Management options for the southern shark fishery

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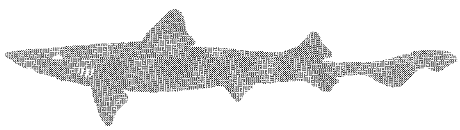
An economic analysis



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Foreword

Reduced shark catches will be required if catches in the southern shark fishery are to be sustained and profits improved. A history of excessive catch and too much investment in the fishery has resulted in reduced shark stocks and poor profitability.

The issue is not whether current landings need to be reduced, rather by how much landings need to be reduced. Accordingly, a forward looking approach in which emphasis is given to improved long term profitability and increased sustainable catch has been taken in this study.

Results from the study provide evidence that overall profitability of the fishery could be improved by a partial or complete closure of the fishery. While closure would result in short term costs to fishermen currently operating in the fishery, it could result in an increase in the net present value of their future earnings from the fishery.

BRIAN FISHER
Executive Director

Australian Bureau of Agricultural
and Resource Economics

December 1991

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Falling shark stocks led to interim management plan . . .

Southern shark stocks are being depleted by overfishing. Scientists have warned for some years that catches have to be drastically reduced to prevent a possible collapse of the fishery. An interim management plan was implemented in April 1988 to try to reduce fishing effort and catch.

. . . based on input controls

The management plan was based on controls on the number of boats and the amount of gillnet that could be used in the fishery. The purpose of the plan was to provide a framework to stabilise and eventually reduce fishing effort.

Task force created to examine future management options

This was seen as a first step in the development of a long term management plan. The Southern Shark Fishery Structural Adjustment Task Force was subsequently created to assess the status of the southern shark fishery and to advise on future adjustment in the fishery. The task force issued an information paper to industry in July 1991 setting out a range of management options for the long term management of the fishery.

Several options proposed

These options included the introduction of an annual total allowable shark catch of 400, 800 or 1200 tonnes (a substantial reduction from the present catches of over 3000 tonnes). Several different management options were proposed for achieving this reduction. These included the use of input controls in the form of further reductions in the amount of nets that fishermen could use, or output controls such as individual transferable catch quotas.

Purpose of this study

In this study the purpose is to estimate the likely effects of each of the proposed management options on shark stocks and the shark fishing industry. A

bioeconomic model of the fishery has been developed to help in this assessment.

Background

Fishery is worth about $15 million a year

The southern shark fishery is located in state and Commonwealth waters off Victoria, Tasmania and South Australia, with catches worth about $15 million a year. The fishery is primarily based on the capture of gummy and school sharks, although 15 per cent of landings consists of other shark species. Most of the shark catch is sold in fish and chip shops in Victoria as flake.

Most catch taken by gillnets

The southern shark fishery dates from early settlement, with offshore operations commencing off Victoria in the early 1920s. Until 1964, when gillnets were introduced, most of the catch was taken using longline. Since then the share of the catch taken using gillnets has increased to around 90 per cent.

Interim management plan reduced number of nets . . .

Under the 1988 interim management plan, 1678 units of gillnet were permitted, each unit being a 600 metre length of net. The units were allocated among 248 boats with Commonwealth endorsements to fish for shark in southern waters. Depending on their catch history the boats with Commonwealth endorsements were issued with either an ‘A6’ endorsement, entitling the fishermen to six units of net, or a ‘B5’ endorsement, entitling the fishermen to five or fewer units of net. In the first two years of the plan two A6 endorsements could be amalgamated to form an A10 entitlement, following the surrender of two units.

By 1991, 40 per cent of the Commonwealth net units had been removed from the fishery following surrender after amalgamation or as a result of forfeiture following the non-payment of licence fees.

The interim management plan failed to reduce fishing effort or catches to a level which biologists had indicated would probably sustain the commercial fishery.

. . . but not effort by enough

In 1990, biologists advised that fishermen were operating over a wider area than ever before and that the average size of shark landed was falling. Both factors provided indications that the shark fishery was still overfished. The results of biological modelling reinforced the need to urgently reduce shark catches. As a result, the Commonwealth announced in early 1991 that landings should immediately be reduced and that this would be achieved by reducing the number of net endorsements available to fishermen by just over a third.

Urgent need to reduce catch

Modelling the fishery

Financial data from an economic survey of the fishery, together with logbook data supplied by the Marine Science Laboratories in Victoria, and biological information from ongoing research by scientists in the Southern Shark Research Group have been used by ABARE as inputs into a bioeconomic model of the southern shark fishery. The biological component of the ABARE model is based on the 'SharkSim 1' model constructed by the South Australian Department of Fisheries

Bioeconomic model developed . . .

The ABARE model is a nonlinear optimisation model of the southern shark fishery and incorporates the major biological, physical and economic features of the fishery. The model was used to analyse the likely economic and biological impacts on a range of management options for the fishery.

. . . to analyse impacts of management options

As there is considerable biological uncertainty about the population dynamics of gummy and school shark stocks, two series of simulations were carried

Alternative biological assumptions

out. The first, the 'baseline' series, reflects the most commonly held views by biologists at the time of the project commencing. The second series of simulations incorporates more recent alternative biological views about the nature of shark stocks.

Baseline results

Twelve year closure

Under the baseline model simulations it was found that a twelve year closure of the fishery, followed by an annual sustainable catch of around 2200 tonnes would be likely to result in the largest potential stream of profits from the fishery over a thirty year period. The net present value of these profits was estimated to be around $27 million.

400 tonne annual catch

With an annual catch of 400 tonnes, the model results indicate that the catch could be increased to about 1400 tonnes after about twelve years, with the net present value of fishery production being reduced by more than 40 per cent compared with the 'optimal' simulation just mentioned.

800 tonne annual catch

An annual total allowable catch of 800 tonnes may not be sustainable much beyond eighteen years, with the net present value profits of this alternative estimated to be reduced by about 80 per cent compared with the 'optimal' simulation.

1200 tonne annual catch

The results of the simulation with an annual total allowable catch of 1200 tonnes were that this level could be maintained for only six years, after which time the catch would rapidly decrease. The net present value of profits for the fishery in this case was estimated to be only around 10 per cent of those achievable under the 'optimal' simulation.

Alternative simulations

Population size doubled

Under the second set of simulations, the assumed population size was doubled. This resulted in the net present value of profits under the 'optimal' simulation increasing to about $40 million, while the closure time required to maximise the net present value of profits fell to about eight years.

– effect on profits

With a larger population size, there may be little difference in the net present value of profits between the 'optimal' simulation and a 400 tonne annual total allowable catch for eight years followed by a 1400 tonne annual total allowable catch.

The 800 tonne annual total allowable catch was found to be sustainable under the higher population size assumption, while the 1200 tonne total allowable catch was not.

Lower juvenile survival rate

The sensitivity of the results was further tested by assuming an alternative lower juvenile survival rate. Although the net present value of profits for all of the management options considered was reduced, there was no change in their relative profitability compared with the baseline analyses.

Increased shark growth rates

The effects of uncertainty about growth rates for gummy shark were also examined. Growth rates, which affect weight and reproduction, were increased and the simulations rerun. This was found to have little effect on the relative benefits of either system, although the net present value of profits increased.

Constant recruitment of gummy sharks

Another biological possibility that was modelled was that the current catch of gummy sharks in the Bass Strait sector of the fishery could be sustained at 1500 tonnes a year. This biological assumption relies on the notion that there is a stock of adult gummy sharks off southern Tasmania that is inaccessible to fishermen. Under this assumption, the net present value of the profits of the gummy shark harvest could be as high as $47 million, depending on the form of management used. However, if the school shark component of the fishery was closed for eight to twelve years, the total sustainable yield of school and gummy sharks could be increased to as much as 3000 tonnes, and the net present value of profits increased to about $70 million.

Conclusion

Choices facing industry and managers

The choices being faced by the industry and those who manage it are either to reduce shark catch to a level which is currently sustainable (maybe 400 tonnes a year or less) or to temporarily reduce shark catches to an even lower level so that future landings and profits can be increased.

– for school sharks

Despite considerable biological uncertainty about the dynamics of the shark population, certain relationships in the fishery do appear to remain clear. Under all alternative biological simulations, the optimal outcome for the school shark fishery is consistent — close it for eight to twelve years to allow the stock to recover. While it may be impossible to totally avoid catches of school sharks, area closures and restrictions on gear type and mesh size may help to reduce catches of school sharks to a level sufficient to allow stocks to recover.

– for gummy sharks

The optimal use of the gummy shark component of the fishery is less clear. Under the baseline assumption, the 'optimal' outcome involves closing the fishery for eight to twelve years. Under the alternative constant recruitment assumption, the optimal outcome involves reducing the fleet to about twenty boats while maintaining current catch levels. Whichever assumption is correct, reducing the number of boats in the fishery is an essential step to conserve the shark resources and improve the future profitability of the industry.

