The fishery for rig, *Mustelus lenticulatus*, in Pegasus Bay, New Zealand, 1982–83

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Cover: Rig fishermen Jack Waller (left) and Graeme Sinclair (right) on their owner-operated set net vessel *Hanimyn*.

MAFFish

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Inquiries to:
The Editor,
Fisheries Research Centre,
P.O. Box 297,
Wellington,
New Zealand.

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Abstract

Massey, B.R. 1989: The fishery for rig, *Mustelus lenticulatus,* in Pegasus Bay, New Zealand, 1982-83. *N.Z. Fisheries Technical report No. 8.* 19 p.

The fishery for rig (*Mustelus lenticulatus*) in Pegasus Bay developed during the early 1970s. Set net target fishing expanded rapidly in the 1976–77 and 1977–78 fishing seasons. However, a decline in profitability then forced many vessels from the fishery, and numbers halved between 1978–79 and 1982–83.

The east coast South Island rig stock was in a serious biological condition in 1982–83. Catch rates were declining because of severe overfishing. Overall, landings were about four times the estimated sustainable yield. This was of great concern, especially because rig are likely to be vulnerable to recruitment overfishing.

Three groups of fishermen were identified in the fishery in 1982–83: full-time fishermen who netted for rig during summer (group A), fishermen who fished full time during the rig season, but did not fish for the rest of the year (group B), and fishermen who fished only occasionally (group C). Vessel characteristics and catch compositions varied between groups because of different methods of operation.

Group A operations were more profitable than group B operations because their costs per unit of effort were much lower. Group C fishermen seemed to be incurring significant losses, but not all their operations appeared to be run strictly for profit. None of the groups obtained reasonable returns on capital and entrepreneurship. Thus, even with catches four times the sustainable level, none of the groups could make the fishery financially viable, even in the short term, and the economics of fishing would continue to deteriorate further until the stock size increased significantly. Catch reductions were implemented to achieve this, with the result that most vessels left the fishery. Recovery from about 10 years of heavy fishing pressure is expected to be slow.

Introduction

The development of rig fisheries

Rig (*Mustelus lenticulatus*) were only lightly exploited until the early 1970s, despite their known seasonal abundance around much of the coastline. There was little incentive to fish for rig because of the low value of the catch (Graham 1956); there was consumer resistance against shark flesh and most traditional fish stocks were healthy. Thus, rig remained a by-catch, mainly from trawling (Watkinson and Smith 1972).

By the mid 1970s the economics of fishing for rig had become favourable, mainly because:

1. Traditional stocks were depressed in some areas (e.g., butterfish (*Odax pullus*) at Kaikoura (Francis 1979) and elephant fish (*Callorhynchus milii*) in Pegasus Bay (A. Coakley pers. comm.)).
2. Rig were abundant and now commanded high prices. Price and demand had risen because of the decline in availability of some traditional species.
3. New technology had made it possible to catch large quantities of rig. Monofilament nylon mesh (which has a much greater catching efficiency than cotton mesh) became widely available during the early to mid 1970s. In addition, mechanical net hauling equipment was introduced, and this made it possible to work more net and to work the net in deeper water.

4. The capital required to set up a set net operation was not substantial. The technology was not expensive, and the gear could be operated effectively off small, cheap vessels.

Because of these factors, many vessels changed from trawling (especially in the Canterbury Bight) or dredging (in Golden Bay-Tasman Bay) to netting during the rig season (Mace 1981). There were also many small, high-speed vessels built specifically for set netting.

Once rig became target fished by set net fishermen, set netting began to displace trawling as the dominant method of capture for the species (Francis and Smith 1988). In 1975, only 36% of rig was taken by set net, whereas 60% was taken by trawl (King 1985). However, by 1978, 63% of the total New Zealand rig catch was taken by set net, and trawlers only caught 34% (King 1985). Set netting is still the most important method for rig.

Rig landings increased rapidly*. Between 1970 and 1978 the national rig catch rose from 930 to 3300 t, and rig's contribution to the national wetfish landings increased from 2.3 to 4.5% (Ritchie *et al.* 1975, King 1985, MAFFish unpublished data). Catches have fluctuated since 1978, but rig are still important. In 1985 the total New Zealand rig catch was 3195 t.

* All rig landings used here were compiled from the following landings statistics: 1960–80, rig, dogfish unspecified, and spiny dogfish (*Squalus acanthias*); 1981–82, rig and dogfish unspecified; 1983–85, rig only. Data were presented this way because of the way fishermen reported rig catches.

Recent research

Catch rates began to decline in many rig fisheries during the late 1970s (Francis and Smith 1988). This decline continued throughout the 1980s and caused concern for the future of the fishery. Because little was known about rig biology, several studies were initiated. Francis (1979) and Francis and Mace (1980) studied the reproductive biology of rig from Kaikoura and Nelson. King and Clark (1984) examined the feeding habits of rig, and King (1984) studied changes in female condition associated with inshore migration. Further details on the biology of the species were presented by Massey (1984). Francis (1988, in press) conducted an extensive tagging experiment to examine stock boundaries and migration patterns and to estimate stock sizes around the South Island.

The present study was made in 1982–83 with the aim of assessing the state of the Pegasus Bay rig fishery in the 1982–83 season and determining appropriate management measures for the fishery. Places mentioned in this study are shown in Figure 1.

History of the fishery

There was no significant rig fishery in Pegasus Bay until the mid 1970s. Some target fishing may have occurred, but most rig were taken as trawl by-catch (A. Coakley pers. comm.). Landings generally increased parallel to the total Lyttelton wetfish catch (Figure 2). The only sustained drop in landings was from 1967 to 1969, when many Lyttelton vessels left to fish for red rock lobster (*Jasus edwardsii*) at the Chatham Islands.

Target set netting for rig probably began in 1973 or 1974 as the fishery grew from the demise of the elephant fish fishery. The initial impact of target fishing would have been low because little set netting was done at first (A. Coakley pers. comm.), and the fishing patterns changed little (fishermen continued to fish the shallow areas closed to trawling).

There were substantial changes in the 1976–77 season (October-March). Trawl landings increased to a record 270 t and set net landings more than trebled to 72 t (Figure 3). There must have been a lot of target trawling to have produced these landings. Set net fishermen also increased their effort substantially. Vessel numbers were the same as in the previous season, but the mean number of fishing days per vessel nearly doubled (Figure 4). Good catches were made during the end of the 1976–77 season (in February-April 1977), and expansion of the fishery seemed likely.

Set net fishing increased greatly in the 1977–78 season (October-March) as many new vessels joined the fleet. The mean number of vessels set netting for rig each month during this season was more than three times that of the previous season.

The expansion of the set net fleet was probably stimulated by increased catches by the set net vessels in the 1976–77 season, a large increase in the price obtained for rig in 1977–78 (Figure 5), the introduction of monofilament nylon nets, and the introduction of

