ABARE CONFERENCE PAPER 93.6

Use of a stochastic investment model for evaluating the development of an Australian inshore albacore fishery

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37th Annual Conference of the
Australian Agricultural Economics Society
University of Sydney, 9–11 February 1993

A stochastic investment model was used to evaluate the prospects for developing an inshore albacore tuna fishery off the east coast of Australia. This modelling technique allows the likely distribution of output, costs and returns to be taken into account explicitly, and provides the range of possible outcomes with associated probabilities. It was found that if the fishery is set up on a six month seasonal basis, fishermen have a 75 per cent chance of making a real rate of return to capital of 5 per cent or more, and a 40 per cent chance of a real rate of return in excess of 10 per cent

The authors are grateful for the assistance of Paul Morris, Rhonda Treadwell and Lindsey Change at ABARE; Lindsay Chapman at the Bureau of Resource Sciences; and members of the Tasmanian Fishermans Association. Funding was provided by the Fisheries Resources Research Fund.

ABARE project 9343.110

Although it is known that there is a potential to establish an albacore tuna fishery off the east coast of Australia, this potential has not been exploited by Australian fishermen. Albacore tuna (*Thunnus alalunga*) is a highly migratory species, and the south Pacific albacore fishery is based on a single stock. This stock is fished by operators from Japan, Taiwan, Korea, the United States, New Zealand and, to a far lesser degree, Australia. The purpose in this study is to evaluate the prospects for developing an inshore albacore tuna troll fishery off the east coast of Australia.

The analysis in the paper is undertaken using a stochastic investment model. Such models may be a useful tool to assist decision makers engaged in exploratory and developmental fishing. In particular, such models can be used to analyse the possible benefits of additional investment and to examine the possible effect of alternative policy or management changes on the expected financial status both of individual operators and of the fishery.

Background

At present, mature albacore are taken by longline throughout the South Pacific and juvenile albacore are taken using surface fishing methods in international waters in the Tasman Sea, in the subtropical convergence zone east of New Zealand and in New Zealand coastal waters (Garvey 1991). The New Zealand albacore troll fishery, which operates from December to May each year, has annual landings of 2000–4000 tonnes. In 1991-92 over 3000 tonnes of albacore were taken over the five months December – April, with most of the catch taken January–March (Chapman, Ward and Ramirez 1993). About 200 boats are licensed to troll for albacore in the New Zealand troll fishery, although 90 per cent of the catch is usually taken by 25 per cent of the boats (Garvey 1991)

Within the Australian fishing zone, mature albacore are taken as bycatch in the Japanese and domestic longline fisheries, the domestic troll fishery, and the domestic recreational fishery. From 1985 to 1990, around 1200 tonnes of albacore were taken annually by the Japanese longline fishery. This was mostly taken from southeastern areas of the Australian fishing zone. About 250–600 tonnes are taken annually by Australian fishermen and anglers (Caton and Ward 1991).

In the past, the main markets for Australian albacore have been the local coastal markets for fresh fish, the Sydney fish market, the Melbourne fish market and the Heinz cannery in Eden. Additional markets, such as for smoked albacore, are under development, and there is also a large world trade in albacore.

Because the domestic market for albacore is small, there is a wide variation in price. The price received for albacore delivered to the Heinz cannery in 1990 was $1.20–1.50 a kilogram (Gavin 1991). During the Bureau of Rural Resources study referred to below, albacore from the study vessels was shipped from Eden to the Sydney and Melbourne markets. There was a wide range in the prices received, although the average Sydney and Melbourne prices were similar at $2.34/kg and $2.16/kg respectively. The lower Melbourne price was no doubt partly due to the fact that twice as much of the catch was sold onto this market (Chapman et al. 1993).

In 1991-92 the then Bureau of Rural Resources (now the Bureau of Resource Sciences) initiated a program to demonstrate the possibility of an Australian albacore fishery. Although albacore occurs along both the east and west coasts of Australia, the Bureau of Rural Resources' study was focused on stocks along the Australian east coast. Under the program, the operations of two albacore trolling vessels off eastern Australia were monitored and operational cost data and catch returns data for these boats were collected (Chapman et al. 1993). It appears that catch rates similar to those obtained in New Zealand are possible off eastern Australia. The analysis presented in this study is in large measure based on data collected during the Bureau of Rural Resources program.