1

Introduction

The Australian southern shark fishery has shown signs of declining stock levels for a number of years. This decline in stock has been largely attributed to overfishing (Southern Shark Fishery Restructuring Task Force 1991). Not only is the stock in serious danger of collapse, but a recent ABARE economic survey of the fishery (Battaglene and Campbell 1991) revealed that the average profitability of operators in the fishery was low and that a sizable proportion of the fleet was making a loss.

In 1984 the Southern Shark Task Force was set up by the Australian Fisheries Council to review future management options for the southern shark fishery. Following advice from the task force, a limited entry management scheme based on the assignment of non-transferable shark endorsements for boats operating in Commonwealth waters was introduced in 1986. In April 1988 an interim management plan was introduced. This was intended to reduce fishing effort to the 1982 level — a time when it was considered that fishing effort and catch rates were stable.

In 1989 the Commonwealth government released its policy statement for the management of Commonwealth fisheries through the 1990s (Commonwealth of Australia 1989). A management objective set out in the Commonwealth policy statement was the need for fisheries management to maximise economic efficiency subject to maintaining the biological sustainability of the resource. To assist this process the Commonwealth government proposed the establishment of a specialist task force to examine the need for structural adjustment on a fishery by fishery basis. In late 1990 the Southern Shark Fishery Structural Adjustment Task Force was created to assess the status of the southern shark fishery and to advise on future adjustment in the fishery.

In November 1990 the Southern Shark Research Group (1990) concluded that the controls introduced in 1988 were ineffective in cutting back fishing effort and shark landings to the 1982 level. Recent scientific research indicates that unless catches in the fishery are reduced to between 500 and 1000 tonnes, the fishery faces collapse (Southern Shark Research Group 1990).

In March 1991 the Southern Shark Fishery Structural Adjustment Task Force (1991) outlined a number of possible management options for the southern shark fishery. These options included gear restrictions and individual transferable catch quotas with various total allowable catch levels — 400 tonnes, 800 tonnes and 1200 tonnes. To assist in assessing these alternative management options, the task force set out a number of guidelines:

- the need to establish future levels of sustainability on the basis of scientific and economic advice,
- the desirability for adjustment to be achieved through economic incentives in the market rather than through across the board controls on who can fish and the amount of gear that can be used,
- equitable treatment of current operators,
- the use of efficient and cost effective fishing practices and
- the need to set out as soon as possible the shape of future management arrangements.

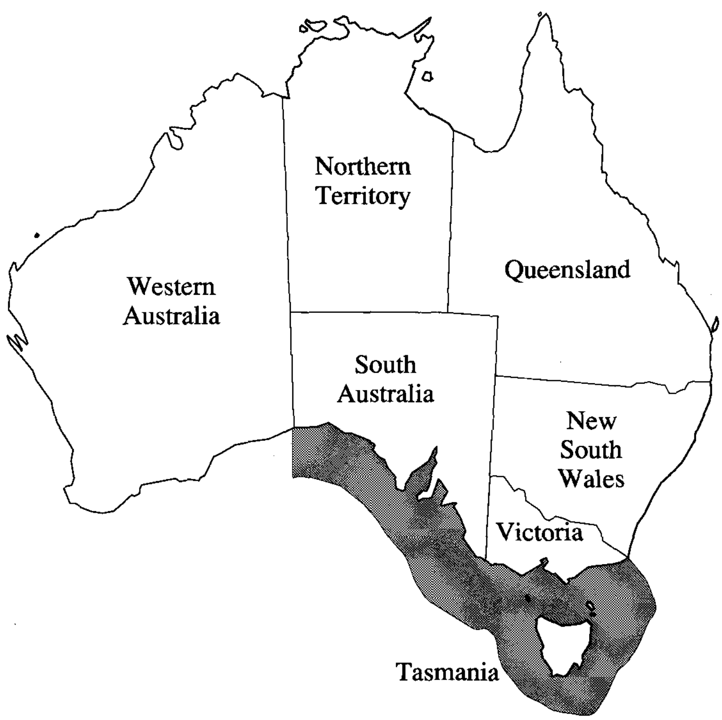
In this study the purpose is to identify the economically optimal level of sustainable catch and to assess the various forms of management according to economic criteria and the criteria set out by the Southern Shark Fishery Structural Adjustment Task Force. To do this a bioeconomic model has been developed that incorporates the major biological, physical and economic features of the fishery. The model is used to estimate the sustainable catch rates that maximise total fishery profits over time for a number of possible policy options.

Background

The southern shark fishery includes state and Commonwealth waters off South Australia, Tasmania and Victoria (figure A). In 1990, production from the fishery was around 3000 tonnes (carcass weight) with a value of over $15 million. In January 1991, there were 1000 net units of 600 metres length in the fishery. The net was allocated among 158 Commonwealth endorsed vessels (Walker 1991a).

The fishery is based primarily on catches of gummy shark (*Mustelus antarcticus*), which make up just over 40 per of the catch, and school

A The southern shark fishery



shark (*Galeorhinus australis*), which also make up just over 40 per cent of the total catch. Other species, including common saw shark (*Pristiophorus cirratus*), southern saw shark (*Pristiophorus nudipinnis*) and elephant fish (*Callorhynchus milii*) account for about 15 per cent of the total catch. Most of the shark is caught using gillnet, with about 10 per cent being taken by longline (Walker 1991a).

The same species — possibly from the same shark stocks — are also caught off the Western Australian and the New South Wales coasts, but these fisheries are managed separately from the southern shark fishery. The quantity of gummy and school shark caught in the New South Wales fishery is negligible, while the catch of gummy shark in Western Australia is only around 5 per cent of the total Australian gummy shark catch (Walker 1991a).

In general, the fishery operates all year round, but is heavily reliant on weather conditions. Gillnets cannot be worked in rough weather, so fishing effort is concentrated in summer and autumn when calmer seas prevail. As many rock lobster fishermen also hold shark endorsements, there is an increase in shark fishing in the autumn following the closure of the rock lobster season.

Stock characteristics of shark

The majority of commercial shark fisheries throughout the world have experienced serious overfishing problems. Examples of this include not only the Australian southern shark fishery, but the Californian soupfin, mako, thresher and angel shark fisheries and the western Atlantic porbeagle fishery. In many cases, poor or nonexistent management has contributed to the stock problems in these fisheries; in addition, shark have a number of biological characteristics that also make them vulnerable to overfishing (Simpfendorfer 1991).

Shark, in contrast to many marine species, produce only a few young at a time. The pups are of a relatively large size and are born alive. Other biological characteristics of shark that may pose a problem for their management are that they are slow growing and take a long time to mature sexually. Therefore, shark stocks may take a long time to recover in the event of overfishing (Walker 1991a).

One biological factor that may have an important effect on the management of the shark fishery is that of density dependent mortality. The size of an unexploited fish population depends on its rates of natural mortality and reproduction. Sharks are considered by many biologists to be density dependent — that is, their survival rate is a function of population size. If this is the case, the removal of the older part of the stock by fishing may have resulted in greatly increased survival rates for juvenile sharks. The importance of density dependent mortality to the biological model is investigated in detail in Pascoe, Battaglene and Campbell (1992).

Historical background to the fishery

Historical records show that sharks were first caught for commercial purposes off southern Tasmania in 1882. Oil was extracted from the livers by boiling and the fins were dried and exported to China. Later, sharks were captured in the inshore waters of Tasmania for use as bait in rock lobster pots and for fertiliser in apple orchards. In Victoria, in the period immediately following European settlement, small quantities of shark captured in the inshore fishery were marketed for their meat (Olsen 1984).

In the initial phase of development there was a seasonal fishery on gravid female school shark entering the bays and inlets along the Victorian coast to give birth. In response to increased domestic demand for fresh shark, the southern shark fishery was extended offshore in the mid-1920s. The size of the fishery again increased significantly during the Second World War because of the high demand for the vitamin A oil extracted from shark livers (Olsen 1984). It was during this period that fishermen based in South Australia and Tasmania entered the fishery. The increased fishing activity led to a decline in the abundance of school shark close to shore, and by 1946-47 shark fishermen began to concentrate on offshore fishing (Olsen 1984). With the development of synthetic vitamins in the 1950s, the demand for shark liver oil slumped, temporarily halting further expansion of the fishery until the early 1960s (Walker 1987).

Until the early 1960s, school shark were targeted using the longline fishing method. In 1964, eastern Victorian fishermen introduced monofilament gillnets into the offshore fishery and longline fishing subsequently diminished in importance. An important factor in the rapid uptake of gillnetting was that school shark stocks until that time had been overfished and the use of net gave fishermen access to the previously unfished gummy shark stocks.

