns and the three cities, these differences are not large. The air freight of livestock (1991) to all three

Table 13.7 Ranking by Sydney aquarium retailers of attributes of giant clams, frequency of responses and average rating

Attributes[(a)]	Ranking[(c)]					Average	
	Excellent	Very good	Good	Not very good	Poor	(a)	(b)
Colourful (9)	1	3	4		1	3.3	2.3
Exotic (9)	1	4	3			3.4	2.4
Shell (9)		2	2	1		2.2	1.2
Nitrate removal (6)[d]	1		3			3.5	2.5

(a)No. of respondents in brackets.
(b)Ranked on a scale of 1 to 5 corresponding to Poor to Excellent.
(c)Ranked on a scale of 0 to 4 corresponding to Poor to Excellent.
[d]Five were uncertain about nitrate removal.

Table 13.8 Ranking by Melbourne aquarium retailers of attributes of giant clams, frequency of responses and average rating

Attributes[(a)]	Ranking(c)					Average	
	Excellent	Very good	Good	Not very good	Poor	(a)	(b)
Colourful (9)	2	4	3			3.9	2.9
Exotic (9)	1	1	4	3		3.0	2.0
Shell (9)			3	4	2	2.1	1.1
[d]Nitrate removal (6)		2	3	1		3.2	2.2

(a) No. of respondents in brackets.
(b) Ranked on a scale of 1 to 5 corresponding to Poor to Excellent.
(c) Ranked on a scale of 0 to 4 corresponding to Poor to Excellent.
[d]Three were uncertain about nitrate removal.

destinations incurs a basic initial charge of A$30. The per kilogram charge, on top of this, then varies, being A$11.22 for Brisbane, A$12.05 for Sydney and A$14.55 for Melbourne. A packaged box of 50 clams weighs 5.5 kilograms.

Given this information it is possible to tabulate the wholesale costs inclusive of air freight so that comparisons can be made. This has been done in Tables 13.9–13.11. Because Brisbane retailers expected to sell only 50 clams annually, costs have been estimated on the basis of a batch of this size.

These figures indicate the cost price to be far higher in Queensland than the other states due to the imposition of the Queensland Department of Primary Industry permits. Retail prices in Brisbane were, however, somewhat lower than

Table 13.9 Estimated minimum cost of 50 clams (2.5–5.0 cm) to Brisbane retailers

Item	Total (A$)	Cost/clam (A$)	%
Air freight	91.71	1.83	19.57
Cost of clams @ $5.50 each	257.00	5.50	54.83
Local delivery charge	20.00	0.40	4.27
Department of Primary Industry permit	100.00	2.00	21.33
Total	468.71	7.73[a]	100.00

[a] Without permits $5.53

Table 13.10 Estimated minimum cost of 50 clams (2.5–5.0 cm) to Sydney retailers

Item	Total (A$)	Cost/clam (A$)	%
Air freight	96.28	1.93	24.61
Cost of clams @ $5.50 each	275	5.50	70.28
Local delivery charge	20.00	0.40	5.11
Total	391.28	7.83	100.00

Table 13.11 Estimated minimum cost of 50 clams (2.5–5.0 cm) to Melbourne retailers

Item	Total (A$)	Cost/clam (A$)	%
Air freight	110.03	2.20	27.17
Cost of clams @ $5.50 each	275	5.50	67.90
Local delivery charge	20.00	0.40	4.93
Total	405.03	8.10	100.00

Melbourne and Sydney, with clams in the survey selling at between A$10 and A$13 (Tisdell 1991, p 31). These cost estimates do not account for all overheads, particularly shop rental, which may be somewhat higher in the other states. It was also expected that the profit margin for the larger sized clam, 5–10 cm, would be higher, given a higher retail price and less than proportional increases in other costs. Nevertheless, it would appear that a more profitable market in Australia exists for giant clams as aquarium specimens outside Queensland, despite Queensland being their state of origin. This is due largely to Queensland permit requirements but also partly to the fact that giant clams can command a higher retail price in the southern states of Australia.

Conclusions

Indications are that giant clams, as aquarium specimens, would be purchased by aquarium outlets at higher prices in Sydney and Melbourne and sold at higher prices than in Brisbane. These higher prices are greater than is needed to cover extra transport costs of sending clams to southern capitals. As for the quantities of sales to be expected, the estimates given by retail outlets are of limited value, because most saltwater aquarium outlets contacted have had little or no experience in selling giant clams as aquarium specimens. However, two outlets were very experienced in selling farmed clams and the results from those were very encouraging. While a market exists, results seem to support the conclusion of Tisdell (1991 or see Chapter 12, 1989 or see Chapter 11) that it is not large and is consistent with annual sales of giant clams as aquarium specimens in Australia of around 5000/year. The pattern of sales in Sydney and Melbourne may be concentrated on fewer outlets and so differ from that likely in Brisbane. Only special outlets currently sell farmed giant clams in Sydney and Melbourne and their annual sales volumes seems comparatively large at around 1000 and 300–400 respectively.

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14 The Value of Tridacnid Clam Attributes in the Hawaii Aquarium Market: Conjoint Analysis

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Abstract

Conjoint analysis is used to estimate the value of size and colour (characteristics) of *Tridacna derasa* among aquarium distributors in Hawaii. The theoretical basis for estimating the value of the characteristics using stated preferences is discussed. Then the experimental techniques used to elicit the stated preferences of aquarium distributors in Hawaii are described and the results are presented. Most distributors are willing to pay a substantial premium for colour-enhanced *T. derasa* compared to unenhanced *T. derasa*. In relation to size of *T. derasa*, different groups of distributors seem to have different requirements. While one group places a premium on *T. derasa* of larger size, another prefers smaller sizes. A number of complications involved in using conjoint analysis to assess the value of attributes are pointed out.

Introduction

In the last two years, the mainland U.S. demand for saltwater aquariums of 'mini-reef' systems has grown and now accounts for 20% of the value of the national aquarium trade (Heslinga 1990). The U.S. trade in ornamental fish, invertebrates and supplies had an estimated value of over U.S.$700 million in 1989 (Winfree 1989), while, outside the U.S., the value for marine aquarium fish and invertebrates, excluding supplies, sold in 1985 was estimated to be U.S.$100 million (McLarney 1985). The use of spectrum actinic and metal halide lights in 'mini-reef' aquariums makes it possible to keep tridacnid clams in closed-cycle tanks for long periods of time. With technologies currently available, tridacnid clams can be transported to aquarium markets worldwide (Heslinga 1990). Tisdell (1989) and Deese (1989) indicate that the demand for these clams in the aquarium market has the potential to increase.

In order to realise the full profit potential of giant clams in the aquarium markets, producers must understand the tradeoffs buyers are willing to make for attributes of the product (Anderson 1987). This information can be used to guide producers' production and marketing decisions (Steencamp 1987). While economists often determine the value of a product's characteristics by fitting hedonic price models using revealed preference data, giant clams have not been sold in aquarium markets long enough to generate sufficient time series information to make estimation possible. In addition, because the preferences of aquarium owners change rapidly, such models may not be useful for predicting the future (Miklius and Leung 1990). Conjoint measurement is a quantitative research method that has been used in a number of marketing studies to determine the tradeoff between product attributes using experimental information (Beilock et al. 1986).

In this chapter, we use conjoint analysis to estimate the value of size and colour for *Tridacna derasa* among the aquarium distributors in Hawaii. First, the theoretical basis for estimating the value of characteristics using stated preferences is discussed. Then, the experimental techniques used to elicit the stated preferences of aquarium distributors in Hawaii are described and the results of the experiment are presented. The final section presents a discussion of the research findings and their implications for further research.

Theoretical framework for conjoint measurement

Based on the ordinal rankings given to alternative bundles of product attributes, conjoint analysis infers estimates of willingness to pay using statistical techniques to quantify how much each attribute contributes to the overall utility (Carol et al. 1989). The choice of one variation of a product over another is decomposed into a set of attributes (x) and the attributes are assigned weights (w) such than an index I, $I = f(wx)$, is a monotonic transformation of the original ordinal data. The index I is interpreted as an ordinal utility function which is estimated using a two step process (Beilock et al. 1986).

First, information must be collected from individuals about their preferences. To accomplish this, respondents participate in an experiment requiring them to rank descriptions of the same products with different attributes. Concerns with the external validity of these experiments centre on the use of a series of artificial choices, rather than actual market situations, as a basis for estimating the value of attributes. Louviere (1988) provides evidence that if stated preference experiments, which include the use of conjoint measurement and contingent valuation, are properly designed and administered, no bias will result.

The rankings for each individual can then be analysed using maximum likelihood techniques in order to estimate an ordinal utility function. If the rank order information is converted to binary data or Bernoulli variables, a probability model such as logit or probit can be used to estimate the ordinal utility function. If the ranks (R) range in value from 1 to N and the values are assumed to be functions of the attributes (x), then $N(N\text{-}1)/2$ of the following equations can be formed:

$$R_i - R_j = F_i(x_i) - F_j(x_j) \qquad 14.1$$

for all i and j, given $i > j$

If, $R_i - R_j > 0$, then $R_i - R_j$ becomes equal to one and zero otherwise. The paired comparisons are assumed to be probablistically independent. This means that to make the first choice all bundles are compared to each other. Then, after the first choice is made, the bundle that is ranked first is then removed from the choice set and the remaining bundles are then compared independently to each other. This process repeats until all the bundles are ranked.

According to McFadden (1987) the following indirect utility function can be estimated from the converted data where: $z_i = F_i(x_i) - F_j(x_j)$

$$C = \alpha + \beta_1 z_1 + \beta_2 z_2 + \ldots + \beta_n z_n \tag{14.2}$$

where $C = \exp[U/1-U]$ and U is the utility individuals obtain from consuming the product. Utility is assumed to be maximised subject to a constraint that includes income, savings, the price of the product in question and the price(s) of other goods. However, if income, savings and the price of other goods are assumed to remain constant, this leaves the price of the product as a variable (z_i) in the indirect utility function (Hensher et al. 1988).

In order to determine the value of the attributes, the total derivative of the indirect utility function (14.2) is taken, giving:

$$0 = 0 + \beta_1 \delta z_1 + \beta_2 \delta z_2 + \ldots + \beta_n \delta z_n \tag{14.3}$$

Because the indirect utility level (C) is assumed to remain constant, its derivative, on the left hand side of equation (14.3) is equal to zero. Now, assuming that only the product's price (z_i) and the level of one attribute (z_2) are changing while all other attributes remain the same, solving equation (14.3) for $\delta z_2/\delta z_1$ gives:

$$\delta z_2 / \delta z_1 = \beta_2 / \beta_1 \tag{14.4}$$

Equation 14.4 indicates the change in the level of an attribute that will be needed, given a change in price, in order to keep the consumer just as satisfied. the expression, β_2/β_1, is the value for all other attributes of the product found in the indirect utility function.

Survey methods and design

Since the demand of aquarium distributors is derived from the anticipated demand of final consumers, and the smaller size of the distributors of such an activity is prohibitive; the demand of aquarium distributors is derived from the demand of final consumers and the size of the group makes the distributors less costly to survey. Further cost constraints made a survey of all aquarium distributors worldwide or in the United States impossible. Therefore, only aquarium distributors in Hawaii were included in the survey. While this group is not a randomly drawn sample of distributors, the fact that 58% of the U.S.$5 million worth of saltwater fish and equipment sold annually by this group is exported mostly to the mainland U.S. means that the group represents the final demand of various U.S. consumers.

In order to determine which characteristics of clams are desirable and over which ranges these attributes are desirable (Louviere 1988), some preliminary work with the distributors was required. Live *T. derasa* from the Micronesian Mariculture Demonstration Centre (MMDC) in Palau in the size range from 7–12 cm were supplied to the distributors. The colour of the clams varied, some were unenhanced with brown or translucent mantles, while others were enhanced with neon green and blue. Enhancement involves the addition of ammonium nitrate as fertiliser for the zooxanthellae algae in the clam's mantle, resulting in enhanced mantle colouration (Heslinga 1990). Follow-up interviews with distributors were conducted to determine their feelings about these clams and how much they would be willing to pay for them.

The enhanced animals with more colour were preferred to the unenhanced animals by all distributors. The distributors also said they were willing to pay more for the larger animals, but this preference for larger animals may not be because of size alone. Larger animals are rare in the market and colour variations are more apparent.

The stated preference data was obtained by personal interviews of aquarium distributors. Each survey participant was shown twelve cards, with each card describing four clams using three attributes. The three attributes were colour, price and size. Each participant was asked to indicate which clams they would buy first, second, third and fourth on each card. Size ranged between 6–15 cm in one centimetre increments, prices ranged between U.S.$1.50–15.00 in U.S.$0.25 increments and colour was enhanced or unenhanced. Photos of unenhanced and enhanced animals, along with shells of each clam size were displayed to remind each distributor of the variation between attribute levels.

The attribute combinations used to describe the four clams on each card always put a higher price on a larger clam and on an enhanced clam. The desired attributes must be more expensive in order to force a trade-off between that attribute and price, otherwise the respondent's rankings would be perfectly predictable (Beilock 1986). The cards were designed so that the desired attributes would become progressively more expensive, eventually causing the respondent to switch to a cheaper clam with less desirable attributes. The point at which the higher price causes this switching behaviour identifies the maximum value of the attribute to the respondent.

The twelve cards were shown to distributors in a randomly assigned order and the four clams were arranged in a randomly assigned order on each card. Thus, no order bias should result because every distributor was shown the cards and choices in a different sequence.

Empirical results

The indirect utility functions were estimated using the logit algorithm in SHAZAM (White 1978). The estimates of the indirect utility function for one group of respondents using price, colour and size as the product attributes are presented in Table 14.1, along with the percentage of right predictions (%RP) and the log-likelihood function (ln(LR)). Enhanced clams were preferred by all respondents in this group. However, although the focus group results indicated that larger clams were preferred, the stated preference data indicated that not all respondents actually do. As indicated in Table 14.1, four respondents preferred larger and five preferred smaller. This result did require that the choice cards be redesigned for those distributors preferring small sizes to ensure that their utility functions could be estimated.

Table 14.1 Utility functions for distributors valuing tridacnid clam size and colour

Distributor	Intercept	Size	Colour	Price	%RP[a]	ln (LR)[b]
D1	1.37**[c]	0.34**	2.70**	-0.77**	72	-32.48
	(0.46)[d]	(0.19)	(0.69)	(0.30)		
D17	-0.12	1.64**	3.59**	-1.49**	86	-21.67
	(0.55)	(0.47)	(1.01)	(0.54)		
D4	0.71**	0.64**	0.72*	-0.23*	74	-38.05
	(0.33)	(0.15)	(0.41)	(0.13)		
D3	1.21**	0.66**	1.28*	-0.54	61	-20.35
	(0.54)	(0.34)	(0.72)	(0.41)		
D7	0.27	-0.07	0.55**	-0.32**	72	-102.11
	(0.18)	(0.06)	(0.32)	(0.09)**		
D5	1.41**	-0.89**	2.45**	-1.73	94	-14.78
	(0.54)	(0.28)	(0.85)	(0.65)		
D2	0.35	-0.48**	3.22**	-0.37	92	-21.92
	(0.49)	(0.19)	(0.90)	(0.33)		
D20	0.99**	-0.29**	1.43**	-0.66**	82	-36.84
	(0.30)	(0.12)	(0.52)	(0.22)		
D21	0.86*	-0.71**	2.31**	0.92**	92	-18.30
	(0.46)	(0.22)	(0.78)	(0.44)		

[a]Percentage correct predictions.
[b]The log-likelihood function.
[c]*Coefficients are statistically significant using 90% confidence interval.
[c]** for 95%.
[d] Asymptotic standard errors.

Figure 14.1 gives the partial demand curve for the colour enhancement for *Tridacna derasa* as derived from the utility functions presented in Table 14.1. The curve indicates the amount of money these distributors are willing to pay for enhanced clams as compared to unenhanced clams. This demand curve, because it is a partial demand curve, does not indicate how many clams each distributor is willing to buy, only that each distributor will buy at least one.

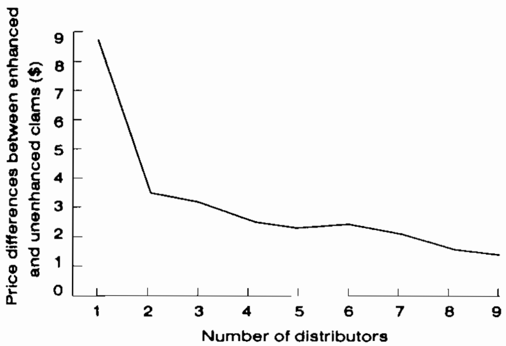

Figure 14.1 Partial demand curve for enhanced tridacnid clams

The partial demand curves for a 1 cm increase and decrease in size are shown in Figures 14.2 and 14.3 respectively. Figure 14.2 represents how much distributors who preferred larger animals (Table 14.1) are willing to pay for a 1 cm increase in size. Figure 14.3 represents how much distributors who preferred smaller animals (Table 14.1) are willing to pay for a 1 cm decrease in size.

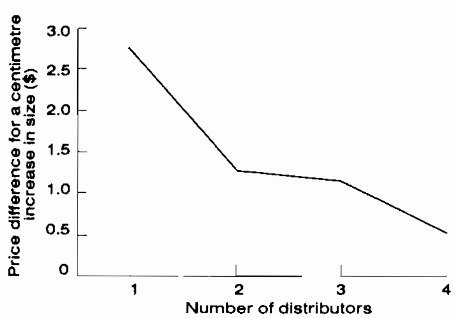

Figure 14.2 Partial demand curve for a 1 cm increase in size of tridacnid clams

Two distributors did not value colour as much as was indicated by the focus group results. Therefore, the estimated function for these respondents, as shown in Table 14.2, include size only. These distributors may differ from the others because they understood the enhancement process and could enhance clams themselves. Because the process is not costly, they were not willing to pay much for an enhanced clam as compared to an unenhanced clam.

Results also indicated that another group's estimated utility functions were not consistent with the hypothesis formed from the focus group results that larger animals were preferred. While this group appears to prefer smaller animals, smaller animals were always less expensive. Thus no significant estimates for the value of a smaller animal could be obtained. Table 14.3 shows the estimated functions of these respondents assuming they valued enhancement only. Figure 14.4 shows the partial demand curve for this group indicating how much this group is willing to pay for an enhanced clam as compared to an unenhanced clam. These distributors need to be surveyed again, with a new set of cards to determine if a smaller animal is preferred. Since a large portion of these distributors market to small retail stores in which the average size of aquariums is 40–55 gallons (180–250 L) (Moe 1989), a smaller animal may be more attractive to their consumers.

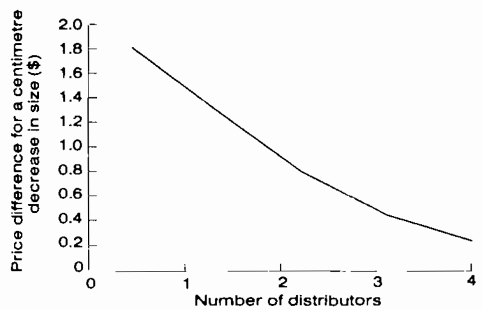

Figure 14.3 Partial demand curve for a 1 cm decrease in size of tridacnid clams

Table 14.2 Utility functions for distributors valuing tridacnid clam size

Distributor	Intercept	Size	Price	%RP[a]	ln(LR)[b]
D8	-0.38	0.80[c**]	-0.54**	83	-28.55
	(0.34)[d]	(0.22)	(0.24)		
D16	0.89**	0.40**	-0.16*	63	-41.76
	(0.34)	(0.12)	(0.09)		

[a]Percentage correct predictions.
[b]The log-likelihood function.
[c*]Coefficients are statistically significant using 90% confidence interval,
[c**] for 95%.
[d]Asymptotic standard errors.

Conclusion

Conjoint analysis was used in this chapter to estimate the value of a 1 cm change in the size and the value of an enhanced *T. derasa* among aquarium distributors in Hawaii. This method is often used to determine the value of product attributes in the marketing research found in business literature. The major drawback of conjoint measurements is the use of experimental techniques to elicit stated preferences, rather than the use of revealed preferences from actual time series market data.

The preferences of aquarium distributors in Hawaii for the attributes of tridacnid clams fall into four different groups. These include those valuing colour enhancement and larger size, those valuing colour enhancement and smaller size, those valuing colour enhancement only, and those who value larger size only. Those that value colour enhancement only may also value smaller size, but no significant results supporting this conclusion have currently been obtained.

Table 14.3 Utility functions for distributors valuing tridacnid clam colour

Distributor	Intercept	Colour	Price	%RP[a]	ln(LR)[b]
D12	0.19	1.50**[c]	−0.34**	75	−38.71
	(0.29)[d]	(0.44)	(0.12)		
D11	0.25	3.82**	−0.21*	82	−26.34
	(0.37)	(1.03)	(0.13)		
D10	−0.04	2.05**	−0.32**	79	−36.39
	(0.31)	(0.51)	(0.12)		
D9	0.94*	5.86**	−0.83**	96	−13.84
	(0.52)	(1.47)	(0.28)		
D13	0.94**	3.35**	−0.32*	88	−24.45
	(0.38)	(0.80)	(0.17)		
D14	0.34	4.12**	−0.52**	90	−22.37
	(0.40)	(1.07)	(0.21)		
D18	1.01**	3.37**	−0.49*	85	−26.27
	(0.37)	(0.78)	(0.27)		
D15	1.51**	3.53**	−0.7	85	−23.12
	(0.43)	(1.14)	(0.32)		

[a]Percentage correct predictions.
[b]The log-likelihood function.
[c*]Coefficients are statistically significant using 90% confidence interval,
[c**] for 95%.
[d]Asymptotic standard errors.

These results pinpoint the need to collect accurate information from focus group participants. Although a focus group of Hawaiian distributors indicated larger sizes were preferred, the conjoint experiment found this not to be the case for the majority of distributors surveyed. Inaccurate hypotheses about the expected range over which attributes will be valued prevent the estimation of the indirect utility function.