Method

Development of a new fishery can involve high financial risks. Regardless of whether the development work is financed from public or private sources, it is important that potential financial benefits are evaluated against expected costs. The expected financial status of a developing fishery can be reassessed as development proceeds and more information on the fishery becomes available.

The effect of risk on returns from investment can be included in both point estimation models and stochastic models. Risk can be included in point estimation models by increasing the assumed discount rate and thus giving less weight to future returns; by applying risk adjustment to the single estimates used for each parameter; or by carrying out sensitivity analyses for alternative values of the uncertain parameters. In the results from stochastic models, risk is explicitly represented by presenting the returns from investment as a probability distribution (Treadwell, McKelvie and Maguire 1991). The range of possible returns is obtained with the associated probabilities. The likely probability distributions of output, costs and prices are explicitly included in the calculations. Moreover, the graphic presentation of the results (as for example in figure 1) provides decision makers with a concise summary of possible outcomes and their estimated probabilities. This is a particular advantage in an environment of limited information and high risk. A stochastic model can be used to assess the effect of alternative assumptions and alternative policies on future returns, and to assess which additional information may have the highest payoff. Stochastic investment models have been used in assessing risky investments in several primary industries, including livestock (Cassidy, Rodgers and McCarthy 1970), new horticultural crops (Brown and Hall 1982; Treadwell and Woffenden 1984) and new aquaculture industries (Treadwell, McKelvie and Maguire 1991).

Two fundamental questions relating to any fisheries development are whether fishermen are likely to make returns from the fishery commensurate with what they could make elsewhere, and whether returns from the fishery are likely to be sufficient to warrant additional developmental research. The question of whether returns to fishermen would be sufficient can be addressed by using a stochastic investment model to calculate the range of expected internal rates of return. The internal rate of return of an operation is the discount rate at which the estimated future net benefits equal zero. Whether additional investment in fisheries exploration and development is warranted can be addressed by using the stochastic investment model to calculate the effects of such development on the expected range of possible net present values of the fishery as a whole. This involves calculating the net present value of future benefits and costs for a given assumed discount rate.

Expected annual net benefit for an individual fisherman entering the albacore fishery will depend on the catches of albacore and bycatch species, the prices received for the fish, the fixed costs of entering the fishery (for instance, purchase of boat and fishing gear), the variable costs associated with the fishing activity, and in the final year of the project, any salvage value for the boat. This can be represented for each year by the following equation:

(1) $$NB_{jt} = \sum_{i=1}^{s} P_{it} Q_{ijt} + S_{bj} - C_{fjt} - C_{vjt}$$

where NB_{jt} is the net benefit received by fisherman j in period (year) t; P_{it} is the price of the ith species of fish in period t; Q_{ijt} is the catch of the ith species by fisherman j in period t; S_{bj} is the salvage value of fisherman j's boat (included only in the final year); C_{fjt} is total fixed costs of fisherman j in period t (in years when fixed costs are incurred); and C_{Vjt} is total variable cost of fisherman j in period t.

The net benefit for the fishery as a whole, in any year, is then:

(2) $$NB_t = \sum_{j=1}^{n} NB_{jt} - R_t$$

where R_t is the research cost incurred in developmental fishing in year t. Developmental costs, including research costs, should be included as a capital cost when estimating the net present value of the fishery as a whole. It is assumed that the cost of any exploratory or developmental research or infrastructure required for the development of the fishery is not borne by individual fishermen and is independent of the number of operators and the operations of individual fishermen.

The question of depreciation does not arise in estimating a fisherman's internal rate of return or the net present value of the fishery, because both of these measures are based on summations of the above yearly expressions over the evaluation period, with all costs entering in full in the year in which they are incurred.

The expected internal rate of return (*IRR*) for an individual fisherman is defined by:

(3) $$\sum_{t=1}^{T} \left(\frac{1}{1+IRR} \right)^t NB_{jt} = 0$$

where T is some specified time horizon. The net present value (*NPV*) of osts and returns over the whole fishery, for a given annual discount rate (r), can be calculated as:

(4) $$NPV = \sum_{t=1}^{T} \left(\frac{1}{1+r} \right)^t NB_t$$

The net present value of the fishery may be important when reviewing additional developmental costs.