Landings of shark reached a peak in 1969. However, following health concerns raised over the high mercury content found in many shark species, a ban was placed on the landings and sale of large school shark in Victoria in 1972. The ban caused a fall in both catch and fishing effort, and the gummy shark became the major commercial species because of its lower average mercury content. This contributed to the expansion of the gillnet fishery, because even though both school and gummy sharks are taken by a variety of fishing methods (including gillnet, longline and trawling) about 90 per cent of the catch of gummy shark is taken in gillnets (Kirkwood and Walker 1986). The introduction of gillnets and the concentration on gummy shark stock also gave temporary relief to the overexploited school shark stock (Walker and Gason 1991).

During the 1980s fishing effort continued to increase, and catches recovered to the level prior to the implementation of the mercury ban. The mercury ban was removed in 1985. Evidence was provided from several shark assessment workshops throughout the 1980s that the stocks of gummy and school sharks were in jeopardy because of overfishing.

Management in the southern shark fishery

Responsibility for the management of the southern shark fishery is shared by the Commonwealth government and the state governments of Victoria, Tasmania and South Australia. State jurisdiction extends up to three nautical miles from the coastline and the Commonwealth is responsible for the area from the three mile limit to the 200 mile limit of the Australian Fishing Zone.

Before the introduction of limited entry in 1986, no specific licence or endorsement was required to fish for shark in Commonwealth, Victorian or Tasmanian waters. Any vessel could operate in the shark fishery provided appropriate licences to fish in state and Commonwealth waters were held. To fish for shark in South Australian waters required a state endorsement but, while Victoria retained the provision for issuing shark licences, this was not enforced.

The southern shark fishery has come under a number of different management strategies including closed seasons, minimum and maximum lengths of capture for shark, minimum gillnet mesh size, closed areas and limited entry and effort controls. A chronological summary of the major management schemes implemented in the southern shark fishery is given in table 1.

The Southern Shark Fishery Task Force was established by the Australian Fishing Council in 1984 to develop management proposals for the conservation and 'optimum utilisation' of the resource. Following advice from the task force, a limited entry management scheme in the form of non-transferable shark endorsements for boats operating in Commonwealth waters was introduced in 1986. The task force accepted biological advice that shark stocks were overexploited and that fishing effort should be reduced to its estimated 1982 level — a time when shark stocks appeared to be relatively stable. To meet this target would involve an effort reduction of around 40 per cent from 1988 levels — which it was hoped would reduce catch by around 20 per cent to about 2700 tonnes a year.

In April 1988 an interim management plan designed to reduce fishing effort and the number of vessels in the fishery was introduced.

1 Management in the southern shark fishery

1949	Tasmania and Victoria introduced legal minimum lengths for school and gummy sharks.
1953	South Australia introduced legal minimum lengths for school sharks. South Australia introduced a closed season on school shark that was revoked after four months.
1955	New South Wales introduced a legal minimum size limit for school sharks.
1956	The Commonwealth government introduced a legal minimum size limit for school sharks.
1957	A November closure for school sharks was adopted by the Commonwealth government and the state governments of Tasmania, South Australia, New South Wales and Victoria.
1966	CSIRO reported that school sharks were underexploited. As a result the November closure and associated regulations was abolished by the Commonwealth, Tasmania, South Australia and New South Wales.
1967	Victoria abolished the November closure.
1972	Victoria introduced a legal maximum length limit for school shark because of concerns about mercury levels in large sharks.
1985	A prohibition was placed on the sale and possession of most species of shark in Victoria with the exception of eight species.
1986	Limited entry was introduced into the Commonwealth sector of the southern shark fishery.
1988	An interim management plan was introduced into the Commonwealth gillnet fishery based on the issue of gillnet endorsements to fishermen with a history of operating in the southern shark fishery.
1991	In March the net allocations to all fishermen in the Commonwealth sector of the fishery were reduced by an average 36 per cent.

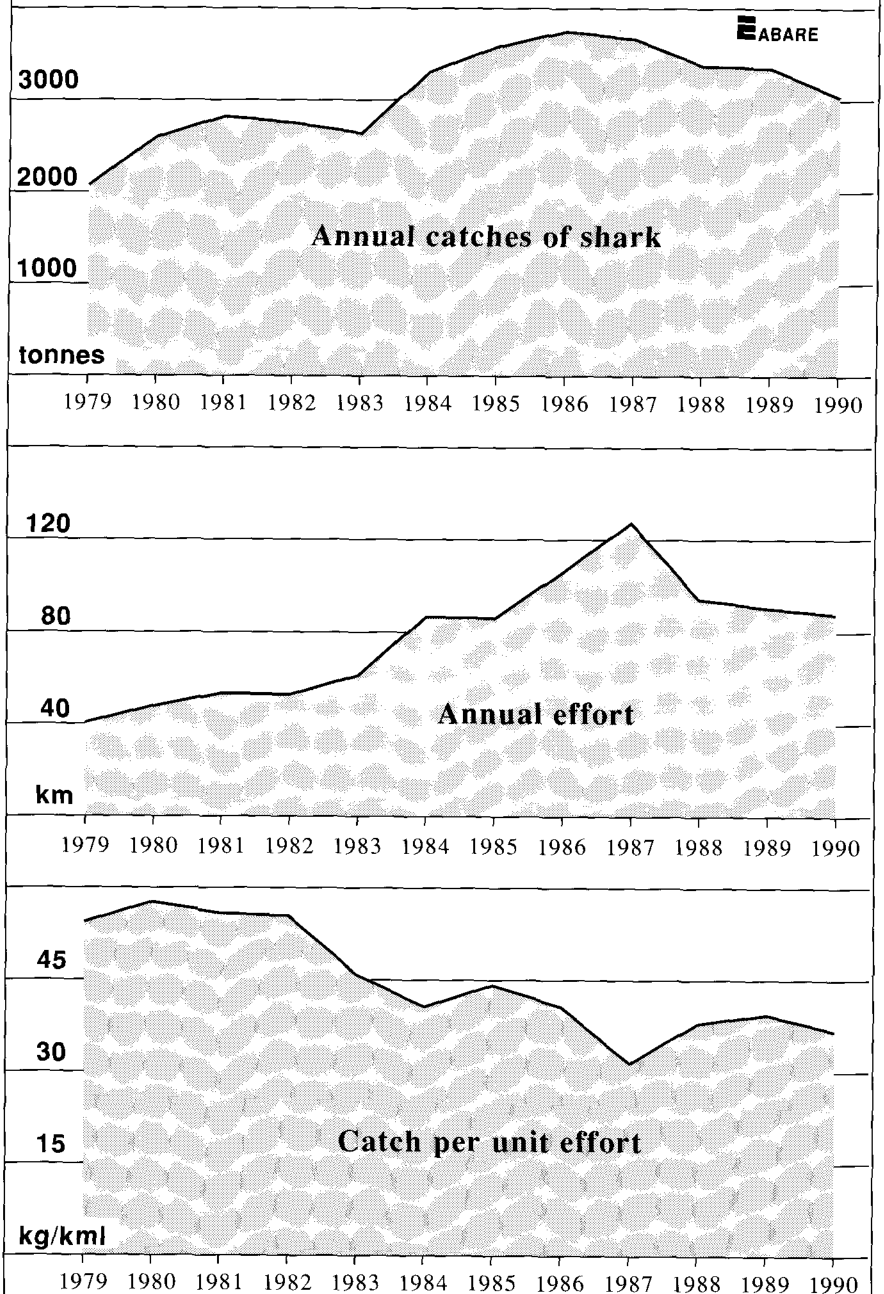
The interim management plan was based on the assignment of gillnet endorsements to Commonwealth endorsed fishermen with a history of operating in the southern shark fishery. Depending on their catch history, fishermen were issued with either a category A endorsement for six 600 metre units of net (A6), or a category B endorsement for five or fewer units of net (B5). A total of 1678 net units were allocated between the 248 boats with Commonwealth licences. During the first two years of the plan's operation, fishermen could amalgamate two category A endorsements to a single boat at the cost of forfeiting two units of net to the management authority. These units were withdrawn from the fishery. Amalgamation of two A class licences thus resulted in the endorsement category termed 'A10'. The B category licences were not transferable. The longline component of the fishery was not regulated under the provisions of the interim management plan. Vessels licenced to operate in state waters were also not included in the management plan.

Following the introduction of the interim management plan, effort levels in the Commonwealth fishery fell from the record level in 1987 (figure B). Approximately 40 per cent of the nets initially allocated to fishermen in April 1988 have been removed from the fishery. In January 1991, there were 1000 nets in the fishery allocated among 158 Commonwealth endorsed vessels (Walker 1991a).

Forfeitures, resulting mainly from the non-payment of licence fees, were responsible for just under 90 per cent of the reduction in net units. As the licence fee was initially around $250 a net (rising to around $570 a net in 1990), fishermen who were not actively fishing shark had an incentive to surrender their shark fishing rights. This was particularly the case for those in the B sector of the fishery who did not have the option of selling their endorsements as did the A sector fishermen. Forty A6 licence amalgamations resulted in just over 10 per cent of the total net reductions. However, the level of effort is still far in excess of that in 1982, the target of the interim management plan.