The factors that appear to affect the preferences of a distributor include the size of the distributor, the type of products handled by the distributor, and the nature of the markets used by the distributor in his or her marketing channel. For example, one distributor may purchase a variety of aquarium products for a large export market and merchandise to large retailers throughout the U.S., while another may deal only in one product line using a local supplier and selling to small retailers. A means of quantifying these characteristics could be investigated in order to estimate a model predicting into which preference group a distributor would fall. Such predictions would provide producers with *a priori* information about how a given distributor would value clam attributes.

Another refinement which would prove useful is the ability to estimate the relative value of one unit of an attribute, rather than the absolute value of one more unit. For example, one more centimetre may be worth different amounts to a consumer, depending on the current size of the clam. The model estimated here assumes an additional centimetre is always worth the same to the respondent, whether the clam in question is 5 cm or 12 cm in length. In reality, this may not be the case. The relationship between changes in the attribute levels and changes in price may not be smooth, linear functions.

Other information that would improve the usefulness of the analysis presented here is estimates of the quantity bought by each distributor. This would mean that an actual demand curve would have to be estimated, which is difficult given the ordinal ranking data collected in a conjoint experiment. Respondents could be asked to allocate their expected purchases over the different products presented on each card. However, this assumes that the purchase of twice as much of one product over another yields twice as much utility. This is not necessarily consistent with utility theory.

While the methodological refinements discussed here would be useful, conjoint analysis nevertheless provides estimates of the value of product attributes in the aquarium market for *T. derasa*. The results presented in this chapter can be used in an optimisation framework by tridacnid clam producers. However, if the majority of the aquarium consumers prefer smaller clams, producers will have to examine alternative markets for larger clams. The seafood and shell markets can then be targeted. Incorporating the product attributes from these additional markets will allow the researcher to develop a joint optimisation model to predict how a producer of tridacnid clams can maximise profits in all three markets.

This technique can be further used in tridacnid clam market research investigating aquarium buyers' preferences between different species of clams such as *T. maxima* and *T. crocea*. A comparison of the costs associated with the production of different species can then incorporate the results from conjoint analysis to determine if it is worthwhile to diversify aquaculture species production.

The tridacnid clam attributes preferred by the distributors can be explicitly weighted against the costs of producing the attribute to design minimum cost/market share maximising products (Anderson 1987). As the aquarium markets for tridacnid clam products become more sensitive to distributor demands, producers will incorporate such information in their production decisions, product design and marketing strategies. This will suggest more efficient forms of aquaculture management resulting in a win/win situation for both producers and consumers of aquaculture products.

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Part IV

The Market for Tridacnid Shells

15 An Overview of the Shell Trade

Clem Tisdell

Abstract

An overview is provided of the domestic and international trade in giant clam shells. Observations on the shell trade in the Philippines, Indonesia, the Pacific islands, and Japan and other countries are followed by a consideration of the characteristics of shells permitting their use for purposes ranging from ornaments to floor-tile manufacture. The chapter concludes by considering the likely contribution of shells to the commercial success of giant clam mariculture enterprises.

Introduction

There is a substantial international and domestic trade in shells. Shells are usually traded for (a) decorative or (b) utilitarian purposes. Often, both the decorative and the utilitarian aspects of particular shells are significant. Shells are an important item in the souvenir trade. Souvenir shops at seaside resorts usually offer a range of shells and products made from them, but sales of shells for souvenirs are not limited to the retail trade at seaside resorts. Often, the shells used in the souvenir trade in developed countries are exported from less developed ones. On the whole, most developed countries, including Japan, are net importers of shells.

Some shells have high-value uses for jewellery and buttons, e.g. mother-of-pearl shells and trochus. Giant clam shells are purchased for ashtrays, soap holders, and food dishes, as well as for aquarium decorations, and for landscaping and interior design. Low-value uses for shells in some countries include use as aggregate for building material. Large quantities of stony coral and shells are used industrially for building, road construction, and lime production (Wells 1981).

Observations on the shell trade in selected countries

The Philippines

The Philippines has traditionally been the main exporter of ornamental shells (Abbott 1980) and appears still to be so. It is the main source of ornamental shells imported into Australia (Table 15.1). The Philippines exports large quantities of shellcraft items worldwide, many of which include mother-of-pearl and the window-pane oyster (*Placuna placenta*), known in the trade as Capiz shell (Wells 1981). Not all shells exported by the Philippines are obtained from its own waters. Supplies from Indonesia, for example, are re-exported. There is also a domestic market for shells, which are widely sold at tourist resorts in the Philippines (Figure 15.1).

Figure 15.1 'Petty traders' selling shells on the beach outside The Tourist Hotel, Dumuguete City, the Philippines (C. Tisdell, 1987).

Indonesia

Shells are a popular souvenir for tourists visiting the beach areas of Indonesia, where souvenir shops sell clam and other seashells and corals. Domestic tourists and local householders are the main purchasers of these products in the Jepara area of Indonesia, for instance. They buy clam shells for decorating their home gardens, ponds, and aquariums, and for ashtrays and ornaments in the house (Firdausy and Tisdell 1992).

Pacific Islands (Fiji and others)

In former times, the shells of many species of molluscs from coral reefs and lagoons were used by French Polynesians. The mother-of-pearl oyster (*Pinctada margaritfera*) was principally used for making of fish hooks and necklaces. Other molluscs, especially in atolls without volcanic rock, were also used as scraping tools and water containers (Salvat 1981). Such practices were common throughout the Pacific islands.

Japan and other countries

Over 13000 t of shell were imported by Japan from various supplier countries in 1988. These shells are used for processing and for other purposes (Chapter 4, this monograph).

Major exporters of shells apart from the Philippines include Japan, Taiwan, South Korea, and Australia. Exports from Japan, Taiwan, and South Korea include a substantial amount of re-exports. In the past, Taiwanese fishing and shrimp boats making long trips into the South Pacific collected shells as a sideline, and catalogues of Taiwanese shell dealers advertised a wide range of species from Philippine and Australian waters. These included volutes and cowries costing up to US$500 (Wells 1981). Australia's rich coral reefs have long been an important source of shells for collectors, but over-collection has led to the depletion of a number of species. The giant triton (*Charonia tritonis*), the giant helmet (*Cassis cornuta*), and the giant clam (*Tridacna gigas*) are now protected throughout Australian waters under the *Continental Shelf (Living Natural Resources) Act* (CSA) *1968* (Wells 1981). East Africa has also long been an important supplier of shells. Zanzibar was the main source of helmet and cowrie shells for the cameo industry (Boss 1969)

The U.S., Japan, and Europe are the main consumers of ornamental shells. The U.S. has its own sources off the coasts of Hawaii and Florida, but many of the popular species, including the queen conch (*Strombus gigas*), the queen helmet (*Cassis madagascariensis*) and the Florida horse conch (*Pleuroploca gigantea*) are now reported to be uncommon.

While Australia is both an importer and exporter of shells, it is a major net exporter in value terms. The Philippines is by far the major source, by value, of Australian imports of shells and similar items, followed by the U.S. and Taiwan. It is possible that a significant proportion of Taiwan's shell exports to Australia are re-exports, and some of those from the Philippines are likely to be also. It appears likely that U.S. exports to Australia consist mainly of items other than shells, because the imports are of very low value in relation to their mass. As for the destinations of Australia's exports of shells and similar products, the Republic of Korea is the main market by value, followed by Hong Kong, France, and Japan. Virtually all of Australia's shell exports are obtained from domestic sources. Exports to the Republic of Korea include high-value mother-of-pearl shell. Tables 15.1 and 15.2 give details of the value of Australia's imports and exports of shells and similar items.

Giant clam shells

Shells of clams are a marketable product and in the past have been traded internationally. In recent years, giant clam shells have been of greater commercial value than the meat and muscle of these molluscs (Juinio et al. 1987). Crawford et al. (1987) also found that the value of the shell exceeds that of the meat in many retail

Table 15.1 Australian imports of shells of molluscs or crustaceans, coral and similar products, by value and by country of origin, 1991–92

Country	Value $'000
Philippines	114
United States of America	29
Taiwan	18
Malaysia	17
Papua New Guinea	17
France	15
Japan	15
Other countries	18
Total imports	243

Source: Based on Australia Bureau of Statistics, Foreign Trade Australia, Merchandise Imports Detailed Commodity Tables, 1991-92, Catalogue No. 5437.0, Canberra, 1993, p. 23.

markets. However, in more remote locations, the shell is often valueless because of the high cost of shipping it to market (Tisdell 1986). Giant clam shells are often sold by shell shops at beach locations, irrespective of whether they are indigenous to the area.

Japan

The market for giant clam shells in Japan is diverse. They are used in sushi bars as serving dishes, in flower shops as vases, in furniture stores as decorative items, and in hotels. Souvenir shops sell them as gift items. Rental stores in Japan charge very high prices for the sale or rental of giant clam shells (Chapter 4, this monograph).

In September 1991, C. Tisdell visited souvenir shops in Ishigaki City and Naha in the far south of Japan. Substantial stocks of giant clam shells were available in these shops (see Figs 15.2 and 15.3). The prices observed for these in Ishigaki City are set out in Table 15.3. The most commonly stocked shells were *H. hippopus* and *T. squamosa*. Prices of giant clam shells in International Street, Naha, Okinawa, appeared to be about 20–30% higher than in Ishigaki City. No shortage of giant clam shells was apparent at the time. Although there were *T. gigas* shells in the shops (Fig. 15.4), they were not marked for sale but were used for display or as containers for smaller items for sale. While *T. squamosa* (the fingernail clam) is very colourful, it is purely decorative, as the 'fingernails' are inclined to break off unless the shells are handled carefully. Most of the giant clam shells available in souvenir shops in Japan appear to have been imported but some shells come from local sources (see Fig. 15.5).

Table 15.2 Australian exports of shells of molluscs, crustaceans or echinoderms and cuttle-bone, coral and similar material, unworked or simply prepared, by value and country of destination, 1991–92

Country		Value $'000
Republic of Korea		1448
Hong Kong		599
France		348
Japan		178
Thailand		67
Philippines		46
Singapore		36
Germany		20
Italy		20
Federated States of Micronesia		14
Egypt		11
Other countries		11
Total shells etc.		2796[a]
Coral and similar[b]		
Australian produce	3	
Re-exports	3	6
Total exports		2802

[a]Australian produce $2764000. Re-exports $32000
[b]Coral and similar products not included above
Source: Based on Australia Bureau of Statistics, Foreign Trade Australia, Merchandise Exports Detailed Commodity Tables, 1991-92, Catalogue No. 5436.0, Canberra, 1993, p. 23.

Philippines

Junio et al. (1986) reported the results of interviews with various shell dealers and visits to shell shops and warehouses in Zamboanga, Cebu, and Manila, and found that seven of the eight species of the tridacnids were used in varying degrees in the shell trade. Of these, *Hippopus hippopus, H. porcellanus,* and *Tridacna squamosa* were the most widely used, either as specimens/ornamental shells or materials for various shellcrafts (e.g. ashtrays, lamps, vases, and choker beads). International markets were established by the Philippines for the shells of the giant clam for such items as ornaments, ashtrays, and salad bowls. There was also considerable demand for large *T. gigas* shells, which are sold in their natural state

Figure 15.2 Display cabinet in a shell shop in Ishagaki City, Japan. Giant clam shells, *Tridacna squamosa* and *Hippopus hippopus* are a prominent part of the stock (C. Tisdell, 1991).

Figure 15.3 Display cabinet containing shell lamps including one lamp making use of a giant clam's shell. This photograph was taken in a shell shop in Ishigaki City. Giant clam shells are well represented (C. Tisdell, 1991).

Figure 15.4 A very large *Tridacna gigas* shell used as a display item in a gift shop in International Street, Naha, Okinawa (C. Tisdell, 1991).

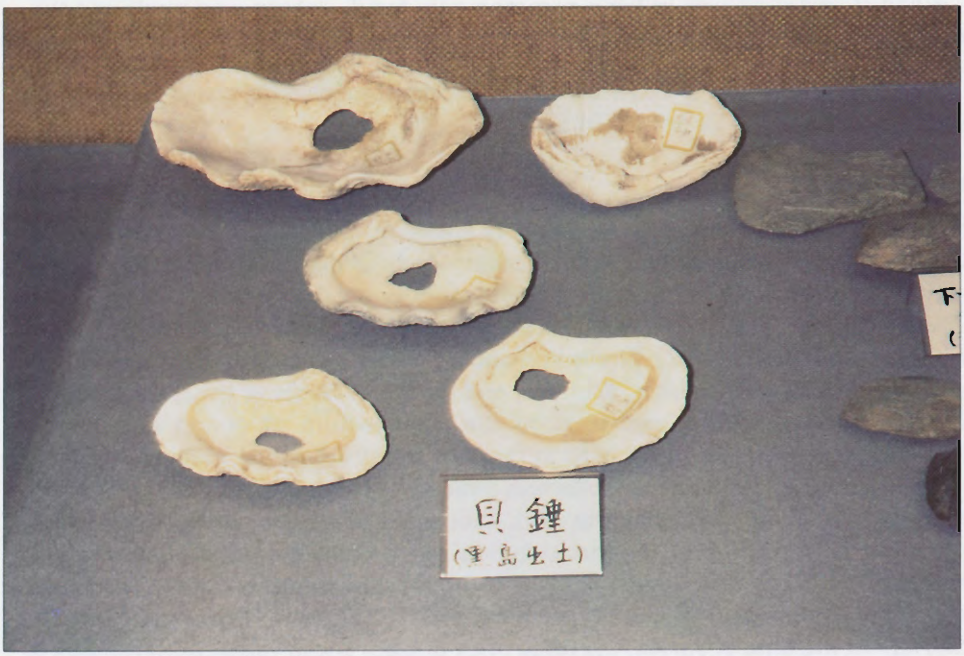

Figure 15.5 Giant clam shells on display at a hotel on Iriomote Island in the far south of Japan. In all probability, they are from this island (C. Tisdell, 1991).

Table 15.3 Prices observed for giant clam shells in souvenir shops in Ishigaki City, Japan, September 1991

Species	Description	Size (cm)	Price (¥)	$A (approx.)
H. hippopus	1/2 shell	8-10	1300	12.40
	1/2 shell	20	2500	22.22
	Full shell tied	≈5	400	3.70
	As above but better quality	≈5	600	5.55
T. squamosa	Full shell (coloured)	7-10	1000	9.26
	Full shell (coloured)	12-14	1500	13.89
	Full shell (coloured)	30	9000	83.33
T. maxima	1/2 shell	6	450	4.17
T. derasa	Full shell with light	28	12900	119.44

for use as bird baths, wash basins, and garden ornaments. *T. derasa* was often seen as a 'heavier' variety of *T. gigas* or *H. porcellanus* rather than being distinguished by shell dealers as a separate species. Small shells of *T. derasa* were found to be occasionally grouped with *H. porcellanus,* while bigger shells were grouped with *T. gigas. T. maxima* was in fairly common use, but *T. crocea* was rarely encountered in considerable quantities (Juinio et al. 1986).

The Philippines was a major centre for export of giant clam shells to Australia, Japan, and the USA (Tisdell 1989).

Indonesia

In past times, when they were more readily available, clam shells were collected for use as livestock troughs and water containers by Indonesian villagers. Coastal people placed large giant clams shells near wells, or outside their houses to hold or collect rainwater. They also used clam shells for building house walls and for fences (Firdausy and Tisdell 1992). Shells of giant clams are still collected for a variety of purposes, such as ornaments, ashtrays, and jewellery. Shells of the giant clam are broken into small chips and used in the manufacture of teraso and teralux floor-tiles, and are extensively used in modern constructions in Indonesia (Brown and Muskanofola 1985). Four collectors (traders) sell clam shells to the floor-tile industry in Central Java, Jakarta and East Java (Firdausy and Tisdell 1992). According to one trader of 20-years standing, demand for giant shell clams for this industry has risen. Every fortnight about 10–20 t of processed clam shells are purchased by the floor-tile industry in Jakarta, at a price (in April–July 1990) of Rp. 250/kg. At the time of survey, the retail price of clam shells varied from Rp. 500 to Rp. 5000 each depending on the size and species of shells and their appearance (Firdausy and Tisdell 1992).

Pacific island countries

According to Dawson (1986) fine giant clam shells in the size range 10–20 cm retail for $5–10 in the Pacific islands, sometimes less. This price range applied to imported shells, usually from the Philippines. Locally collected shells sold at the market vendor level appear to have very low 'reserve' prices, characteristic of an already over-supplied, buyer's market (Dawson 1986).

In Kiribati, large *T. gigas* shells are used as pig feeding troughs. Because of high shipping costs the shell is virtually worthless as an export commodity (Crawford et al. 1987). A pair of similar shells in good condition would fetch over U.S.$100 (Crawford et al. 1987) in the Philippines.

Clean, unprocessed clam shells are the most common form in which giant clam shells are sold in the Pacific. In Fiji, giant clam shells are readily available in the many tourist-orientated souvenir and craft outlets. In established, upmarket outlets, giant clam shells are available but, almost without exception, are imported. In Tonga, where there are fewer tourists than in Fiji, a local dealer accumulated giant clam shell for opportunistic sale to tourists, using a roadside plot for this purpose. Over 3000 shells were on display, mainly large (40 cm) *T. maxima* but with some *T. derasa*. Attractive smaller shells (15 cm) were available for $0.20, and large shells for $4.00. It was reported that the large *T. maxima* were being accumulated for an export order at $5.00 each; approximately 2000 such shells were on hand (Dawson 1986).

Australia

In 1990, 100000–120000 giant clam shells were sold in the Australian market (see Chapter 16). The most popular species for its shell is *Hippopus hippopus* (the horseshoe clam). It accounted for more than 80% of sales in the Australian market, and did so even when giant clams were not in as short supply as they were in 1990 (Herbert 1986). Horseshoe clams serve a number of utilitarian purposes. They can be used for as food containers, ashtrays, and soap holders. They are not easily broken and are suitable for microwave use. In addition, there are attractive markings on the back of the shell. A shell size of 15–20 cm is most popular.

Shells of *Tridacna squamosa* (the fingernail clam) are the second-most frequently sold of the clam species and are used mostly as indoor decorative items. The shells of *Tridacna porcellanus* (the china clam) are also in demand as indoor decorative items, but they were in extremely short supply.

Of the larger species of clams, demand is principally for the shells of the largest of all, *Tridacna gigas*, which are used mainly for outside landscaping (e.g. around pools) and for interior decorating. Preference is for the larger shells.

There is little demand for the shells of *T. crocea* (the burrowing clam). Neither do the shells of *T. maxima* and *T. derasa* seem to be in great demand. The outside of these shells is often 'pocked' like concrete, lacking in colour, and without an attractive conformance. The interior of these shells is usually off-white or cream.

Consumers prefer the insides of shells to be white, and as clean in appearance as possible (see Chapter 16).

Potential importance of giant clam shells for the commercial success of giant clam mariculture

A number of commentators have observed that in some markets the retail value of giant clam shells is higher than the value of their meat. This raises the possibility that it may be profitable to farm giant clams for their shells, or as an adjunct to their sale for meat. However, the latter would require giant clams to be shucked; that is, for the meat to be sold separately from the shell.

As noted in Chapter 16, species of clam which are most highly regarded for the quality of their meat are not necessarily those with the highest value shells. For example, *T. crocea* is highly regarded for its meat in the far south of Japan, but does not as a rule have an attractive shell. If shells and meat are to be jointly produced and marketed, the most economic species to choose for production depends on the value of both meat and shell. Supplies of aquarium specimens are, of course, incompatible with joint supply of shells, although it would be possible to sell the shells of specimens which die, or to grow separate batches for the shell market.

In the past, high transport costs in a number of the Pacific islands have limited the export of giant clam shells, particularly larger ones such as those of *T. derasa*, which are of comparatively low value (Tisdell 1986). However, the growing shortage of giant clams available from natural sources is liable to raise the price of shells, and it is possible for those farming giant clams to concentrate on the production of specimens with high-value shells. Conformation and shell colour are amenable to manipulation. Shell colour, for example, can be influenced by additions of various minerals to the water in tanks in which clams are held.

A sideline market outlet for giant clam farms catering for tourists is to sell shells to tourists. Because of their portability, even smaller shells are likely to find a good market. Also, small clams shells can be dipped in metal, e.g. silver, to enhance their desirability and, depending on taste, appearance. Such small shells can be used as pendants. Several types of shellcraft can be based on giant clams. The Micronesia Mariculture Demonstration Center in Palau caters for tourists, and has established a souvenir and gift shop which makes extensive use of shells from its giant clam farm. By selling on site, it avoids transport costs as well as providing tourists with authentic reminders of their visit.

Unfortunately, no detailed economic study has been made of the economics of producing giant clams for shells. Economic studies have usually concentrated on farming giant clams for meat, or for supplying specimens to the aquarium trade. The ACIAR-sponsored studies have had as their main focus the culture of giant clams for food and for the restocking of tropical reefs. So far, CTSA studies have also given little specific attention to the shell trade.

Concluding comments

The shell trade is a substantial one within which trade in ornamental shell is significant. In the past, giant clams have had an important niche in the market, for their decorative and utilitarian value. Supplies of giant clam shells from natural sources are now severely limited because of overexploitation of their stocks. Scope exists for farming giant clams specifically for their shells or for a combination of their shells and meat. In some cases, it may be more profitable to produce shells than meat, particularly as the quality of the shells can be manipulated under conditions of mariculture so as to supply the types in greatest demand. A strong case could be made to fund studies on the economics of producing giant clams for their shells.

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16 The Australian Market for Giant Clam Shells

Clem Tisdell

Abstract

This chapter contains the results of a survey of wholesalers and retailers of giant clam shells undertaken in Southeast Queensland in August 1989. The most common variety of clam shell sold was *Hippopus hippopus* (the horseshoe clam) with *Tridacna squamosa* (the fingernail clam) being the second most frequent. Shells of *Tridacna porcellanus* (the china clam) and of *Tridacna gigas* were also available but in extremely short supply. Only shells of these species appear to be in real demand. Shells of other species have unsatisfactory characteristics but shells of the species in demand are not perfect substitutes—the market is segmented. Information is presented on prices and quantities of clam shells sold. In January 1989, the size of the Australian market for giant clam shells appeared to be about 100 000 to 120 000 clam shells/year. Practically all clam shells were imported from the Philippines but supplies are becoming scarce as CITES takes effect and natural stocks become exhausted. This is reflected in the unavailability of larger shells and the sale of shells of lower quality than in the past. Tourists possibly account for 60–70% of sales of clam shells but only a small percentage (about 10%) of sales are to overseas tourists because of weight problems. A reasonably high proportion of clam shells appear to be purchased by restaurants and directly by householders. Practically all shell outlets expressed interest in obtaining clam shells from farms and provided information on the type of shells which they would like to see produced. Most thought that there would be a 'good' market for clam shells obtained by mariculture.