The simulation model was made stochastic in the non-deterministic coefficients (see Cassidy et al. 19/0) using the SAS Monte Carlo simulator. The internal rates of return and net present values obtained were then plotted against their frequencies of occurrence to get their probability distributions.

The model was first used to explore possible differences in return between a full time (twelve months) albacore fishery and a six month seasonal fishery. To demonstrate the use of the model to compare alternative developments, the model was then used to assess the likely returns to the fishery with changes in marketing, which may require policy changes and additional capital expenditure.

Data and assumptions

Full time verses seasonal fishery

The analysis was carried out on the assumption that an efficient level of fishing effort occurs — that is, resource rent is not dissipated. Operational catch, cost and price data (tables 1 and 2), were obtained from the Bureau of Rural Resources albacore survey (Chapman et al. 1993). Costs and returns were valued at constant 1992 values. As the operational costs for the two vessels used in the 1991-92 east coast albacore operational survey were similar, single average values were used for these costs (table 1). Variations in the unit cost of catch are accounted for in the ranges of catch rates used (table 2). Boat catch, costs, and returns were assumed to remain unchanged over the period for which the analysis was carried out. This time horizon was set at 50 years in order to close the analysis. The final values will differ little from those for an infinite time horizon.

The catch and catch per unit of effort during the operational survey were greatest in the period December through June. It was assumed that outside the six months of a seasonal fishery, the boat would be operating in an alternative fishery such as rock lobster, longline or dropline fisheries. For this reason, the capital costs associated with the boat and electronic equipment which are attributed to the six month albacore fishery are only half those for a 12 month fishery. However, the full capital costs of trolling booms and equipment and admiralty charts are attributed to the six month fishery, since these are assumed to have no other use (although allowance for a longer life span is made for trolling booms in the case of the six month fishery).

It was necessary to assume a total annual catch rate. This was set at 3000 tonnes on the basis that it is believed that similar catch rates to that obtained in New Zealand will be possible (Chapman et al. 1993). A discount rate of five per cent was assumed. Regarded as a measure of the opportunity cost of capital, this is less than the current real 10 year bond rate (ABARE 1992), but substantially more than the average rate of return made by

Table 1: Costs incurred in albacore fishing operators a

	Costs by fishery			
	Yearly fishery b	Half yearly fishery c	Life d	Salvage value
	$	$	Year	$
Capital costs				
Boat	225 000	112 500	20	50 000
Trolling booms	2 120	2 120	5	–
Trolling equipment	2 500	2 500	20	–
Vessel electronic equipment	15 000	7 500	5	–
Admiralty	84	84	20	–
Annual operating costs				
Fuel and oil	21 697	12 441	–	–
Slipping	6 000	3 000	–	–
Fishing gear replacement	1 200	600	–	–
Frozen bait for chum	1 000	573	–	–
Vessel electronics and electronic repair				
License fee	460	460	–	–
Commonwealth permit	1 500	1 500	–	–
Communication	200	100	–	–
Skipper and crew	40% of landed value of catch			
Administration	1 500	750	–	–
Insurance	8 000	4 000	–	–
Handling e	6 750	4 735	–	–

a Based on average cost values (in 1992 dollars) for the *Eileen M* and *Ocean Lady* in the 1991-92 survey (Chapman et al. 1993). b Cost values for 1991-92. c Cost values for January to June 1992. It was assumed that fixed costs, such as the boat hull and electronic equipment, would be shared between the albacore fishery and alternative fisheries when the boat was not being used in the albacore

agricultural producers from 1976-77 to 1987-88 (Campbell and Haynes 1990). No fishery development costs were assumed.

Four parameters were allowed to vary. These were the catch rates and prices received for albacore and for other species (table 2). The ranges in catch rates assumed were a 50 per cent deviation on either side of the average catch rate of the two vessels during the 1991-92 survey. The range in prices was based on the observed price range for fish caught during that survey.