Although the total number of net units in the fishery was reduced under the interim management plan, the overall fishing power of the fleet appears to have increased because of the greater investment by the more efficient operators. The boats that had left the Commonwealth sector of the fishery by July 1990 accounted for 40 per cent of the original net entitlements but only about 20 per cent of the catch (Campbell, Battaglene and Shafron 1991). The amalgamation of licences has resulted in the more

B Catch, effort and catch per unit of effort in the southern shark fishery



Source: Marine Science Laboratories

efficient operators buying out the less efficient ones and those less active in the catching sector.

Despite the removal of a large number of vessels from the Commonwealth fishery through amalgamation and forfeiture, many of those operators continued to fish in state waters (Campbell, Battaglene and Shafron 1991), effectively increasing the amount of net being used in the fishery. However, recent legislation by the Victorian and Tasmanian governments has restricted shark fishing in state waters and prevents those fishermen who sold their Commonwealth entitlements from fishing for shark in state waters.

Despite the introduction of the interim management plan, catch and effort levels have remained well above the target of 1982 levels (figure B) and overall profitability in the fishery is low (Campbell, Battaglene and Shafron 1991). Recent biological research presented to the Southern Shark Research Group supports the evidence that the fishery is overexploited and unless the catch is substantially reduced immediately, the fishery may collapse (Southern Shark Research Assessment Group 1990). The Southern Shark Restructuring Task Force acted on this information and recommended management designed to substantially reduce the number of nets permitted to be used by Commonwealth endorsed fishermen.

In March 1991 the Commonwealth government implemented further interim controls in the Commonwealth fishery in an attempt to reduce catches of shark while the scientific forecasts were refined and longer term management arrangements developed. Under the new gear restrictions, fishermen with an allocation of ten nets had their allocation reduced to seven; fishermen with six nets had their allocation reduced to four; and fishermen licensed with five or four nets had their allocation reduced to three. Fishermen with fewer than four nets retained their allocations.

As at December 1991 controls had not been introduced into the hook fishery for school and gummy sharks. Fishermen who wish to continue to operate in the hook fishery after this year are required to prove a dependency on the fishery. Hook and state fishermen who fail to qualify for a Commonwealth endorsement to operate in the southern shark fishery will not be allowed to target school or gummy sharks, but will be allowed to land a by-catch of up to 50 kilograms or five carcasses of these species per trip (Gorrie 1991).

Markets for shark

Although most shark species caught are edible, it is the smaller species that receive the best prices for meat. If harvesting shark for fins or skin, the best prices are obtained for the larger fish. This effectively means most of the species targeted or caught as by-catch in the southern shark fishery have limited potential for leather or fins and are usually marketed purely for meat.

There is little export trade for shark flesh — most of the shark passes to the fresh food trade for local consumption, particularly through 'fish and chip' shops. In 1989-90 only around 10 tonnes of frozen shark meat was exported from Australia, with over 90 per cent of this being produced in Western Australia.

Victoria is the main market for shark caught in the southern shark fishery and most of the shark landed in the southern states are marketed there. Around 25 per cent of the total catch of school and gummy shark in the southern shark fishery and most of the Victorian catch is marketed through the Melbourne fish market. Most of the Tasmanian and South Australian shark are sent to local Victorian processors rather than to the Melbourne fish market. The landed price for shark in Tasmania is substantially less than that obtained on the mainland. As a result many of the Commonwealth licensed boats fishing in the Bass Strait and off the west coast of Tasmania land their catches in Victoria. A number of Tasmanian operators airfreight their catch directly to mainland processors.

3

Model and results

The main objective in the study was to examine the effect on the fishery of a number of different management options proposed by the Southern Shark Fishery Restructuring Task Force. To this end, a bioeconomic model of the southern shark fishery was developed incorporating the biological relationships developed by Olsen (1984), Walker (1991b) and the South Australian Department of Fisheries (1991) with financial and physical data from the ABARE economic survey and from logbooks respectively. The model can be used to obtain an estimate of the impact of various management options on both the profitability and structure of the fishery as well as on the biological state of the shark resource.

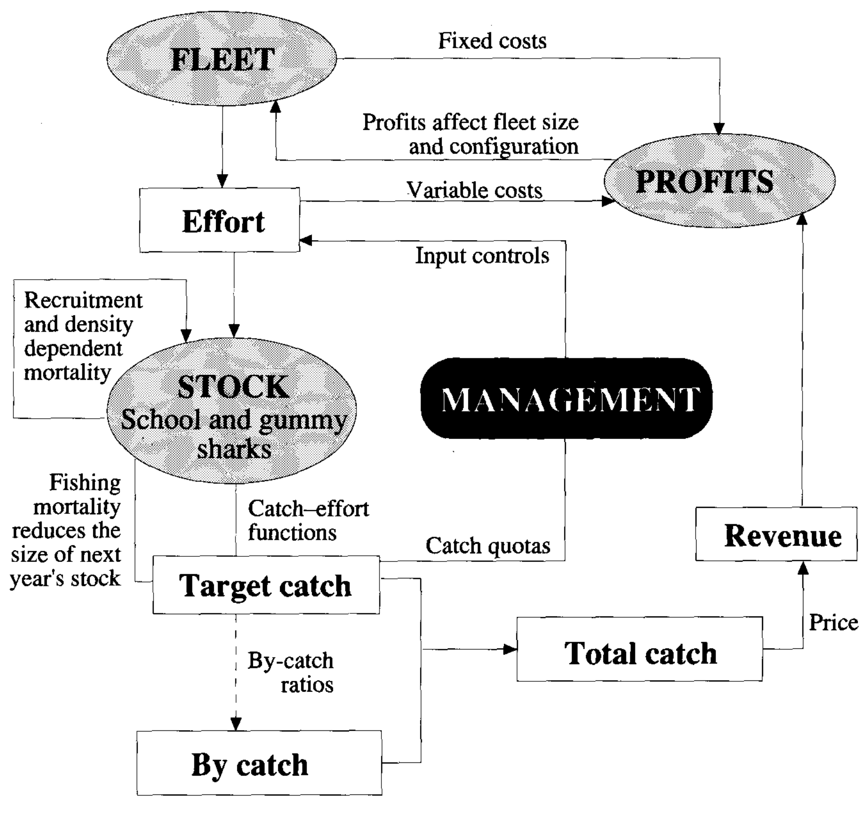
Previous biological models of the fishery have been useful in highlighting the state of shark stocks and the need for urgent action to protect the resource. In particular, the 'SharkSim 1' model (South Australian Department of Fisheries 1991), which is used to simulate the dynamics of the school and gummy shark stocks in the southern shark fishery, has captured the attention of both industry and managers. It is this model, together with unpublished research by members of the Southern Shark Research Group on the validation of its parameters, that provides the basis for the biological relationships contained in the ABARE bioeconomic model.

The model

The principal components of the ABARE model are shown in figure C. The model has three distinct components — biological, physical (fleet structure) and economic. These components are integrated in the model, which is then used to estimate the likely biological, economic and physical outcomes in the fishery under different management strategies. Full technical details of the ABARE model are given in Pascoe, Battaglene and Campbell (1992).

The economic characteristics of the fishery that existed in 1988-89 were incorporated in the base model. These included costs of fishing as well as the average price received for sharks, and were derived from a survey of the fishery (Battaglene and Campbell 1991). However, because the

C Diagrammatic representation of the ABARE model



structural characteristics of the fishery had altered significantly since the survey period, the structural characteristics of the fishery as it existed in 1991 were used in the model. To allow for these changes, the only survey data used in the model were for boats that were eligible to operate in 1991.

A range of possible options for the future management of the fishery, including those identified by the Southern Shark Fishery Restructuring Task Force, are outlined in table 2. These are the options which were used in the model simulations.

The model was modified so that it could be used to estimate the likely outcome for the different management strategies. In addition, the model was modified to take into account uncertainty about some of the biological parameters. Further simulations were then run under these differing conditions and assumptions to test the sensitivity of the model results to them.

A thirty year time frame was used in the simulations. This was a technical constraint, as the amount of computer time required to solve the model over a longer period was impractical. While thirty years may be considered a reasonable time frame for most models, it represents only one complete generation of school sharks and about two generations of gummy sharks.

The main variables examined using the model were catch, effort levels and total fishery profits. For the purposes of the analyses, profits were defined as total returns less all cash costs, including an allowance for owner operators. No allowances were made for non-cash costs such as the opportunity cost of the capital or depreciation. While many shark boats are endorsed to operate in some other fisheries, such as in the rock lobster fishery, shark boats are still prevented from operating in most other fisheries. Even when they do hold endorsements to operate in other fisheries the ability of operators to increase their income from those fisheries is still limited because those fisheries are already overcapitalised.

