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A SOCIAL COST-BENEFIT ANALYSIS OF A SMALL-SCALE CLAM FISHERY IN THE EASTERN CAPE, SOUTH AFRICA

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When a proposal was advanced in 1991 to harvest the wedge clam *Donax serra* in the Eastern Cape, South Africa, for commercial gain, it elicited a huge public outcry. In order to shed light on the issue, a social cost-benefit analysis (CBA), based on a biologically sustainable extraction rate of 100 ton of clams per year, was carried out on its commercial exploitation. Because fishery activities might exact a price on society in the form of negatively altering the quality of people's recreation experience in the area, as well as damage the aesthetic and ecological attributes of the beach system, such external effects were identified and valuated. Results from the CBA yielded positive net present values (*NPV*s) for project options involving live clams being sold on the export market (to Hong Kong) for R24.70 kg^{-1} and negative *NPV*s for domestic market options (Johannesburg and Cape Town), where the clam would be sold for R6.50 kg^{-1}. Assuming a discount rate of 8%, the highest *NPV* was obtained for the scenario in which total production was sold on the foreign market and the firm rented facilities of an existing organization. The external cost was the single largest component of the cost of the fishery. The conclusion drawn is that the social benefit of the project exceeds the social cost – a conclusion which supports commercial exploitation of clam stocks along the St Francis Bay beach, but one which does not include the costs associated with policing.

Key words: benefit cost ratio, contingent valuation, cost-benefit analysis, *Donax serra*, internal rate of return, net present value

The wedge clam *Donax serra*, popularly known as the white sand mussel, is a common member of the sandy beach macrofauna along the southern African coast. Large populations occur west of Port Elizabeth on a 25-km stretch of beach between the Maitland and Gamtoos river mouths (Fig. 1; McLachlan *et al*. 1996). Anatomically, the wedge clam is distinguished by a large muscle or "foot", with which it burrows into the sand (Brown *et al.* 1989). Although the entire, shucked animal is edible, it is the foot that is particularly sought. The meat is smooth, clean and firm, with a fleshy, pink colour. It can be eaten raw or cooked and has a unique, delicate, sweet flavour. Not surprisingly, to the private sector the clam stocks represent a vast utilizable and potentially profitable resource. However, in 1991, when a local seafood company submitted a proposal to harvest *D. serra* for commercial gain, public opposition was so vehement that permit applications to the Chief Directorate of Sea Fisheries (now Marine & Coastal Management) were withdrawn pending further research. Questions were raised as to the biological, ecological and economic feasibility of such activities.

A biological assessment of the *D. serra* populations in St Francis Bay revealed that they could be exploited sustainably at an extraction rate of 100 tons live mass per year, after taking into account the recreational take and incidental mortality (Schoeman 1998). The high frequency of recreational clam collectors who remove them for their own consumption confirms the status of this stock as a potential luxury food resource, which could be marketed beyond the immediate vicinity of the beach (Schoeman 1996).

The proposed method of harvesting would involve no mechanized implements and be relatively labour-intensive, implying that the initiation of such a fishery in the Eastern Cape has the potential to create employment opportunities for local unskilled labour. However, the site where the *Donax* stocks are located is a popular recreation venue, which attracts a large number of people (66 318 per year, Schoeman 1996). The area derives part of its recreational appeal from being largely undeveloped and the absence of commercial activity. Therefore, the presence of a clam fishery could have a negative affect on the region's aesthetic appeal. In addition, *D. serra* is a component of a complex sandy beach community (Brown and Mclachlan 1990) and, as Defeo and De Alava (1995) have demonstrated, disturbance of the sediment through clam harvesting activities could have a detrimental effect on other macrobenthic organisms in the substratum. As a result, harvesting *D. serra* populations could mean forgoing benefits provided by the undisturbed beach area in terms of quality of recreation in a wilderness setting for beach-users and undisturbed habitat for other