Background

A direct survey (using the questionnaire attached as Appendix 1) of souvenir/gift shops and of wholesalers of shells located in the Brisbane–Gold Coast–Sunshine Coast region was undertaken in August 1989. However, one wholesaler (Columbus Imports) from Sydney, New South Wales, was interviewed by phone and the results are also included in this report. This wholesaler is possibly the largest shell wholesaler in Australia and supplies shells Australia-wide, including to the

Brisbane-Gold Coast-Sunshine Coast region. The survey area ranged from Noosa Heads 120 km north of Brisbane on the Sunshine Coast, south to Tweed Heads at the edge of the Gold Coast. Map 11.1 (Chapter 11) indicates the general location of the survey area.

The population of the Brisbane-Gold Coast-Sunshine Coast region is approximately 1.5 million and it is a major tourist area receiving more tourists, including international tourists, than any other region of Queensland. The beaches of the Gold Coast and the Sunshine Coast are an important attraction of the area. Amongst other things, it was hoped as a result of the survey to establish the extent to which tourists, both domestic and foreign, have an interest in purchasing giant clam shells.

We attempted to survey all establishments marketing clam shells in the region. Using the Yellow Pages (Trade Directory) of the appropriate telephone directories as an initial source of information, we contacted all establishments by telephone that might be selling clam shells. Once it was determined that an outlet was or had been selling clam shells, arrangements were made for a direct interview.

There were 15 outlets in the survey. Of these establishments, three were wholesalers, one was both a wholesaler and a retailer, and eleven were engaged in the retail trade.[1] All respondents except one were currently selling giant clam shells or products made from them. The retail outlet which was not selling clam shells had sold them in the past but had discontinued sales because of a shortage of space in the shop. The shop did not intend to sell clam shells again in the future even though the shop received a number of enquiries from customers.

Varieties of clam shells sold, sizes and uses, market segmentation

By far the most commonly traded shell was that of *Hippopus* (the horse-shoe clam). Every outlet in our survey stocked shells from this species as can be seen from Table 16.1. In her survey of the Queensland market for shells undertaken in 1985-1986 Herbert (1986, p. 57) found that *H. hippopus* accounted for the lion's share of sales of giant clam shells in Queensland. While both demand and supply determine the actual proportions of sales of various types of shells, *H. hippopus* has a number of characteristics which make it very suitable for meeting a significant segment of demand. It has an attractive clean shell which is usually sparkling white with symmetric decorative reddish markings on the outside of the shell. It has a generous bowl-like cavity and can be machined on the outside so that it stands firmly as a bowl. It is quite sturdy and can be used in conventional and microwave ovens. The preferred size for this species appears to be 15-20 cm (6"-8") because it is widely used for ashtrays, soap holders, general purpose

[1] A list of respondents, their addresses and whether they are engaged in the wholesale or retail trade are given in C. Tisdell (1989, Appendix B).

Table 16.1 Number of outlets selling giant clam shells by species, features of shells and most popular sizes of shells

Species	Most popular size (cm)	Features	Number of outlets selling[a]
Hippopus hippopus	15–20	Versatile (ash tray, soap holder, *entree* and *mornay* sets); attractive markings on back of shell; not easy to break	14
Tridacna squamosa	15–25	Attractive appearance (with fingernails); used in bathroom or for decorative purposes	7
Hippopus porcellanus	25–30	Attractive appearance; resembles china (decorative)	4
Tridacna gigas	The larger, the better	Landscaping and interior design use	3
Tridacna crocea	–	–	5
Tridacna maxima	–	–	1
Tridacna derasa	–	–	0

[a]Total number of outlets selling clam shells—14.

holders and in mornay sets for entrees. The available sizes of shells for this species in outlets ranged from 10–35 cm (4"–14").

There appears to be a reasonably strong demand for *H. hippopus* shells. Their sales volume was relatively large even when other types of clam shells were not in as short supply as currently is the case. They combine utilitarian characteristics with aesthetic appeal.

The second most widely sold type of shell is that from *Tridacna squamosa*. Seven of the fourteen outlets (the number still selling clam shells) sold shells from this species which is commonly called the fingernail clam. While the shell is usually of a dull ivory-white colour, it also comes in attractive colours ranging from yellow or orange to pink and can have a ceramic-like sheen. These attractive colours and the shell's unusual form make it appealing as a decorative item. It is mainly used for this purpose and as a soap-holder. It is not as sturdy as *H. hippopus* and if it is roughly handled the fingers are inclined to break off. The sizes of shells on sale were in the 10–30 cm (4"–12") range. Because of its decorative nature and the fact that it is usually used as an ornament within the house, even the smaller sizes seem to be in demand.

While *Tridacna crocea* shells ranging in size from 8–10 cm (3"–4") were available in five souvenir shops, there does not appear to be a great demand for them because they are small, have little utilitarian value and the outside of the shell is generally rough and concrete-like in appearance because they are usually prised from their substrata. This species, which is popularly called the burrowing clam, is still relatively abundant.

Four souvenir shops were selling *Hippopus porcellanus*, or at least claimed to be. This is rather unusual given that this species is the rarest of the clam species and appears to be on the verge of extinction in the wild. The available sizes appear to be in the 25–50 cm (10–20") range. The shell of this species, which is popularly called the china clam, are thin and delicate (has the quality of thin china ware) which makes the item most attractive. They are almost translucent and the white colour in them is a pure white. This shell is subject to breakage and cannot be used in the same way as that of *H. hippopus*, e.g. for entrees. Nevertheless, because these shells have a very attractive appearance they tend to sell more rapidly than those of *H. hippopus* when both are available. One wholesaler (The Golden Cowrie) has been unable to obtain stocks of *H. porcellanus* shells for the last four years and believes that any available supplies are being sent to Japan for jewellery making.

Three souvenir shops had stocks of shells of *Tridacna gigas*, the largest of the clam species, although they were seen on sale only at one shop (Doug's Souvenirs) and ranged in size from 30–60 cm (12–24"). They had been obtained several years ago with a shell consignment from the Philippines. The shells of *T. gigas* can be over 1 m in size and are used both for indoor and outdoor decoration. The shells are whitish and sturdy and relatively smooth on the outside with regular conformation.

Larger *T. gigas* shells are in great demand but their supply is inadequate (has virtually dried up) due to eradication of much of the natural stock and the operation of the Convention on International Trade in Endangered Species (CITES). For example, the 'Big Shell' believed that it could sell about ten *T. gigas* shells a week if they were available. The wholesalers W.W. Trading, Columbus Imports and The Golden Cowrie all indicated a large demand for big *T. gigas* shells and a shortage of supply. Mr McLeod of The Golden Cowrie said there was a big demand for *T. gigas* by interior decorators and landscape designers.

While the owner of the 'From Down Under' shop said that he was selling *Tridacna maxima* shells none were in the shop at the time of the visit and there did not seem to be a large quantity of sales of these.

Shells of the second largest of the clam species, *Tridacna derasa* were not sold by any of the outlets. The shells of this species are not very attractive. Their exterior is concrete-like in appearance, pitted and rough as a rule, and the inside is often off-white rather than pure white.

Thus it can be seen that the shells of only four species of giant clam, namely *H. hippopus, T. squamosa, H. porcellanus* and *T. gigas* seem to be in real demand for the shell trade. There appears to be little demand for the shells of *T. derasa, T. crocea* and *T. maxima*. The shells which are in demand have rather different uses. Shells of *T. squamosa* and *H. porcellanus* appear to be sought mainly as smaller indoor decorative items, whereas those of *T. gigas* are sought as larger indoor decorative items and for exterior landscapes. Shells of *H. hippopus* seem to have the most practical use and at the same time they are attractive in appearance.

The market for clam shells appears to be segmented. Small shells of *T. gigas*, because they are less beautiful, do not seem very substitutable with those of *H. hippopus, T. squamosa* and *H. porcellanus*. They do not appear to have as many practical uses as those of *H. hippopus*. Large *T. gigas* shells seem to have no close substitutes as decorative items.

Souvenir shops have tried to concentrate on the size range of clam shells which are most popular with consumers. For *H. hippopus* this appears to be 15–20 cm, for *H. porcellanus* 15–25 cm, for *T. squamosa* 15–25 cm and for *T. gigas* sellers would like shells as large as possible. But unavailability of adequate supplies, except for *H. hippopus*, appears to prevent them attaining their desired range.

Prices

From the survey, wholesale and retail prices of shells being traded in August 1989 were obtained. The market was small for shells of all species other than *H. hippopus*. The unweighted average prices wholesale and retail for *H. hippopus* shells are shown in Table 16.2 and Figure 16.1. These prices are average prices for outlets trading in these shells.

In the most frequently traded size range 15–20 cm, the average retail price for *H. hippopus* shells was A$3.22 and wholesale A$1.55. The retail margin was a little over 100%. The margins for other sizes were higher. Primary suppliers of shells could expect to receive less than the wholesale price.

Table 16.2 Average retail and wholesale price according to size of *Hippopus hippopus* shells

	Average prices (A$)				
Size	10–15 cm	15–20 cm	20–25 cm	25–30 cm	30–35 cm
Wholesale	0.59	1.55	3.40	0	3.98
No. of observations	4	9	4	0	1
Retail	2.04	3.22	9.32	14.50	23.31
No. of observations	5	11	3	1	3

Figure 16.1 Average retail and wholesale prices of *Hippopus hippopus* shells according to size as at August 1989.

Prices for *H. porcellanus* shells are higher on average than for *H. hippopus*. From the sketchy information available from our survey, the wholesale price of *H. porcellanus* shells in the 20–25 cm range appears to be about 4–5 times higher than that for *H. hippopus*. Whereas the shells of most clam species are traded as half-shells, the shell of *T. squamosa* are usually traded as complete shells (that is as paired shells). Paired shells of this species of 15 cm size were available wholesale at A$2.50/pair. On a half-shell basis, these shells were therefore just a little less expensive than *H. hippopus* of a similar size. Virtually no trade occurred in *T. gigas* shells but one retailer quoted A$39.95 for a 60 cm shell and about A$80 for the largest sized shells (0.9–1.2 m).

Despite the worldwide shortage of stocks of giant clam shells in 1989 most respondents suggested that prices had been relatively stationary in the last few years. However, one wholesaler (W.W. Trading Company) said that prices had risen in real terms by 40% in the last 10 years and one retailer (Savoy Souvenirs) said that giant clam shells had gone up considerably in price in the last year.

As for whether the supply of clam shells is sensitive to price (Question 18 of survey) the results from the survey were inconclusive. While slightly more respondents answering this question believed the supply to be sensitive to price (5), almost as many thought otherwise (4) and there were a large number of respondents who did not answer this question (6).

Question 9 was designed to provide evidence on the responsiveness of price to variation in supply of clam shells. Overall it emerged that price was relatively inelastic in relation to supply (which means that demand is relatively elastic in relation to price). Most respondents thought that up to a doubling of supply of clam shells would lead to a reduction in price of clam shells by less than one half. Eight respondents thought this to be so. One respondent had the opposite opinion and six did not answer this question. If the majority view is correct, an increase in supplies of clam shells will lead to some reduction in price, but also to a rise in total revenue. Many respondents believed that up to a 20% increase in supply of clam shells would make no difference to prices. It seems that the market for shells may not be as limited as one might initially imagine. Demand at least seems to be rather elastic in the current price range.

Quantities sold of shells, sources and availability of supply

The wholesalers in the sample were not very specific about the quantity of their sales of clam shells. One said many thousands were sold by him, another sold 3000–4000; another said not so many now were sold as in the past and another said several hundred were being sold. Together they indicated that they could sell over 10000 clam shells/year in the Australian market if they were available. The retail outlets in this sample together sell approximately 15 000–21 000 clam shells/year and earn in the order of $40 000–55 000 in total revenue from clam shells (see Table 16.3).

Table 16.3 Approximate quantities of clam shells sold, revenue from sales and quantities of clam shells that could be sold by establishments

Establishment		Approximate quantity sold	Approximate revenue	Quantity could sell
1	Wholesaler	Many 1000's	–	Maybe 50 000
2	Wholesaler	3000–4000	$6000–8000	Larger quantity
3	Wholesaler	Not many now	–	Tens of thousands
4	Wholesaler and retailer	Several hundred	–	Possibly 20 000
5	Retailer	2000–3000	$4000–6000	–
6	Retailer	300	$1050	–
7	Retailer	1800	$6000	–
8	Retailer	1000	$2500	–
10	Retailer	500	$1200	–
11	Retailer	200 +	$600–700	–
12	Retailer	150–200	$600–800	–
13	Retailer	500–700	$3000–4000	–
14	Retailer	A few hundred	–	–

Virtually all clam shells entering the Australian trade in this region were imported from the Philippines. This was also the case in 1985–1986 (Herbert, 1986). Herbert found that about 86% of shells sold in Australia were imported in 1985–86, mostly from the Philippines.

Approximately five respondents indicated giant clam shells to be in short supply and six said that this was not so but the answer of one of the six was qualified by saying that larger shells are now in short supply. Overall answers to questions 11 and 21 indicate that larger clam shells and those of *T. gigas* are now in increasingly short supply. Answers to Question 21 indicate that many outlets find available supplies of larger clam shells have dwindled and shells of *T. gigas* to be difficult (almost impossible) to obtain. In part, this is consistent with a pattern of overharvesting of natural stocks and the changing of composition (distribution) of the natural stock as harvesting pressures on it reduces populations. It is evidence of the precarious position of natural stocks. Apart from the actual natural scarcity of *T. gigas* due to depletion, CITES seems to be having some effect in limiting trade in its shells.

Some of the comments on Question 21 were as follows:

> 'Clam shells are getting more expensive and harder to get. The larger ones are no longer available. We used to sell more of the smaller ones when they were very cheap—99c.' (Savoy Souvenirs)

> 'Clam shells are getting harder to get especially good quality ones. Our range of clam shells has changed because we cannot get big ones.' (The Big Shell)

Type of customer purchasing giant clam shells

The type of customer purchasing clam shells varied somewhat by the location of the retail souvenir shop. Overall tourists (mostly Australian) accounted for more than half of sales by value but there was also a surprisingly large proportion of clam shells purchased by local householders.

One of the largest retailers of clam shells (Savoy at the Gold Coast) said that most of its sales of clam shells were to tourists and restaurants. It estimated that 80% by value were to tourists, but of this only 5% were to overseas tourists because clam shells were considered too heavy to carry e.g. by plane. The 'Big Shell' at the Sunshine Coast reported a similar pattern of purchases with 90% of sales to tourists and 10% to overseas visitors and said that this was low because of the weight problem. It was said that 'Germans love shells' and were amongst the main overseas customers. 'Doug's Souvenirs' reported 80–90% of its clam shells being sold to tourists with only 20% being sold to overseas tourists (mainly New Zealanders) because they are too heavy. Seaworld reported that most of its sales were to Australian tourists with a small proportion being sold to overseas visitors, with New Zealanders being the principal purchasers from overseas.

Curran's Corner (another major retailer of clam shells) located in Brisbane estimated that 50% of its sales of clam shells were to tourists of whom 20% were from overseas. Similar percentages (but a lower percentage of sales to overseas visitors) were reported by Cotton Tree Souvenirs. 'From Down Under' and 'Wharf Souvenirs' estimated that only 30% and 25% of their sales were to tourists with a low percentage of them being to overseas tourists. Italians were prominent purchasers from Wharf Souvenirs.

'Jewels of the Sea', Stafford, Brisbane, reported that most of its sales were to local householders buying clam shells for use in their homes. Only 10% of sales of clam shells were to tourists and of these only 1% were to overseas tourists.

The evidence suggests that more than half of clam shells retailed in the region are sold to tourists with the proportion being highest at beach resorts. Over 80–90% of sales to tourists appear to be to domestic tourists. The low percentage of sales to foreign tourists seems to be on account of the weight of the shells. Sales of giant clam shells for local household use are surprisingly high.

Market prospects for giant clam shells obtained from mariculture

Most outlets (11) said that they would be interested in selling clam shells from clam farms (Question 8). Two did not answer the question, one said 'No' without giving a reason, and the other saying 'No' had gone out of clam shells altogether and did not plan to begin selling them again. Two wholesalers saying 'Yes' said that it depended on the price of farmed shells being commercially acceptable. Two retailers saying 'Yes' added comments. One said it is interested especially in big shells and another stressed that there was a large demand amongst tourists for Australian products so clam shells from Australian farms would gain greater purchaser acceptance on this basis if identified. Clearly there is widespread interest among present sellers of giant clam shells in obtaining shells from mariculture.

Sellers of clam shells were asked (Question 16) 'If clams are to be bred for their shells, which characteristics would you like to see breeders concentrate on from the point of view of obtaining sales?' Answers received were as follows:

1. Ensure good clean shells. Unless they are white inside they will not sell. In *T. gigas* try to breed for prominent 'teeth' and grow shell to at least 25 cm in size.

2. Like to see *H. hippopus* (*H. maculatus*) grown.

3. Shells should have a lack of encrustation. Surface should be smooth. Inside they should be pure white because people eat from them and this colour gives an impression of cleanliness and purity.

4. Bigger clams would be better.

5. Attractive colours and patterns, with pleasing texture and white inside.

6. Nice and white. While shells of the china clam are very popular, they are thin and can break more easily than those of *H. hippopus* which are much stronger.

7. Larger shells.

8. Larger shells without imperfections.

9. Good clean shells. China clam shells.

10. The whiter they are the better. China clams sell well because they are thin and delicate and white.

11. Breed for attractive patterns on the outside. Pairs are very popular and it would be excellent if large-sized shells could be grown in a short period.

From the above, it is clear that whiteness, especially on the inside of shells, is an important characteristic and encrustations and surface imperfections should be absent. *H. hippopus, H. porcellanus* and large-sized *T. gigas* were mentioned as species where cultured shells would fill a market need. In general, outlets were hoping to obtain larger-sized clam shells from farms because it is here that an immediate gap existed in the market.

In Question 20, outlets were asked whether they consider there to be good prospects for expanding the demand for clam shells, especially from clam farms. Answers were mostly related to the market prospects of shells from farms and were as follows:

1. Yes, good prospects, especially for big shells.

2. Yes, because stocks are running low.

3. Yes, with clam meat being used in Japan and Australia as well.

4. The largest Australian wholesaler of shells said: Possibly, provided there is a regular supply of about 50 000 shells/year. At present clam shells come from Third World countries where labour costs are low and the price of clam shells is also low.

5. Yes, provided farming can extend the range of clam shells available.

6. Yes, especially if advertising is used to expand demand. Clam shells will always be popular.

7. Yes.

8. Yes, since there is a strong demand for clam shells.

9. Yes.

10. Yes. Good market for shells. Australian firms should consider exports. Within Australia, Australian cultured clams can reduce clam shell imports, especially from the Philippines.

11. Yes. This large wholesaler said he could sell tens of thousands of extra clams if they happened to be available.

Two respondents said No. One added, 'unless someone thinks of a good idea for using them' and the other said 'Maybe an expansion of 30–40% in Australian supplies of shells from farms would have good prospects. But beyond this the Australian market would be too small to absorb the extra supply'. The remainder of respondents did not answer this question. In general, sellers of shells seem to think that there are good prospects for selling clam shells obtained from mariculture.

Respondents were also asked if they wished to make any general comments about the economics of possibly farming giant clams for their shells. The following comments were received:

1. Supplies of shells should be available at stable and consistent prices and continuity of supply is important.
2. Economic success of farming will depend upon finding a market for the clam meat.
3. The Australian market is too small to support farming. Need exports to U.S. and Europe.
4. Farming has potential if it can supply a greater range of types of clam shells than those now available.
5. Must sell at a competitive price with supplies from natural sources. Prospects for sale in Australia better if product identified as Australian.
6. Prices should be reasonable.
7. Very big shells will find a ready market.

Discussion

Supplies of clam shells are clearly becoming shorter (1989) as evidenced by the lack of availability of larger-sized shells, increased reliance on lower grades of shells and the absolute shortage of *T. gigas* shells and those of *H. porcellanus*. As CITES becomes more rigorously enforced and existing stocks of clam shells held by wholesalers and retailers dwindle, the shortage will become more evident because no new stocks can legally be imported. It would seem therefore that this would leave a potential market in Australia for about 100000 clam shells/year, the bulk of which is currently filled by shells of *H. hippopus* (horse-shoe clams). There is a potential for Australian giant clam farms to fill this gap. However, at present preferences are for larger-sized shells but these still take longer to grow and are more costly to produce. But the gap is probably larger than 100 000 for apart from wholesalers some retailers import clam shells directly from the Philippines. Nevertheless the Australian market probably does not exceed 120000/year, and could be met by a few (2 or 3?) clam farms.

The quantity of annual sales of shells in Australia might be extended beyond the 120000/year mark by advertising and promotion. Also attention needs to be directed to creating greater demand for smaller sized shells in order to obtain greater sales to overseas travellers who do not purchase larger-sized shells because of weight problems. There would seem to be scope for marketing smaller shells as Australian identified products associated with the Great Barrier Reef. Brightly coloured small giant clams from *T. squamosa* are often purchased by overseas tourists in the Philippines.

Whether or not the shell will be a marketable by-product for clam farms will depend upon whether clam meat is marketed in the shell or separated from the shell and say chilled. In the latter case, the shells would be available as a by-product. However, it may conceivably be economic to grow some types of clams for the value of their shells alone.