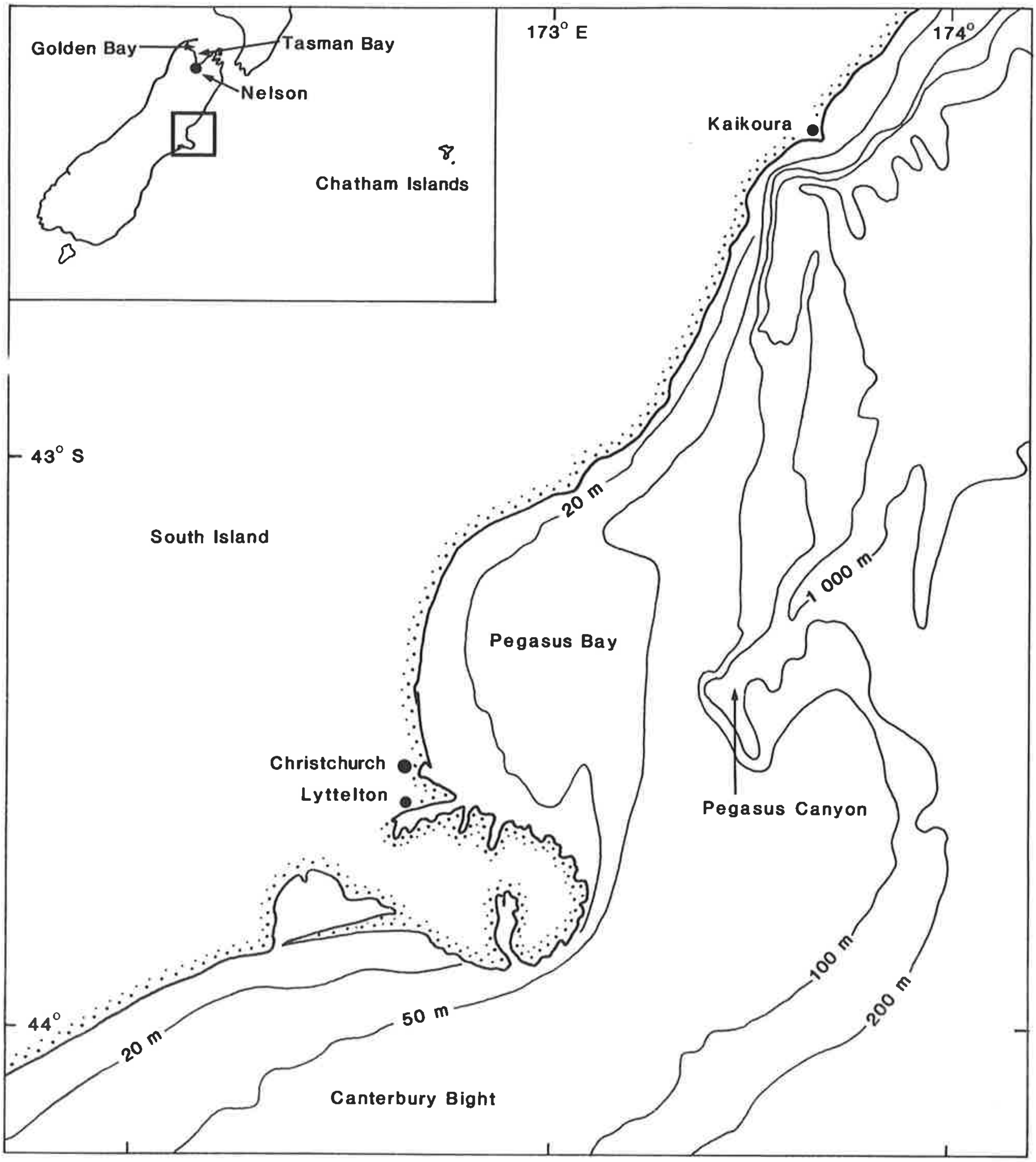

Figure 1: Places mentioned in the text.

mechanical net hauling equipment, which was used on only a few vessels in the early development of the rig fishery (W. Matthews, J. Waller pers. comm.).

Trawl landings fell sharply in the 1977–78 season and have continued to fall slowly. Set net landings increased again in 1977–78, and set netting displaced trawling as the main fishing method.

Set net landings varied greatly between 1977–78 and 1982–83, but overall they remained at about the same level. However, set net catch per unit of effort (CPUE) decreased steadily, and this reduced the profitability of the fishery. Profits were further depressed by rising costs and a real decline in the unit price paid to fishermen for rig.

The fishery underwent substantial changes, the most obvious of which was a reduction in the number of fishermen. The largest reduction occurred between 1978–79 and 1980–81, when the mean number of vessels fishing each month fell from 24.2 to 12.8. Vessel numbers remained stable between 1980–81 and 1982–83.

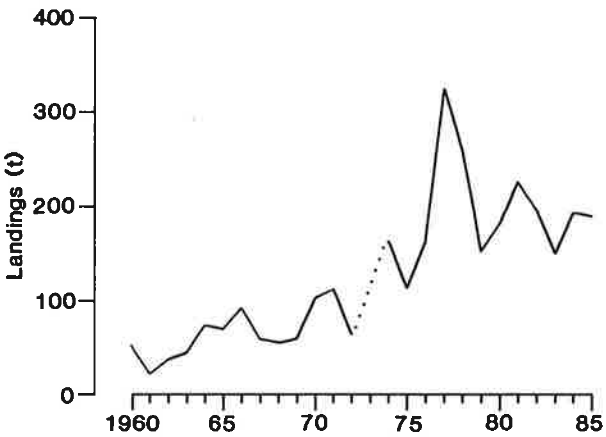

Figure 2: Lyttelton rig landings for the calendar years 1960–85. (Data for 1973 were not available.)

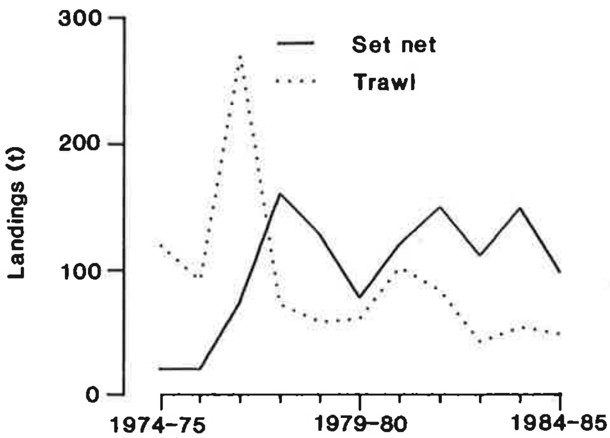

Figure 3: Lyttelton rig landings by fishing method for 1 July to 30 June years, 1974–75 to 1984–85.

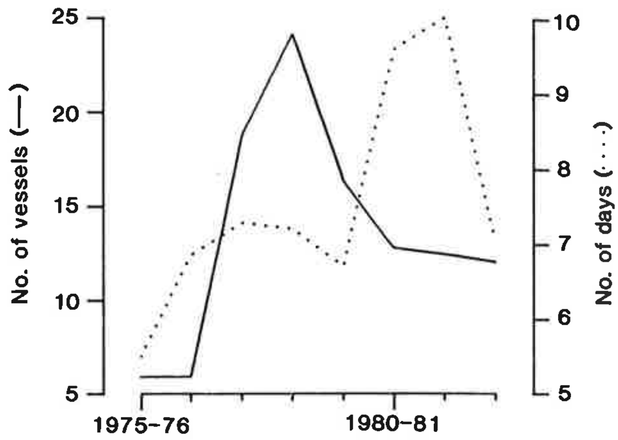

Figure 4: Mean number of vessels per month and mean number of fishing days per month per vessel for rig vessels fishing in Pegasus Bay for 1 July to 30 June years, 1975–76 to 1982–83.

Figure 5: Real changes in the port price of rig for the calendar years 1973–82.

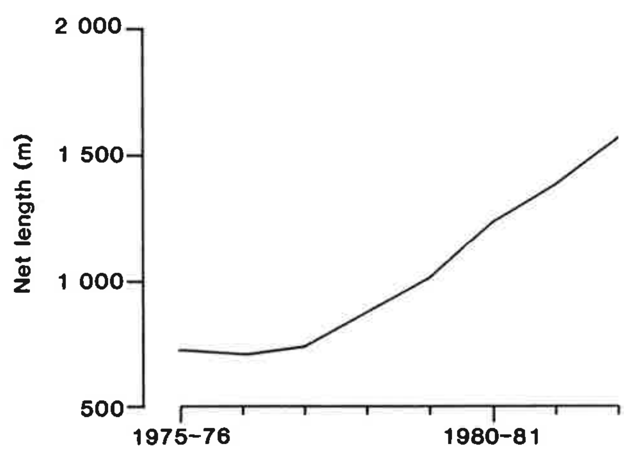

Figure 6: Mean length of net per vessel for rig vessels fishing in Pegasus Bay for 1 July to 30 June years, 1975–76 to 1982–83.