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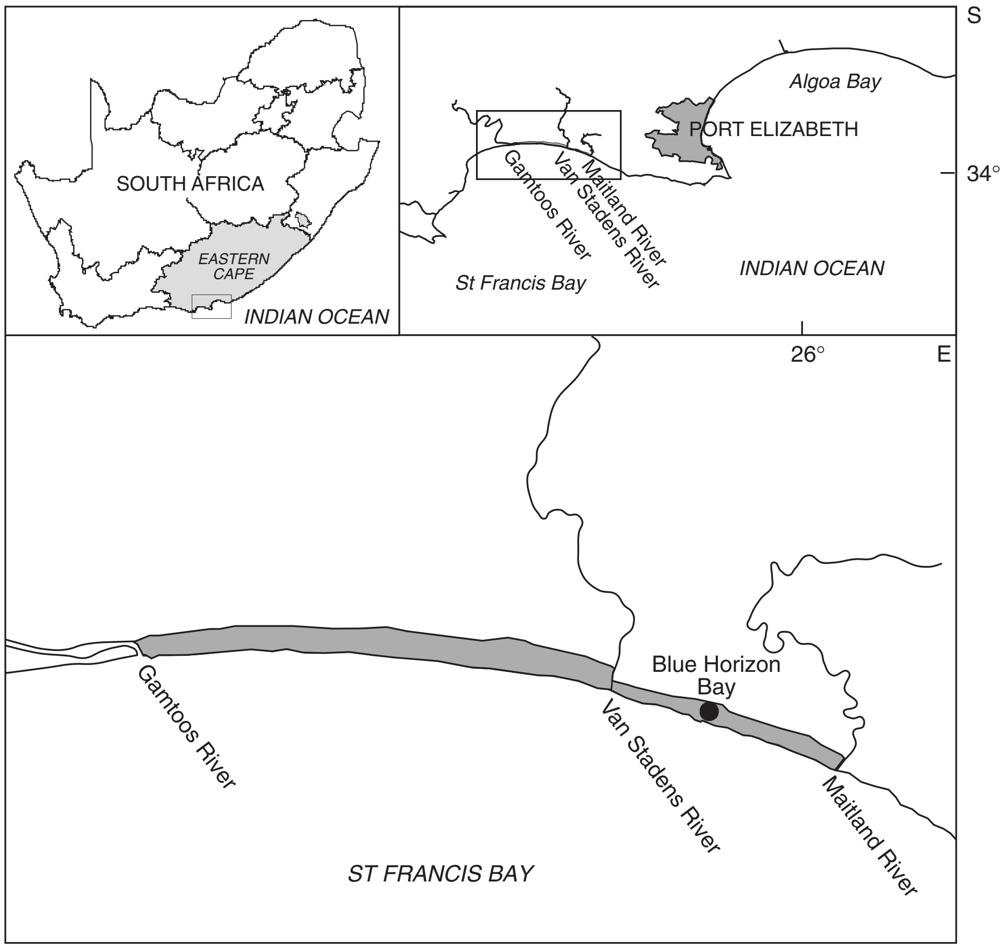

Fig. 1: The study area showing the regions and locations mentioned in the text

sandy beach organisms co-existing in the substratum. The damage associated with such environmental degradation may have little affect on the private company, but could affect others in society in the form of external costs.

There is therefore a classic economic dilemma, where a scarce resource has to be allocated among competing uses (Hartwick and Olewiler 1986). In the present case, these are to exploit the *D. serra* populations commercially for private gain or to leave them for the use and enjoyment of society at large. From an economic efficiency perspective, all effects need to be taken into account, including external ones. The latter are effects not reflected in market transactions and therefore not reflected in a private financial appraisal (Pearce and Nash 1981, Dixon 1986, Turner *et al.* 1993). This category of effects includes costs and benefits such as the cost of damaging ecosystems or those incurred by reducing the recreational and aesthetic enjoyment of the area, and benefits such as new employment opportunities and generating foreign exchange. An appropriate instrument for capturing all these effects and generating decision criteria from this information is social cost-benefit analysis (CBA). This paper reports the findings of such an analysis, which investigates the proposal to commercially exploit *D. serra* stocks in St Francis Bay.

MATERIAL AND METHODS

Study site

The sandy beach between the Maitland and Gamtoos river mouths is approximately 30 km south-west of Port Elizabeth in St Francis Bay (33°59´S, 25°10´E) and is one of a series of log-spiral bays along the coast of the South-Eastern Cape (Fig. 1). Located in the northern sector of the bay and being south-facing, the beach is very exposed to ocean swells, which approach mainly from the south-west (McLachlan 1977a, b, 1980, McLachlan *et al*. 1980). Resultant heavy wave action forms surf zones 150–400 m wide, and the considerable wave energy released in these zones is responsible for driving surf circulation patterns (McLachlan 1983), creating favourable conditions for generating large aggregations of the diatom *Anaulus australis* (Donn 1987). Such large densities of diatoms (up to 6×10^6 cells ml^{-1}) support massive populations of intertidal, filter-feeding, benthic macrofauna, dominated by *D. serra* (McLachlan and Hanekom 1979, Donn *et al.* 1986).

The beach between the two river mouths is unbroken for 24.5 km, except during spring high tides and flood events. With its uninterrupted expanses of sand, good fishing, plentiful bait supplies and numerous other attractive environmental features, it is a popular recreation venue (Heinecken and Heydorn 1983, De Ruyck and McLachlan 1993). Along its entire length, the beach has only four access points: the Maitland River carpark, the boardwalk over the foredunes at Blue Horizon Bay, the Van Stadens River holiday resort and the Gamtoos River caravan park (Fig. 1). Most beach activities concentrate around these points of access, forming nodes of high recreational use and human impact.

Cost-benefit analysis

A CBA has various elements:

(1) A critical step in the social CBA is to identify the costs and benefits of the project and to express them in monetary terms, in the present case South African Rands (R). It is a difficult step because external effects, such as environmental impacts, are not reflected in market prices and are therefore difficult to place a monetary value on (Little and Mirrlees 1980, Pearce *et al.* 1990).

(2) The cost-benefit flows (the net difference between costs and benefits over the study period) are all equated to a base value (the present value) by discounting. Discounting involves reducing all receipts and payments over time to those equivalent to present values (Anderson 1977, Abelson 1979). This reduction is achieved by multiplying each receipt and payment by a discount factor

$$\frac{1}{(1+i)^t} \quad ,$$

where i is defined as the discount rate and t is time in number of years (after the date defined as the present – the base year). The social discount rate should reflect the opportunity cost of the project in terms of returns available on alternative projects. Where these are too difficult to determine and the project involves government funding, it is often advocated that the government borrowing rate be used as the discount rate (FitzGerald 1978). Alternatively, if the government is not directly involved as an investor, a sensitivity analysis with respect to discount rates is advocated, which is the approach adopted in this study (Pearce and Nash 1981; Dixon and Meister 1986).