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Appendix 1

Survey of souvenir shops re demand for clam shells and products made from giant clam shells

Confidential August, 1989.
(Please answer questions wherever possible)

1.	Name, address and telephone number of outlet
2.	Do you sell shells of Pacific giant clams or products made from their shells? Yes/No If Yes go to question 5 If No go to question 3
3.	Have you sold Pacific giant clams in the past or products made from them? Yes/No If Yes to question 3, why have you discontinued selling them? If No to question 3, did you have a special reason for not including them in your stock?
4.	Would you be interested in possibly selling Pacific giant clam shells in the future, for example from farmed stock? Yes/No
5.	What range of giant clam shells do you sell?
6.	From where do you get your stock?
7.	Why have you concentrated on the particular range which you now sell?
8.	Would you be interested in the possibility of selling clam shells from farms? Yes/No
9.	What prices are you charging for your clam shells? (Please specify by size, type and quality to extent possible.)
10.	How much are clam shells costing wholesale these days? (Please specify by size, type and quality to extent possible.)
11.	Do you consider shells to be in short supply at present? Yes/No
12.	Farmed shells could well be in the smaller size range (<10 cm, 10–15 cm, 15–20 cm). Would you please comment on the extent of demand in these price ranges? For example, would you agree that there is little demand for shells in the 10–15 cm range or in these smaller size ranges?
13.	Could you please give some indication of the type of customer who buys clam shells? For example, are they mostly tourists?
14.	What percentage of your sales (by value) are in your view made to tourists and visitors to your area?%
15.	What percentage of your sales (by value) would in your view be made to overseas visitors?%
16.	If clams are to be bred for their shells, which characteristics would you like to see breeders concentrate on from the point of view of obtaining sales?
17.	Has the price of clam shells risen in recent times? Could you give some indication of the price change.
18.	Do you feel that the market price for shells of clams is likely to be very sensitive to changes in the available supply? Yes/No

19.	Please complete the following: I expect: (a)A 20% increase in clam shell supplies to reduce the current price of clam shells - by 20% - by less than 20% - by more than 20% (b)A doubling of supply of clam shells to reduce their current price - by a half - by less than a half - by more than a half (c)A fivefold increase in the supply of clam shells to reduce their price - to one-fifth of current price - to a lower price than this - to a price not as low as one-fifth of the current price.
20.	Do you consider there are good prospects for expanding the demand for clam shells, especially from clam farms? Yes/No. Please elaborate
21.	How has the range of shells which you offer changed in recent years? If the range has changed please give reasons for the change.
22.	Do you sell any products manufactured from giant clam shells? Yes/No If Yes, please list
23.	Are you finding it increasingly difficult to obtain products made from giant clam shells? Yes/No. Please comment
24.	What products made from giant clam shells are in particular demand?
25.	Approximately how many clam shells do you sell/year? What would approximately be the value of your revenue from these?
26.	Are there any general points that you feel should be made about the economics of possibly farming giant clams for sale for their shells?
27.	Would you like a complimentary copy of the report on this survey? Yes/No

Thank you very much for your co-operation,
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University of Queensland,
St. Lucia, 4067.
Tel. (07)365 6306

Part V

Business Strategies and the Economics of Production of Tridacnids

17 Business Strategies for the Growing of Giant Clams

Clem Tisdell

Jeremy Barker

Bruce Stevens

Abstract

This chapter outlines development strategies of firms which have engaged in giant clam mariculture, particularly Australian firms, with special attention being given to Reefarm Pty Ltd, the longest surviving *commercial* company involved in giant clam mariculture. Considers methods which companies in this area have used for coping with business uncertainty, examines the development of Reefarm Pty Ltd and the choice of product-mix by Reefarm. The product mix involves pearl oysters, and supply of giant clams for a variety of markets (the aquarium trade, seed sales, the restaurant trade for food and provision of tourism/educational services). The analysis indicates the importance of considering the development of firms from an evolutionary perspective.

Introduction

Commencing any new business venture is always a risky enterprise. This is even more so when a new product is to be produced for which production techniques are new and evolving and markets are only partially or incompletely established. Enterprises embarking on the commercial mariculture of giant clams (*Tridacnids*) have had to contend with the latter situation. In the last decade, techniques for the mariculture of giant clams have been evolving and, in most developed countries, markets for giant clams have been very limited, for example mostly to their sales as aquarium specimens or to the sale of their shells collected from the wild and in a few places, such as Okinawa, to their sale for food. Commercial farming of giant clams has required the establishment of market structures to take care of the farmed product.

Despite the above risks and difficulties, several enterprises have embarked on the commercial growing of giant clams. It is worthwhile considering the business strategies which they have employed. In this study the main focus will be on Reefarm Pty Ltd, the longest surviving commercial farm involved in giant clam farming—an enterprise which it embarked on in 1984. It operates a land-based marine hatchery and growing facilities on Fitzroy Island near Cairns, in northern Australia. It was started by a small group of Cairns entrepreneurs but today (1993), Bruce Stevens is the only remaining shareholder from the original group. The company continues to produce giant clams commercially.

Other Australian ventures have tried giant clams. Pacific Clams Ltd was formed for this purpose and managed by Bruce Marcum. Its headquarters were also in the Cairns area. Its aim was to engage in entirely marine-based aquaculture of giant clams using floating pontoons and platforms. It secured a small marine lease off Fitzroy Island and also had a lease at Sudbury Reef on the Great Barrier Reef. Its approach to the farming of giant clams was highly experimental/innovative and considerable investment in capital for its structures were required. It went into liquidation before it was able to achieve significant production and sales, partly because of cash flow problems and the destructive impact of a cyclone on its marine-based facilities. It concentrated on the production of *T. gigas*. It seems that the market for its product was very uncertain.

In 1986, Seafarm Ltd was operating saltwater land-based aquaculture facilities near Innisfail. Its prime purpose was to produce seed prawns (shrimp) but it also held some giant clams when Dr Rick Braley was there. This facility was struck by a cyclone which caused considerable damage including destruction of many circular corrugated iron pools containing giant clams. Remaining giant clams were transferred to Orpheus Island when Dr Rick Braley joined the ACIAR Giant Clam Project there. So Seafarm Pty Ltd never actually embarked on the process of using its giant clams commercially.

It was also reported that Kaillis Brothers, a large Australian fishing enterprise, experimented for a short time with the culture of giant clams in the Gulf of Carpentaria. Juvenile clams were sent from Orpheus Island near Townsville but the temperature of the waters of the Gulf were too hot in the summer for these juvenile giant clams to survive. However, giant clams do exist in the Gulf of Carpentaria and if local animals are used as broodstock they may be more likely to survive.

In 1989, W.A. Clams made an application to the Fisheries Department of Western Australia for a licence to mariculture giant clams of the species *Tridacna gigas* in Exmouth Gulf using a land based hatchery and an adjacent marine growout area. While we lack information on how that application/venture fared, it is interesting to observe from the application for the licence, the paucity of information which the principals of the proposed venture appeared to have had about the market for their product. They said, in the application (p.2), 'It is proposed to market the product in Southeast Asia. Definite plans are not presently available but enquiries are underway. The present illegal operation of Taiwanese clam boats indicates the strong demand for the product, as does the expansion into clam mariculture in the Pacific. It will be at least three years from the commencement of this project until harvesting, thus, sufficient time is available for market development.'

Like many other enterprises, W.A. Clams seemed prepared to make a substantial capital outlay *before* determining the market for its product, the cost of developing this market and the expenses of delivering and distributing its product to market generally.

Mention might also be made of the efforts of James Cook University to establish a joint commercial venture to mariculture giant clams. In 1989, James Cook University advertised for a joint venture partner, and an agreement was signed with a company controlled by David Clark, a Queensland businessman. An economic feasibility study financed by David Clark's company was to be undertaken and if the venture appeared to be economically feasible, James Cook University was to receive a 12.5% shareholding in the joint venture company *gratis* for its assistance. Financial constraints resulting from the economic recession, however, meant that David Clark's company could not continue with this joint venture development and another partner was found. The final outcome, however, was that the venture did not proceed.

Outside Australia, commercial enterprises for the growing of giant clams exist in the Marshall Islands and in Samoa. The farm operating in the Marshall Islands is reported to be facing financial difficulties for a number of reasons. These include:

1. The fact that the Marshall Islands is not a signatory to CITES making it difficult to export the product of the farm.
2. The farm is located on an island to which transport is difficult. This apart from adding to shipping and other costs, means that the facility cannot be used as a tourist attraction.
3. *T. gigas* is being grown and this species may not be best for tapping existing markets for giant clams, e.g. the market for aquarium specimens or the Japanese market.

The Micronesian Mariculture Demonstration Center (MMDC), Palau, has a long history of involvement in the aquaculture of giant clams. It has gone from a facility virtually completely dependent on government funding (much of which was supplied through United States aid) to one which must generate a substantial amount of its own revenue. As a result, its giant clam operations have had to be commercialised. It earns revenue through:

1. The sales of giant clams as aquarium specimens.
2. Fees charged for tourist visits.
3. Sales to tourists of souvenir items relating to giant clams, e.g. shells, standing lights using clam shells as shades.
4. Sales of giant clams for meat to local restaurants in particular.
5. Sales of seed clams.
6. Fees for training individuals in the techniques of giant clam farming.

It therefore has a relatively diversified market for its clams.

It has been reported (J. Heslinga, pers. comm., June 1992) that a new giant clam farm is to be established in Palau. This is to be entirely commercial and is planned to be the world's largest giant clam farm. We have no knowledge of the business strategy that it plans to adopt.

Coping with uncertainty in business

Since to embark on giant clam farming in the early phases of the development of this industry is clearly a risky and uncertain enterprise, it may be useful to review some of the general means which firms use to cope with business uncertainty. These include:

1. Information gathering and learning.
2. Experimenting continuously on a small scale e.g. by trial-and-error.
3. Diversifying in terms of the range of products produced and in relation to markets served.
4. Ensuring that equipment and techniques adopted have multiple uses. This aspect involves making sure that equipment is flexible or adaptable in use. It will be more flexible if it can be easily used for producing a number of different products.
5. Risks may also be reduced for individuals by ensuring that the venture is based upon the participation of a large number of individuals each holding a small proportion of the capital of the business as in a joint stock company.
6. Risks may also be reduced by ensuring that the non-escapable and/or possible sunk costs of the venture are low. For example, less durable equipment than is likely to be optimal if the venture is proven viable may be installed initially if this equipment is cheaper. If the venture is not a success the financial loss on this equipment may be smaller. Or again, where possible it may be preferable to rent or hire equipment or lease it rather than purchase it initially.

While some of the firms embarking on the mariculture of giant clams seem to have taken some account of these principles, many did not. For example, Pacific Clams Ltd invested heavily in equipment with a specific purpose—namely for the ocean-based cultivation of giant clams. Thus a large sunk cost was incurred. Its equipment was not flexible and adaptable to other uses. Furthermore, it adopted in a non-incremental manner unproven experimental methods of production. It failed. Conceivably, the theories of its managers could have worked out, but since they did not in practice, the company faced a substantial loss. It seems also that Pacific Clam Pty Ltd was not very diversified, nor very sure of its markets. As observed earlier, W.A. Clams had very little market knowledge, but was still prepared to take a risk and go ahead with its investment.

In the light of the above, it is useful to consider the approach taken by Reefarm Pty Ltd—the longest surviving *commercial* enterprise involved in giant clam mariculture.

Some background on Reefarm

Reefarm Pty Ltd is a relatively small business which operates a marine hatchery/nursery at Fitzroy Island. It was founded by a group of Cairns entrepreneurs. Due to unforeseen circumstances two of the original principals are no longer involved with the company so Bruce Stevens is the only remaining principal. It is now essential for the firm to obtain a satisfactory cash flow since means for covering its deficits have become limited.

The manager says that the main aim of the company is to realise a profit. Recent developments such as tourism and the production of the seed of South Sea pearl oysters have been an important means of adding to the company's cash flow. Although the mariculture of giant clams is less profitable than that of pearl oysters, Reefarm expects to continue producing giant clams for the reasons to be discussed below. This production will continue to be restricted to land-based operations unless extra (venture) capital is injected into the company from outside e.g. through the formation of a joint venture to make use of its Arlington Reef lease. Since its inception, Reefarm has concentrated on land-based mariculture (in contrast to Pacific Clams) even though it has a lease on Arlington Reef which makes growout of giant clams possible.

At its Fitzroy Island site (see Figures 17.1–17.3), Reefarm has cultured species other than those now being cultured, namely giant clams and South Sea pearl oysters. In the past these have included prawns (shrimp) and barramundi but these are no longer being produced. Most growers of barramundi in the region, mainly cane farmers, now breed their own barramundi so insufficient demand exists for hatchery supply of barramundi fingerlings. Clearly the company has *explored* a number of commercial possibilities in the past and tried these. Search and exploration have been an important part of its business behaviour.

It has also engaged in experimental behaviour to increase its yields from giant clam mariculture. An earlier manager of the aquaculture facility, Phillipe D'Or, experimented with the addition of fertiliser to tanks so as to enhance the growth rate of giant clams. Reefarm was one of the earliest organisations to use fertiliser for this purpose, even though at that time the most effective ingredient had not been identified. Now ammonium-based agents are known to be the most effective growth-enhancing agents.

In addition, macroalgal bloom in tanks were a problem. Phillipe D'Or found that amphipods were effective grazers on the algae. This was an important discovery for Reefarm making the holding of giant clams in land-based tanks practical over a long period of time. But as with many discoveries, it was, to a large extent, a chance discovery.

Another 'chance' event which has recently benefited Reefarm has been the growth of tourism to Fitzroy Island. The extent of this growth was probably not fully anticipated at the time of establishment of Reefarm. The Daikyo tourist development on the island has been a factor encouraging this growth. Tourist visits to Reefarm's facilities have now become an important revenue earner for the company. Management believe that up to 100 tourists per day could visit Reefarm's facilities, especially if this visit becomes part of the package of the tours offered by 'Sunlover Cruises' and 'Great Adventures'.

Figure 17.1 Jetty at Fitzroy Island

Figure 17.2 An overview of tanks at Reefarm on Fitzroy Island

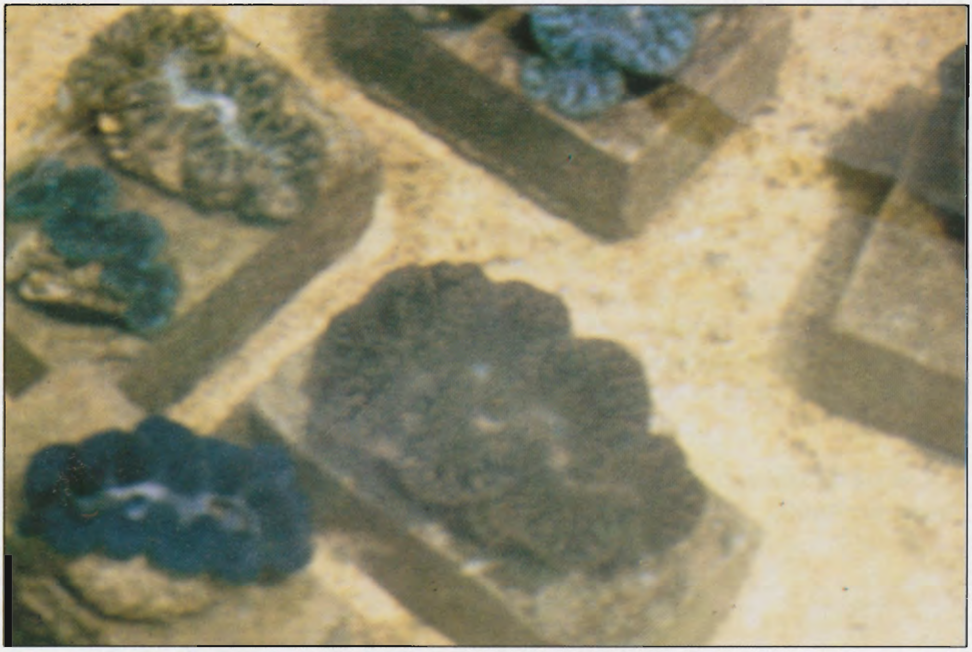

Figure 17.3 *T. crocea* and *T. maxima* broodstock at Reefarm.

It can be seen that exploratory, trial-and-error behaviour has influenced the development of Reefarm. The company has tried exploratory (trial-and-error) behaviour in its search for profitable possibilities which if discovered can become routine, if the outside world does not change too rapidly. Its behaviour is rather different to that suggested by static models in microeconomic textbooks.

Since inception (up to the end of 1992) Reefarm had not operated profitably and has encountered cash flow problems. To improve the profitability of its operations, it commenced production of South Sea pearl oysters in 1991 and in July 1992 embarked on the use of tourist visits to the hatchery/aquarium as a means of generating revenue. These activities were added to its activities involving the rearing of giant clams. The giant clam species being cultured are (1) *Tridacna crocea*, (2) *Tridacna maxima* and (3) *Tridacna gigas*. Thus basically three main commodities are being produced at Reefarm: (1) giant clams, (2) South Sea pearl oysters and (3) aquarium-based tourism services.

Three to four people are employed at Reefarm (November 1992). Three are concerned entirely with aquaculture facilities whereas the fourth person mainly acts as a tourist guide.

The land area available to Reefarm at Fitzroy Island is relatively small but at present is not fully utilised. Only about half of the area available for growout tanks is used at present. The company could achieve economies of scale if it could utilise all the space for holding tanks. Depending upon the demand for its products the company plans to expand the number of its tanks, all of which are made of fibre-glass. These are considered to be much better than splasher pools with polythene liners because they are more durable.

Reefarm has a small marine lease at Fitzroy Island. However, it has a lease of 67 hectares on Arlington Reef, some considerable distance from Fitzroy Island. This was intended for the growout of *Tridacna gigas* and *Tridacna crocea* but because of cash constraints and other limitations (particularly the absence of readily accessible markets for clams for food) it has not been developed for commercial use. In order to fully develop it, it is estimated that a cash investment of about A$1 million would be required and this could only be considered by Reefarm if a joint venture were prepared to contribute most of this capital. The reef is distant from Cairns and since there is no land in the area a platform would have to be built for servicing the growout farm.

Let us consider the various commodities being produced by Reefarm as at November 1992.

Pearl oysters

In order to diversify and generate cash, Reefarm began producing South Sea pearl oysters in 1991 (see Figure 17.4). The oyster seed are sold at 3–4 months of age at A$1.00 each to farmers culturing pearls. Cash is generated quickly and the production of sea pearl oysters is much more profitable than that of giant clams.

Figure 17.4 Mr Jeremy Barker, manager of Reefarm, holding the shells of South Sea pearl oysters, which are now being bred at Reefarm. The heavy shadecloth in the background is used to exclude light from tanks containing juvenile pearl oysters. This reduces algal bloom which can otherwise be a problem. Unlike giant clams, pearl oysters do not require sunlight for their survival.

The same types of tanks used for rearing giant clams can also be used for rearing pearl oysters. However, while giant clams must have access to sunlight, oysters can be placed in multi-layered tiers in the tank. They therefore make more intensive use of available space, even though separate algal tanks must be kept in order to supply the young oysters with food.

While the production of pearl oysters is potentially much more profitable than giant clams, the market for the juveniles is limited because the company can only sell to registered pearl oyster farmers in Queensland. Interstate movement of pearl oysters is restricted because of the risks of diseases and pests being spread.

White and gold-lipped oysters are endemic to Australia and produce the highest quality pearls in the world. Black-lipped oysters produce black to grey pearls and research is being undertaken into the mariculture of these. Black-lipped pearl oysters provide the basis for a A$40 million industry in French Polynesia.

The international market for pearls has been controlled by the Japanese, even though a few Australian producers now sell directly to the USA. Western Australia is Australia's major producer of cultured pearls and in general has cooperated in cartel arrangements to restrict the supply of pearls.

Because pearl oysters can now be produced by hatcheries, it has been suggested that this may lead to an increase in the supply of pearls and a fall in their price. However, this may not happen. Demand for pearls may increase because a number of countries in Asia are experiencing economic development which could add to the demand for pearls. Furthermore, hatcheries may enable the quality of pearls to be improved and this may result in some increase in demand.

In any case, it may be counterproductive for the Australian pearl oyster industry to prevent or hinder the introduction of pearl oyster hatcheries in Australia. Indonesia is interested in hatchery-produced pearl oysters and unless Australia moves into this activity it could lose out to Indonesia. Australia should be able to compete with Indonesia by better quality control enabling a superior product to be produced.

No hatcheries, other than Reefarm, exist for the breeding of South Sea pearl oysters on the east coast of Australia and in 1992, Reefarm made a major effort to increase its production. While a hatchery exists in Darwin and another in Broome, these are only allowed to supply local areas because of the risk of the spread of diseases and pests. The Queensland Department of Primary Industries has placed a moratorium upon the establishment of new pearl farms and pearl oyster hatcheries in Queensland pending the outcome of its investigation of the industry. So at this time (1993), entry into the breeding of pearl oysters is restricted and the market for seed is also restricted.

Giant clams at Reefarm

As mentioned earlier, Reefarm is producing three species of giant clams—*T. crocea* and *T. maxima* for the aquarium trade, and some *T. gigas* are also produced. Let us consider its supplies for different markets.

Sales to the aquarium market

Giant clams are held for about two years to satisfy the aquarium trade. Mostly *T. crocea* and *T. maxima* are used for this purpose (see Figure 17.3). At this age, they are 5-6 cm in length and *T. crocea* sell for A$5.50 each and *T. maxima* for A$6.50 each. A premium of A$1.00 each may be paid for brightly coloured *T. maxima*. *T. maxima* are slightly larger in size than *T. crocea* after 2-3 years of growth. In addition, Reefarm is able to selectively breed *T. maxima* so as to obtain specimens with desirable bright colours.

Reefarm still continues to rear some *T. gigas* not only for historical reasons but also to keep its options open. Most aquarium wholesalers ask for some *T. gigas* to be included in their order.

Despite the licensing requirements of the Queensland Department of Primary Industry, which hampers sales of giant clams as aquarium specimens in Queensland, Reefarm reports that it continues to make some sales in Queensland to the aquarium trade, even though most Australian sales are to other states. It makes its international sales through a Cairns wholesaler of aquarium specimens and its international sales are rising.

As can be seen, Reefarm keeps a variety of species of giant clams to satisfy the aquarium trade. This is because it wants to spread its risk and the aquarium dealers appear to demand mixed batches of clams.