Decreasing profits also changed the way fishing operations were run. As catch rates fell, fishermen set more net to maintain their catches. From 1977–78 to 1982–83 the mean length of net fished increased by about 150–200 m per year (Figure 6). Mesh sizes also decreased. Data collected during the 1979–80 season showed that most fishermen used 178 mm mesh nets, but that 191 and 185 mm mesh were common (MAFFish unpublished data), whereas few 165 mm mesh nets were used. In the 1982–83 season most fishermen still used 178 mm mesh nets, but 165 mm mesh was also common, and mesh sizes larger than 178 mm were rare.

When the fishery first developed, most fishermen were setting their nets in the shallow, trawl-prohibited areas near the coast. By the 1979–80 season, most fishermen were setting in 15–25 m of water, some were fishing in 10–12 m, and very occasionally nets were set in 35–40 m. However, by the 1982–83 season, most set net fishing was in 35–40 m, a little occurred out in "the weed" at about 70 m, and the largest boats regularly fished on the continental slope in the Pegasus Canyon. There was very little fishing in waters less than 25 m. Because the bay has a fairly gentle slope, fishermen had to travel much greater distances to fish these deeper waters. This increased fishing costs substantially because fuel was a major running expense.

The fishery, April 1982 to March 1983

The fishermen

The set net fishermen involved in the fishery during the 1982–83 season were a very diverse group. The size, economic importance, and operation of fishing units varied greatly. These differences were mainly because of different motives for fishing for rig.

Three groups of set net fishermen were identified for this study: full-time fishermen who target fished for rig in summer (group A); part-time fishermen who fished seriously during the rig season, but did not fish outside this season (group B); and "the rest" (group C).

Group A was the smallest and comprised only five vessels (Table 1). All fishermen netted for rig in summer, but reverted to either trawling or dredging for the rest of the year. All vessels were owner-operated. Two were run on a partnership basis with both partners working on the vessel, whereas the other three had only one owner. All vessels were worked by two fishermen. The owners had a mean of about 12 years commercial fishing experience.

Three of the vessels usually remained at sea for 2–4 days and lifted and reset their nets every 12 hours. At the end of a fishing trip, the nets were brought back to shore. These fishermen typically fished much further out than the other set net fishermen. They often fished 25–30 n. miles from port. The other two vessels were operated in a similar manner to group B vessels.

Group B comprised 10 vessels, 9 of which were owner-operated. Two of the owner-operated vessels were owned by a partnership, the rest had only one owner. All were worked by two fishermen.

These vessels were worked only seasonally. The owners relied mainly, or in some instances solely, on fishing for an income during the rig season, but they did not fish outside the rig season. Most were tradesmen (e.g., plumbers, bricklayers) in the off-season. Most crew members were also tradesmen or labourers in the off-season. The fishing experience of the vessel owners in this group ranged from 1 to 20 years. The mean was about 10 years.

Group B fishermen made only day trips. They cleared their nets, reset them, and then returned to the shore. Fishing was usually carried out 15–20 n. miles from port.

Group C comprised 15 owner-operated vessels, most of which were worked by the skipper alone. It included rig fishermen who fished only occasionally and set net fishermen who did not target fish for rig.

Table 1: Pegasus Bay set net fleet, 1982–83*

	Group		
	A	B	C
No. of operations	5	10	15
Sample size	4	9	11
Ownership			
No. of sole owner-operators	2	7	11
No. of partnership owner-operators	2	2	0
Commercial fishing experience of skippers (years)			
Mean	11.8	10.6	14.0
s.d.	5.5	6.6	14.9
Off-season occupations of skippers and crew members	Full-time fishermen	Mostly tradesmen or labourers	Variable
Mean No. of crew members (including skipper)	2.0	2.0	1.3
Vessel characteristics			
Hull length (m)			
Mean	10.5	7.1	5.9
s.d.	1.7	1.0	1.1
Hull age (years)			
Mean	19.4	3.7	14.4
s.d.	12.0	1.8	13.0
Engine horsepower			
Mean	147.0	337.0	52.8
s.d.	86.2	108.1	45.1
Engine age (years)			
Mean	7.8	2.1	7.3
s.d.	5.4	1.3	5.8

* Only set net vessels which landed rig in the 1982–83 season are included.

The fishermen who did target fish for rig generally used moderate lengths of net and did not usually venture far offshore. The operation was treated as a means of supplementing income from another full-time occupation.

Most group C fishermen did not fish specifically for rig and fished inside Lyttelton Harbour or close inshore along the coast. Two were full-time commercial fishermen, but most did not regard their operation as a financial enterprise, fishing was merely a weekend or retirement activity that was done for pleasure. Only very small lengths of net were used (the mean was about 200 m). Furthermore, little of the fish some fishermen caught was sold, most was kept for personal consumption or given away. It was sometimes traded for farm produce.

Fleet structure

The Pegasus Bay set net fleet was very diverse in vessel size and design. Group A vessels were the largest; they were 8.5–13.2 m long. All had displacement hulls made from kauri or plywood. Engine size was variable. The hulls and engines were both old; hulls were 11–40 years old and the engines were 1–13 years old.

Group B vessels were small, high-speed vessels, built specifically for set netting. They all had fibreglass or fibreglass-on-ply planing hulls, which were 6.0–8.4 m long. Most hulls were new. Nearly all the vessels had large, stern-drive or outboard engines of 250–450 horsepower (h.p.). Because the engines operated at high revolutions they had a short lifespan (e.g., 3–5 years for outboards). Consequently, the mean age of the engines was low (2 years).

There was a large range of vessels in group C, and it was difficult to identify any distinguishing characteristics. The vessels had wood, aluminium, or fibreglass-on-ply hulls, which were 3–80 years old. Most were driven by inboard engines. Engine ages also varied greatly. However, overall the vessels were smaller and the engines less powerful than in the other groups. The hulls were 4.3–9.2 m long, and most engines were 20–70 h.p.

Catch composition

The mean annual trawl and set net landings of the major species caught by the Lyttelton set net fleet for the calendar years 1981 and 1982 are given in Table 2. The mean catch composition of group A, B, and C operations for October–April in the 1982–83 season is given in Table 3. Tables show recorded landings. Actual landings could differ substantially. Group C sample size was very low in relation to the population size, and, because the operation of fishing units varied greatly in this group, the data may not accurately represent the true mean catch composition.

Marketing

Fish marketing is very complex in Christchurch, because two different types of marketing system are used: an auction system and an agency system.

Table 2: Mean annual (1981–82) trawl and set net landings at Lyttelton of the major species caught by the set net fleet*

Species	Landings (t) Set net	Trawl	Total
Rig (*Mustelus lenticulatus*)	140.0	74.0	214.0
School shark (*Galeorhinus galeus*)	58.8	27.0	85.8
Tarakihi (*Nemadactylus macropterus*)	23.1	122.7	145.8
Spiny dogfish (*Squalus acanthias*)	13.2	14.5	27.7
Warehou (mainly *Seriolella* spp.)†	12.2	94.7	106.9
Elephant fish (*Callorhynchus milii*)	11.3	47.1	58.4
Flounders (*Rhombosolea* spp.)	9.4	61.7	71.1
Hapuku (*Polyprion oxygeneios*)	4.7	26.1	30.8
Stargazer (*Kathetostoma giganteum*)	3.2	50.9	54.1
Dogfish unspecified	2.6	5.0	7.6
Shark unspecified	2.1	3.3	5.4
Soles (mainly *Peltorhamphus novaezeelandiae*)	1.9	165.0	166.9
Red gurnard (*Chelidonichthys kumu*)	1.3	73.7	75.0
Flatfish unspecified	0.7	110.4	111.1

* Fisheries Statistics Unit unpublished data.
† Recorded landings of silver warehou (*Seriolella punctata*) are excluded. Recorded "warehou" landings contain a mixture of several species, including silver warehou.

Most of the fish sold in Christchurch is sold by auction. The two wholesaling and processing companies which handled most of the fish in 1982–83, Feron Seafoods Limited and United Fisheries Limited, both operated a daily auction. These companies accepted fish from any vessel and sold it in its landed state to retailers (or occasionally wholesalers) on behalf of the fishermen. The fishermen were then paid the auction price, less a handling fee. Fish which was unsold at the auction or which did not fetch the floor price set by the auctioning company was bought by the company for processing in its own plant. Therefore, there was much variation in price, even from day to day, because prices varied according to the availability of fish.