(3) Typically, one or more of three decision criteria are used together in a CBA: net present value (*NPV*), internal rate of return (*IRR*), and benefit-cost ratio (*BCR*). A project is deemed socially desirable if the *NPV* is positive, if the *IRR* exceeds the applicable discount rate or if the *BCR* exceeds unity. The main reason for use of more than one criterion is because there is usually uncertainty over the real value of the discount rate. However, where more than one criterion is used, there may be ambiguous results, with one criterion indicating acceptance and another rejection (Turner *et al*. 1993).

When the capital input varies between project scenarios, the *NPV* cannot be relied upon to select the economically optimal project because it favours more capital-intensive projects (Abelson 1979, Pearce and Nash 1981). For this reason, alternative criteria, such as internal rates of return and benefit-cost ratios, are favoured to rank the projects. The *IRR* criterion is the most popular of these options because it links to the widely used concept of a rate of return and does not require knowledge of the discount rate in its calculations. There are also problems with this criterion when the discount rate differs from the *IRR* or there are multiple changes in the sign of the net benefit flows (FitzGerald 1978, Pearce and Nash 1981). Under these circumstances the BCR may be preferred.

The *NPV* is the sum of benefit-cost streams discounted to base-year value, in this case 1994, and is defined as

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} \quad ,$$

where B_t is the benefit in year t, C_t the cost in year t, n the number of years over which the project runs and i is the discount rate.

The *IRR* is the discount rate (i), which equates the net benefit stream (*NPV*) to zero, as illustrated in the following equation:

$$\sum_{t=0}^{n} \frac{B_t - C_t}{(1+i)^t} = 0 \quad .$$

The *BCR* is defined as follows:

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}} \quad .$$

Estimating costs

In order to estimate the total cost of initiating a small-scale clam fishery, as well as harvesting a specified quota of *D. serra,* lists were drawn up (using 1994 market prices, excluding VAT) of all costs that would arise from the point of extraction up to when the clams reached their market destination.

CAPITAL COSTS

The initiating company could choose to commission the job out to others, which would reduce its expenditure on capital requirement. Another choice is which market to target for selling the clams. The choice of market destinations is dictated by the need to cover local coastal and inland options as well as an export one. Whereas more distant markets are more costly to sell to, they often yield higher returns.

To gain information on the merits of these choices, six variations of the project of exploiting the *D. serra* population were distinguished:

(1) Full capital outlay (FCO) and selling of the clams through Cape Town;
(2) FCO and selling of the clams through Johannesburg;
(3) FCO and selling of the clams through Hong Kong;
(4) Utilization of existing facilities (UEF) and selling of the clams through Cape Town;
(5) UEF and selling of the clams through Johannesburg;
(6) UEF and selling of the clams through Hong Kong.

OPERATING COSTS

Estimates of costs used in this analysis were based on the expenditures of existing companies with similar operating requirements. Transaction costs, or delays in cash payment by the distributor for the product, were not included in the analysis. Operating costs included land lease rent, maintenance costs, administration, personnel, packaging and fuel costs.

EXTERNAL COST ESTIMATION

Another important category of costs is external costs and particularly the social benefits foregone as a result of the clam fishery. If unpriced environmental resources are used or degraded during production, no internal cost would be incurred by the company, but it would impose an external cost upon society (Turner *et al.* 1993). These considerations are important because the beach under study is used extensively by the public. In order to take full account of all possible costs to society, it is therefore essential to identify and to value any effects fishery activities might have on human well-being (Abelson 1979). Unpriced resources potentially affected by clam-fishery operations include quality of recreational experience for current beach users, aesthetic and relaxation use, and a well-functioning natural ecosystem.

Personal interviews, based on the contingent valuation method, were carried out on the beach between the Maitland and Gamtoos river mouths to ascertain how beach users valued certain environmental changes. Established techniques in survey design, questionnaire structure and interviewing were applied and adhered to (see Schnetler *et al.* 1989). Both open-ended and set format questions were used. To prevent attitudes to and perceptions of the beach being biased towards preconceived opinions regarding the exploitation of the clams, no discussion regarding *D. serra* was made in the initial sections of the questionnaire, which dealt with beach quality, sense-of-place and recreational experience. By way of introduction, respondents were informed that the survey was part of an effort to improve management decisions regarding the beach. Only the final section of the questionnaire dealt with people's attitudes towards the proposed clam fishery and the amount they were willing to pay to maintain the qualities of the beach they enjoyed. The payment vehicle used by which respondents could express their willingness to pay (WTP) was that of a "gate fee" or admittance fee payable at all nodes of access to the beach area. Those respondents not in favour of clam harvesting were asked to specify the maximum amount they were willing to pay per visit to prevent the fishery from going ahead, so preserving the attributes, qualities and services which they considered important for the beach (Hartwick and Olewiler 1986, Kahneman and Knetsch 1992). Respondents were not reminded or made aware of their budget constraints. The total economic value of the intact and undisturbed beach (complete with unexploited *D. serra* populations) was estimated by multiplying the average WTP observed in the sample by the number of individuals in the entire beach-user population who were opposed to the fishery and were willing to pay to prevent it (Kahneman and Knetsch 1992). This amount was included as an annual cost for each year of the project and used in the final calculation of net present values (*NPV*) for each project scenario.