2 Management options examined using the ABARE model

Simulation	Management option	Key assumptions in the simulation
1	Continue with the current gear restrictions: a one-third reduction in individual net unit allocations from 1990 levels	All boats will continue to fish as long as all cash costs are covered
2	Close the fishery to allow the stock to grow to the optimal size	The fishery remains closed until a stock level is achieved that is capable of sustaining a yield that maximises the net present value of returns to capital over time
	Reduce the annual catch to:	
3	• 400 tonnes	Operators will equate marginal returns to marginal costs (to maximise gross margins)while ensuring that all cash costs are covered
4	• 800 tonnes	
5	• 1200 tonnes	

Consequently, the opportunity cost of the boats used to catch shark is low, and was assumed to be zero. Depreciation was also excluded since different operators calculate depreciation at different rates. In addition, depreciation depends on the age of the vessel — some vessels may be fully depreciated while others are only partly depreciated.

In order to compare management options, a common unit of measurement is necessary. Different management options have different effects on the fishery, resulting in different levels of profit at different times. The net present value of profits represents the value of profits over time, taking into account when they occur. In calculating the net present value of profits, much depends on the choice of discount rate — that is, the rate at which society prefers one dollar now to one dollar at some time in the future. The discount rate used in the model is the long term real interest rate of 5.3 per cent, derived from the ten year bond rate (ABARE 1991).

Results of the long run analysis

Interpreting the results from the long run analysis requires care since the model cannot be used to predict what the exact state of the fishery will be in the future. But (based on current technology, prices, costs and understanding of stock dynamics) the model can be used to estimate what may happen under a given set of circumstances.

Since capital costs (such as depreciation and opportunity cost of capital) were not included, the absolute value of the profits are likely to be overestimates of the true profits accruing in the fishery under the various management options. Although an allowance for capital costs would make a difference to the net present value of profits, the relative differences between the options would remain. Consequently, the results are better compared with each other for assessing the relative effects of different policies rather than being taken as absolutes in their own right. Furthermore, valid comparisons can only be made between outcomes with a common underlying biological assumption. Consequently, the results of the model using the 'SharkSim' assumptions cannot be compared with the results obtained using alternative biological assumptions.

Continuation of current gear restrictions

The first option modelled was to continue with the current gear restrictions, reducing the number of nets used by Commonwealth endorsed vessels by about a third. In the model, it was assumed that a linear relationship holds between the number of nets and the level of effort. Longline boats and state endorsed net boats were not affected by these restrictions, so the amount of effort they could employ in the fishery was modelled at their 1988-89 level.

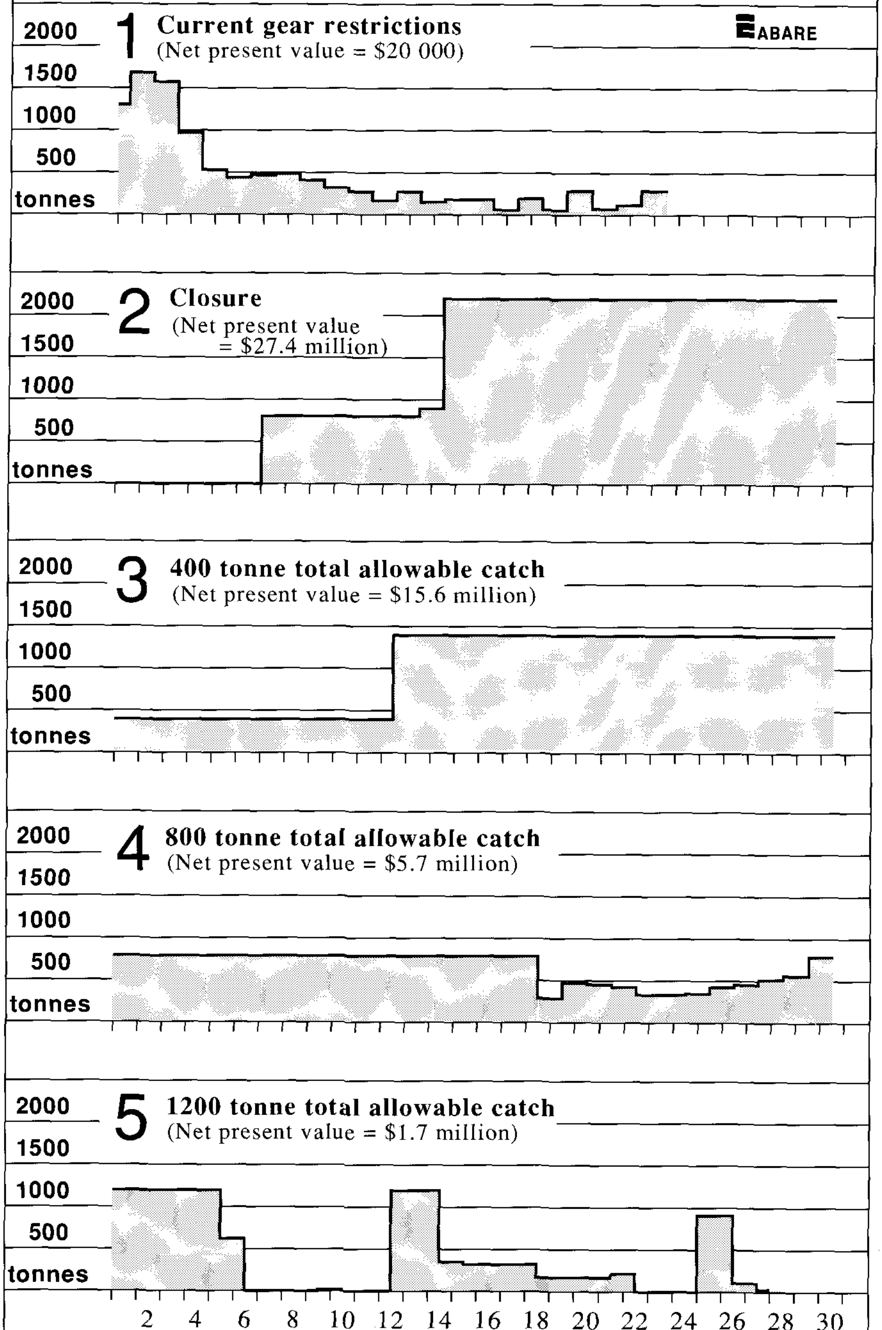
The objective function used in the model was the maximisation of total fishery revenue, subject to all cash costs being covered. This had the effect of forcing individual operators to fish only if they could cover all cash costs. Since gear restrictions do not give fishermen a property right over the shark resource, individual operators will fish as much as they can now rather than risk other operators depleting the stock. To simulate this behaviour in the model, operators were assumed to place little value on uncaught shark which may or may not be caught in subsequent years.

From figure D, it can be seen that the estimated net present value of total fishery profits under this option is small ($20 000). While a small number of boats may continue operating for most of the thirty year period examined, these boats are unlikely to generate any substantial profits, as shark stocks and hence catches of shark diminish over time.

Boats may continue to operate in the shark fishery despite making negligible profits since many of the operators are also endorsed for other fisheries. If the income that is derived from these alternative fisheries is sufficient to offset the annual costs associated with the boat, a positive gross margin (revenue less actual fishing costs) may be all that is necessary to keep the boats operating in the shark fishery. To examine the effect of this assumption, the model was also run assuming that only actual fishing costs (such as fuel and crew) needed to be covered rather than all cash costs. The result was a greater number of boats operating in the fishery. However, the fishery would not be likely to sustain the additional effort, and fishing ceased in the model after about twelve years. The length of time necessary for stocks to build up to allow a commercial fishery to resume was not estimated.

The catch and earnings obtained from this simulation may be less than what has actually occurred, as there is some evidence that before 1991 fishermen were not using all of their net entitlements (Anderson, W., Licensing and Surveillance, Australian Fisheries Service, personal communication, 14 November 1991). However, if this is the case, then the shark stocks are likely to be depleted at a far faster rate than under the

D Catch and net present value of profits under each management option



assumption of a linear relationship between the number of nets and level of effort as used in this simulation. Even if the current net restrictions have been ineffective in reducing effort to the level desired, this will not affect the ranking of the outcome from this simulation. If the reduction in effort is less than that assumed, the probable outcome would be for a relatively shorter period of fishing with higher fishery profits. As a consequence of the probable higher catch rates, there would be an earlier collapse of shark stocks such that a commercial fishery could no longer be viable.

Closure of the fishery followed by an optimal sustainable yield

The model was run over a thirty year time span to determine the length of closure required to enable the stock to recover to the level that could produce an economically optimal sustainable catch, as against a maximum sustainable yield. In this case, economically optimal sustainable yield was taken as the sustainable catch that would produce the greatest net present value of profits.