Table 2: Economic characteristics of the fishery a

	Unit	Average	Range
Full time fishery b			
Albacore			
Total line hours	100 line hours	181.31	–
Catch rate c	kg/100 line hours	192.29	96.15 – 288.44
Price received by operator d	$/kg	1.76	0.60 – 4.47
Other species			
Total line hours	100 line hours	181.31	–
Catch rate c	kg/100 line hours	53.07	26.54 – 79.61
Price received by operator d	$/kg	1.63	0.40 – 2.68
Seasonal fishery e			
Albacore			
Total line hours	100 line hours	103.96	–
Catch rate c	kg/100 line hours	235.27	117.64 – 352.91
Price received by operator d	$/kg	1.76	0.60 – 4.47
Other species			
Total line hours	100 line hours	103.96	–
Catch rate c	kg/100 line hours	55.46	27.73 – 83.19
Price received by operator d	$/kg	1.63	0.40 – 2.68

a Based on Chapman et al (1993). b Ten months per year operation. c Range is 50 per cent on either side of the average. d The average value is weighted by catch. e Six months: January to June.

Marketing alternative

An alternative set of assumptions was used to examine the possibility of selling albacore caught off the Australian east coast to Pago Pago, Samoa, (shipping the catch either directly from Eden or via Sydney) for canning and sale into the world canned albacore market.

If albacore are in perfect condition and exceed 4 kg whole weight, a price premium over other tuna species can be obtained by selling them onto the world market as canning tuna. The price received for trolled albacore in Pago Pago in the years 1990, 1991 and 1992 ranged from $2.13/kg to $3.23/kg, and averaged $2.63/kg (Chapman et al. 1993). Albacore can be directly freighted from Eden to Pago Pago by inter-island reefer or road freighted to Sydney and transhipped by container. The cost of shipment directly from Eden to Pago Pago is $0.45/kg and that of shipment to Pago Pago through Sydney is $0.67/kg (personal communication, David Bateman, Heinz Greenseas cannery, Eden, November 1992).

These costs include all handling, processing, freezing, storage, financing, crating, loading, container and Australian quarantine inspection costs. In addition it is possible, though unlikely, that transhipment by inter-island reefer from Eden will require capital expenditure for wharf improvements. This hypothetical cost was included to demonstrate the treatment of development costs in the model, and was set at $500 000.

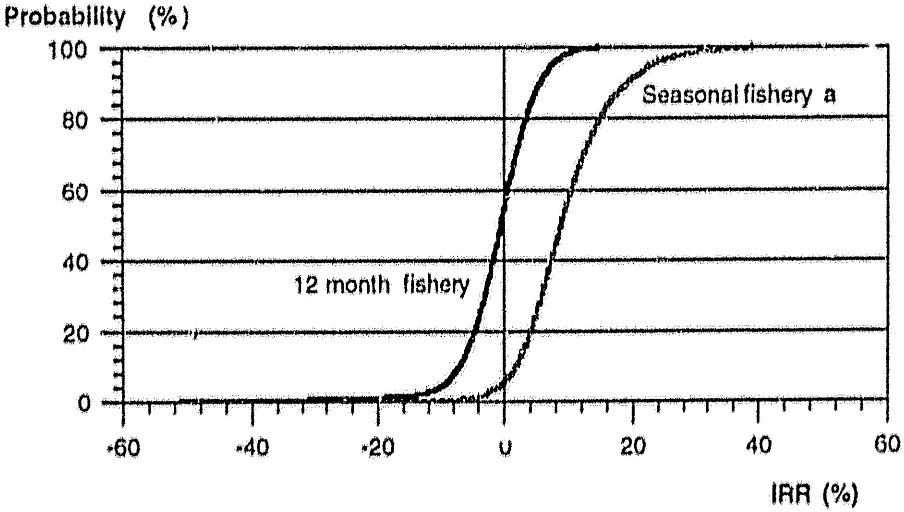
Transhipment of albacore from Eden would require the quantity to be sufficient to warrant bringing in an inter-island reefer. Based on expected Australian catch and catch rates, such quantities are unlikely to be accumulated without substantial holding costs. The quantity would be sufficient without appreciable holding costs, however, if United States albacore fishermen operating in international waters in the Tasman sea were permitted to land their catch in Eden. For this alternative to be possible a change in Commonwealth policy would be required.