Two estimated values for external costs were considered, high and low. The high estimate was the WTP value expressed by beach users opposed to the clam fishery. It assumes a loss of well-being to these individuals simply through their knowledge of the fishery's existence, as their preference is that the fishery should not be allowed. The low estimate of external costs was based only on the impaired experiences of the recreationists who come in direct contact with fishery activities (i.e. those beach users frequenting the remote beach area between the Gamtoos and Van Stadens river mouths during off-peak holiday season weekdays).

External costs associated with loss of recreation experience, aesthetic quality and integrity of the local ecosystem were also subject to sensitivity analysis; the values of these variables were largely unknown and could fall within a wide range. The evaluation of possible benefits foregone as a result of the fishery commencing was subject to great uncertainty, primarily because of the intangible and unquantifiable nature of the goods and services provided by the beach. In addition, inherent weaknesses within the contingent valuation method, as reviewed by Loomis (1989) and Johansson (1991), as well as with general survey techniques (Schnetler *et al.* 1989; e.g. misinterpretation of questions, variability between interviewers) need to be taken into account.

Project benefits

The revenue benefits were estimated as the product of the annual sustainable yield of *D. serra* (100 tons live mass year) and their wholesale price. The latter was determined by a market demand survey conducted by means of a postal questionnaire. Respondents were asked whether they would be interested in dealing with the clam; how much they expected to pay per kg for it; and what quantity they would require.

A telephonic interview was conducted with a Cape Town distributor to determine what costs, revenues and returns could be expected should a sole distributorship be agreed upon for the St Francis Bay *D. serra*.

Hong Kong was chosen as the potential export destination for *D. serra* because European and North American markets were perceived to be flooded with clam supplies or close substitutes. Communications with Hong Kong were undertaken through a local seafood distributor who has a marketing agent there. As part of this survey, samples of legal-sized, purged clams were removed from the beach and air freighted to Hong Kong. Information was obtained regarding the price the clam might fetch on the export market, the processed state in which it would be preferred, and the quantity that would be demanded.

RESULTS

Proposed production process

The proposed clam fishery would entail harvesting, purging, cooling, packing, selling and transporting the clams. Because recreation is concentrated on the section of beach between the Van Stadens and Maitland river mouths, no harvesting was considered there. Rather, to avoid spatial conflict with other beach users, harvesting activities would take place within the intertidal zone along the beach between the Van Stadens and Gamtoos river mouths (Fig. 1). Furthermore, no harvesting was considered on the beach up to 5 km east of the Gamtoos River mouth and up to 1 km west of the Van Stadens River mouth, because this is where recruitment peaks and overall clam abundance is low (Schoeman 1998). This leaves 11 km of the total 25 km beach available for harvesting.

D. serra spawns continuously throughout the year (De Villiers 1975, McLachlan and Hanekom 1979). For this reason, there are no biologically defined seasons for harvesting, but it was considered feasible only during low tide, in daylight and on weekdays. For social reasons, no harvesting could be conducted during weekends, public holidays or peak summer holiday season, equating to a harvesting period of approximately 10 months, with 15 days available in each month. To meet the aforementioned annual quota of 100 tons live mass (as set by Schoeman 1998), the average daily removal rates would be 660 kg day^{-1}.

Restrictions on harvesting techniques would be no

Table I: Annual airfreight costs to Johannesburg and Hong Kong

Market destination	Price (Rands per kg)	Chargable mass (kg)	Number of 20 kg boxes/chargable mass	Number of air-freights per annum	Total air-freight cost per annum
Johannesburg	1.29	660	33	150	R127 710
Hong Kong	4.96	660	33	150	R558 540

use of machinery, i.e. manual removal only. To harvest 660 kg day^{-1}, eight unskilled labourers would be required (82.5 kg per labourer – based on calculations by Sims 1997), supervised by a foreman. The location of high densities of adult clams within the intertidal zone would first be selected, after which the labourers would turn the sand over using standard large garden forks to remove legal-sized clams by hand. Clam removal is legally limited to individuals with a shell length of at least 55 mm.

Extracted clams need to be kept in covered, insulated crates with moist packing material to keep them cool. Following extraction, the clams would be relocated to purging tanks in Port Elizabeth and be submerged in fresh, flowing seawater for 24–48 h to remove sand. They would then be packed in cardboard boxes layered with wood-cotton and ice-bottles to ensure a temperature of 2°C, after which they would be air-freighted to the market destination.

Costs

CAPITAL COSTS

Capital equipment required includes a prefabricated office building, covered concrete depuration tanks, a seawater pump, off-road vehicles and refrigerators. The advantage of shared use of capital between the proposed clam fishery and another company is that capital items would not need to be purchased or leased. It only requires the acquisition of two off-road vehicles, crates and forks. Capital costs in the latter case were R42 322 lower than a full capital outlay (R157 561 v. R199 883, using 1994 market prices, excluding VAT).

Based on a project period of 16 years, the salvage value of physical capital at termination was estimated to be R108 570; it could be used productively in other economic activities thereafter. This value was added to economic benefits in the terminal year of the project.