Sales to scientific institutions

Some sales of giant clams can possibly be made as specimens for use in scientific institutions and Reefarm has received one such order.

Sales of giant clam as seed for culture

The company has not concentrated on the supply of giant clam seed. However, some orders have been received from overseas for *T. gigas* seed. An order for 100000 seeds has been received from an Australian/Indonesian joint venture planning to farm giant clams in West Timor, and a possible order for seed has been received from Cocos Island. Reefarm is willing to supply seed of three months old at A$0.25 each or one year old at A$1.20 each.

Reefarm would like to dispose of its seed in the earliest stage possible. This would optimise their use of facilities and access to broodstock. The company is willing to produce seed to order.

Sales to the restaurant trade and for food

Regarding sales of giant clam meat to the local restaurant trade, Reefarm has been disappointed by the response. While a small amount of meat has been introduced to restaurants in Cairns, the main problem encountered was that most chefs did not know how to prepare it. This included Japanese restaurants. Furthermore, most chefs seemed to require a slightly larger sized clam than those of 5–6 cm produced by Reefarm for the aquarium trade.

No-one is currently (1993) buying giant clams from Reefarm for the restaurant trade. However, Reefarm could supply two or three restaurants on a regular basis. Some interest has been expressed from Japan in buying 5–6 cm *T. crocea* to supply the food market. The best Japanese offer received so far has been ¥13 000 per kg in the shell delivered. For 5–6 cm clams, this works out at about A$2.50 per clam delivered. For regular contracts for clams for food, Reefarm may be prepared to accept A$2.50 at the farmgate. The best price offered so far by Australian restaurants is $1.50 per clam.

A major inquiry was also received from Singapore for supplies for the food trade. The prospective purchaser wanted to buy 20 000 giant clams, but Reefarm could only offer 5000 and still meet the demands of its regular customers.

Given its current scale of operations, the cost of producing 2–3-year-old giant clams is possibly too high for Reefarm to be able to supply the restaurant trade even if chefs could use giant clam meat effectively. Only if its volume of production were substantially raised would Reefarm be able to lower the price for its giant clams substantially and be in a better position to meet demand from the restaurant trade. Substantial economies of scale exist in the growing of giant clams in land-based facilities (cf. Tisdell et al. 1993).

Tourism, giant clams and the nursery

In October 1992, Reefarm began using its nursery as a tourist attraction (see Figures 17.5–17.6). The additional cost of doing this was moderate. It involved the installation of touch tanks, a loudspeaker system and the provision of some chairs. The visit takes about one hour during which time a guide gives a presentation.

Figure 17.5 Advertisements on Fitzroy to encourage tourists to visit Reefarm.

Figure 17.5 (contd) Advertisements on Fitzroy to encourage tourists to visit Reefarm.

Figure 17.6 Tourists attending a touchtank presentation at Reefarm.

In November/December 1992 the guide was employed on a short-term contract. In the future, however, it was anticipated that the tour guide would be hired on a casual basis from a Cairns company. It was anticipated that the guide would travel daily to the island by the regular ferry to conduct the tours. In fact, it is reported that the staffing for the tours in early 1993 is one full-time tourism manager, one full-time presenter with a junior assistant, all employed by Reefarm on casual rates.

As at the end of 1992, Reefarm was charging A$5.00 per visit with concessions for families. On average 35 visitors per day were being received. This is still only a small share of the total number of visitors to Fitzroy Island. It is estimated that Fitzroy Island receives on average about 250 visitors per day for about 200 days of the year.

Currently gross receipts from tourist visits are running at about A$100+ per day. However, there appears to be scope for raising this sum. An entry fee of A$5.00 is considered to be low. It probably could be doubled without appreciably reducing the demand for visits. Also it may be possible to increase the proportion of visitors to the Island who visit Reefarm. For example, if the ferryboat operators to the island were to promote a visit to the clam nursery, this would increase the number of visitors to Reefarm. There is a possibility of this happening.

Visits to the Giant Clam Hatchery have been advertised in the following way:

> 'Fitzroy Island, close to Cairns, famous for its rainforest, fringing reef and lighthouse now has a new attraction for visitors.
>
> The Reefarm, Giant Clam Farm Hatchery which has operated for eight years has opened its doors to the public. Reefarm is one of only two clam hatcheries in the world and is now successfully breeding South Sea pearl oysters.
>
> Thousands of the hatchery bred clams, live corals and other reef animals are housed in an 18 metre touch pool with seating for 65 people.
>
> The animals enjoy the environment free of their natural predators with constantly changing seawater from the half million litres which passes through the hatchery daily.' (*About Cairns and the Tropical Far North*, October–December 1992, p. 16).

The addition of tourism visits as an extra revenue earner for the nursery seems to be a profitable development. It is a good cash earner with further potential for growth. It has required little extra expenditure and to a large extent makes use of existing facilities. However, it would seem essential to keep the production side of the nursery/farm operational because a part of the tourist attraction is that it is involved in commercial production of giant clams. As yet, there has been no development of tourist souvenirs for sale but this may be a future possibility, e.g. drawing on items made from giant clam shells (small ones can be dipped in metal) or involving pearls.

Reefarm's development policy and more on its tourism/education objectives

This section summarises the development policy of Reefarm as basically seen by its Director and principal shareholder, Mr Bruce Stevens. According to Mr Stevens, Reefarm's development philosophy is entirely based on the 'development of market-driven production' because there is no point in producing large quantities of product *unless* it is required by the market.

Reefarm's approach to developing giant clam production has been to produce a limited amount of product to enable it to test the market in southern Japan and Taiwan. If a favourable response is received from these markets, then Reefarm would look for a joint venture partner involved in seafood distribution in southern Japan or Taiwan to support financially the commercialisation and expansion of Reefarm's production unit in the Cairns area. Therefore it has a long-term aim to export giant clams for food to the northeast Asian region if markets can be tapped economically. Meanwhile, Reefarm has concentrated on hatchery production and small-scale growout of giant clams, and supply of alternative products. Reefarm commissioned a market consultant in the early stages of its development to assess the potential for sales of giant clams. The confidential findings of the consultant suggested that a large food market for clam meat exists in southern Japan (Okinawa).

The market-driven, cautious, exploratory approach of Reefarm has been a conscious choice by its management. It involves the following ingredients:

1. The company proving that it can produce a product, prior to attempting to produce it on a large scale, before borrowing heavily to do so and involving many shareholders.
2. Allowing time for full assessment of market requirements relying on production of a limited quantity of product.
3. Acting prudently so that the company does not commit itself beyond a level which may exceed its financial base and result in bankruptcy or takeover.
4. Maintaining a degree of flexibility in the company's production. If clams are uneconomic then perhaps pearl shell, tourism/education or other hatchery products may eventually form the 'core business' of the hatchery.

Tourism/education was a part of Reefarm's activities in its early days. The company began operations on Fitzroy Island in July 1984 and established a pilot hatchery on the site which now belongs to Fitzroy Island Resort. Tours were conducted through the pilot hatchery but when the hatchery was moved to a new site on the island, tours were discontinued. However, Reefarm began catering for school groups in marine studies at its new site in 1990. In 1990, 30 school groups visited and this increased to 55 groups in 1991.

At the end of 1991, the company adopted the idea of offering a substantial educational/tour program relying on dedicated staff. This required the conversion of one of the large tanks into a touch tank and required it to be well stocked with a suite of reef animals, corals and a variety of clams. Beginning in July 1992, a complete educational presentation of one hour was offered daily. On average, 35 people have attended daily since the presentation has become available.

An all-inclusive tour including Reefarm is now becoming available through buying ferry tickets for tours to Fitzroy Island, the two island tour (Green Island plus Fitzroy Island) and Moon Reef. Reefarm expects that its daily visitation rate will increase to 100–150 tourists daily. An expanded exhibition and presentation will allow the entrance fee to be raised to A$8.00 per adult. According to Mr Stevens, this planned development will enable Reefarm to realise an opportunity which was foreseen by the founders of Reefarm when they first applied for a site on Fitzroy Island.

Comments on strategy and bureaucratic impediments

While Reefarm has adopted an exploratory approach, it has been relatively cautious in its development. The techniques which it used were in the main already tried elsewhere and found to work e.g. the land-based facilities of James Cook University at Orpheus Island. It has also tended to rely on established markets. In particular, it has relied heavily on sales to the aquarium trade of giant clams. Distribution networks are already well established for the sale of aquarium specimens and it was able to plug into existing networks. Sale of giant clam seed is, however, more irregular, and no established readily accessible marketing networks for the sale of giant clams as food for use in restaurants seem to exist. This combined with the currently relatively high price of small clams in relation to the amount of meat supplied as well as the unfamiliarity of most chefs with this product mean that this is a difficult market to develop.

In the development of its nursery/farm, Reefarm has tried to maintain flexibility. Most of its equipment can be used for culturing species other than giant clams. It is, for example, currently cultivating South Sea pearl oyster seed in tanks which could also be used for giant clams. None of its equipment is as highly specialised as was much of that manufactured by Pacific Clams for its own use.

Reefarm has also attempted to maintain some diversification in the products produced by it at the nursery/farm. Furthermore, in the case of giant clams, its policy has been to produce a range of species. Once again this represents some diversification. Reefarm has therefore used a number of the strategies for reducing its business risk.

Entry into a new industry or business always involves unanticipated difficulties, but these appear to be greatly increased by 'red tape' and bureaucratic controls. Reefarm has to deal with as many as 14 public authorities per year and obtain many permits. This involves both time and cost.

Concluding comments

Few firms that have been entirely commercial since their inception have continued to be involved in the culture of giant clams. However, Reefarm is one such firm. Other firms have entered or have planned to enter the industry with different production strategies and/or markets in mind to those used by Reefarm. For example, Pacific Clams attempted to implement a radically different technique of producing giant clams. It seemed also that many firms who enter the industry do so with little knowledge of market and economic possibilities. A relatively diverse range of strategies have, therefore, been tried. Evolutionary economists argue that this tends to be typical of newly emerging industry and that behaviour is typified more by trial-and-error procedures than by optimising (Metcalfe and Gibbons 1989). It is possible that some of the enterprises that failed could have succeeded but without actual attempts, it may be difficult to separate winners and losers. Progress initially involves winners and losers. Errors are also an important part of learning. Nevertheless, this should not be interpreted as support for foolhardy trials or for those enterprises which do not take reasonable steps to cover themselves and their shareholders against risk and uncertainty.

Acknowledgments

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18 Production Economics of Giant Clam (*Tridacna*) Culture Systems in the U.S.-affiliated Pacific Islands

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Yung C. Shang

K. Wanitprapha

Xijun Tian

Abstract

The first part of this chapter compares production cost of culture systems currently being used or experimented with in the Republic of Marshall Islands, Republic of Palau, Kosrae, and American Samoa.

There are two distinct systems being tested in the Republic of Marshall Islands. One system uses raceways in the hatchery phase while the other system uses floating tanks. Both systems utilise floating platforms with plastic trays for the nursery phase. Clams are then grown-out on shallow fringe reefs. The estimated cost of producing 8-month old *T. gigas* of about 2.5 cm for the raceway hatchery system is U.S.$0.41/clam while the cost for the floating tank hatchery system is U.S.$0.23/clam. The cost of raising the clams to about 3 years old is estimated to be U.S.$5.08/clam for combined raceway hatchery system and floating platform nursery and U.S.$4.83 /clam for combined floating tank hatchery system and floating platform nursery. Total costs amount to U.S.$9.44/clam if the clams are then grown-out for another 2 years on shallow fringe reefs for the system using raceways in the hatchery phase and U.S.$9.13/clam for the other system using floating tanks.

The Micronesian Mariculture Demonstration Center (MMDC) in the Republic of Palau uses a land-based hatchery and a combined land-based and ocean-cage nursery system to produce *T. derasa* to approximately 2 years of age. The estimated cost of raising the clams to 1 year of age on the land-based hatchery and nursery part of the system is U.S.$0.82/clam. The cost per clam increases to U.S.$1.41 if the clams are planted in ocean nursery cages for another year. The farm-gate prices charged by MMDC for 1 and 2-year-old clams are U.S.$1.00 and U.S.$3.00/clam, respectively.

The system in Kosrae and American Samoa are similar to the system in Palau except with smaller annual throughput. The estimated cost of producing 2-year-old *T. derasa* is U.S.$1.23 per clam for the system in Kosrae. The system in American Samoa costs U.S.$0.76 to produce a 1-year-old and U.S.$3.40 to produce a 2-year-old *T. derasa*.

The second part of the chapter analyses the optimal harvest time (replacement cycle) to maximise economic returns for the giant clam, *T. derasa*. The optimal harvest age ranges from no production to 13.2 years if only shell is assumed to be saleable, from no production to 9.2 years if only adductor muscle is assumed to be saleable, and from no production to 10.5 years if only other meat is assumed to be saleable. If all clam products are assumed to be saleable, the optimal harvest age ranges from no production to 10.7 years. If only meat is assumed to be saleable, the optimal harvest age ranges from no production to 9.0 years. The results indicate that clam farming can be profitable if prices of clam products are high or juvenile and annual operating costs are low. If all clam products can be sold, clam farming is generally profitable. If only meat can be sold, clam farming is profitable only if the production costs are low and the prices of the meat products are high. Marketability of shell is an important factor affecting optimal harvest age and the profitability of production.

Introduction

Pilot giant clam farming has been practiced or experimented with in several U.S.-affiliated Pacific islands, in Solomon Islands and Australia and elsewhere. The two fastest-growing species are being cultured in these locations: *T. gigas* and *T. derasa*.

The key to the success of the giant clam industry, like that of any other industry, is coordination of the marketing and production operations. To evaluate the potential of the giant clam industry, information on market and production economics are urgently needed. The markets of the giant clam products have been studied (Shang et al. 1991, 1993). However, information on production economics is very limited.

The purposes of this production economics study are:

1. to document and compare production costs of giant clam culture systems in the U.S.-affiliated Pacific islands; and
2. to identify the optimal harvest age for giant clam (*T. derasa*).

Production cost comparisons of giant clam culture systems in the U.S.-affiliated Pacific islands

There are two distinct culture systems being experimented with in the Pacific island countries. One system uses land-based tanks/raceways while the other system uses floating tanks in the hatchery and nursery phases (Figure 18.1).

Production cost data were collected during 1991 and 1992 from giant clam culture facilities in the following U.S.-affiliated Pacific islands: the Republic of Palau, the Republic of Marshall Islands, Kosrae, and American Samoa. Wherever possible, information was collected for the three phases of clam production, i.e., hatchery, nursery and growout. Information was obtained through personal interviews with facility managers at each site. Discounted costs were estimated at the various stages of production using a discount rate of 10% and assuming an operation life of 20 years. The analysis also assumed that 100% of the required capital is borrowed at an annual interest rate of 10% with a 10-year loan period. Sensitivity analyses were also performed on key production and financial parameters. The results of the analysis are detailed in the following sections.

Republic of Marshall Islands

Two systems of culturing *T. gigas* are being experimented with by Mr Neal Skinner in the Republic of Marshall Islands. One system uses raceways in the hatchery phase while the other system uses floating tanks. These two systems are designed for small operations and mainly rely on solar energy to generate electricity. In the nursery

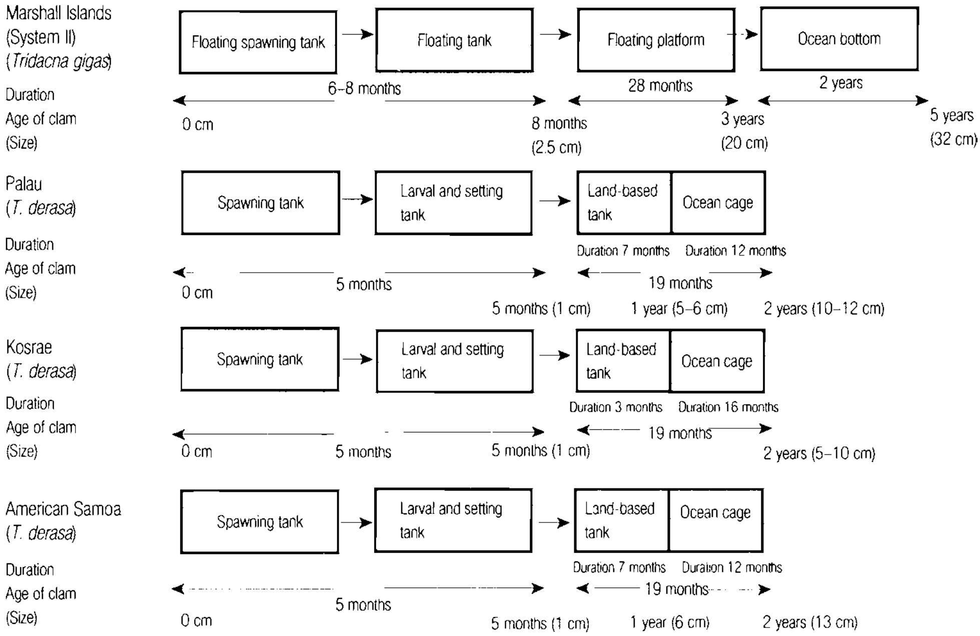

Figure 18.1 Giant clam production system.

phases, both systems utilise floating platforms with plastic trays. Clams are then grown-out on shallow fringe reefs. Figure 18.1 summarises the major production phases and the associated ages and sizes of clams at the various stages.

Hatchery

For the hatchery phase, a target of 40000 clams is assumed to be produced in eight months to an average size of 2.5 cm. The capital costs for both the raceway system and the floating tank system are shown in Appendix Tables A18.1a and A18.1b respectively. As expected, total capital costs for the raceway system are higher than the floating tank system, $12330 vs. $10 135. Typical annual operating costs for the raceway system are estimated to be $16881 and for the floating tank system, $9753. Breakdowns of the annual operating costs for the two systems are shown in Appendix Tables18.2a and 18.2b, respectively. The annual operating cost breakdowns are similar for the two systems, with labour costs (wages and salaries) accounting for over 70% of total operation costs (Figures 18.2 and 18.3). The estimated cost of producing 8-months old *T. gigas* using the raceway hatchery system is $0.41/clam while the cost for the floating tank system is $0.23/clam.

Figures 18.4 and 18.5 show, respectively, the sensitivity of production cost to the changes in major cost items for the hatchery phase of both systems. As expected, changes in labour costs have the most effect on cost of production. A 10% increase in labour cost would raise the production cost per clam by 7.3% (from $0.41-0.44/clam) for the raceway system and by 8.7% (from $0.23-0.25/clam) for the floating tank system.

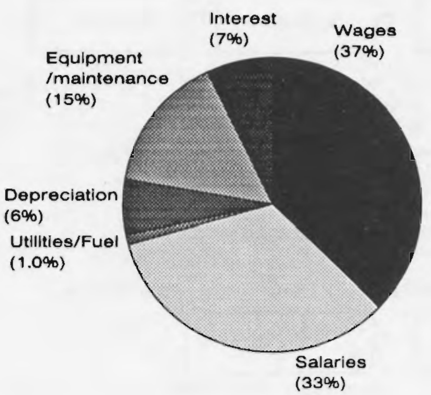

Figure 18.2 Annual operating costs of hatchery operation (raceway system) on Marshall Islands (to nearest percentage point).

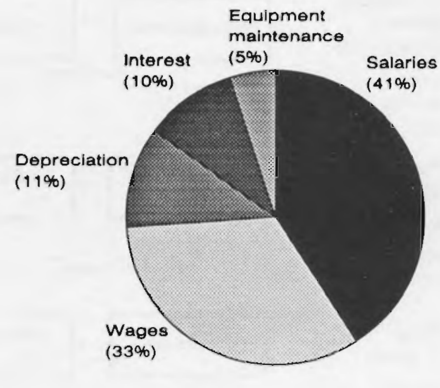

Figure 18.3 Annual operating costs of hatchery operation (floating tank system) on Marshall Islands (to nearest percentage point).

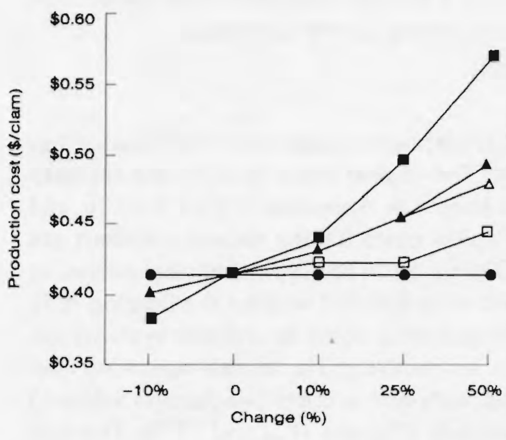

Figure 18.4 Sensitivity of production cost to changes in labour costs, energy costs and capital costs for hatchery operation using raceways on Marshall Islands.

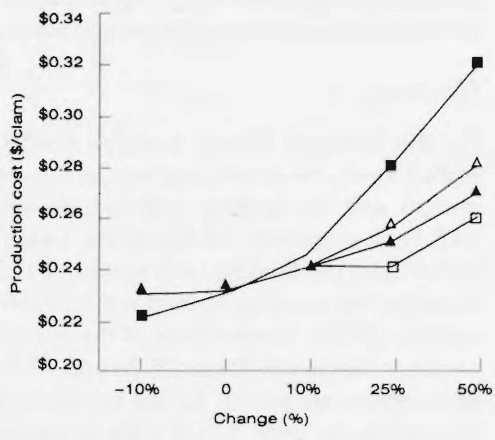

Figure 18.5 Sensitivity of production cost to changes in labour costs and capital costs for hatchery operation using raceways on Marshall Islands.

Legend:
Wages -▲-; Salaries-Δ-; Total labour costs -■-; Energy costs -●-; Capital costs -□-.

Nursery

The nursery phase assumes an annual target production of 800 clams to be raised from 2.5–20 cm in 28 months. Survival rate is assumed to be 80%, i.e., stocking rate is assumed to be 1000 clams. It is assumed that there are 15 floating platforms which can hold 9 trays each and each tray can hold twelve 3-year-old *T. gigas*. The nursery capital costs are shown in Appendix Table A18.3. The annual operating costs for nursery are shown in Appendix Table A18.4 (assuming juvenile clams are from the raceway hatchery system). The estimated cost of raising a clam to 3-year-old is about $5.08/clam if the stocking cost per clam is $0.41 (i.e., juvenile clams from the raceway hatchery system). However, if the stocking cost per clam is $0.23 (i.e., juvenile clams from the floating tank hatchery system), the estimated cost decreases to about $4.83/clam.