Wholesalers who operated under the agency system sold their fish to a regular clientele of retail outlets. Fishermen who sold fish to these wholesaling companies were paid a fixed price for the fish. The price varied throughout the season, but less erratically than with the other system.

Although there were large price variations during the season, the general trend in both systems was for higher prices to be paid at the beginning and end of the season and lower prices to be paid during times of peak catch. Most fishermen were receiving $2.40–2.60 per kilogram for rig "trunks" (headed, gutted, and fins removed) at the peak of the 1982–83 season. Before November and after February, prices were usually $3.00–3.30 per kilogram, but the price did go up to $3.70 (A. Coakley pers. comm.).

The wholesaling and processing companies sold most of their rig to either retail or fast food outlets. Retailers sold rig fillet as "lemonfish". Each month observations were made at 10 Christchurch retail outlets, and rig sold for $5.50–7.00 per kilogram. No shops showed large price variations from month to month.

Table 3: Mean catch composition of group A, B, and C operations, October 1982 to April 1983*

Species	Group A Green weight (kg)	Group A % of total catch	Group B Green weight (kg)	Group B % of total catch	Group C Green weight (kg)	Group C % of total catch
Rig	7 810	59.3	10 070	49.0	870	50.2
School shark	2 240	17.0	5 910	28.7	100	5.9
Elephant fish	1 890	14.3	730	3.1	110	5.7
Spiny dogfish	540	4.1	1 360	6.6	60	3.5
Hapuku	130	1.0	160	1.1	0	0.0
Warehou	110	0.9	210	2.0	0	0.0
Flounders	20	0.2	250	2.2	320	2.7
Others	430	3.2	720	7.3	320	32.0
Total	13 170		19 410		1 490	

* MAFFish unpublished data. Not all operations could be used to compile the table because some fishermen did not return statistical forms to MAFFish. Sample sizes: group A, 3; group B, 6; group C, 3.

Biology

The aims of the biological field work were to define the fish size, sex, and maturity compositions of the commercial catch and to investigate the reproductive biology of the species. The results of this investigation are given in detail by Massey and Francis (in press).

Of the estimated 30 000 rig caught in set nets from November 1982 to June 1983, 56% were males (Table 4). Males dominated catches in November and December 1982 and females were dominant from January 1983. Eighty-four percent of males were mature, compared with 30% of females. Overall, the set net fishery was based on mature males and immature females (48 and 31% of the total set net catch respectively).

If size at sexual maturity is expressed as the length at which 50% of a size class is fully mature, then males mature at about 89 cm and females mature at about 106 cm. There were unexpected differences between the size at sexual maturity of Pegasus Bay and Kaikoura fish. These differences were probably caused by uneven mixing within the population. Samples from widely scattered locations along the coast are probably needed to determine accurately female size at maturity.

Table 4: Estimated sex and maturity compositions by number of Pegasus Bay set net rig catches, 1982–83

	Total catch (%)		
	Male (n = 16 800)	Female (n = 13 000)	Total (n = 29 800)
Immature	9	31	39
Mature	48	13	61
Total	56	44	100

Most females probably gave birth to their pups in September-October and ovulated a new set of eggs in October-December. The timing of reproduction was similar for Kaikoura and Pegasus Bay females. Too few data were obtained to estimate the length-fecundity relationship and the rate of reproductive failure.

Catch per unit of effort analysis

Assumptions

Catch per unit of effort can be very useful for monitoring the abundance of recruited fish. However, Ricker (1940) stated that the following "ideal" conditions must be met before CPUE would be perfectly proportional to abundance.

1. The commercially useful portion of a stock is fished with equal intensity in every part of the population's geographical range.

For management purposes, the east coast South Island rig population can be regarded as a unit stock (Francis 1988). To satisfy this assumption fish of similar size and sex would need to have an equal chance of being caught regardless of their location along the coast. However, the distribution of effort was not ideal; effort was much more intense near the fishing ports and, even within a fishery, it was often concentrated into small areas. Nevertheless, because rig are highly migratory, fish of a similar size and sex probably have an equal chance of being caught.

2. The same amount of effort is applied in the fishery throughout the fishing season.

As with the previous assumption, there is a large difference between the observed and ideal situations. However, Ricker (1940) stated that "as long as the gear used at different times is more or less in the same proportion in successive years, this will probably not be an important source of error". Figure 7 shows the proportion of the total October-January set net effort which was applied in each of these 4 months for the period analysed (these were the only months used in the CPUE analysis). Although the proportion of effort applied in any month varied between fishing seasons, it appeared to be similar in most of the seasons examined. It was not expected that any serious bias would result from this assumption.

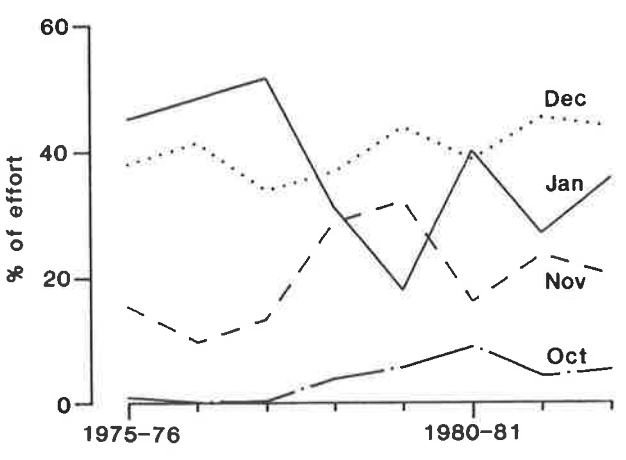

Figure 7: Percentage set net effort in each month for October-January, 1975–76 to 1982–83.

3. The catching efficiency of the fishery remains constant throughout the period examined.

There are several factors which could produce changes in the fishing efficiency of the gear: environmental factors, interactions between nets, net saturation, technological improvements, and increases in the level of total fishing skill.

Environmental factors are considered to contribute a minimal source of error because any events which would affect the efficiency of the nets are unlikely to be frequent or prolonged.

The effect of interactions between nets is unlikely to be an important consideration now, but it may have been in the past. During the years when there were many vessels fishing close inshore there may have been some crowding of gear, which would have reduced the fishing efficiency of each net and caused an underestimate of abundance in these early years.

Net saturation is probably the most significant factor which affects catching efficiency. Rig catches are now generally low and, therefore, saturation effects are only ever likely to occur with heavy by-catches of spiny dogfish. Large catches greatly inhibit the efficiency with which rig are landed, but they are seldom made (R. Beggs, J. Waller pers. comm.). Thus, net saturation is not likely to be an important source of error now, though it may have been during earlier years when rig catches were much larger. If the catches were large and frequent enough, abundance would have been underestimated in the earlier years.

Technological improvements and changes in the level of total fishing skill may also lead to biased estimates of abundance in this fishery. Some technological improvements have occurred, e.g., conversion to more efficient oval mesh (Francis and Smith 1988), and fishermen's skill will have undoubtedly increased over the years. Both these effects would probably have led to an underestimation of abundance in the early years of the fishery.

Therefore, this assumption may have resulted in a significant underestimation of the abundance of fish in the earlier years of the period examined.

4. Natural increases and decreases are balanced within the population during the fishing season.

It is impossible to adequately assess the validity of this assumption because there is virtually no information on growth, recruitment, and natural mortality. Recruitment is the factor which is most likely to create problems with the assumption, but it is not likely that it is highly variable for elasmobranchs (Holden 1974) such as rig.

Catch and effort units

There are two main problems with the catch data available for the analysis. First, the quantity of fish landed is rarely the same as that which is killed by the fishing operation. Some fish caught in the nets drop out while the net is still set or while it is being hauled, and some of these may die later from injuries sustained in the net. Substantial but unrecorded quantities of fish also die from predation and spoilage. For low-value species, even good quality fish are frequently discarded. Therefore, landings may bear little relation to the actual catches. Second, fishermen frequently underreport their catches on the statistical return forms they submit to MAFFish. Thus, even when fish are landed, they are not always recorded. The overall result of these factors is that recorded "landings" substantially underestimate true catches. The extent of this bias is unknown and probably variable.