Results

Full time versus seasonal fishery

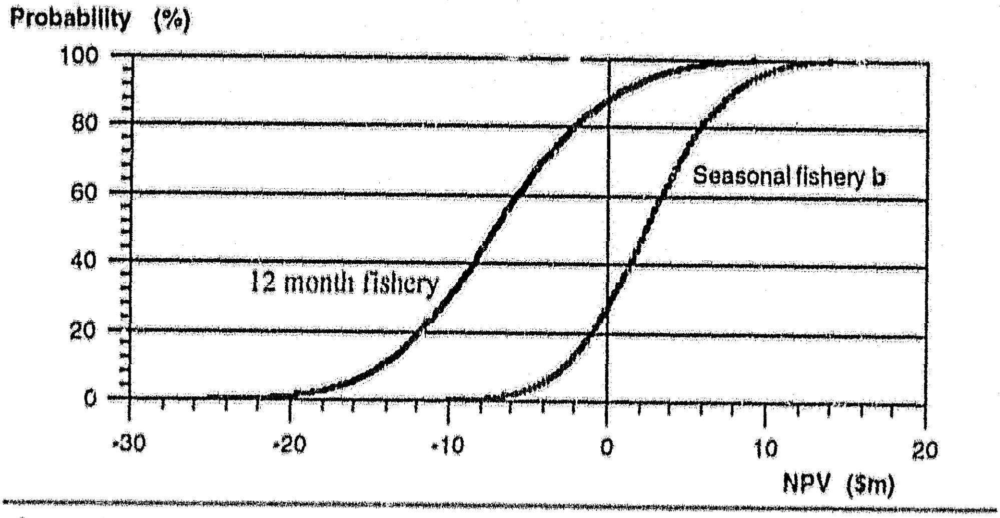
If the fishery were run full time, operators could not expect much better than a 10 per cent chance of making a five per cent return on capital (figure 1), and, conversely, there is a

Figure 1: Probability distributions of operator's internal rate of return



a Only half of the boat's capital cost is included

Figure 2: Probability distributions of net present value of the fishery a



a 5 per cent discount rate, annual catch 1000 tonnes. b Only half of the boat's capital cost is included.

greater than 50 per cent chance of fishermen making negative returns. Thus, assuming that the opportunity cost of capital is five per cent, there is a nearly 90 per cent chance that this cost of capital will not be met. The results for the fishery parallel those for individual operators (figure 2). Assuming a five per cent discount rate, there is nearly a 90 per cent chance that the net present value of the fishery is negative. On the basis of this analysis, the albacore fishery is not commercially viable as a full time fishery.

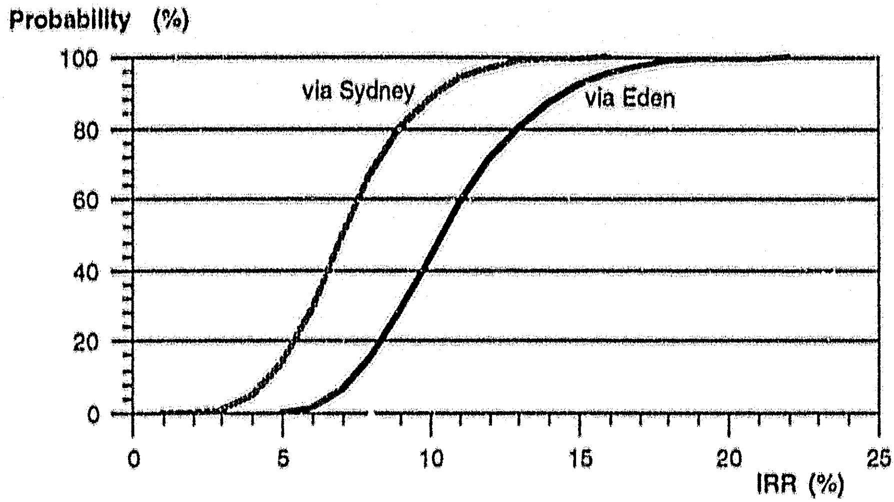
The analysis was re-run for a six month fishery operated from January to June. For a seasonal fishery, there is a better than 75 per cent chance that operators would make a return on investment of 5 per cent or more, and a 40 per cent chance that operators would make in excess of 10 per cent (figure 1). Based on previous ABARE research, this compares favourably with the returns made from other Commonwealth fisheries (for example, see Campbell, Battaglene and Shafron 1992).