The percentage breakdowns of annual operating costs for the nursery phase are very similar for either system used in the hatchery phase, since the only difference is in stocking costs which is higher if the juveniles are from the raceway hatchery system (Figures 18.6 and 18.7). The percentage changes in major cost items also have similar effect on the production cost per clam for both hatchery systems with labour costs the most sensitive as expected (Figures 18.8 and 18.9).

Growout

The ocean growout phase assumes a 2-year cycle with an annual target production of 720 clams. Three-year-old clams of about 20 cm are assumed to grow to 32 cm in two years with 10% mortality. The capital cost for ocean growout is shown in Appendix Table A18.5. Appendix Table A18.6a shows the annual operating costs assuming the stocking cost of a 3-year-old *T. gigas* is $5.08 and Appendix Table A18.6b shows the annual operating costs assuming the stocking cost of a 3-year-old clam is $4.83. Estimated total cost of producing a 5-year-old clam is $9.44 if the raceway hatchery system is used. The cost is lower, $9.13/clam, if the floating hatchery system is used.

As in the nursery phase, the percentage breakdowns of annual operating costs for the ocean growout phase using either hatchery system are almost identical (Figures 18.10 and 18.11). As a result, changes in production cost parameters have similar effects on the cost of producing a 5-year-old clam by either system (Figure 18.12 and 13). Stocking cost shows the greatest effect on production cost for both systems since it constitutes the largest cost item.

Republic of Palau

The Micronesian Mariculture Demonstration Center (MMDC) in the Republic of Palau uses a land-based hatchery and a combined land-based and ocean-cage nursery system to produce 2-year-old *T. derasa*. The hatchery phase takes about 5 months and produces clams of about 1 cm. The nursery phase consists of 7 months in land-based tanks and 12 months in ocean cages. The 1-year-old clam

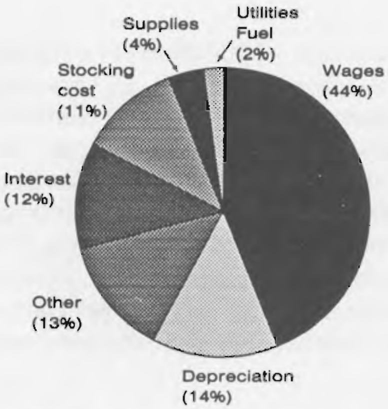

Figure 18.6 Annual operating costs of nursery operation using raceway hatchery system on Marshall Islands (to nearest percentage point).

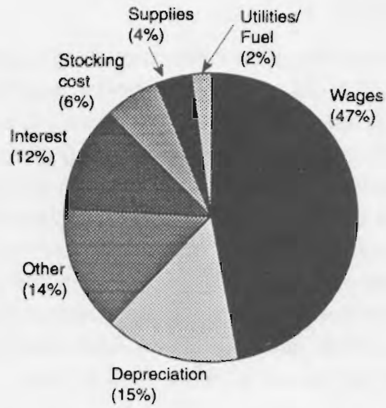

Figure 18.7 Annual operating costs of nursery operation using floating tank hatchery system on Marshall Islands (to nearest percentage point).

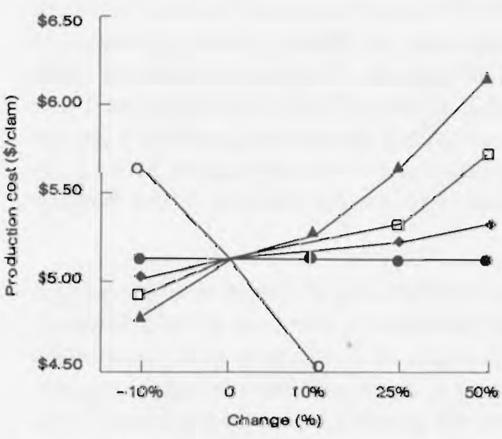

Figure 18.8 Sensitivity of production cost to changes in wages, energy costs, capital costs, stocking cost and survival rate for nursery operation using raceway hatchery on Marshall Islands.

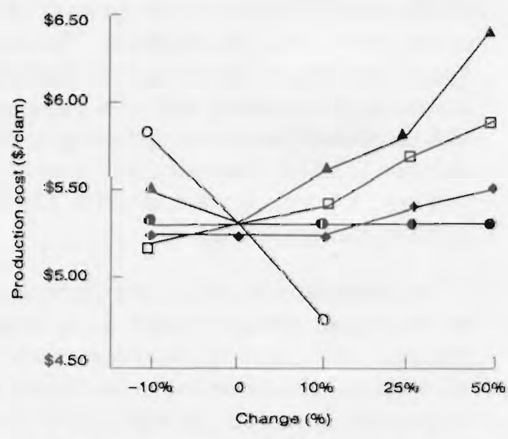

Figure 18.9 Sensitivity of production cost to changes in wages, energy costs, capital costs, stocking cost and survival rate for nursery operation using floating tank hatchery on Marshall Islands.

Legend:
Wages -▲-;Survival rate-O-; Stocking cost -◆-; Energy costs -●-; Capital costs -□-.

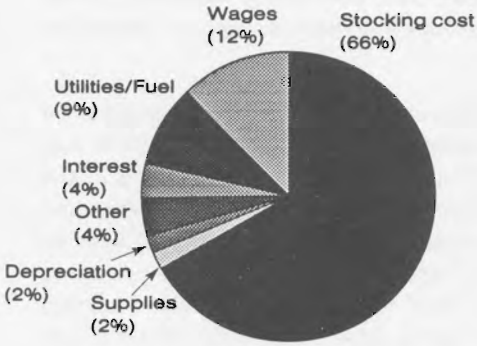

Figure 18.10 Annual operating costs of growout operations using raceway hatchery system on Marshall Islands (to nearest percentage point).

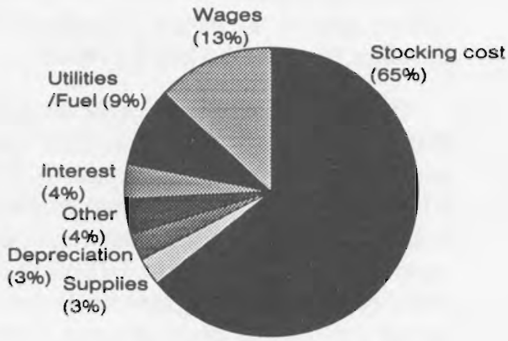

Figure 18.11 Annual operating costs of growout operation using floating tank hatchery system on Marshall Islands (to nearest percentage point).

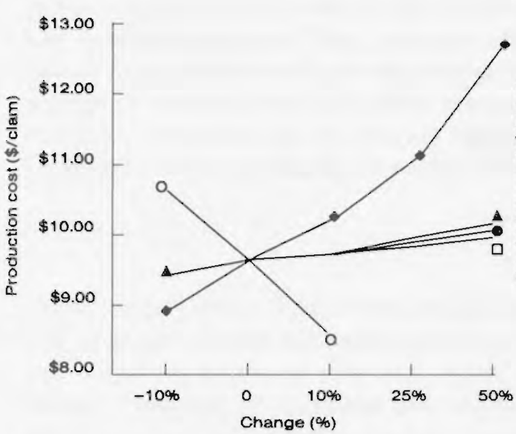

Figure 18.12 Sensitivity of production cost to changes in wages, energy costs, capital costs, stocking cost and survival rate for growout operation using raceway hatchery on Marshall Islands.

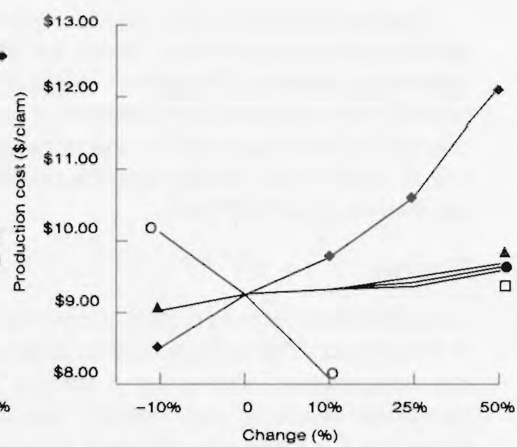

Figure 18.13 Sensitivity of production cost to changes in wages, energy costs, capital costs, stocking cost and survival rate for growout operation using floating tank hatchery system on Marshall Islands.

Legend:
Wages -▲-;Survival rate-O-; Stocking cost -◆-; Energy costs -●-; Capital costs -□-.

after the land-based nursery is about 5–6 cm and the 2-year-old clam after the ocean cage nursery is about 10–12 cm. Figure 18.1 provides a summary of the culture system at MMDC. Details of the production system can be found in Heslinga, Watson and Isamu (1990).

The annual throughput of the hatchery and land-based nursery is assumed to be 200000 1-year-old *T. derasa*. Total capital costs amount to about $299000 and annual operating costs amount to $173433 (see Appendix Tables A18.7 and A18.8 for detailed breakdowns). Production cost of a 1-year-old clam is estimated to be about $0.82. The ocean cage nursery assumes a 75% survival rate with an annual production target of 150000 clams. Capital costs and annual operating costs are detailed in Appendix Tables A18.9 and A18.10, respectively. The estimated total cost of producing the 2-year-old clam is $1.41. The estimated costs of production are well below the farm-gate prices charged by MMDC for 1 and 2-year-old clams which are $1.00 and $3.00/clam, respectively.

The percentage breakdowns of annual operating costs for the combined hatchery and land-based nursery and ocean-cage nursery are shown in Figures 18.14 and 18.15, respectively. With the combined hatchery and land-based nursery, labour (wages and salaries), depreciation, and interest payment accounted for 78.6% of total annual operating costs, while for the ocean-cage nursery, these costs are less than 23%. The major cost item for the ocean-cage nursery is stocking cost.

Figures 18.16 and 18.17 show, respectively, the sensitivity of production cost to the changes in major cost items for the hatchery and land-based nursery and ocean-cage nursery. Production cost is most sensitive to relative changes in capital costs for the hatchery and land-based nursery while it is most sensitive to relative changes in stocking cost for the ocean-cage nursery. A 10% increase in survival rate in ocean-cage nursery operation would reduce the production cost from $1.41 per clam to $1.28 per clam.

Kosrae

The giant clam farm in Kosrae is operated by the government of the Federal States of Micronesia. The culture system used is adapted from the MMDC. However, it is still experimental and is on a smaller scale than the operation in Palau. The combined hatchery and nursery operations are assumed to produce 100000 2-year-old *T. derasa* annually with an average size of 5–10 cm. The hatchery phase takes about 5 months. Clams are then transferred to land-based nursery tanks and kept there for 3 months. Finally, clams are planted in ocean nursery cages for 16 more months or until they reach 2 years of age (see Figure 18.1).

The total capital costs for this operation are about $183000 and the annual operating costs amount to $116040. The production cost for a 2-year-old clam is estimated to be $1.23. It should be noted that electricity and fertiliser costs are provided by the government, therefore, the production cost per clam would increase slightly if electricity and fertiliser costs are included.

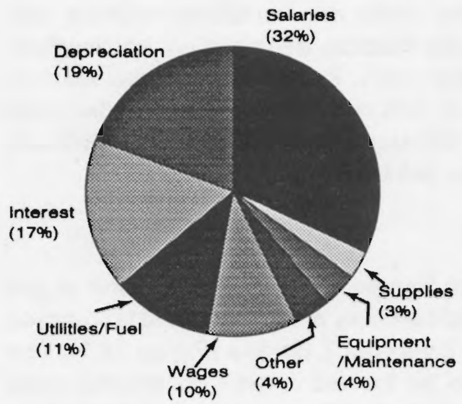

Figure 18.14 Annual operating costs of combined hatchery and landbased nursery operations in Palua (to nearest percentage point).

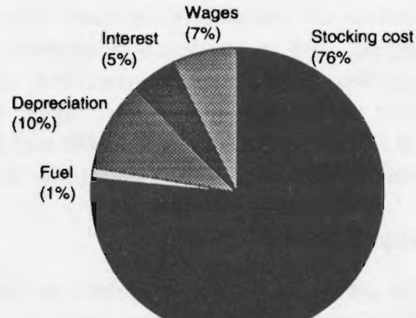

Figure 18.15 Annual operating costs of ocean-cage nursery operation in Palau (to nearest percentage point).

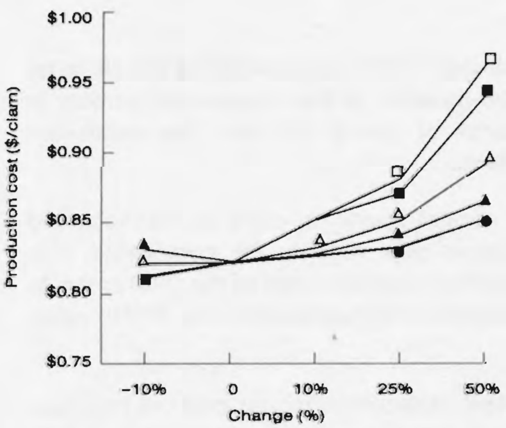

Figure 18.16 Sensitivity of production cost to changes in labour costs, energy costs and capital costs for combined hatchery and land-based nursery operations in Palau.

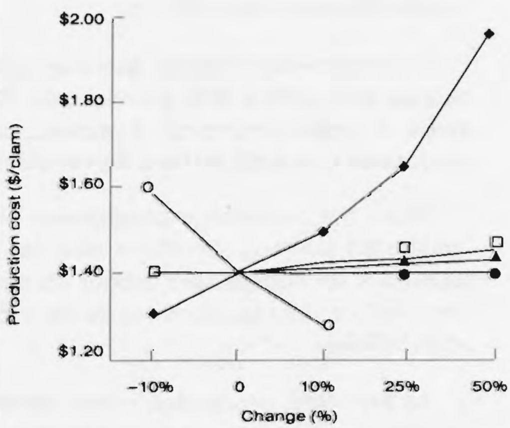

Figure 18.17 Sensitivity of production cost to changes in wages, energy costs, capital costs, stocking cost and survival rate for ocean-cage nursery operrations in Palau.

Legend:
Wages -▲-; Salaries-△-; Total labour costs -■-; Energy costs -●-; Capital costs -□-.

When the percentage breakdown of operating costs of the hatchery and nursery phases are considered, almost 60% of total costs are for labour (salaries and wages). The remaining 40% of total costs are interest, depreciation, utilities/fuel, supplies, equipment maintenance, and other costs. Production cost per clam is most sensitive to labour and capital costs. A 10% rise in labour and capital costs would result in additional $0.08 and $0.04 increases in production cost per clam, respectively. (For details of data for this case, see Leung et al. 1993.)

American Samoa

The giant clam culture system in American Samoa is also an adaptation of the MMDC system. The system uses a land-based hatchery and a combined land-based and ocean-cage nursery system to produce 2-year-old *T. derasa* (Figure 18.1). The hatchery and land-based nursery operations are located in the same facility, while ocean-cage nursery operations are located in three different villages: Ofu, Alofau, and Nuuuli.

The goal for the hatchery and land-based nursery operations is to produce 100000 1-year-old *T. derasa* annually. The hatchery phase spans about 5 months and the land-based nursery lasts about 7 months. 1-year-old clam is about 6 cm in length. Currently, only a small amount of 1-year-old clams are distributed to the three nurseries. The remaining clams are used for teaching and training purposes, replacement, and sales. Total capital costs and annual operating cost are estimated to be about $52 940 and $77560, respectively. The cost of producing a 1-year-old clam is about $0.76.

The ocean-cage nursery assumes a total of 3050 clams stocking for all three nursery sites with a 60% survival rate. The duration of the ocean-cage nursery is about 1 year, producing 2-year-old clams of about 13 cm. The estimated production cost is $3.40 for a 2-year-old clam.

When the percentage breakdowns of annual operating costs of hatchery and land-based nursery operations and the ocean-cage nursery are considered, it is found that for both phases, labour accounts for more than half of the total costs. In terms of percentage, labour costs are substantially higher than for the MMDC operation in Palau.

As expected, production cost is the most sensitive to labour costs in hatchery and land-based nursery operations as well as for the ocean-cage operation. A 10% increase in survival rate for the ocean-cage nursery operation would reduce the cost of production per clam by $0.31. (For details of data for this case see Leung et al. 1993.)

Discussion

Although not directly comparable, the estimated costs of production for the cultured systems in the Republic of Marshall Islands for the various sizes of *T. gigas* appear to be well below the farm-gate prices charged by MMDC for *T. derasa*. The farm-gate prices charged by MMDC for 3- and 5-year-old *T. derasa* are $9.00 and $50.00/clam, respectively. Production cost for the floating tank hatchery system in the Marshall Islands is lower in comparison with the raceway hatchery system. However, it has not been demonstrated whether the two systems will provide the same consistent production levels. It seems that the floating tank system is riskier and may not provide consistent production as compared to the land-based raceway system.

For the purpose of comparison, Tisdell et al. (1990) estimated the cost of producing 1-year-old *T. gigas* in Australia to be between A$0.32–A$1.57 depending on the size of operation. (These figures need to be reduced by about 25–30% to give U.S. dollar estimates, because of the exchange rate difference). The higher estimated cost in Australia is expected as production costs especially labour costs are generally higher than developing nations such as the Republic of Marshall Islands.

The system used in Kosrae is similar to the MMDC system for culturing *T. derasa* and hence the estimated production costs are very similar. In fact, the estimated cost of producing 2-year-old *T. derasa* is $1.23/clam in Kosrae. Although the system used in American Samoa is adapted from the MMDC system, it has a much higher cost of producing a 2-year-old *T. derasa*, $3.40 vs. $1.41. This is because of high labour costs associated with the training and teaching components of the American Samoa system. Otherwise, production costs for the two systems would be quite similar. Table 18.1 provides a summary of the production costs of giant clams for the various phases in the U.S. affiliated Pacific islands.

It appears that the current giant clam culture production technology as practiced or experimented with in the U.S.-affiliated Pacific islands can be profitable. However, efforts in coordinating the supply from the entire Pacific region producing giant clams to the various demand centres may be necessary in order to ensure the continuing growth in this industry.

Table 18.1 Production cost comparisons of giant clam in the U.S.-affiliated Pacific Islands —1991, 1992 (U.S.$)

	Age of clam				
Site	8 months	1 year	2 years	3 years	5 years
Marshall Islands					
Raceways in the hatchery phase	0.41			5.08	9.44
Floating tanks in the hatchery phase	0.23			4.83	9.13
Palau		0.82	1.41		
Kosrae			1.23		
American Samoa		0.76	3.40		
1991 farmgate price (MMDC, Palau)		1.00	3.00	9.00	50.00

Economic optimal harvest age for giant clam *Tridacna derasa*[1]

Much technical progress has been made in giant clam, *Tridacna derasa*, culture in the past decade and, according to Tisdell (1986) and Heslinga and Fitt (1987), it is not unrealistic to envision large-scale commercial farming in the Pacific by the end of the 1990s. As Watson and Heslinga (1988) put it, 'It is now possible to begin quantitative assessment of the question: What is the best time to harvest cultured specimens?' In their paper, they analysed the optimal harvest schedule that permitted the clam farmer to maximise average annual production of biomass per unit area. This section extends their analysis in addressing the question of identifying the optimal harvest schedule (replacement cycle) to maximise economic returns.

Tisdell (1986) constructed a model to estimate the optimal length of the growout period that maximised the net present value of a batch of juvenile clams for a range of interest rates. Using growth estimates for *T. gigas* and mortality estimates for *T. derasa*, he estimated that the optimal growout period is 7 years, assuming that the meat can be sold for A$1.5/kg (the only marketable product from the clam)[2] and that the real interest rate is 10%. (Real interest rate is used to account for the effect of inflation and can be defined simply as the nominal interest rate less the expected inflation rate.) At this interest rate, the net present value of a juvenile clam is A$1.37. He concluded that clam farming can be quite profitable, since the price of a juvenile was around A$1.00 at the time of his analysis. It should be noted that his analysis incorporated no other cost. He also recognised that the analysis assumed that available space was not a major constraint on clam farming and suggested further work should be done to assess the optimal growout period if space was a constraint. However, he pointed out that it seems likely that a growout period of about 4 years will be optimal.

Watson and Heslinga (1988) recognised that when space is a constraint, forest management techniques can be useful in managing Tridacnid clam resources. They used the basic principle of biological rotation of maximum biomass production and applied it to the size-at-age data for a cohort of *T. derasa* spawned at the Micronesia Mariculture Demonstration Center (MMDC), Republic of Palau, in 1979. This data is the most comprehensive set available for cultured *Tridacna* containing age-weight data for adductor muscle, other soft tissue, and shell. Using the principle that maximum biomass production occurs at the age when mean annual growth equals periodic annual increment, they found that the optimal harvest age for adductor muscle is 6 years, that for other soft tissues is 6 years, and that for shell is greater than 7 years. The objective of this section is to use Watson and Heslinga's (1988) data to determine the optimal length of the replacement cycle that maximises economic returns.

[1] This section is based largely on Leung et al. 1993.
[2] A$1 = U.S.$0.78 at the time of this (1986) writing.

Methods

Optimal harvest age for maximum biological production

The point of maximum biomass production occurs when mean annual growth equals periodic annual increment (Avery 1975; Watson and Heslinga 1988). Mean annual growth is also referred to as average growth, and periodic annual increment is also referred to as marginal growth. If a growth equation for each clam product can be estimated, then this equation can be used to determine marginal growth by taking the first time derivative of the growth equation. Average growth is simply total growth divided by time.

Optimum harvest age for maximum economic returns: the Faustmann model

Maximising biological production does not usually maximise economic returns. With limited space, one generation of clams is in competition with a younger generation for the same area. By harvesting older clams whose marginal values are decreasing, space can be made available for younger clams, which grow faster and thereby yield a greater increase in value. This problem is similar to the optimal rotation problem in forest management as developed by Faustmann (1849). Clark (1976) and Bjorndal (1988) have demonstrated the use of Faustmann's model in fishery and aquaculture management, respectively. For the mathematical details of the Faustmann's model as applied to giant clams culture, readers are referred to Leung et al. (1993).