OPERATING COSTS

Three permanent staff were budgeted for: a foreman to oversee harvesting activities of the eight labourers on the beach; a full-time administrator to carry out clerical duties; and the director who would be responsible for marketing, supervision and the running of the company. It could be argued in the case of unskilled labourers that there is a zero opportunity cost in employment because they are often unable to find alternative work (Hufschmidt *et al.* 1983). A counter-argument is that no matter how destitute an individual, he or she will not work for a zero wage, implying that the wage is a real cost (Munasinghe 1993). The latter thinking was adopted in this analysis and the full costs of both the skilled and unskilled labourers were recorded as social costs.

Based on the above expenditure items, total annual ex-factory operating costs (i.e. air freighting costs not included) associated with the first year of production for a small-scale clam fishery amounted to R364 517 per year (based on 1994 prices). These are social costs and therefore do not include VAT.

Air-freighting was considered to be the only feasible method to transport *D. serra* (especially live) because rail and road are too time-consuming. Air-freight costs associated with each market destination are summarized in Table I. Shipment to the export market include the services of a freight forwarding agent.

EXTERNAL COSTS

External costs by beach users opposed to the fishery amounted to R1 007 186 year (R21.60 per person per visit), whereas direct user costs incurred as a result of first-hand contact with clam fishery operations totalled R45 013 per year (R17.78 per person per visit). Only 4% of all beach users would likely come into direct contact with the proposed clam fishery activities during the year, mostly weekday surf-anglers who use the beach more extensively than any other recreation group during off-peak holiday season weekdays. Totals for all costs are summarized for each of the project options in Table II.

Project benefits

The results of the survey are summarized in Table III. Of the 23 seafood distributors to whom questionnaires were sent, 10 responded. In Johannesburg, 60% of

Table II: Summary of costs for each project option in the base year of production (year = 0) with respect to the three cases where (A) impaired quality of recreation experience is represented by the section of the beach-using population opposed to the fishery (external cost = R1 007 186 per annum), (B) the cost of impaired recreation is represented by individuals coming in direct contact with fishery activities (external cost = R45 013 per annum) and (C) the private case scenario where external costs are disregarded. Prices are social costs (excluding VAT) and apply to 1994. The percentage each individual cost comprises of the total cost is listed in parenthesis

Item	Cost (Rands)					
	Hong Kong		Johannesburg		Cape Town	
	UEF	FCO	UEF	FCO	UEF	FCO
(A)						
Capital cost	157 561 (8%)	199 883 (9%)	157 561 (10%)	199 883 (12%)	157 561 (10%)	199 883 (13%)
Operating cost	923 058 (44%)	923 058 (44%)	492 228 (30%)	492 228 (29%)	340 518 (23%)	340 518 (22%)
External cost	1 007 186 (48%)	1 007 186 (47%)	1 007 186 (60%)	1 007 186 (59%)	1 007 186 (67%)	1 007 186 (65%)
Total	2 087 804	2 130 127	1 656 974	1 699 297	1 505 264	1 547 587
Cost kg^{-1} (excluding EC)	10.81	11.23	6.50	6.92	4.98	5.40
Cost kg^{-1} (including EC)	20.88	21.30	16.57	16.99	15.05	15.48
(B)						
Capital cost	157 561 (14%	199 883 (17%)	157 561 (23%)	199 883 (27%)	157 561 (29%)	199 883 (34%)
Operating cost	923 058 (82%)	923 058 (79%)	492 228 (71%)	492 228 (67%)	340 518 (63%)	340 518 (58%)
External cost	45 013 (4%)	45 013 (4%)	45 013 (6%)	45 013 (6%)	45 013 (8%)	45 013 (8%)
Total	1 125 632	1 167 954	694 802	737 124	543 092	585 414
Cost kg^{-1} (excluding EC)	10.81	11.23	6.50	6.92	4.98	5.40
Cost kg^{-1} (including EC)	11.26	11.68	6.95	7.37	5.43	5.85
(C)						
Capital cost	157 561 (15%)	199 883 (18%)	157 561 (24%)	199 883 (29%)	157 561 (32%)	199 883 (37%)
Operating cost	923 058 (85%)	923 058 (82%)	492 228 (76%)	492 228 (71%)	340 518 (68%)	340 518 (63%)
Total	1 080 619	1 122 941	649 789	692 111	498 079	540 401
Cost kg^{-1} (excluding EC)	10.81	11.23	6.50	6.92	4.98	5.40

FCO = Full capital outlay
UEF = Facilities of existing company utilised
EC = External costs

distributors indicated that they would like to buy the clam. A prominent international seafood distributing agency in Cape Town expressed interest in initiating a clam fishery in the Eastern Cape. They are currently the largest manufacturer, distributor and marketer of live mussels and oysters and perceived clams as being part of their product range. They proposed a sole distributorship in which they would finance packaging and air-freight costs to Cape Town. They had an existing client base for distribution nationally where this product would be marketed.