A suitable measure of fishing effort must incorporate fishing power and fishing time. The fishing power of set nets is mainly influenced by the characteristics of the gear itself. Vessel characteristics may be important, but usually only indirectly (e.g., they may determine where and how much gear can be used). The three major factors which influence the fishing power of set nets are the amount of net, the selectivity and efficiency of the net, and the skill of the fishermen. Net length is probably the most important (FAO 1976). Because it is impossible to incorporate all the above factors into a single measure of fishing power, it is probably best to measure fishing power in terms of net length and watch for changes in the other factors.

It is difficult to describe an accurate measure of fishing time for set nets because catches do not always increase in proportion to the amount of time a net is in the water. Kennedy (1951) stated that "at very low levels of availability, doubling the interval between lifts will probably double the average catch [per lift], at moderate levels of availability a given number of nets will probably yield more if cleared daily than if cleared at longer intervals, and at high levels of availability nets can probably become "saturated" during the first day so that they will catch no more fish if they are left in the water for a longer time".

Therefore, at low abundance the best measure of fishing time is the number of days that the nets are in the water. At high abundance, the best measure is the number of days that the nets are cleared. At moderate abundance, neither of these measures are ideal. This presents real difficulties in a fishery which is fished from high to low abundance because it means that neither of these measures will accurately describe fishing time throughout the history of the fishery.

Only data from fishermen working more than 350 m of net were included in the analysis. Fishermen using less than this were probably "weekend" fishermen, and they accounted for only a small proportion of both the catch and effort for the fishing years 1975–76 to 1982–83. Although they accounted for a slightly larger proportion of both catch and effort in earlier years, the difference was not thought to be significant.

Only the October-January catch and effort data were used for each of the seasons examined. Some fishermen were known to have target fished for other species when rig catches were low, but it was unlikely that this had occurred in the above period. These 4 months almost always showed the highest catch rates, and they accounted for most of the yearly set net catch and effort; in all but 1 year they accounted for more than 80% of the catch and more than 70% of the effort.

As rig are trunked before being landed, all landed weights must be multiplied by a factor of 2.0 to obtain the corresponding green weight (MAFFish unpublished data). All catch data used in this analysis are in kilograms green weight.

Effort data are in units of 100 m days, where "days" is the number of days that fish were landed. This is not an ideal measure of fishing time, but it is the only measure that is consistently recorded (M. Francis pers. comm.). It will correspond closely with the number of days that the gear is lifted because few fishermen stay out at sea for more than 1 day. Thus, effort was calculated by multiplying the number of 100 m lengths of net each fisherman used by the number of days he landed fish and then summing the individual figures for all fishermen. This measure is the best available, though it does not account for many of the variables which affect fishing effort, as discussed previously.

Catch per unit of effort data are expressed in units of kilograms per 100 m day. The seasonal CPUE index was calculated as the mean of all the individual monthly catch rates in October-January.

Trends in catch, effort, and catch per unit of effort

The total October-January set net catch and effort for all vessels fishing more than 350 m of net for the 1975–76 to 1982–83 seasons is shown in Figure 8. The total number of days fished from October to January in each season by these vessels is shown in Figure 9. The seasonal CPUE indices for the same period are shown in Figure 10. Although the period examined in the analysis was short, there were significant changes in catch, effort, and CPUE.

Catch and effort were low in the 1975–76 and 1976–77 seasons because few vessels were fishing. However, there was a substantial increase in the mean catch rate between the two seasons. Although individual catch rates varied, the mean catch rate for 1976–77 was more than double that of the previous season, and this influenced the fishery in the following season.

Many new vessels joined the fleet for the 1977–78 season and they fished more frequently; there was a 400% increase in the total number of fishing days. Although there was a small decrease in mean net length, effort increased 270%. This generated a 940% increase in landings, from 19 t in 1976–77 to 198 t in 1977–78. Because the rise in landings was much greater than that in effort, CPUE again rose rapidly to reach its peak of about 34 kg per 100 m day.

The 1978–79 season was a turning point for the fishery. There was another large increase in effort (probably because of the previous season's success), but the catch dropped slightly. Therefore, the mean catch rate fell sharply, and it has continued to fall.

In the 1979–80 season there was a substantial reduction in effort, back to the 1977–78 level. This was one reason for the large (44%) drop in landings. However, the drop in landings was greater than that in effort, and there was a further decline in CPUE.

Total effort increased again in the 1980–81 season. The greater effort occurred because of an increase in the mean net length being used. The total number of fishing days was about the same as it had been in the previous season, despite a substantial fall in the number of vessels for the second year in succession. Landings increased again, but the CPUE declined slightly.

Fishing effort increased to a record peak in the 1981–82 season, and there was now a regular increase in mean net length. The total number of fishing days remained virtually unchanged. Even with this extra effort, landings fell by 22%. Catch per unit of effort again declined abruptly.

In the 1982–83 season landings were low and there was a significant reduction in effort. Although the mean net length increased by 180 m (13%), effort decreased overall by 22% because of a large decrease in the number of days fished. The catch also slumped to its lowest level in 6 years, partly because of the reduction in effort and partly because of another drop in catch rate. Catch and catch rate have never shown any prolonged stability. They both rose rapidly between 1975–76 and 1977–78, during the fishery's development phase, and simultaneously peaked in 1977–78. Since then the catch rate has declined at a steady and rapid rate, as has the catch in all but one season. Both catch and CPUE have diminished at an average rate of about 14% per year. The real decline in catch rate is probably more than this because the catchability coefficient is not constant for the period examined.

Interpretation

The classical interpretation of the observed decline in catch and CPUE would be that the average abundance of rig in Pegasus Bay was decreasing. There are at least three other possible explanations which are not necessarily consistent with a decrease in the average abundance of fish: an increasing proportion of the fish are now only present in the bay before October or after January; other fishing methods are collectively catching an increasing proportion of the available fish and, therefore, less fish are left for the set net fishermen; or, the fish are becoming more adept at avoiding capture.

None of these possibilities are supported by the available data. The mean catch rate for the months before October and after January has actually declined since 1977–78. Therefore, it is unlikely that rig are simply migrating into the bay at a different time. Trawl landings have also shown a general decline since 1977–78 (*see* Figure 3). Fish can learn to avoid capture, but catch rates for some seasons have fallen more than 30% in 1 year. It is difficult to believe that enough fish could learn fast enough to cause and maintain such

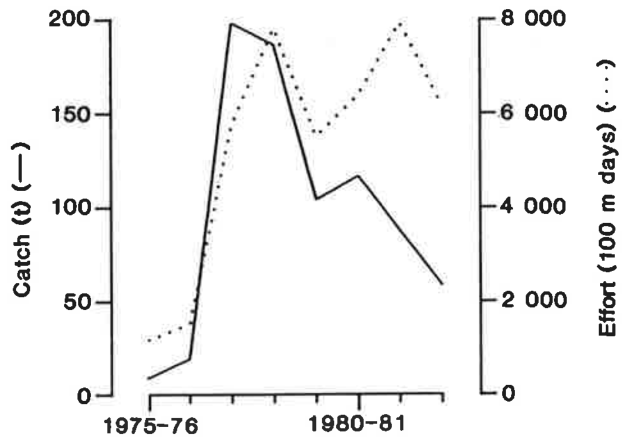

Figure 8: Set net catch and fishing effort of vessels fishing in Pegasus Bay for October-January, 1975–76 to 1982–83.