Assumptions

To apply the Faustmann rule, assumptions on survival, price of clam products, annual operating cost, and juvenile cost have to be made. Munro (1988) estimated a constant survival rate of 0.9873 after one year of growth, using the same set of data that are analysed in this section. The constant survival rate did not seem appropriate since clam survival rate tends to increase with age. For this reason, the survival rates shown in Table 18.2 were assumed.

Table 18.2 Assumed survival rates of giant clams

Years of growout	Survival rate (%)
1	90
2	95
3	97
4	98
5	100

The farm-gate prices were assumed to be U.S.$0.60/kg for shell, U.S.$22.00/kg for muscle (Heslinga and Watson 1985) and U.S.$2.20/kg for other meat (Kona Clam Co. Ltd 1986). Cost of juveniles was assumed to be U.S.$1.50 per clam if purchased (including packing and shipping cost) (MMDC 1989) and U.S.$0.53 per clam if produced on farm (unpublished data). Annual operating costs were adapted from unpublished data as shown in Table 18.3. Real interest rate was assumed to be 10%.

Table 18.3 Annual operating cost, MMDC unpublished data

	Year in growout		
	1	2	3
Fuel (U.S.$/clam)	0.64	0.36	0.01
Number of trips	104	52	2
Cost per trip (U.S.$)	10	10	10
Number of trays	60	60	60
Number of clams/tray	27	24	22
Labour (U.S.$/clam)	0.64	0.33	0.01
Depreciation (U.S.$/clam)	0.16	0.16	0.10
Total (U.S.$/clam)	1.44	0.88	0.13

To take into account the various possible farm configurations, four cases were analysed. They were:

Case 1 Clams were situated far from shore, so boat and scuba diving gear were needed; annual production cost included fuel, labour, and depreciation; juvenile cost was assumed to be U.S.$1.50/ clam.

Case 2 Clams were close to shore, so boat and scuba diving gear were not needed; only labour cost was assumed to be incurred; juvenile cost was assumed to be U.S.$1.50/ clam.

Cases 3 and 4 were the same as Cases 1 and 2 except that seed was assumed to be produced on the farm at U.S.$0.53/clam.

The annual production costs for the four cases are presented in Table 18.4.

Table 18.4 Annual production cost (U.S.$/clam) under different farm configurations: Case 1—Clams were situated far from shore and juvenile cost was U.S.$1.50/clam; Case 2—Clams were situated close to shore and juvenile cost was U.S.$1.50/clam; Case 3—Clams were situated far from shore and juvenile cost was U.S.$0.53/clam; Case 4—Clams were situated close to shore and juvenile cost was U.S.$0.53/clam.

Year in growout	Case 1	Case 2	Case 3	Case 4
1	2.94	2.14	1.97	1.17
2	0.88	0.36	0.88	0.36
3	0.13	0.01	0.13	0.01

Results and discussion—estimated growth equations

Using the seven years of *T. derasa* growth data from Watson and Heslinga (1988), the following growth equations were found to be most plausible for each commercially important product:

Shell	$WS = 9114.30\,[\,1\text{-}e^{-0.31\,(t-1.63)}\,]^3$ (6.05) (6.70)(8.64)	$R^2 = 0.99$	D-W = 2.81
Adductor muscle	$WM = 95.78\,[\,1\text{-}e^{-0.69\,(t-2.16)}\,]^3$ (9.39) (4.02)(5.81)	$R^2 = 0.97$	D-W = 2.82
Other meat	$WO = 831.26\,[1\text{-}e^{-0.49\,(t-2.05)}]^3$ (6.15) (3.71) (4.98)	$R^2 = 0.99$	D-W = 2.86

where: WS, WM, and WO are weights in grams for shell, muscle, and other meat respectively; t is age in years; numbers in parentheses are t-statistics; D-W is the Durbin-Watson d-statistic. A juvenile is approximately 2 years old; consequently, t = 7 refers to the seventh year of age or the fifth year of growout. The functional form employed in estimating the above equations is the von Bertalanffy (1938) growth function, which is commonly used in describing shellfish growth.

The estimated growth equations are generally very well-fitted as shown in Figure 18.18. The purpose of estimating these equations is to facilitate the calculations of the optimal replacement cycle which will be discussed later.

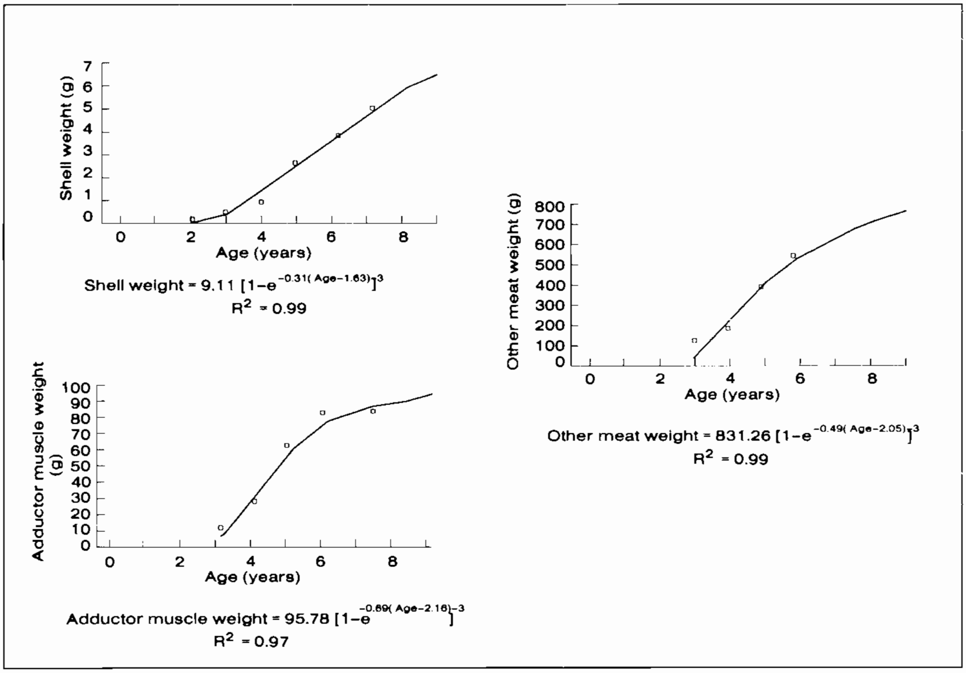

Figure 18.18 Average shell weight, adductor muscle weight, weight of other meat and their estimated growth equations.

Optimal harvest age for maximum biological production

Using the estimated growth equations for each clam product, the optimal harvest age for maximising biological production can be calculated by equating the average growth and marginal growth. The optimal harvest age for shell was estimated to be 8.8 years, that for muscle was 5.9 years and that for other meat was 7.0 years. The results are slightly different from Watson and Heslinga's (1988) because estimated growth equations were used. They estimated the optimal harvest age for both muscle and other meat to be 6.0 years. The similarity of the results between these studies indicates that the estimated growth equations can approximate the actual growth process very well.

Optimal harvest age for maximum economic returns

Table 18.5 shows the optimal harvest time of the four cases for each individual clam product and some combinations of products. This table also shows the changes in optimal harvesting time when clam product prices vary within ±25% of the assumed prices. The optimal harvest time for shell, in terms of clam age, ranged from no production to 13.2 years. No muscle production should be carried out except for higher prices, and no other meat production should be done except in the case where the price is the highest and the production cost is the lowest. 'No production' refers to the case where NPV (net present value) is negative indicating an unprofitable situation; hence, the best decision is not to grow clams.

Table 18.5 also shows the optimal harvest time assuming (a) all the products could be sold, and (b) only the meat products could be sold. In (a), the optimal harvest time ranged from no production, where the prices were the lowest and the production cost was the highest, to 10.7 years, while in (b), it ranged from no production, where product prices were low and production costs were high, to 9.0 years.

Table 18.6 presents the corresponding net present values at optimal harvest time for each case. If only shell was assumed to be saleable, the net present values were generally positive except for Case 1 and Case 3 with lower prices. If only muscle or other meat was saleable, the net present values were generally negative except for Case 4 with higher product prices. If all the products were saleable, all the net present values were positive except for Case 1 with lower product prices. If only meat could be sold, the net present values were positive only if the production costs were low and product prices were high. The results indicated that if all the products could be sold, clam farming was generally economically feasible and the optimal harvest time, in terms of clam age, ranged from 7.0–10.7 years. If only meat was assumed to be saleable, clam farming could be profitable only when the product prices are high and production costs are low and the optimal harvest time, in terms of clam age, ranged from 6.5–9.0 years. In general, the results indicated that as clam product price increases, the optimal harvesting time decreased as expected. The optimal harvesting time decreased with decreasing costs as well. Sensitivity analysis (not shown here) also shows that optimal harvesting time decreased with increasing survival rates and decreasing real interest rates.

Table 18.5 Optimal harvesting time (in years) under different farm configurations: Case 1—Clams were situated far from shore and juvenile cost was U.S..$1.50/clam; Case 2—Clams were situated close to shore and juvenile cost was U.S.$1.50/clam; Case 3—Clams were situated far from shore and juvenile cost was U.S.$0.53/clam; Case 4—Clams were situated close to shore and juvenile cost was U.S.$0.53/clam. The numbers in bold are the assumed prices and the numbers above and below are ±25% of the assumed prices. Note: No indicates that 'no production' is the best choice since the cost of production is higher than the revenue.

Saleable product	Product price (U.S.$/kg)	Case 1	Case 2	Case 3	Case 4
	0.45	No	13.2	No	
Shell only	**0.60**	No	10.9	12.3	9.0
	0.75	13.0	9.9	10.6	8.5
	16.50	No	No	No	No
Muscle only	22.00	No	No	No	9.2
	27.50	No	No	No	7.5
	1.65	No	No	No	No
Other meat only	2.20	No	No	No	No
	2.75	No	No	No	10.5
All products					
Shell	0.45				
Muscle	16.50	No	9.7	10.7	8.0
Other meat	1.65				
Shell	**0.60**				
Muscle	**22.00**	10.7	8.5	9.0	
Other meat	**2.20**				
Shell	0.75				
Muscle	27.70	9.3	7.9	8.2	7.0
Other meat	2.75				
Meat only					
Muscle	16.50				
Other meat	1.65	No	No	No	7.8
Muscle	**22.00**				
Other meat	**2.20**	No	9.0	No	7.0
Muscle	27.50				
Other meat	2.75	No	7.8	8.3	6.5

Table 18.6 Net present values at harvest time (in U.S.$/clam) under different farm configurations: Case 1—Clams were situated far from shore and juvenile cost was US $1.50/clam; Case 2—Clams were situated close to shore and juvenile cost was U.S.$1.50/clam; Case 3—Clams were situated far from shore and juvenile cost was U.S.$0.53/clam; Case 4—Clams were situated close to shore and juvenile cost was U.S.$0.53/clam. The numbers in bold are the assumed prices and the numbers above and below are ±25% of the assumed prices. Note: N indicates that the net present value is negative.

Saleable product	Product price(U.S.$/kg)	Case 1	Case 2	Case 3	Case 4
	0.45	N	0.16	N	0.47
Shell only	0.60	N	0.48	0.02	0.82
	0.75	0.03	0.82	0.38	1.17
	16.50	N	N	N	N
Muscle only	22.00	N	N	N	0.04
	27.50	N	N	N	0.24
	1.65	N	N	N	N
Other meat only	2.20	N	N	N	N
	2.75	N	N	N	0.07
All products					
Shell	0.45				
Muscle	16.50	N	0.60	0.14	0.97
Other meat	1.65				
Shell	0.60				
Muscle	22.00	0.30	1.13	0.69	1.50
Other meat	2.20				
Shell	0.75				
Muscle	27.50	0.84	1.66	1.24	2.01
Other meat	2.75				
Meat only					
Muscle	16.50				
Other meat	1.65	N	N	N	0.32
Muscle	22.00				
Other meat	2.20	N	0.23	N	0.66
Muscle	27.50				
Other meat	2.75	N	0.56	0.13	1.00

One of the weaknesses of this study is the use of the estimated growth equation beyond the data for which the equation is estimated. However, the results are fairly plausible using the von Bertalanffy functional form. With longer growth data series available in the future, the present analysis can be updated.

Recently, two other giant clam products have been identified as having strong potential markets. They are small clams for sushi and for the aquarium trade. When more pricing information becomes available, this study can be extended to include these products.

Acknowledgments

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Appendix 1

Table A 18.1a Hatchery capital costs, raceway system—Marshall Islands

Item	No of units	Cost/unit (U.S.$)	Total cost (U.S.$)	Useful life (years)	Annual depreciation U.S.$)
Spawning tank	1	2000	2000	20	100
Solar panels	1	3000	3000	20	150
Battery	1	500	500	5	100
Battery charger	1	150	150	3	50
Generator	1	600	600	3	200
Raceways	2	1500	3000	20	150
Trays	64	1	80	10	8
Diesel pump (back up)	1	2000	2000	10	200
Solar pump system	2	500	1000	10	100
Total			12330		1058

Table A 18.1b Hatchery capital costs, floating tank system—Marshall Islands

Item	No of units	Cost/unit U.S.$)	Total cost (U.S.$)	Useful life (years)	Annual depreciation (U.S.$)
Floating spawning tank	1	3500	3500	10	350
Solar panels	3	300	900	20	45
Batteries	3	200	600	5	120
Floating settlement tanks	2	2500	5000	10	500
Trays	108	1.25	135	10	13.5
Total			10135		1029

Table A 18.2a Hatchery annual operating costs, raceway system—Marshall Islands

Item	U.S.$	Total (%)
Salaries		
Manager	3600	21.3
Technician	2000	11.8
Wages	6240	37.0
Overhaul of diesel pump	500	3.0
Diesel fuel	150	0.9
Repairs and maintenance	2000	11.8
Solar pump replacement	100	0.6
Interest	1233	7.3
Depreciation	1058	6.3
Total	16881	

Table A 18.2b Hatchery annual operating costs, floating tank system—Marshall Islands

Item	U.S.$	Total (%)
Salaries:		
Manager	2000	20.5
Technician	2000	20.5
Wages	3210	32.9
Repairs and maintenance	500	5.1
Interest	1014	10.4
Depreciation	1029	10.6
Total	9753	

Table A 18.3 Nursery capital costs—Marshall Islands

Item	# of units	Cost/unit (U.S.$)	Total cost (U.S.$)	Useful life (years)	Annual depreciation Ul.S.$
Tray platform	15	120	1,800	5	360
Tray	135	1.25	169	5	34
Boat	1	3000	3000	20	150
Total			4969		544

Table A 18.4 Nursery annual operating costs using raceway hatchery system —Marshall Islands.

Item	U.S.$	Total (%)
Wages[a]		
Tray separation[b]	1215	33.0
Diving[c]	405	11.0
Harvesting[d]	117	3.2
Miscellaneous	500	13.6
Dive gear	150	4.1
Fuel[e]	60	1.6
Stocking cost[f]	230	6.2
Interest	466	12.6
Depreciation	544	14.8
Total	3687	

[a]U.S.$1.50/hr; [b]Once a month, 30 minutes/tray; [c]Once a month, 10 minutes/tray; [d]Harvesting, cleaning, 5 minutes/clam; diving, 5 minutes /tray; [e]U.S.$5/trip [f]U.S.$0.23/clam.

Table A 18.5 Growout capital costs—Marshall Islands

Item	No of units	Cost/unit U.S.$	Total cost (U.S.$)	Useful life (years)	Annual depreciation U.S.$
Boat	1	3000	3000	20	150
Total			3000		150

Table A 18.6a Growout annual operating costs using raceway hatchery system —Marshall Islands

Item	U.S.$	Total (%)
Wages[1]		
Diving[2]	624	11.0
Harvesting[3]	126	2.04
Miscellaneous	250	4.06
Dive gear	150	2.43
Fuel[4]	520	8.43
Stocking cost[5]	4064	65.92
Interest	281	4.56
Depreciation	150	2.43
Total	6165	

[1]U.S.$1.50/hr; [2]Checking clams twice a week, 4 hrs/trip, 2 trips/wk; [3]Harvesting: cleaning, 5 minutes/clam; diving, 2 minutes per clam; [4]U.S.$5/trip, 2 trips/wk; [5]U.S.$5.08/clam

Table A 18.6b Growout annual operating costs using floating tank hatchery system —Marshall Islands

Item	U.S.$	Total (%)
Wages[1]		
Diving[2]	624	10.5
Harvesting[3]	126	2.1
Miscellaneous	250	4.2
Dive gear	150	2.5
Fuel[4]	520	8.7
Stocking cost[5]	3864	64.8
Interest	281	4.7
Depreciation	150	2.5
Total	5965	

[1]U.S.$1.50/hr; [2]Checking clams twice a week, 4 hrs/trip, 2 trips/wk; [3]Harvesting: cleaning, 5 minutes/clam; diving, 2 minutes per clam; [4]U.S.$5/trip, 2 trips/wk; [5]U.S.$4.83/clam

Table A 18.7 Hatchery and nursery capital costs—Palau

Item	No of units	Cost/unit U.S.$	Total cost (U.S.$)	Useful life (years)	Annual depreciation U.S.$
Tanks w/ditches	50	2000	100000	15	6667
PVC pipes	50	200	10000	5	2000
Sea water pumps	5	600	3000	2	1500
Air blowers	20	500	10000	2	5000
Hatchery building w/pad & security service	1	30000	30000	15	2000
FRP tanks and equipment	1	10000	10000	15	667

Table A 18.7 (contd.) Hatchery and nursery capital costs—Palau

Item	No of units	Cost/unit U.S.$	Total cost (U.S.$)	Useful life (years)	Annual depreciation U.S.$
Office building	1	30000	30000	15	2000
Computer and printer	1	12000	12000	5	2400
Copier	1	2000	2000	5	400
Fax	1	1000	1000	5	200
Binder	1	500	500	5	100
Broodstock	1000	50	50000	50	1000
Pickup truck	1	10000	10000	5	2000
Microscopes	2	2500	5000	5	1000
Centrifuge	1	500	500	5	100
Tools and misc. hardware	1	5000	5000	5	1000
Nursery trays	50	250	12500	5	2500
Dive gear	5	1000	5000	2	2500
Misc. equipment	1	2500	2500	5	500
Total			299000		33534

Table A 18.8 Hatchery and nursery annual operating costs—Palau

Item	U.S.$	Total (%)
Electricity	12000	6.9
Phone, fax and telex	6000	3.5
Wages		
Technicians	10000	5.8
Aids	7000	4.0
Fuel/Lubes	600	0.3
Gravel	600	0.3
Air blowers	3000	1.7
Sea water pumps	1200	0.7
Filter bags	1000	0.6
Office supplies	2400	1.4
Lab supplies	2400	1.4
Fertiliser	600	0.3
Misc. hardware	2000	1.2
Maintenance	2000	1.2
Salaries		
Manager	30000	17.3
Farm manager	26000	15.0
Accounting	1200	0.7
Legal	2000	1.2
Interest	29900	17.2
Depreciation	33533	19.3
Total	173433	

Table A 18.9 Ocean-cage nursery capital costs—Palau

Item	No of units	Cost/unit U.S.$	Total cost (U.S.$)	Useful life (years)	Annual depreciation U.S.$
Trays[a]	12000	1.25	15000	5	3000
Boat	1	2500	2500	10	250
Boat engine	1	1000	1000	5	200
Cages[b]	6000	15	90000	5	18000
Snorkels, fins, masks	6	100	600	2	300
Total			109100		21750

[a]Two trays per cage; [b]One cage can hold 25 2-yr-old clams, 150000 clams output/25 = 6000 cages.

Table A 18.10 Ocean-cage nursery annual operating costs—Palau, Marshall Islands

Item	U.S.$	% of total
Stocking cost[a]	164000	76.3
Wages[b]	15600	7.3
Fuel[c]	2600	1.2
Interest	10910	5.1
Depreciation	21750	10.1
Total	214860	

[a] U.S.$0.82/clam; [b]U.S.$1.25/hr, one full time worker can handle 1000 cages, 6000 cages/1000 cages/worker = 6 full time workers; [c]U.S.$5/trip, 10 trips/wk.

19 Economics of Australian Tridacnid Production and Future Research Needs

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Yung C. Shang

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Abstract

This chapter uses Australian data to estimate the costs of production of *T. gigas* seed by techniques similar to those employed at the Orpheus Island Marine Research Station of James Cook University. Economies in scale of production are shown to be very strong in the hatchery/nursery stage of giant clam farming. The economics of ocean growout of *T. gigas* using the intertidal method developed at James Cook University is examined. Possible internal rates of return are estimated, assuming that the clams are to be marketed for their meat. The internal rate of return is expressed as a function of the number of years of ocean growout of the clams, and the profit-maximising duration of growout is estimated. Even allowing for loss in weight of the clam meat due to drip-loss, it is shown that, for conservative price estimates, at least a modest profit from the ocean farming of *T. gigas* is achievable. Comparisons are made between these results from Australian data and those of Shang, Leung and co-researchers from data from U.S.-affiliated territories in the Pacific. In conclusion, unresolved socioeconomic issues affecting giant aquaculture are highlighted. These would benefit from further research.

Introduction

The previous chapter examined the economics of producing giant clams in the Pacific islands affiliated with the United States, concentrating on the production of *T. derasa* and *T. gigas*, and considered alternative methods of culture. This chapter reports results on the economics of production of *T. gigas* for the main system of culture developed by Dr John Lucas and his team at James Cook University in northern Queensland. Their aquaculture facilities were located north of Townsville on Orpheus Island, a continental island in the Great Barrier Reef region, and their research was supported by the Australian Centre for International Agricultural Research. Comparisons will be made between results obtained from this culture and those obtained for the U.S.-affiliated territories by Leung, Shang, Wanitpraha and Xijun Tian, bearing in mind that differences in location and techniques can influence productivity considerably.

As will be apparent from the previous chapter, various production techniques have been adopted by economic units engaged in giant clam mariculture. In the early phases of the development of a new industry, such diversity seems to be normal (Metcalfe and Gibbons 1989). As an industry develops, techniques are assessed and the least economic ones discarded. An evolutionary selective process involving learning by experimentation is a part of industrial development.