The possibilities for the fishery as a whole again parallel those for individual operators. With a discount rate of five per cent, there is a 75 per cent chance that the net present value will be positive, and a 40 per cent chance that it will exceed $4 million (figure 2).

Marketing alternatives

For the analysis of the net benefits of the marketing alternatives, the fishery was assumed to be operated seasonally, as above. On the basis of the analysis, if albacore are transhipped

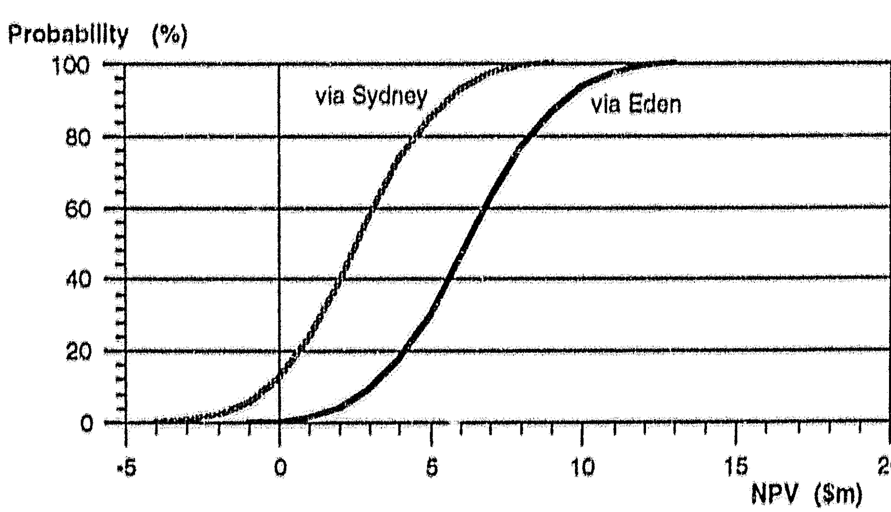
Figure 3: Probability distributions of operator's internal rate of return, selling to Pago Pago a



a Fishery operated seasonally

to Pago Pago through Sydney, there is a better than 85 per cent chance that returns to individual fishermen will exceed 5 per cent (figure 3). The possible returns range between zero and 19 per cent. For the fishery as a whole, if catch is transhipped to Pago Pago through Sydney, and again assuming a five per cent discount rate, there is a 13 per cent chance that the net present value of the fishery will be negative (figure 4). This is a similar

Figure 4: Probability distributions of net present value of the fishery, selling to Pago Pago a



a Fishery operated seasonally, 5 per cent discount rate result to that obtained for individual fishermen. The range of possible net present values of the fishery is –$4 million to $8 million.

However, fishermen could expect to do best by directly transhipping albacore from Eden to Pago Pago. Under this option fishermen could expect to make a return of 5 per cent or better, with about a 40 per cent chance of a return of at least 10 per cent. In this case, the range of possible returns is from around 5 per cent to 25 per cent.

For the fishery as a whole, the apparent benefit of shipping albacore to Pago Pago from Eden is not quite as good as that for the individual fishermen. In this case, there is a slight possibility of a negative net present value, although there is a 98 per cent probability that it will be positive, and it may be as high as $13 million. The slight difference between the outcome expected for fishermen and that expected for the fishery as a whole arises because of the assumed capital cost of $500 000 for infrastructure in Eden.

Conclusion

From an examination of the results of the analysis, for individual operators and for the fishery as a whole, a 12 month albacore tuna fishery off the east coast of Australia is unlikely to be economically viable, although a six month seasonal fishery could be.

Returns could be increased by shipping product to Pago Pago for canning through either Sydney or Eden. Because of differences in transport and handling costs returns would be greater for product shipped from Eden than from Sydney. Such an option is likely to reduce the risk of low or negative returns. At this stage, however, the option of shipping fish to Pago Pago from Eden does not appear to be feasible due to the small quantities of fish involved. This problem might be overcome if the Australian catch could be combined with a catch from another country's fishing fleet. However, this would require a change in Australian government policy governing port access by foreign fishing vessels.

The use of the stochastic investment model to assess the likely returns of different development options in an as yet undeveloped fishery was demonstrated in the study. This approach has the advantage that the likely distributions of output, costs and prices are incorporated into the calculations so that the spread of risk associated with investment in fish exploration and development can be calculated.

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