The annual sustainable yield that maximised profits over the model time horizon was found to be about 2200 tonnes. In order to achieve this yield, however, the fishery as modelled would have to be closed down for a period of twelve years, followed by two years of catches of around 1000 tonnes. Under the conditions simulated in the model, this is estimated to result in a net present value of profits of about $27.4 million (figure D).

This result, however, may still be influenced by the thirty year time horizon of the model since in the simulation there are no benefits beyond year 30. Even so, the only effects of using a longer time period in the model may be to defer the opening of the fishery, allowing a higher stock level and sustainable catch to be achieved.

Restrictions on the total allowable catch

A further option proposed by the Southern Shark Fishery Restructuring Task Force was to introduce restrictions on the total allowable catch that could be taken in any one year. To estimate the effects of such a strategy, the model was run with the three proposed total annual allowable catches, of 400 tonnes, 800 tonnes and 1200 tonnes.

The objective function used in these simulations was the maximisation of short term gross margins (table 2) — that is, revenue less actual variable fishing costs. Since many operators in the fishery hold multiple endorsements, it is likely that each operator would decide how much time to spend fishing in each fishery for which they are endorsed according to the expected marginal costs and returns from that fishery. While gross margins were maximised in these simulations, the net present value of profits was estimated as a basis for comparison between these and other options. To remain in the fishery, the boat must also have been able to cover all cash costs.

The first option examined was a 400 tonne quota. For this simulation, the catch restriction was initially imposed for twelve years, which was the period of closure estimated using the simulation model to be economically optimal. After that period, the quota was adjusted to the sustainable yield that could be harvested given the stock size in the twelfth year. After running the simulation for twelve years, examination of the model results indicate that the stock may recover sufficiently to allow the total allowable catch to be increased to 1400 tonnes a year (figure D). The net present value of profits under this scenario was estimated to be about $15.6 million, which is 57 per cent of that achieved with the twelve year closure followed by the higher sustainable catch.

A total allowable catch of 800 tonnes a year is likely to result in a gradual depletion of the shark stocks. While the fishery may be able to generate some profits over the first fifteen years under this option, operators who continue to fish after this period just break even. The net present value of profits under this option was estimated to be about $5.7 million, well below the estimated net benefits derived from the simulation of a total allowable catch of 400 tonnes a year.

A total allowable catch of 1200 tonnes a year is unlikely to be sustainable for more than about six years (figure D), after which it would most likely become unviable to operate continuously in the fishery, although some pulse fishing may be possible. This scenario resulted in a net present value of profits of $1.7 million.

Alternative biological assumptions

There is uncertainty about some of the key biological parameters used in the model. A number of key areas of uncertainty were identified and the effect of these parameters on the outcome of the model was investigated. The parameters investigated were the size of the shark population in 1992, the influence of population size on the survival rate of juvenile sharks (density dependent mortality), the growth rate of gummy sharks and the effects of the spatial distribution of shark stocks.

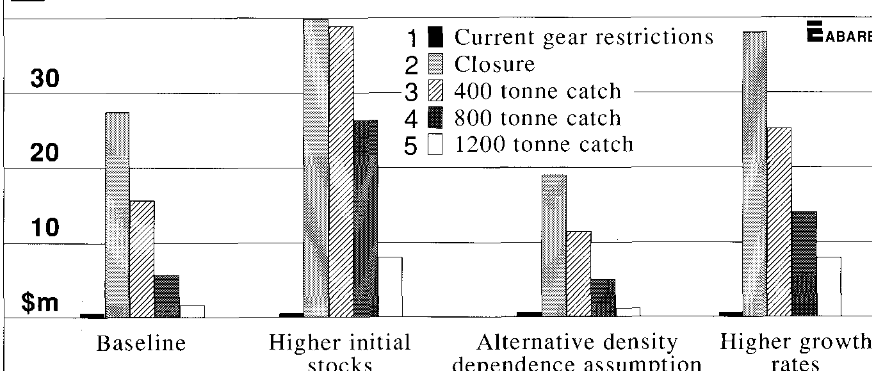
Further runs of the model were undertaken incorporating these alternative biological assumptions. The results of these analyses are presented below, and are graphically compared with the baseline results in figure E.

The effect of a larger initial shark stock

The 'SharkSim' model was used to obtain an estimate of the starting stock size of shark in 1992 and this was then used in the ABARE model. There has, however, been some suggestion that the size of the shark population estimated for 1992 using the 'SharkSim' model may be 50 per cent lower than the actual stocks of shark (Southern Shark Research Assessment Group 1991). The effect of this possibility on the results of the ABARE model was tested by doubling the value of the starting stock size in the model and rerunning the simulations.

From figure E it can be seen that the net present value of the profits from the closure could be about 28 per cent greater if the initial stock size were twice that used in the baseline simulations. The same sustainable yield of 2200 tonnes a year that maximises profits in the baseline simulation could be achieved by closing the fishery for eight years rather than for twelve years.

E Net present value of profits generated by the proposed options



Under the assumption of a larger shark stock size, the benefits of closing the fishery for eight years are likely to be only about 2 per cent greater than those from introducing a total allowable catch of 400 tonnes a year for the same period. The allowable catch can be gradually increased over years 9 to 13, after which the allowable catch could be maintained at the optimal level of 2200 tonnes a year. As a result, the profits achieved in the first eight years would largely offset the profits forgone by closing the fishery and enjoying the higher catches earlier over years 9 to 13.

The net present value of profits resulting from maintaining the current input controls is likely to be small relative to the other options. This is because the profits are competed away by the greater number of boats operating under this scenario.

The effect of a different density dependent mortality assumption

While density dependent mortality may be an important factor determining changes in the shark populations, the exact effects are uncertain. Density dependent effects have been estimated through fitting models to data, rather than through any detailed biological research. As a consequence, the exact cause and magnitude of density dependent effects (if any) is not known at this stage.

The ABARE model is based on a different density dependent mortality assumption than that used in 'SharkSim'. In 'SharkSim' the number of adult school sharks affects the survival of school sharks aged between 0 and 4 years. In the ABARE model, following advice from Dr Jeremy Prince (Southern Shark Research Group, personal communication, 11 July 1991), only the 0 to 2 year age cohorts are affected by density dependent mortality. Juvenile gummy shark density dependent mortality is the same in both 'SharkSim' and the ABARE model.

The sensitivity of the model outcomes to the density dependent mortality assumption for school sharks was examined by incorporating the 'SharkSim' density dependent mortality assumption and rerunning the model. It was found that the net present value of profits are lower under all policy options compared with the baseline simulations (Figure E). The relative ordering of the options, however, remains unchanged.

The effect of a higher growth rates for gummy sharks

A criticism of 'SharkSim' has been that the estimates of catch produced from the model are lower than has been observed given the same level of effort. The ABARE model incorporates a density dependent catchability function to overcome this problem (see Pascoe, Battaglene and Campbell 1992). An alternative explanation for the inability of 'SharkSim' to replicate historical catches may be that the shark growth rates used are too low (Walker, T., Marine Science Laboratories, Department of Conservation and Environment, personal communication, 25 October 1991).

An alternative set of growth parameters was included in the model that had the effect of increasing the weight for age of gummy shark and, consequently, the number of pups produced. The effect of these alternative parameters on the weight and reproduction of school shark was negligible. The model was run incorporating the greater weight and pupping rate for gummy shark. Gear selectivity, which is a function of net mesh size, was also adjusted to reflect the increased size of gummy shark.

The greater number of pups resulted in the gummy shark stock recovering to a greater level, resulting in an increase in the optimal sustainable catch (2500 tonnes a year rather than 2200 tonnes). The net present value of profits also increased as a result of the higher catch rate. Similarly, the net present value of the fishery under the other options was also increased slightly (see figure E). The relativities between the options, however, were not changed markedly by the alternative growth rate assumptions.

The effect of the spatial distribution of shark stocks

A deficiency of the fundamental biological model used in 'SharkSim' is that it is non-spatial and is not useful in illustrating the regional variations in the fishery.

An alternative biological model was proposed at the October Southern Shark Assessment Workshop. The main features of the alternative model include a series of regional stocks (in varying degrees of depletion) and the possibility of a breeding stock for gummy shark off southern Tasmania that is somehow not vulnerable to fishing (due to being located in water either too deep or too rough to fish), resulting in (possibly) a constant recruitment of juvenile gummy shark to the Bass Strait region of the fishery (Prince, J., Southern Shark Research Group, personal communication, 25 October 1991).

If the assumed stock from which recruitment into Bass Strait is occurring is maintained, it can be incorporated into the model by splitting the model into two separate submodels — one each for gummy sharks and school sharks. If the proposal that recruitment of gummy sharks to the Bass Strait region of the fishery is constant and independent of fishing effort, then the optimal strategy involves determining the most efficient fleet configuration to harvest the resource. Under this assumption, there is no benefit from reducing catch rates since this will not lead to increased future catch rates. The catch, however, could most likely be taken more profitably with less fishing effort.