Table III: Potential revenues accruing from various market options, foreign and domestic

Market destination	Quantity (tons per annum)	Price (Rands per kg fresh, whole clams)	Revenue (Rands per annum)
Johannesburg	100.00	6.50	650 000
Cape Town	100.00	3.75	375 000
Hong Kong	100.00	24.70	2 470 000

In terms of the responses, by far the most promising market in terms of profit was Hong Kong, with indications of a price of US\$5.0–8.0 kg^{-1} in 1994 R19.00 –30.40 kg^{-1} in 1994 when R3.8 = US\$1). These values covered the normal selling price range of clams on the Hong Kong market. The Hong Kong respondent sought to buy the entire production of 10 tons (500 × 20-kg boxes of clams – preferably live) per month.

Discount rate

In this analysis, 1994 prices define the present values. The social discount rate used in the analysis was the average long-term real rate of return on government stock with a 10-year maturation, i.e. the real cost of government borrowing on the bond markets; a rate of 8%. In 1994, the nominal rate was 16.9%. The real rate was calculated by subtracting the inflation rate from this rate. As the production price index for South African goods increased during 1994 by 8.9%, the real rate of return on government stock was 8%, i.e. 19.9% less 8.9%. Given the importance of the choice

Table IV: Summary of the decision criteria resulting from the cost-benefit anaysis (CBA) using different external costs: (A) R1 007 186, (B) R45 013 and (C) R0 per annum

Project	CBA criteria						
	NPV (R million)			IRR	BCR		
	Discount rate (%)				Discount rate (%)		
	5	8	10		5	8	10
(A)							
Hong Kong UEF	5.96	4.97	4.56	Undefined	1.27	1.27	1.27
Hong Kong FCO	5.92	4.93	4.42	Undefined	1.27	1.26	1.26
Johannesburg UEF	-9.85	-8.31	-7.50	Undefined	0.43	0.43	0.43
Johannesburg FCO	-9.89	-8.35	-7.54	Undefined	0.43	0.43	0.43
Cape Town UEF	-11.25	-9.48	-8.56	Undefined	0.28	0.28	0.28
Cape Town FCO	-11.29	-9.53	-8.60	Undefined	0.28	0.28	0.27
(B)							
Hong Kong UEF	16.91	14.17	12.74	Undefined	2.50	2.50	2.49
Hong Kong FCO	16.87	14.13	12.70	Undefined	2.49	2.48	2.48
Johannesburg UEF	1.10	0.89	0.78	252%	1.17	1.17	1.16
Johannesburg FCO	1.06	0.85	0.74	129%	1.17	1.16	1.15
Cape Town UEF	-0.30	-0.29	-0.28	Undefined	0.93	0.93	0.92
Cape Town FCO	-0.35	-0.33	-0.32	Undefined	0.93	0.92	0.91
(C)							
Hong Kong UEF	18.91	15.86	14.25	Undefined	3.05	3.04	3.03
Hong Kong FCO	18.87	15.81	14.21	Undefined	3.03	3.02	3.01
Johannesburg UEF	2.19	1.81	1.61	Undefined	1.42	1.41	1.40
Johannesburg FCO	2.14	1.76	1.56	Undefined	1.40	1.39	1.38
Cape Town UEF	-0.94	-0.82	-0.76	Undefined	0.82	0.81	0.81
Cape Town FCO	-0.99	-0.87	-0.80	Undefined	0.81	0.81	0.80

NPV = Net present value
IRR = Internal rate of return
BCR = Benefit-cost ratio
UEF = Facilities of existing company utilized
FCO = Full capacity outlay

of discount rate, sensitivity analyses were used (Little and Mirrlees 1980, Pearce *et al.* 1990). In addition to 8%, values of 5 and 10% were selected to indicate the impact of lowering and raising the discount rate respectively.

Net benefit stream

Because of a short construction period (the office and tanks could be established within two months), production would be able to proceed at the beginning of the base year. Therefore, accrual of revenues was recorded from year 0. All cash flows (costs or benefits) were assumed to accrue at the end of each year.

The two factors that normally influence the time horizon most are (i) the expected life of the project in terms of the yield of outputs and (ii) the discount rate selected (Little and Mirrlees 1980, Dixon and Meister 1986). For any given discount rate and nominal value of annual benefits, the more distant the year in the future, the smaller the present value of the benefits for that year (Dixon and Meister 1986, Turner *et al.* 1993). For this project, which has a long useful life in terms of beneficial outputs (effectively in perpetuity because of the sustainability criterion – Tietenberg 1992, Turner *et al.* 1993) but a high discount rate (8%), the project duration used can be much shorter than the expected useful life of the project because net benefits in later years would have had negligible effect on net present value (Dixon and Meister 1986). With this in mind, a period of 16 years was set for the project (years 0–15).

Clam prices were not adjusted to reflect real price changes that could be expected as a result of greater demand as the product got better known. The revenue from the sale of capital assets still existing at the end of the project (estimated at R108 507 for all scenarios) was added to the income generated in the terminal year of the project.

The total undiscounted costs over the entire economic life of the project were obtained by summing the capital, operating and external costs, then aggregating this total over 16 years. The inclusion of external effects caused costs to escalate dramatically. In addition, choice of external cost yielded substantial differences between resultant costs within each scenario.

Decision-making criteria

Within each of the project scenarios, comparisons of subsequent years of production against the base year were carried out once the net benefit flows were discounted to present values. Comparisons between scenarios (using each of the discount factors) indicated a significant discrepancy between cash flows of different market options, but very little difference within market option scenarios, i.e. between scenarios involving different capital expenditures but like market options. The results of the CBA in terms of decision criteria are listed in Table IV.