Consider the range of production techniques being used for giant clam mariculture by productive units. As Usher and Munro (1988, p. 108) have stated, the production of giant clam seed can involve use of intensive or extensive methods. This choice can occur at the hatchery stage, e.g. high-tech methods may be used similar to those used by oyster hatcheries, or low-tech extensive methods can be used in which the fertilised eggs are allowed to develop naturally in raceways. The latter technique was used by the Micronesian Mariculture Demonstration Center (MMDC), whereas James Cook University (JCU) adopted the former technique. The raising of seed in the hatchery stage may occur in land-based raceways or in tanks (as is the practice at MMDC and was the practice at JCU) or in marine floating cages, as practiced by the International Center for Living Aquatic Resource Management (ICLARM) at its South Pacific Aquaculture Centre near Honiara in Solomon Islands, the latter in combination with a relatively short nursery period on land. Attempts have also been made to base both the hatchery and nursery phases of giant clam mariculture entirely on floating culture, e.g. by the Pacific Clam company which had its headquarters in Cairns in northern Australia.

In the ocean phase of giant clam culture, a variety of methods is also being used or tried. Intertidal and subtidal methods are in use. The appropriate choice will be influenced to some extent by the species being cultured. Some species, e.g. *T. gigas* and *H. hippopus*, are well adjusted to the intertidal zone whereas others, e.g. *T. derasa*, are best suited ecologically to the subtidal zone. Cultural factors can also influence choice; e.g. members of some South Pacific communities do not like to dive so it would be culturally inappropriate for them to select a species to be grown subtidally. There are many other variations. For example, the clams may be grown on raised platforms rather than on the ocean floor and they may be provided protection from outside predators by means of cages or boxes, net enclosures, and so on, constructed from a variety of materials.

The range of production methods is even greater than indicated above. In the hatchery-nursery phase, different possibilities exist, for example, for nutrition, lighting, and temperature control. In addition, at present there is no universal agreement about the species best suited to commercial culture. Biologists in Western countries favoured the culture of *T. derasa* and *T. gigas*, mainly on the basis that these accumulate more meat biomass than giant clams of smaller size, such as *T. crocea*. The former species were preferred in the programs fostered by MMDC, ACIAR and ICLARM. On the other hand, researchers into giant clam mariculture in Japan concentrated on *T. crocea*, a species well adjusted to environmental conditions in the far south of Japan and with meat of a quality sought after by Okinawans.

As is well known, gain in biomass is not an adequate basis for economic choice of a species to culture. The cost of culturing alternative species must be taken into account, as must the relative demands of consumers for them. This demand will depend not only on the quantity of the product involved but also on its characteristics.

The results reported here are for the economics of culturing *T. gigas* for meat, assuming use of the cultural methods developed at the Orpheus Island Marine Research Station of JCU. These methods involve land-based, semi-intensive production of seed, and intertidal culture of giant clams (Lucas et al. 1988). Giant clams spend the first 10 months or so in a land-based, hatchery-nursery stage. They are then transferred to an intertidal area such as a rock platform where they are placed on the substratum and protected either by galvanised steel-mesh cages or arranged in 'lines' covered by plastic meshing for protection (Figures 19.1–19.3). This is sometimes called the ocean-nursery phase and is the first of the ocean phases. The next phase involves growout on the ocean floor, either without protection (Figure 19.4) or using floating netting fences as enclosures.

We will consider first the cost of seed production, then the economic returns which may be earned from growing-out giant clams.

The cost of production of giant clam seed

The cost of production of one-year-old giant clam seed was estimated using data from Orpheus Island Marine Research Station. The costs may be somewhat higher than one would expect under commercial conditions because the station was involved in research rather than commercial operations. Furthermore, one year may be a slightly longer period than needed for holding seed. Nevertheless, the results do provide useful indications of the likely magnitude of commercial costs.

The costs of production of seed have been estimated for nurseries/hatcheries producing 100000, 500000 and 1 million seed annually. Costs were divided into capital costs and operating costs.

Capital costs included the cost of the hatchery, accommodation and amenities for workers, the seawater supply system, fibreglass nursery tanks, hatchery and broodstock tanks and other equipment needed. Operating costs consisted of wages, fuel costs and outlays for repairs and maintenance of equipment. Depreciation was allowed for on all capital items, at a rate of 2.5% workers' accommodation and amenities and at 10% per annum on all other items, using the straight line method of depreciation. Details of cost estimates given by Tisdell et al. (1993a) are summarised in Table 19.1.

Interest on funds needed to finance annual operations is taken into account. Interest was allowed for both on capital and operating costs. Operating costs were assumed to be incurred evenly throughout the year. Clearly, such an allowance would be appropriate if the nursery borrowed all its funds. However, even if this is

Figure 19.1 Seed clams in a land-based pool at Orpheus Island in a fish tray. These are ready to transfer from the nursery to the ocean phase (C. Tisdell).

Figure 19.2 Giant clams transferred to the ocean nursery phase at Pioneer Bay, Orpheus Island. These have been protected by steel mesh cases (visible) and are located in the intertidal zone on a rock platform (C. Tisdell).

Figure 19.3 Giant clams arranged in rows and protected by plastic meshing or 'lines' on the rock platform at Pioneer Bay, Orpheus Island. This is an alternative form of protection (to steel cages) for the giant clams in the early ocean phase (C. Tisdell).

Figure 19.4 In due course, *T. gigas* can be grown out on the intertidal zone without protection. This is a naturally occurring *T. gigas* exposed at low tide at Orpheus Island (C. Tisdell).

Table 19.1 Estimated annual costs associated with giant clam seed production (A$).

Production target	100000 seed	500000 seed	1000000 seed
Labour ($30000/employee)	90000 (3)	120000 (4)	125000 (5)
Fuel	5000–10000	15000–20000	20000–35000
Repairs and maintenance			
Pumps and generators	1000–4000	2000–8000	3000–10000
Boats	2000–15000	3000–20000	4000–25000
Glassware and laboratory			
Consumables	1000	2000	3000
Tractor	2000	2500	3000
(a) Total operating cost	101000–122000	144500–172500	183000–226000
Operating cost per clam	1.01–1.00	0.29–0.35	0.783–0.226
(b) Depreciation of worker accommodation and amenities at 2.5% per annum	500–3000	625–3000	750–3250
(c) Depreciation at 10% per annum allowed for all capital items	17443–30443	24624–39624	32680–47680
(d) Interest charges[a] assuming a real rate of interest of 10%	24493–48543	34349–60249	44830–71980
Total (a+b+c+d)	142936–203986	204098–275373	261260–348910
Total cost per clam	1.43–2.04	0.41–0.55	0.26–0.35
If real rate of interest of 5% is assumed: Interest charges	12246–24271	17175–30125	22415–35990
Total	131389–179714	186934–245249	238845–312920
Total cost per clam	1.31–1.79	0.37–0.49	0.24–0.31

[a]Assumption is made that all funds used for capital and operating costs are borrowed, and that operating costs expended progressively through the years.

not the case, interest should be allowed for in the costing because an opportunity is foregone by investing funds in the business rather than investing them elsewhere to earn interest, for example in government bonds. Costs are estimated on the basis of two alternative real rates of interest, 5% and 10%.

Table 19.2 summarises the cost of producing *T. gigas* one-year-old seed given the above assumptions and on the basis of costs in Australia in 1990. Note that a range is given for each estimate in this table. This is because there is some room for variation in the cost components.

It is evident from Table 19.2 that significant economies of scale exist in the production of giant clam seed because the per unit costs of production of seed fall substantially as the annual volume of production increases. Full, operating and fixed costs for seed produced all fall as volume of output increases.

Table 19.2 Per-unit cost (A$) of producing giant clam seed as a function of volume of annual output

Type of cost	Number of seed clams		
	100000	500000	1000000
Operating cost	1.01–1.22	0.29–0.35	0.18–0.23
Total cost (5% interest)	1.31–1.79	0.37–0.49	0.24–0.31
Total cost (10% interest)	1.43–2.04	0.41–0.55	0.26–0.35

Given the techniques considered here, small hatcheries producing about 100000 seed clams per year would need to charge around $A1.50 (that is, in 1990, US$1.10 each) per seed to make a profit. However, nurseries/hatcheries producing 500000 seed per year would make a worthwhile profit if seed sold for $A0.50 each and, at a million seed clams a year, a price of $A0.30 could be sufficient to ensure profitability.

The significant economies of scale in production of giant clam seed indicate that it is likely to be advantageous from an economic point of view to have a few large producers of seeds rather than many small producers. Transport costs, however, are likely to influence the extent to which advantage can be taken of economies of volume in production at a single site. Costs will be influenced by choice of site (Tisdell 1993).

Economics of ocean growout

Ocean growout of giant clams can be considered as a separate economic activity to seed production. As the aquaculture of giant clams develops, some firms may specialise in seed production and others in ocean growout, though some firms may also engage in both activities. Here, the economics of ocean growout is estimated independently of seed production.

An ocean growout company is assumed to place in the ocean each year 100000 seed clams of about one year in age. Each batch of clams is assumed to be held by the firm for the period that maximises the internal rate of return on the funds it employs (cf. Gittinger 1982; Shang 1981). Then the problem is to estimate the optimal length of time to hold each batch of clams and the maximum rate of return achieved on funds employed (for further details see Tisdell et. al 1993b). To do this, account must be taken of the cost of holding and caring for clams, as well as the revenue to be expected from their sales.

To estimate the costs of the ocean phase of the culture of *T. gigas* we obtained data from the Orpheus Island Marine Research Station of JCU which has had extensive experience in this activity (Tisdell et al. 1991a; 1991b, 1993b). This was supplemented by information from a commercial giant clam farm, Reefarm Hatcheries, Cairns in an effort to obtain realistic cost estimates (Tisdell et al. 1993b).

As in the case of seed production, total costs were divided into capital costs and annual operating costs. Capital costs included outlays for a worker's house, tractor, boats, generator, lines and enclosures. Operating costs included the expenses for clam seed, wages, insurance, fuel, repairs and maintenance, and miscellaneous costs such as office expenses and leasing fees for the farming area. These costs are set out in Table 19.3. Depreciation on the house was allowed for at 2.5% per annum and on all other capital items at 10% per annum using the straight line method of depreciation (see Tisdell et al. 1993).

Table 19.3 Annual operating costs (A$) for ocean phase of giant clam farm[a]

Clam seeds (100000 @ 75c)		75000
Wages:		
1 full-time worker	30000	
Casual work	5000	35000
Insurance		9000
Fuel		1800
Repairs and maintenance:		
House	800	
Tractor	200	
Boats	250	
Generator	50	1300
Lease fees		800
Miscellaneous expenditures (e.g. office costs)		6100
Total		129000

[a]In addition to the costs shown in Tables 1 and 2, an initial advertising cost of $2000 is needed. This is allowed for in calculations of IRR.

Apart from costs, revenues have to be predicted. To do this it is necessary to estimate quantities of production of clam meat and per kilogram prices to be expected for it. Production estimates were based on biological data on growth and mortality rates for *T. gigas* suggested by experience at Orpheus Island Marine Research Station and the observations of Munro (1988, 1989). Details of the biological data used are given in Tisdell et al. (1993b). A mortality rate of 5% per annum is assumed to apply after an initial 2-year period of higher mortality rates.

A range of possible market prices for giant clam meat from $A3 to $A7 at the farmgate is assumed. Market surveys by Tisdell and Wittenberg (1990a,b; 1993a,b) indicated that a retail price for giant clam meat of $A10–12/kg would be quite acceptable to potential consumers in Australia. Shang et al. (1991 and Chapter 4 this Volume) also provide price estimates for *T. gigas* meat, mostly muscle, in Taiwan.

Giant clam meat can show considerable drip loss when transported or stored for marketing (Hambrey 1991). Internal rates of return estimated for this case allow for the possibility of a 40% drip loss in the weight of the meat.

In relation to sales of *T. gigas*, the possibility of their sale for the aquarium trade and for the high-priced sashimi and sushi market is ignored. The meat of *T. gigas* does not appear to be very suitable for sashimi or sushi, but sale of *T. gigas* shells could provide extra revenue for a giant clam farm if the meat were removed from the shell prior to sale.

The estimated internal rates of return for ocean growout of *T. gigas* for meat are set out in Table 19.4. The giant clam farm is assumed to buy one-year-old seed for $0.75 each. The alternative returns are shown for a range of farmgate prices for giant clam meat and for a situation without and with postharvest drip loss.

The situation in which the meat sells for $5.00/kg at the farmgate and a 40% drip loss occurs is possibly not over-optimistic. For this situation, a maximum internal rate of return of 11.25% could be achieved by holding giant clams in ocean growout for 14 years. After 11 years of growout, a return of 10.5% would be earned. This implies for this situation that ocean growout of giant clams for meat would be profitable if the rate of interest were less than the internal rates of return mentioned. If, for example, the rate of interest were 10%, ocean growout of *T. gigas* for meat would be profitable but the amount of pure profit (profit after allowance for interest) would be small.

Table 19.5 summarises the maximum rates of return based on the seed clam costs given in Table 19.2. These rates of return would be higher if the price of giant clam seed were lower. If seed sold at $0.50 each, the rates of return would be 2–3% higher.

It thus appears that, under Australian conditions and given Australian data, the ocean growout of *T. gigas* could be profitable for meat, but only marginally so. This is so if one takes the 'middle' scenario, which does not seem overly optimistic. The

Table 19.4 Internal rate of return for ocean farming of *Tridacna gigas*

Year of growout	Price of meat at farmgate					
	$3/kg	$3/kg -40%DP	$5/kg	$5/kg -40%DP	$7/kg	$7/kg -40%DP
8	6.10	0.00	16.30	6.10	23.10	12.80
9	8.40	0.00	17.50	8.40	23.50	14.40
10	9.60	1.30	47.90	9.60	23.30	15.00
11	10.50	3.00	18.00	10.50	22.90	15.40
12	11.00	4.00	17.80	11.00	22.20	15.50
13	11.20	4.80	17.50	11.20	21.60	15.30
14	11.25	5.30	17.00	11.25	20.80	15.05
15	11.21	5.70	16.57	11.21	20.10	14.75
16	11.05	5.87	16.05	11.05	19.30	14.35
17	10.86	6.03	15.57	10.86	18.60	13.96
18	10.60	6.00	15.05	10.60	17.90	13.55

Legend: DP = postharvest drip loss

Table 19.5 Number of years for which *Tridacna gigas* should be held in ocean phase to maximise economic returns and the resulting internal rate of return

Farm-gate price/kg of meat (A$)	Without drip loss		With 40% drip loss	
	No. of years to hold	IRR(%)	No. of years to hold	IRR(%)
3	14	11.25	17	6.03
5	11	18.00	14	11.25
7	9	23.50	12	15.40

clams would have to be held in ocean growout for a comparatively long time (e.g. 14 years) to maximise returns, but in most cases the penalty in terms of profit foregone by holding for a somewhat smaller number of years is not large. Profitability of production of giant clams for meat is significantly influenced by post-harvest drip loss from the meat. Returns will be improved if this loss can be reduced.

Discussion and comparisons

This study indicates that strong economies of scale are inherent in the production of giant clam seed by nurseries/hatcheries. While this can disadvantage smaller-scale producers of clam seed, we have only considered enterprises producing a single product, giant clam seed. A nursery may, through other products which jointly use its overhead facilities, e.g. seawater systems, be able to offset diseconomies in producing a small volume of giant clam seed. Examples of such diversification were given in Chapter 17. They can yield economies and reduce business risks. Tourists are a valuable commercial sideline for some nurseries. Furthermore, a nursery may use its facilities to grow clams for the aquarium trade.

Economies of scale were not specifically studied in relation to ocean growout of giant clams. Some such economies are likely to be present, although not as significant as for nurseries. The costs of overheads such as housing and boats suggest that some economies of scale are possible. However, once again a business venture need not devote itself entirely to the production of just giant clams. By producing multiple items the enterprise can spread the cost of its overheads between them if their production makes use of joint facilities.

It is interesting to compare the results based on Australian data with those obtained for U.S.-affiliated territories. In 1991, the cost of a one-year-old clam in Palau was estimated (see Table 18.1) to be US$0.82 and in American Samoa, US$0.76. At that time, the farmgate price of one-year-old giant clams was US$1.00 from MMDC in Palau. In Australian dollars (assuming that $A1 = US$0.75, as was approximately so in 1990 and 1991) these respective costs/prices are $1.09, $1.01 and $1.33. Taking into account the costs shown in Table 19.2, Australian production would be more costly for a venture producing 100000 giant clam seed per year, but would be well below that of Palau and American Samoa for production of 500000 or more seeds annually.

From Figure 18.4, it can be seen that salaries plus wages account for 42% of the annual costs of the combined nursery operations at MMDC, Palau. Wages and salaries are also the biggest component of annual costs in Australia (Table 19.1) assuming a 10% rate of interest. It is estimated that under Australian conditions, wages and salaries would account for 44–63% of total costs for the production of 100000 clam seeds annually, falling to 43–59% for 500000 clam seeds annually. The percentage of total costs accounted for by fuel and utilities is slightly less in Australia whereas the interest charge as a proportion of total costs is slightly larger. On the whole, there are no major differences in the proportion of costs accounted for by the different components of total annual costs for the hatchery/nursery, except that the wage component is higher in Australia.

From Table 19.3, it can be seen that the cost of giant clam seeds is likely to be the major annual outlay involved in the ocean growout of giant clams. In the case shown, they account for 58% of total annual outlays. Labour is the next largest outlay accounting for 27% of annual total operating expenditure. The percentage shares of the major items are set out in Table 19.6. This table can be compared with Table A18.6a for the Marshall Islands. Stocking cost is the major component of outlays in this case, accounting for about two-thirds of outlays if the small allowances for interest and depreciation are excluded. Allowances for these were not included in Table 19.3 because outlays were being estimated to compute internal rates of return. The proportion of total outlay accounted for by wages is much lower in the Marshall Islands than in Australia, being only 13–14% of total outlays, and reflects lower wage rates there.

Table 19.6 Percentage of total outlay of major components of annual outlay for giant clam growout based on Table 19.3.

Item	%
Clam seeds	58.1
Wages	27.2
Insurance	7.0
Fuel	1.4
Repairs and maintenance	1.0
Leasing fees	0.6
Miscellaneous expenditure	4.7
	100.0

As regards optimal harvesting time, the model used in Chapter 18 is slightly different to that used in this chapter. The model used in this chapter is designed to determine the growout period that maximises the internal rate of return of the farm. The model employed in Chapter 18 resulted in optimal growout periods for *T. derasa* ranging from 6.5 to 12.3 years depending upon the assumptions made and the product assumed to be saleable. The model considered in this chapter and for the situations dealt with (see Table 19.5) suggests an optimal growout period varying from 9 to 17 years depending upon circumstances. The length of growout for the maximum internal rate of return is, on the whole, longer for this case than that in Chapter 18. Partly, this may be because *T. derasa* reaches maturity earlier than *T. gigas* and therefore has a 'shorter' growth curve in comparison to *T. gigas.* While the model in Chapter 18 allows for a variety of saleable products, the one used here does not. However, neither model examines the economics of production for the aquarium trade or production for the sashimi or sushi markets.

While single-product or restricted-product models are useful for providing initial insights into the economics of production of giant clams, it is clear that more complex production and market possibilities exist than have been captured by the models considered here. Giant clams may be harvested, for example, at different ages for different markets, or they may be produced in conjunction with other aquacultured products. Even if this does not involve a form of polyculture, it still has significant implications for the economics of production.

Future research needs

The research results which have been reported in this monograph are but an introduction to the complexities of markets for giant clam products and the economics of the aquaculture of giant clams. Clearly, it would be an advantage to have a wider range of product models, covering a greater variety of species, a larger number of possible end-products and allowing for the production of multiple products.

Concerning markets for giant clam products, considerable research has already been done, but if commercial markets for aquacultured giant clam products grow, they will yield valuable new data which can be analysed to provide new market priorities. At present, there is a need for much more research into markets for shells and the economics of marketing them. Table 18.6 indicates that sale of shells may account for more than half the net present value of saleable products from aquacultured giant clams. It is therefore a very important component. While the cost of transport of shells is high, they have the advantage, unlike the meat, that they are not perishable, an advantage in regions which lack adequate preservation facilities.

Another area of importance as far as markets are concerned and for the development of clam mariculture is the operation of restrictions on trade, especially restrictions on international trade. For example, the Convention on International Trade in Endangered Species (CITES) applies to tridacnids. Has this restricted the development of giant clam mariculture and, if so, in what ways? Other constraints can include health regulations; for example, the attitude of the U.S. Food and Drug Administration (FDA) to imported giant clams and the hurdles involved in satisfying these regulations. These may reduce market possibilities and undoubtedly add to market transaction costs. However, such market transaction costs are not limited to international markets. As observed, for example, in Chapter 13, licensing requirements in Queensland for the sale of giant clams in the aquarium trade restrict the market for cultured giant clams.

Another important issue that needs to be addressed is the cost of preparing giant clam products for the market. If, for example, meat needs to be removed from the shell at or near the farm site and chilled or frozen, the cost of such preparation must be taken into account. In many cases, such operations would not, however, be carried out at the farm. The giant clam may be delivered in the shell to a 'food processor' with a coldstore and prepared there in a basic fashion as, for example, was done by Feeders in Fiji. Of course, it will be an advantage if such facilities are not distant from the farm. The use of such central facilities would result in economies for all growers of giant clams.

Concluding comments

Commercially, the giant clam is a very versatile animal. Virtually every part of it can be used. It does, however, have relatively specific ecological requirements which limit it to tropical and subtropical areas under natural conditions and it requires saline water which is not subject to significant freshwater surges. This makes it ideal for non-estuarine marine areas and tropical/subtropical islands, especially coral atolls. Using aquaculture, however, its range can be extended by means of land-based facilities but at a cost, e.g. winter heating may be required in some areas.

Biological obstacles to the aquaculture of giant clams have been overcome, though improvements in techniques for its mariculture will no doubt continue to be made. The spread of development of the industry of giant clam aquaculture now depends only on entrepreneurship and the economics of production.

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