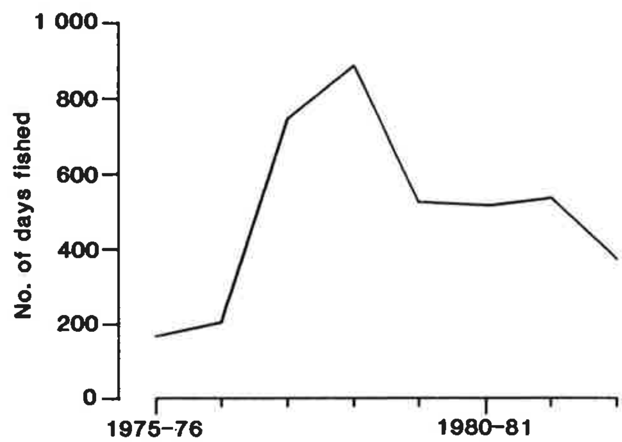

Figure 9: Total number of days fished by rig vessels for October-January, 1975–76 to 1982–83.

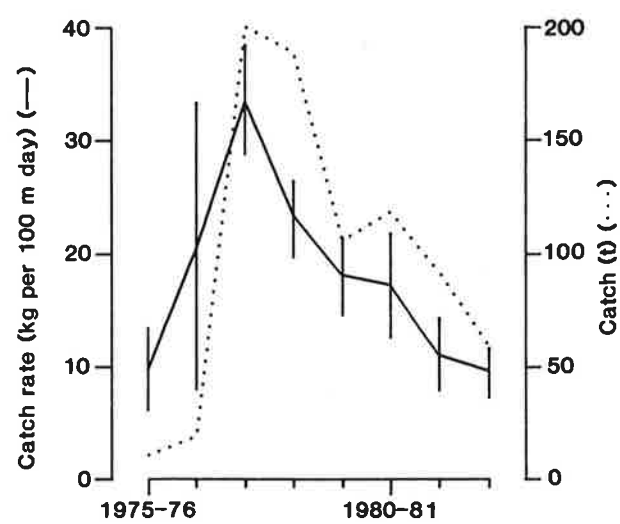

Figure 10: Mean catch rate of rig vessels fishing in Pegasus Bay for October-January, 1975–76 to 1982–83.

a decline. Therefore, it appears that rig are declining in abundance in Pegasus Bay. Catch per unit of effort analysis of the three other major South Island rig fisheries (Tasman Bay-Golden Bay, Kaikoura, and Canterbury Bight) supports this conclusion. Francis and Smith (1988) have shown that catch rates declined at about the same rate in all four fisheries in recent years. Francis (in press) also showed that the exploitation rate of the east coast South Island rig population is extremely high (more than 20%), and rig stocks can probably only sustain an annual exploitation rate of 5–10%. This suggests that the primary cause of the decline is excessive fishing pressure.

Costs and earnings survey

Survey method and response rate

The financial data were collected from a survey of the entire fleet of commercial set net fishermen late in 1983. Ministry of Agriculture and Fisheries records showed that 30 set net vessels caught rig in Pegasus Bay during the 1982–83 season. Of the 29 fishermen who were asked to provide information on their fishing operation, 20 had the surveys delivered personally and 9 received them in the mail.

The survey response rate for group A, B, and C fishermen is shown in Table 5. Twenty-four responses (83%) were received, and four of the remaining five fishermen agreed to send in their survey form, but the replies were not received.

Many replies (usually from group C fishermen, who did not treat fishing as a financial enterprise) contained insufficient financial data and could not be used in the analyses. However, these replies gave valuable information on other aspects of the fishing operation.

Sample sizes were regarded as satisfactory. In groups A and B, the samples represented 80 and 70% of the total population respectively. Although the sample size was only three in group C, this represented most (60%) of the operations which were actually target fishing for rig and which were treated as a financial enterprise.

The data used in the analyses were of variable quality; some forms had been filled out accurately, others had not. However, the information provided a fair indication of each overall performance because the data were regarded as accurate enough for the purposes intended. Furthermore, each sample appeared to be typical of its respective group.

Table 5: Survey response rate

Group	No. of operations: Total population	No. of operations: Survey population	No. of responses: Total	No. of responses: Suitable for analysis
A	5	5	4	4
B	10	10	9	7
C	15	14	11	3
Total	30	29	24	14

Methodology

All costs and earnings data used in both the financial and economic analyses were sample means. Some data (especially cost data) from each group of fishermen showed wide variations between operations. For example, wages were zero where a partnership arrangement existed, but a major cost in all other operations. Therefore, the mean value of a cost may not be typical of any one of the fishermen's costs.

Repairs and maintenance. Fishermen were not required to itemise fixed and variable vessel repair and maintenance costs separately. The relative proportions of fixed and variable costs for these two expenses were assessed in accordance with New Zealand Fishing Industry Board (NZFIB) estimates. For displacement hulls, fixed repairs and maintenance (those on the hull and superstructure) were assumed to represent 33% of the total repairs and maintenance bill. Variable repairs and maintenance (those on the engine and deck machinery) were assumed to account for the remaining 67%. For planing hulls, these expenses were assumed to be 20% fixed and 80% variable. Net repairs and maintenance (a variable cost) were itemised separately.

Shore expenses. Shore expenses were probably the most difficult for fishermen to assess. Their estimate should have included such costs as onshore vehicle expenses, wharfage, NZFIB levies, and wholesale handling fees. It should have also included any accountancy or legal fees and telephone bills associated with the fishing operation. These expenses would have almost certainly been underestimated in all of the surveys. Nevertheless, from the estimates provided, shore expenses were assessed at 80% variable (primarily vehicle expenses) and 20% fixed (e.g., administration and wharfage).

Insurance. This cost also varied widely because not all fishermen had insured their vessels. For group A operations, the insurance cost was divided up in accordance with the time spent in each fishery. It was assumed that fishermen spent an average of 14 weeks in the rig fishery during the 1982–83 season. Therefore, the insurance figure used in the group A analysis was 14/52 of the total annual insurance bill. Group B and C operations had the entire insurance bill charged to the rig season because these vessels were not used outside this period.

Interest. Group A vessels had the cost split proportionately between fisheries as for insurance, whereas group B and C operations had the whole bill charged to the rig season.

Depreciation. Depreciation is a measure of the decline in service potential of an asset (Duncan 1982). The depreciation rates of the vessel components and nets are given in Table 6 and were calculated on a diminishing value basis where each component of the operation was treated separately.

The historically recorded book values of the vessels and gear are reasonable figures to use for depreciation calculations for the assessment of the profitability of fishing operations (S. Andrews pers. comm.). Thus, depreciation is based on the purchase value of the vessel and gear. Because the hulls, engine, deck machinery, and electrical equipment depreciate at different rates, it was necessary to ascribe a fixed proportion of the vessel's purchase value to each of these four components, and this proportion varied with the nature of the vessel (Table 7).

Where an engine had been replaced since the vessel was purchased, engine depreciation calculations were based on the purchase value of the new engine. Purchase values for gear were independently itemised in the survey. However, because most fishermen had some old nets and some new nets, it was assumed that the gear had a mean age of 2 years.

Group A operations only had 14/52 of the total depreciation charged to the rig season, whereas group B and C vessels had the entire amount charged. However, all depreciation of group A gear was included in the analyses because this gear was not used outside the rig season.

Current profitability

Table 8 shows the results of the three group analyses. These figures are the average costs and earnings per operation (not per owner).

The contribution margin is the average amount of money that remains from gross earnings after all variable expenses have been paid. Expressed as a percentage, it represents the average number of cents in each dollar of sales which is available to meet fixed costs and provide an income to the owner(s) of the operation. Total fixed costs are equal to the total cash fixed cost, plus depreciation. Net income is the average net income to an operation before tax.

The financial viability of this fishery for each group of fishermen was calculated by an income equation for each group. These equations also provide a ready basis

Table 6: Annual depreciation rates of vessel components and nets*

Item	Depreciation rate (%)
Hull	
Displacement	10
Planing	20
Engine	
Inboard	20
Outboard and stern-drive	25
Deck machinery	15
Electronic equipment	20
Nets	20

* NZFIB unpublished data.

Table 7: Purchase value of vessels for each vessel component*

Vessel component	Purchase value of vessel (%) Displacement hull vessels	Planing hull vessels
Hull	45	40
Engine	15	40
Deck machinery	20	15
Electronic equipment	20	5

* Based on NZFIB estimates.

for intergroup comparisons because they highlight the financial differences between the groups.