DISCUSSION AND CONCLUSIONS

Decision criteria resulting from the CBA indicate that, once external costs have been taken into account, a small-scale clam fishery in the St Francis Bay area is only economically feasible at the recommended rate of extraction of 100 tons per year if the clams are sold on the export market (to Hong Kong). This applies irrespective of whether a discount rate of 5, 8 or 10% per year is used or whether capital equipment is purchased (FCO) or hired (UEF).

If the clams were to be sold on the Hong Kong market, the private *IRR* (where external costs are not included) is so high that it is undefined, the *NPV* is R15 860 000 (8% discount rate and UEF – Table IV (C) and the *BCR* is 3.04. The latter ratio means that the discounted benefits are more than three times the value of the discounted costs. Even if a higher discount rate is used (so reducing the value of future benefits to a greater extent), i.e. 10%, the *NPV* remains positive at R14 250 000. When external costs are included (the social CBA), the *NPV* remains positive at R4 870 000, the *IRR* remains undefined and the *BCR* remains above one, at 1.27 (Table VI (A) & (B). The depreciation of the Rand since 1994 may have reinforced the economic merit of the project.

By contrast, if the clams were sold in South Africa, the project would not be economically viable. When external costs are taken into account, the *NPV* of the project is negative, irrespective of whether the clams are sold in Johannesburg or Cape Town (Table IV).

In all scenarios, external costs, those resulting from beach users' diminished enjoyment, were the most important and highest. There could be an overestimation of beach-user cost in that the visual impact is unlikely to be as significant as most respondents appeared to envisage. Visual impacts would be temporary and localized, apparent for one tidal cycle both in terms of unsightly disturbances to the sand and workers excavating clams. However, other likely external environmental impacts are very real probabilities, such as reduction in the number of *D. serra* available to the recreational fishery and the effect of removing large quantities of *D. serra* on the beach/surf-zone food chain. For this reason, should a fishery of this nature be approved, management strategies to minimize the above impacts would be desirable.

In terms of fisheries management, adhering to the recommended annual rate of 100 tons of live clams per year (Schoeman 1998) is paramount to sustainability of the resource. Therefore, appropriate methods of regulation, monitoring and prevention of illegal extraction would require careful consideration. As the clam stocks are an open-access resource, the cost of policing will be high. It is important to note that this cost has not been built into the CBA, therefore, should it be prohibitively high, the CBA will no longer favour a clam fishery.

The preferred economic choice would be for a management strategy orientated towards a multiple-use objective of the beach, allowing both recreation enjoyment and development of resources simultaneously.

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LITERATURE CITED

ABELSON, P. 1979 — *Cost Benefit Analysis and Environmental Problems*. Farnborough; Saxon House: 198 pp.
ANDERSON, L. G. 1977 — *The Economics of Fisheries Management*. Baltimore; Johns Hopkins University Press: 214 pp.
BROWN, A. C. and A. McLACHLAN 1990 — *Ecology of Sandy*

Shores. Amsterdam; Elsevier: 328 pp.

BROWN, A. C., STENTON-DOZEY, J. M. E. and E. R. TRUEMAN 1989 — Sandy-beach bivalves and gastropods: a comparison between *Donax serra* and *Bullia digitalis*. *Adv. mar. Biol.* **25**: 179–247.

DEFEO, O. and A. DE ALAVA 1995 — Effects of human activities on long-term trends in sandy beach populations: the wedge clam *Donax hanleyanus* in Uruguay. *Mar. Ecol. Prog. Ser.* **123**: 73–82.

DE RUYCK, A. M. and A. McLACHLAN 1993 — Sandy beach conservation: perceptions and needs of beach managers. *University of Port Elizabeth, Institute for Coastal Research Report* **34**: 34 pp.

DE RUYCK, A. M. C., SOARES, A. G. and A. McLACHLAN 1995 — Factors influencing human beach choice on three South African beaches: a multivariate analysis. *GeoJournal* **36**: 345–52.

DE VILLIERS, G. 1975 — Growth, population dynamics, a mass mortality and arrangement of white sand mussels, *Donax serra* Röding, on beaches in the south-western Cape Province. *Investl Rep. Sea Fish. Brch S. Afr.* **109**: 31 pp.

DIXON, J. A. 1986 — The role of economics in valuing environmental effects of development projects. In *Economic Valuation Techniques for the Environment: a Case Study Workbook*. Dixon, J. A. and M. M. Hufschmidt (Eds). Baltimore; Johns Hopkins University Press: 3–10.

DIXON, A. and A. D. MEISTER 1986 — Time horizons, discounting, and computational aids. In *Economic Valuation Techniques for the Environment: a Case Study Workbook*. Dixon, J. A. and M. M. Hufschmidt (Eds). Baltimore; Johns Hopkins University Press: 39–55.

DONN, T. E. 1987 — Longshore distribution of *Donax serra* in two log-spiral bays in the Eastern Cape, South Africa. *Mar. Ecol. Prog. Ser.* **35**: 217–22.

DONN, T. E., CLARKE, D. J., McLACHLAN, A. and P. DU TOIT 1986 — Distributions and abundance of the white mussel, *Donax serra* Röding, as related to beach morphology. 1. Semilunar migrations. *J. expl mar. Biol. Ecol.* **102**: 121–31.