Assuming that the gummy shark component of the fishery can sustain an annual catch of 1500 tonnes, then the optimal fleet configuration will be twenty A10 boats, each catching about 75 tonnes. This will result in an annual profit of about $3.2 million, giving a net present value over thirty years of about $47.6 million.

It is most unlikely that anything approaching this level of profitability could be realised under the current management plan. The lack of adequately defined property rights results in most (if not all) profits being dissipated through unnecessary competition between the fishermen.

In order to maximise the flow of profits from the school shark component of the fishery over the thirty year period examined, the school shark fishery would need to be closed for twelve years followed by a total allowable catch of about 1500 tonnes a year. Under current price and cost conditions, this would result in a net present value of profits of about $24.2 million, and involve a small number of A10 boats (between four and ten, varying each year) and hook boats. This solution relies on the initial estimate of the school shark population from the 'SharkSim' model.

Continuing the current management plan will eventually result in the school shark stock being depleted below the point of commercial viability, even assuming that the A10 and A6 boats concentrate on the gummy shark fishery. While some short term profits may be made in the South Australian and Western Australia regions, these are only likely to be short lived as the school shark stocks continue to be fished down.

Based on this alternative model, the optimal use of the fishery may result in a net present value of profits of about $71.8 million over the next thirty years. However, under the current input controls, the net present value of profits is likely to be negligible, as competition will most likely result in the dissipation of any potential profits.

A variant of this alternative biological assumption that was not modelled was the possibility that the future breeding biomass, while not directly vulnerable to capture, is reduced by the capture of juvenile shark. The difference between this and the assumption examined above is that the current catch rates of gummy shark may not be sustainable in the longer term. In this case, there may be benefits from closing down the fishery and allowing the breeding biomass to build up. This variant could not be effectively modelled, as it involved details that could not be captured in the ABARE modelling framework.

4

Management options

Short term management options

Sustainability of the fishery and the long run profitably of the fishery will depend on the size of the catch and the type of management used in the fishery. On the basis of the biological assumptions used in the 'SharkSim' model, examination of the simulation results indicate that landings of 800 tonnes or more a year are most unlikely to be sustainable (figure D). Even if shark stocks are double what was originally estimated, examination of the simulation results still indicates that landings of 1200 tonnes a year are unsustainable.

If, instead of closing the fishery, the fishery continued to be operated under the management controls introduced in 1991, a minimal return on current investment could be expected in the long term. In contrast, closing the fishery in January 1992 for twelve years could increase the sustainable yield to around 2200 tonnes a year and the net present value of profits in the fishery could improve to about $27 million. On economic and biological grounds, examination of the simulation results indicates that a closure would lead to an improvement in the fishery. The only difference is that if stock levels are as high as that used in the sensitivity analysis, the closure could be shortened to about eight rather than about twelve years.

The optimal sustainable yield could be greatly increased, however, if the suggestion that a sustainable yield in Bass Strait of 1500 tonnes of gummy shark a year is valid. Depending on the form of management used, and the protection of the breeding stock, the present value of the profits from the gummy shark harvest could be as high as $47.6 million. However, for the net present value of the profits from the fishery as a whole to be maximised, the school shark component of the fishery would still most likely need to be closed for eight to twelve years. Effectively this would mean that shark fishing would continue in Bass Strait while the rest of the fishery was closed. If the school shark fishery were closed down as suggested, the sustainable yield for the fishery as a whole once the school shark fishery was reopened would be about 3000 tonnes a year, which is not much different from landings over the past seven years.

A feature of the results under all alternative biological assumptions was the need to reduce the amount of effort in the fishery, particularly on the school shark component of the fishery. The loss from closing the gummy shark component of the fishery for one year if the constant recruitment assumption is correct is substantially higher than the loss from keeping it open if the more pessimistic assumptions are correct (Pascoe, Battaglene and Campbell 1992). As a result, a short term option may be to keep the gummy shark component of the fishery open, albeit at a reduced level of effort, until the biological status of the stock is confirmed.

While the optimal level of catch may not be known with any certainty, reducing the number of boats in the fishery will most likely result in an improvement in short term profitability. Introducing an input based adjustment mechanism may be a viable option in the short term given the biological uncertainty. Such an option may involve the use of transferable net units with an across the board surrender of net units by each boat. Individual fishermen could adjust their operations by purchasing or selling net units. Catches of school sharks could be reduced further by restricting the mesh size of net used and the areas fished.

While input controls are not likely to be effective long term management options, they may allow more information on the fishery to be collected. The effect of a substantial effort reduction on catch rates will provide more information for biologists to assess the state of the stock. While the same may be true for output controls, such as individual transferable catch quotas, incentives to dump lower quality shark and underreport catches may result in misinformation. Individual transferable catch quotas also require an appropriate total allowable catch to be set. Given the degree of uncertainty in the fishery, this may not be possible in the short term. Until the biological status of the stock is known with confidence, input controls may have some advantages as short term management options.

Long term management options

The long term management options that are available to conserve stocks and improve operational efficiency in the southern shark fishery include the use of input controls, catch quotas and charges. Input controls include the use of controls on the number of endorsements, the number and size of boats, the amount and type of gear, net mesh size (minimum size restrictions) and area and seasonal closures. Quotas include the use of total and individual transferable catch quotas. Charges include landing charges and charges on fishing effort or cost of fishing effort.

Fishery management controls are expensive to introduce, maintain and enforce. If management controls are to be introduced into a fishery, the benefits from these controls must exceed the costs, otherwise the controls are not economically warranted. While all of the above management controls may be capable of protecting shark stocks, their use will not necessarily result in an economically efficient fishery over the long term.

The use of controls on the number and size of boats, the amount and type of gear and the times and areas in which fishing can occur might, with ongoing revisions, be able to protect shark stocks from overfishing and reduce the amount of effective effort in the fishery. However, such input controls are unlikely to result in an economically efficient fishery over the long term (Clark 1980).

Input controls have been in use in one form or another in the southern shark fishery since 1949 (table 1). These controls have neither protected shark stocks from overfishing nor encouraged efficient harvesting and the realisation of resource rent returns (Campbell and Haynes 1990). It must be acknowledged, though, that the introduction of non-transferable shark endorsements into the Commonwealth fishery in 1986 was to stop a 'blowout' in fishing effort rather than to achieve a cutback in fishing effort (McGregor, C., Australian Fisheries Service, personal comment, 1991).

In the case of input controls, as long as fishermen believe profits are to be made they have an incentive to substitute uncontrolled inputs for controlled inputs and will upgrade and operate their boats harder. Research by Squires (1987), among others, supports this view.

Campbell and Linder (1989) have argued that under certain conditions it is possible to achieve long term economic benefits from using input controls. If the input controls drastically reduce fishing effort, short term profits are possible. If the controls are to limit effort in the long term they need to be continually readjusted as technical innovation and substitution of unconstrained for constrained inputs increases fishing effort and costs. The negotiations between industry and management involved in making the readjustments can be an expensive exercise in itself and can bring an additional element of uncertainty into investment in fisheries.

The use of a total allowable catch could potentially protect the shark stock from overfishing. However, if an aggregate quota is used rather than a quota to individual fishermen, there is an incentive for fishermen to race each other to catch as large a proportion of the total quota as they can.

As a consequence of the race to catch fish, fishermen will buy larger and faster boats and will work more fishing gear harder. All of this will lead to an increase in capital and operational costs. This increase in costs will occur with little or no increase in catch and the profitability of the fishery will decrease (Stollery 1986). This race for catch has been the experience in other fisheries managed using total quota (Crutchfield 1981), and there is no reason to expect that the southern shark fishery would be any different.

As with a total quota, individual transferable catch quotas can be used to protect shark from overfishing. In addition, individual transferable catch quotas give fishermen a right to a proportion of the allowable catch. Under these conditions the incentive for an individual fisherman to catch as large a proportion of the catch as possible is removed. Instead the incentive is for fishermen to use efficient and cost effective fishing practices to maximise the value of their quota.

A number of criticisms have been made of the use of individual transferable catch quotas (for instance, see Copes 1986). These criticisms include the additional cost of enforcement, difficulties involved in estimating total allowable catch and the losses which can result from setting an incorrect allowable catch level. At the same time, Copes argues that input controls allow a greater degree of flexibility in the size of catch taken. The criticisms of the use of individual transferable catch quotas need to be examined in comparison with other management options.

A total allowable catch needs to be estimated regardless of whether the fishery is managed using charges, individual transferable catch quotas or, implicitly, when using input controls. Generally, if input controls are effective and constrain catches to meet an identified total allowable catch, they need not allow a greater degree of flexibility than individual transferable catch quotas. Indeed, if there are no gear restrictions, annual individual transferable catch quotas are more flexible.