An income equation is a linear function of the format:

$$Y = MX - C$$

where Y = net income before tax, M = contribution margin as a percentage of total earnings, X = gross revenue, and C = total fixed costs (Duncan 1982). Therefore, the income equations for each group are:

$$Y_A = 0.56X_A - 4910$$
$$Y_B = 0.42X_B - 9670$$
$$Y_C = -0.08X_C - 1130$$

By equating Y with zero and solving the income equations for X, it was possible to determine how much revenue the average operation in each group needed to earn to cover all costs (excluding the cost of the owner's labour). The required revenue for each average operation was:

group A: $8,770
group B: $23,020
group C: no solution

An important assumption of these calculations is that net income was linearly related to gross earnings over the zero to break-even revenue range.

Costs, revenue, and net income per unit of catch and effort

To complete the financial analysis it was necessary to examine the costs, revenue, and net income per unit of catch and per unit of effort. These data describe the efficiency with which each group caught fish. Catch and effort data used in this analysis were obtained from MAF statistical return forms.

Table 8: Financial analysis of group A, B, and C operations*

	Group A		Group B		Group C	
	Gross ($)	% gross earnings	Gross ($)	% gross earnings	Gross ($)	% gross earnings
Total sales	21,030	100.0	27,810	100.0	1,870	100.0
Costs						
Variable costs						
Wages	2,050	9.7	2,690	9.7	160	8.6
Fuel and oil	3,180	15.1	6,510	23.4	1,150	61.5
Variable repairs and maintenance						
Engine and deck machinery	1,090	5.2	3,400	12.2	170	9.1
Nets	1,630	7.8	1,970	7.1	410	21.9
Variable shore expenses	1,340	6.3	1,630	5.9	120	6.4
Total	9,290	44.2	16,200	58.3	2,010	107.5
Contribution margin	11,740	55.8	11,610	41.7	- 140	- 7.5
Fixed costs						
Insurance	700	3.3	490	1.8	120	6.4
Interest	620	2.9	1,790	6.4	130	6.9
Fixed repairs and maintenance	550	2.6	850	3.1	40	2.1
Fixed shore expenses	340	1.6	410	1.5	30	1.6
Total	2,210	10.5	3,540	12.7	320	17.1
Total cash costs	11,500	54.7	19,340	69.5	2,330	124.6
Cash surplus	9,530	45.3	8,470	30.5	- 460	- 24.6
Depreciation						
Vessel	2,000	9.5	5,000	18.0	670	35.8
Nets	700	3.3	1,130	4.0	140	7.5
Total fixed costs	4,910	23.3	9,670	34.8	1,130	60.4
Total costs	14,200	67.5	25,870	93.0	3,140	167.9
Net income	6,830	32.5	1,940	7.0	- 1,270	- 67.9

* Sample sizes: group A, 4 (80% of the group population); group B, 7 (70%); group C, 3 (60%).

One major problem with the analysis was the unreliability of the catch and effort data provided by fishermen. To eliminate as much error as possible, each vessel's catch was estimated from the gross earnings figures provided. Where there were wide discrepancies between the estimated and reported catches, the vessel was eliminated from the sample for this part of the analysis. Therefore, the sample sizes were reduced to three in group A, four in group B, and three in group C. The costs and earnings data of the operations included in the mean catch and effort calculations, rather than the overall figures presented, were used in the analysis. These data for the two different samples were very similar.

The costs, revenue, and net income per unit of catch data are given in Table 9. Net income per unit of catch is defined as the untaxed mean net income to an operation per tonne of fish landed. The variable revenue per tonne values resulted from the different species composition of the three catches.

The effort unit used previously underestimated group A's effort relative to group B's or C's (group A fishermen remained at sea for 2–4 days, whereas group B and C fishermen made only day trips). In this section, effort was calculated as 100 m days fished to obtain valid comparisons. The average number of days fished per trip was first assumed to be 2 then 3 days for the relevant group A vessels. Table 10 shows the costs, revenue, and net income per unit of effort. Net income per unit of effort is defined as the untaxed mean net income per 100 m day fished.

Table 9: Mean costs, revenue, and net income per operation during the 1982–83 rig season for each tonne of fish landed

Group	Mean catch (t)	Cost per tonne of fish landed ($)			
		Revenue	Costs: Variable	Costs: Total	Net income
A	6.71	2,930	1,420	2,040	890
B	12.89	2,480	1,520	2,300	180
C	0.87	2,150	2,310	3,610	- 1,470

Viability of the fishery

The net income which an operation earns provides a return to capital and entrepreneurship (labour and management skills). These returns determine how viable fishing is as a means of earning a living. The current and long term viability of the fishery are both important economic considerations. Viability was assessed in this report by deducting a return to capital from net income and then comparing the remaining income with a "reasonable" return to entrepreneurship.

Table 10: Mean costs, revenue, and net income per operation during the 1982–83 rig season for each 100m day fished

Group	Mean effort (100 m days fished)	Cost per 100 m day fished ($)			
		Revenue	Costs: Variable	Costs: Total	Net income
A					
2-day trip*	850	23.1	11.2	16.1	7.0
3-day trip†	1,240	15.9	7.7	11.1	4.8
B	880	36.3	22.4	33.7	2.6
C	140	13.0	14.0	21.9	- 8.9

* Mean of 2 fishing days per trip for vessels which spent more than 1 day at sea per trip

† Mean of 3 fishing days per trip for vessels which spent more than 1 day at sea per trip.

For this analysis, a reasonable return to capital was conservatively estimated to be 10% per year. This is considered to be the minimum return necessary to retain investment in the industry in the short term (Anon. 1983). It is probably insufficient to prevent disinvestment (through the non-replacement of assets as they wear out) in a fishery in the long term (Anon. 1983). The total annual return to capital for group A operations was apportioned between the different fisheries by charging 14/52 of the vessel capital and all gear capital (set net gear was not used in the other fisheries) to the rig season. The average New Zealand wage ($15,000 per year at the time of writing) is considered to represent a reasonable return to entrepreneurship. It is probably the minimum return necessary to retain employment in the fishery in the long term (Anon. 1983). It was assumed that group A and B owners each spent 14 weeks fishing full time for rig and, therefore, had a return of $4,040. Group C fishermen were assumed to have spent 20% of their working hours fishing for rig during the season, which gave a return of $810. (Information from fishermen suggests this estimate is conservatively low.)

To assess the current viability of the fishery, the book values of the assets are a satisfactory measure of capital (S. Andrews pers. comm.). The only realistic value of assets to use in the assessment of the long term viability of a fishery is the replacement value of the assets (N.Z. Fishing Industry Board 1979). Both estimates were obtained from fishermen in the survey. Comparisons of estimates for similar vessels showed that the estimates were always very compatible. Therefore, estimates were assumed to be realistic. Replacement values for gear were checked against current retail prices.

An important assumption of any long term viability assessment is that earnings and variable costs remain the same with the new vessel. Some fixed costs (insurance, interest, and depreciation) will change. In the analysis which follows, depreciation was calculated in the same manner as described previously. Insurance costs were assumed to be 3.5% of the vessel's replacement value (N.Z. Fishing Industry Board 1979). Only those vessels which were insured for the last season were charged with an insurance cost. Interest was not included in the fixed cost for this part of the analysis because the terms of these loans varied widely. Therefore, net income is net income before interest and tax for this part of the analysis.

All figures in the financial analyses so far represent the costs, earnings, or net income to an operation. The most appropriate figure to calculate in this section was the return to each owner's entrepreneurship. This was done by subtracting the return to capital from each operation's net income and then dividing the resulting return to entrepreneurship by the number of fishermen who owned the operation. The mean return to entrepreneurship was then calculated from the mean of all the individual returns. These data are given in Table 11. Table 12 gives the percentage of owners in each group which was breaking even, attaining a positive return to entrepreneurship, and attaining a reasonable return to their entrepreneurship.

Discussion

Group A was the most profitable group in the 1982–83 season. Although the gross earnings were substantially less than those of group B, the total costs were only half. Therefore, the net income for group A was more than three times that for group B. Cash surplus was also much higher for group A operations.