FITZGERALD, E. V. K. 1978 — *Public Sector Investment Planning for Developing Countries*. London; MacMillan: 200 pp.

HARTWICK, J. M. and N. D. OLEWILER 1986 — *The Economics of Natural Resource Use*. New York; Longman Higher Education: 530 pp.

HEINECKEN, T. J. E. and A. E. F. HEYDORN 1983 — The Gamtoos – an example of beach/estuary interaction. In *Developments in Hydrobiology*. **19**. *Sandy Beaches as Ecosystems*. McLachlan, A. and T. Erasmus (Eds). The Hague; W. Junk: 753 pp.

HUFSCHMIDT, M. M., JAMES, D. E., MEISTER, A. D., BOWER, B. T. and J. A. DIXON 1983 — *Environment, Natural Systems and Development: an Economic Valuation Guide*. Baltimore; John Hopkins University Press: 338 pp.

JOHANSSON, P. 1991 — Valuing environmental damage. *Oxford Rev. Econ. Policy* **6**: 34–50.

KAHNEMAN, D. and J. L. KNETSCH 1992 — Valuing public goods: the purchase of moral satisfaction. *J. environ. Econ. Mgmt* **22**: 57–70.

LITTLE, I. M. D. and J. A. MIRRLEES 1980 — *Project Appraisal and Planning for Developing Countries*. London; Heinemann Educational Books: 388 pp.

LOOMIS, J. B. 1989 — Test-retest reliability of the contingent valuation method: a comparison of general population and visitor response. *Am. J. Agr. Econ.* **71**: 76–84.

McLACHLAN, A. 1977a — Studies on the psammolittoral meiofauna of Algoa Bay, South Africa. 1. Physical and chemical evaluation of the beaches. *Zoologica Afr.* **12**(1): 15–32.

McLACHLAN, A. 1977b — Composition, distribution, abundance and biomass of the macrofauna and meiofauna of four sandy beaches. *Zoologica afr.* **12**(2): 279–306.

McLACHLAN, A. 1980 — The definition of sandy beaches in relation to exposure: a simple rating system. *S. Afr. J. Sci.* **76**(3): 137–138.

McLACHLAN, A. 1983 — The ecology of sandy beaches in the Eastern Cape, South Africa. In *Developments in Hydrobiology.* **19**. *Sandy Beaches as Ecosystem*s. McLachlan, A. and T. Erasmus (Eds). The Hague; W. Junk: 539–546.

McLACHLAN, A., DUGAN, J. E., DEFEO, O., ANSELL, A. D., HUBBARD, D. M., JARAMILLO, E. and P. E. PENCHASZAPEH 1996 — Beach clam fisheries. In *Oceanography and Marine Biology. An Annual Review* **34**. Ansell, A. D., Gibson, R. N. and M. Barnes (Eds). London; UCL Press: 163–232.

McLACHLAN, A. and N. HANEKOM 1979 — Aspects of the biology, ecology and seasonal fluctuations in biochemical composition of *Donax serra* in the East Cape. *S. Afr. J. Zool.* **14**(4): 183–193.

McLACHLAN, A., WOOLDRIDGE, T., SCHRAMM, M. and M. KÜHN 1980 — Seasonal abundance, biomass and feeding of shore birds on sandy beaches in the Eastern Cape, South Africa. *Ostrich* **51**(1): 44–52.

MUNASINGHE, M. 1993 — Environmental economics and sustainable development. *World Bank Environment Paper* **3**: 112 pp.

PEARCE, D. W., BARBIER, E. and A. MARKANDYA 1990 — *Sustainable Development: Economics and Environment in the Third World*. London; Earthscan Publications: 232 pp.

PEARCE, D. W. and C. A. NASH 1981 — *The Social Appraisal of Projects: a text in Cost-Benefit Analysis*. London; MacMillan: 238 pp.

PEARCE, D. W. and R. K. TURNER 1990 — *Economics of Natural Resources and the Environment*. London; Harvester Wheatsheaf: 320 pp.

SCHNETLER, J., STOKER, D. J., DIXON, B. J., HERBST, D. and E. GELDENHUYS 1989 — *Survey Methods and Practice*. Pretoria; Human Sciences Research Council: 233 pp.

SCHOEMAN, D. 1996 — An assessment of a recreational beach clam fishery: current fishing pressure and opinions regarding the initiation of a commercial clam harvest. *S. Afr. J. Wildl. Res.* **26**: 160–170.

SCHOEMAN, D. S. 1998 — Spatial and temporal dynamics of *Donax serra* in St Francis Bay: implications for a potential fishery. Ph.D. thesis, University of Port Elizabeth: 200 pp.

SIMS, R. 1997 — Resource economics of *Donax serra* in the Eastern Cape: evaluation of a small-scale clam fishery. M.Sc. thesis, University of Port Elizabeth: 138 pp.

TIETENBERG, T. 1992 — *Environmental and Natural Resource Economics,* 3rd ed. New York; Harper Collins: 614 pp.

TURNER, R. K., PEARCE, D. and I. BATEMAN 1993 — *Environmental Economics: an Elementary Introduction*. Baltimore; Johns Hopkins University Press: 340 pp.