The information requirements for using charges and input controls are higher than those for managing with individual quotas. For managers to be able to set input controls or charges at the level required to take the estimated total allowable catch, they will require information relating the amount of charge or level of input control to the quantity of catch. In addition, because individual quotas can be adjusted annually, they offer greater flexibility in controlling allowable catch than do input controls. Variability in annual allowable catch can, however, work to reduce the efficiency of individual transferable catch quotas. Because individual transferable catch quotas produce efficient results through markets, the risk of change in the annual catch can undermine the confidence of fishermen in the management system. This may result in a less efficient market for quotas.

The criticism that individual transferable catch quotas are more expensive to implement than input controls is not relevant by itself. The purpose of management is not to maximise the amount of catch nor, for that matter, the value of catch, rather it is to maximise the net value of the catch while sustaining the resource. Therefore, the criteria for selecting the preferred form of management is according to the highest net present value once all costs, including management costs, have been accounted for.

If individual transferable catch quotas are introduced into other adjacent fisheries, the cost of using quotas in the southern shark fishery may be substantially reduced. For instance, individual transferable catch quotas are scheduled to be introduced into the south-east trawl fishery in December 1991. The multispecies south-east trawl fishery involves fishing boats from New South Wales, Victoria, Tasmania and South Australia. The geographic jurisdiction of this fishery overlaps the southern shark fishery. Enforcing the individual transferable catch quota management system in the south-east trawl fishery will be based on a monitoring of a 'paper trail' of landing and sales forms and purchase documentation coupled with landing inspections (Scott 1991). Once a quota enforcement system is in place, the additional cost to include the necessary documentation for the southern shark fishery will be much less than it would be for the shark fishery on its own.

Some of the species taken in the southern shark fishery, such as school shark, gummy shark, other shark species and trevalla, are also taken in the south-east trawl and in other fisheries. If one of these common species is under quota in one fishery, there is a risk of that species being targeted in other fisheries in which there is no quota. In addition, if a fisherman operating in a quota managed fishery holds endorsements in a non-quota managed fishery, there is a risk of the fisherman selling the quota and operating in the other fishery full time. These difficulties are overcome if individual transferable catch quota are used in adjoining fisheries.

Since shark are a slow growing, long lived species (Walker 1991a), the annual total allowable catch will only form a small part of the total stock, and stock numbers and expected available catch will be relatively stable. Therefore, the economically optimal sustainable catch is easier to estimate than that for a fast growing short lived species such as prawns. As the total allowable catch is only a small portion of the stock, fishermen can be reasonably confident that they will be able to capture their share of the catch. Therefore, fishermen should not need to race to ensure the taking of their share of the allowable catch.

A major criticism made of the use of individual transferable catch quotas is that it can result in an increase in wasted product from high grading. High grading is the discarding of lower valued and damaged shark. High grading can occur because the amount of quota available to a fisherman is limited, thus creating an incentive for fishermen to maximise the value of their quotas by discarding low quality shark. The importance of high grading is that it can result in catches being greater than the allowable catch, which may also lead to the depletion of shark stocks.

High grading by tossing shark overboard is not costless as the operator must then expend additional effort to catch more valuable fish. Indeed under individual transferable catch quotas there is a strong incentive for individuals to maximise the value of their quotas by changing their fishing operations. For instance, once shark fishermen are confident they can catch their quota they can restrict their fishing to those nights when there is a full moon and catch rates are up and damage from sea lice attacking the enmeshed shark is down. In addition, depending on unit cost, fishermen may shift their operations from gillnetting to longlining, which gives a better quality and higher priced product.

On the basis of the 'SharkSim' assumptions, school and gummy shark stocks move up and down with decreasing and increasing fishing pressure. This joint relationship of the two major shark stocks means that these species mostly can be managed under a single management regime. Acceptance of the assumptions used in the alternative biological model, however, means that the recruitment of gummy shark into the fishery is mainly independent of fishing pressure, while school shark stocks will continue to move up and down with decreasing or increasing fishing effort. If this is the case, the two stocks will need to be managed independently. Separating the management of the two species gives greater support for using individual transferable catch quotas to manage the fishery.

To effectively control fishing effort, input controls will result in an increase in the unit cost of fishing. Individual transferable catch quotas, however, by allowing fishing operators a freer choice of inputs can result in a decrease in the unit cost of fishing and an increase in the rent returns obtained from the fishery. In some circumstances, however, it may be necessary to introduce input controls in conjunction with individual transferable catch quotas. For instance, if the unit cost of catching shark is lower when sharks are pupping, it may be necessary to introduce area and seasonal closures.

5

Conclusion

The choices being faced by the shark industry and fishery managers are to either reduce the shark catch to a level that is currently sustainable or to reduce shark catch to a lower level from which future landings and profits can be increased (figure D).

No matter which decision is made on the long term management of the southern shark fishery, there will be both winners and losers. The problem for managers and the industry is to resolve the conflicts between the different demands for using the resource. A major conflict appears to be over what is the appropriate rate at which to catch shark. Once the appropriate catch rate has been decided, the issue is how should the fishery be managed. Both of these issues have been addressed in this study.

According to the results of the baseline study, there is a possible wide range of returns to the fishery depending on which annual allowable catch is attained. For instance, under the baseline biological assumptions, the net present value of profits of an allowable catch of 800 tonnes a year could be around $5.7 million. However, such an allowable catch may result in a gradual depletion of shark stocks. A total annual allowable catch of 400 tonnes a year for twelve years could result in a higher net present value of profits of around $15.6 million because of the slow recovery of the fishery. A closure of the fishery for twelve years could result in a net present value of profits of about $27 million and would allow stocks to recover (figure E).

While a complete or partial closure of the fishery would result in an increase in the net present value of profits in the fishery, such a closure would have an adverse effect on current shark fishermen. The extent of the effect would depend on how a partial or complete closure of the fishery was managed. It is important that the long term management options for the southern shark fishery are identified as early as possible so that fishermen can begin to make the necessary financial adjustments.

Under an optimistic biological assumption, an annual catch as high as 1500 tonnes of gummy shark could possibly be sustained in Bass Strait.

The present value of the profits from such a sustainable catch is around $46 million. On examination, the study results appear to indicate that, under this alternative assumption, the net present value of profits from the fishery could be further improved by the introduction of a twelve year closure of the school shark component of the fishery. Such a closure is likely to result in an improvement in the net present value of profits from the school shark component of the fishery of about $24 million. Adding this to the gummy shark component of the fishery results in estimated total net present value of profits of over $70 million.

While not conclusive, examination of the results here indicate that the fishery would be best managed in the long term using individual transferable catch quotas. This is especially so if individual transferable catch quotas are introduced into the south-east trawl fishery. In addition, if school and gummy shark are to be managed separately, this could be achieved more easily under individual transferable catch quotas than input controls. The reason for this is that with individual transferable catch quotas the catch of school and gummy shark can be independently monitored.

From the model results, the cost of keeping the fishery open for a year if the pessimistic assumptions are correct are less than the loss from closing the fishery for a year if the optimistic assumptions are correct. Given the uncertainty associated with the biological status of the fishery, the introduction of an input based adjustment mechanism may be a viable short term option. The short term profitability of the fishery could most likely be improved by substantially reducing the level of effort in the fishery. This might be achieved by using individual transferable net units, associated with an across the board reduction in net units for each boat. Individual fishermen could adjust their own operations by buying or selling net units. This would allow further information to be collected on the fishery, and enable a better assessment of the appropriate long run management options. These net units may then be used as the basis for the allocation of individual transferable catch quotas in the future once the biology of the fishery is better understood.

An attempt has been made to review a number of management options for the southern shark fishery according to economic criteria. The analyses which gave the results presented in this paper were carried out on the basis of the biological knowledge available to ABARE at the time of the study. New information on the biology of the southern shark fishery is likely to become available in the future.

In spite of the uncertainties about the biology of the fishery, some relationships in the fishery do appear to remain clear. These are that southern shark are highly susceptible to overfishing. School shark and, at the very least, in some areas gummy shark have had a history of having been heavily fished. As a result, some if not all southern shark stocks are unlikely to be able to sustain the present catch rates let alone an economically optimal catch rate. If this is so, the achievement of an economically optimal sustainable output in the southern shark fishery will require either a reduction in the total allowable catch or a complete closure of the fishery. Such a reduction in catch and achievement of a long term economically optimal sustainable output in the fishery could most likely be best achieved through the use of individual transferable catch quotas.

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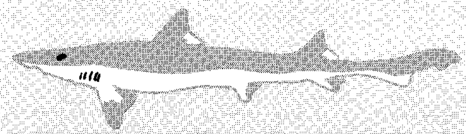

Scientists have pointed out that the southern shark fishery has been overfished. Unless something is done soon about over-fishing, the fishery may collapse. This study has been carried out to identify possible means of preventing a collapse of the fishery and to explore strategies whereby long term fishery profitability can be restored.

DISCUSSION PAPER 91.12

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