The major cost structure differences between the two groups were fuel and oil, maintenance, interest, and depreciation. These costs represented a much lower percentage of the revenue for group A operations than group B operations. Fuel and oil costs were lower for group A vessels because they ran on diesel and most remained at sea for 2–3 days, whereas group B vessels ran on petrol and returned to shore each evening. Group B vessels also wore more rapidly because the engines operated at much higher revolutions. This incurred higher maintenance costs. Although group A vessels had a higher mean purchase value than group B vessels, interest and depreciation costs were substantially less because these costs were spread throughout the year. Furthermore, depreciation rates were higher on group B vessels because of the nature of their vessels (planing hulls with high revving engines).

The total fixed costs of group A were lower than those of group B, and their contribution margin was higher. Consequently, the income equations showed that group A required sales of about $9,000 to break even, compared with $22,000 for group B.

Group A operations also appeared to have been in a more sound financial position than group B operations. The net income per dollar invested and net income per dollar of sales, two indicators of financial strength, were both much higher for group A operations. Because no information was obtained on liabilities in the survey, it was impossible to quantitatively examine net income as a percentage of liability.

However, if interest was taken as an indicator of liabilities, net income would probably have been a much higher percentage of liabilities for group A than group B. This would have put group A operators in a much better position to service their debts and earn a living than group B operators.

Generally, group B operations appeared to have been in a rather precarious position. They caught a lot more than the other groups, but earned a very small net income. This was because their costs were so high. Costs accounted for 93 cents in every dollar of sales, compared with 68 cents for group A. The average group B operation would be vulnerable to small increases in costs (e.g., in fuel) or small decreases in catch.

Group C operations were apparently in an unenviable position. Overall, they were running at a substantial loss because their total costs were 68% higher than their gross earnings. Even their cash surplus was negative. The income equations show that it was impossible for the average group C operator to even cover his costs.

Table 11: Mean returns to entrepreneurship per owner for Pegasus Bay rig fishermen during the 1982–83 season*

Group	Capital investment per operation ($)		10% return to capital ($)		Returns per owner ($) Net income		Returns per owner ($) Return to entrepreneurship	
	Book value	Replacement value	Current	Long term	Current	Long term	Current	Long term
A	41,000	130,000	1,120	4,060	3,450	1,240	2,860	- 660 (4,040)
B	23,000	53,000	2,280	5,290	1,500	- 1,550	- 270	- 5,310 (4,040)
C	3,000	18,000	260	1,820	-1,280	- 4,800	- 1,610	-6,910 (810)

* Figures in parentheses show the "reasonable returns" calculated for each group.

Table 12: Percentage of owners in each sample which are breaking even, attaining a positive return to entrepreneurship, and attaining a "reasonable" return to entrepreneurship

Group	Book value (% owners)			Replacement value (% owners)		
	Breaking even	Positive return	Reasonable return	Breaking even	Positive return	Reasonable return
A	100	100	17	50	17	17
B	57	43	33	43	29	29
C	33	33	0	0	0	0
Total	67	61	22	39	17	17

Only group C fishermen who treated fishing as a business enterprise were included in the financial analyses. However, it is difficult to believe that the average operation could have been losing so much money if these operations were genuinely run as businesses. Therefore, the accuracy of this data must be questionable. It is possible that some income was not declared, e.g., cash wharf sales. This may also be true of groups A and B, but because they caught more fish, small amounts of undeclared cash from wharf sales are less likely to bias the results. Another explanation is that costs were being overestimated. Some group C vessels were probably also used for recreational fishing, and the allocation between commercial and recreational activities may have been wrong. Group A and B vessels were not used for recreational fishing. Although each operation used in the analysis was said to be run as a financial enterprise, it is also possible that some were not really treated as such. Some fishermen may have regarded their operation as a retirement activity, for instance, and not made strictly business decisions. These factors make it difficult to draw conclusions about the finances of group C.

There were several differences between the efficiencies with which group A and B fishermen caught their fish. The average group A operator caught only half as much fish as the average group B operator and expended more effort, yet still managed to earn about five times more net income.

Information from fishermen suggests that 3 fishing days per trip for relevant group A vessels is a more realistic effort measure. This means that the mean fishing effort per vessel was substantially higher for group A vessels than group B vessels. Revenue per unit of effort was lower for group A operations, which is consistent with their lower catch rates. However, total costs per unit of effort were also much lower, which resulted in a significantly higher net income per unit of effort.

Although group A operations were the most profitable, they did not obtain a minimum reasonable return to entrepreneurship. To provide returns equivalent to those which (it is assumed) the average group A owner could have earned through alternative use of his capital and entrepreneurship resources, the average group A operator would have needed to increase his net income by about 35%. The average group B owner did not attain any return to his entrepreneurship after allowances were made for a return to capital. Net income would need to be nearly three times higher to provide a reasonable return to the average group B operator. Because the total costs for group C operations were substantially higher than total revenue, the average group C owner was unable to make his operation viable. The best that he could have done was to minimise his losses by not fishing (assuming costs and earnings data are accurate).

Therefore, it appears that the average owner in all three groups earned much less from having his resources invested in a fishing operation than he would have been capable of earning from another financial venture. Although some individuals in groups A and B did earn reasonable minimum returns to their capital and entrepreneurship, most earned substantially less. It is very unlikely that most operations earned sufficient net income during the season to even provide the owners with a satisfactory wage. The average group B net income of $1,500 was very little for 3 months' work, and even the average group A net income ($3,500) was less than the average New Zealand wage for the same 3 months. These returns were very poor. Most owners earned less net income than their crew members (crew are paid 10–15% of the total sales). If owners could earn an average of 12% of the total sales as crew on another vessel, group A and B owners would have earned $2,500 and $3,300 wages respectively, without any capital tied up in the fishery. Group A owners were marginally better off in the short term because they owned their vessel, but group B owners would have been much better off as crew.

Because most vessel owners did not attain reasonable returns to their capital and entrepreneurship, the fishery was not economically viable in the long term at those catch rates. Long term cost accounting showed that the average group B and C owner did not even cover costs. Although the average group A owner did cover costs, earnings were only about one-fifth of the estimated minimum reasonable return to capital and entrepreneurship.

The above analyses describe the fishery in 1982–83. The 1982–83 season was not considered unusual because it followed the general catch rate trend. However, the 1982–83 landings greatly exceeded the sustainable yield (landings from the east coast South Island were about four times the estimated sustainable yield (Francis 1986)). Therefore, the economics of the fishery would deteriorate even further unless catches were reduced to the sustainable yield and some vessels were removed from the fishery. It would be necessary for the stock to increase in size before an increase in catch rates could restore financial viability to the fishery.

Recent management

Since this project was completed, two important management decisions which affect the fishery have been implemented.

The first was the elimination of "part-time" fishermen (fishermen earning less than $10,000 from fish sales per year) in mid 1984. This removed nearly all group C fishermen, but had little effect on the rig catch because group C fishermen caught only a small percentage of the fish.

The second was the introduction of individual transferable quotas (ITQs). The vessel owners who still had fishing permits in 1986, and who had a documented history of catches between 1983 and 1985, were allocated ITQs of rig and by-catch species. The present sustainable yield for the east coast South Island stock was estimated to be 380 t in 1985 and 320 t in 1986 (Francis 1985, 1986). The total allowable catch for the 1986–87 fishing year was set at 330 t, a 74% reduction in catch from the 1983–84 July-June year (1285 t) and a 71% reduction in catch from the 1984–85 year (1133 t). These large reductions left most fishermen with very low minimum guaranteed rig quotas. Many fishermen decided to tender their quota back to the government and leave the fishery. Some may also have sold quota privately. By February 1987 only five set net permit holders held a reasonable rig quota. Thirty-one other set net permit holders held quotas for less than 1 t of rig, and many of these were primarily trawl or rock lobster fishermen who held another method permit.

Thus, the fishery has undergone massive changes since this study was done. Recovery from about 10 years of heavy fishing pressure on the population is expected to be slow, and it is unlikely that the Pegasus Bay rig fishery will develop into a significant fishery again for many years.

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