THE COMMERCIAL FISHERY FOR SNAPPER *Chrysophrys auratus* (Teleostei: Sparidae) IN NEW SOUTH WALES.

Summary

The snapper, *Chrysophrys auratus* (Bloch and Schneider, 1801), is an economically valuable common property resource that occurs in large numbers in New South Wales waters. Allegations of a resource decline in this major target species of both commercial and recreational fishermen have led to conflict over fishing access and levels of exploitation. In order to investigate claims of a resource decline, the Fishing Industry Research and Development Council funded a three year research project by New South Wales Agriculture and Fisheries.

The mean annual New South Wales commercial snapper catch from 1949 to 1984 was 716 tonnes ranging from 484 tonnes (1956) to 980 tonnes (1975). Although the catch of snapper over this 35 year period showed an increasing trend (averaging 4.9 tonnes per year), there was a sharp decline in catch from 1982 to 1986. However, total snapper catch, fishing effort and catch per unit of effort for trap, setline and handline fishermen did not differ significantly over the two subsequent years (1986-87), nor did the size of snapper decline, although catches have remained at a low level.

Since large fluctuations in catch have been a part of the history of this fishery, the recent downturn may be a cyclic event related more to environmental factors than fishing pressure. Should the present low catches be a result of environmental factors then an improvement in catches may be expected in the near future.

However, the present low level of the annual catch, the limited prospect of discovering unexploited snapper grounds, the possibilities of real growth in fishing effort and further adverse environmental effects oblige managers to maintain careful watch over the New South Wales snapper fishery. Even a small further decline in future catches from the present low level would be critical for this fishery. Some critical managerial decisions may be required in the near future.

It is recommended that:

1). no further growth in the number of commercial snapper fishermen be permitted until catches improve.

2). ways of reducing fishing effort be devised for implementation in the event of a further reduction in snapper catch.

3). a more accurate technique for the determination of fishing effort be devised and implemented.

4). careful monitoring of the snapper fishery be continued.

Introduction

The Sparidae is a diverse and widespread family of marine teleost fish. More than 100 species of this family are distributed throughout the world's temperate and sub-tropical waters (Migdalski and Fichter, 1977), with their centre of distribution adjacent to South Africa (Rowland, 1977). The genus *Chrysophrys* (Fowler, 1933) comprises two species of Sparidae found between the latitudes of approximately 20° and 40° in continental shelf waters of the Indo-Pacific region. The taxonomic relationships of species of the genus *Chrysophrys* have been the subject of debate, with three southern and a single northern species being proposed (Whitley, 1931; Fowler, 1933; Yasuda and Mizuguchi, 1969). Southern fish are generally referred to as snapper while those from the north are called red sea bream. MacDonald (1980) concluded from biochemical and morphological evidence that the genus *Chrysophrys* consists of only two species, the northern hemisphere red sea bream, *C. major*, and a single snapper species, *C. auratus*, distributed throughout the Australasian region.

The snapper, *Chrysophrys auratus* (Bloch and Schneider, 1801) occurs in the waters of all Australian states, Lord Howe and Norfolk Islands and New Zealand. Snapper are a highly esteemed and widely distributed fish species of commercial and recreational value. Juvenile snapper are abundant in the estuaries, ocean rocks and inshore reefs but they appear to migrate seaward as they mature. Adult snapper are found from the coast to depths of approximately 200m, usually over reef or rocky bottom. Snapper occur in large numbers in New South Wales waters where they have become a major target species of commercial and recreational fishermen.

Commercial snapper fishing probably began well before European settlement of Australia. Snapper bones are a common feature of aboriginal

middens so it is probable that coastal tribes exchanged snapper for other food items. Large scale commercial exploitation of snapper probably began with the arrival of the Europeans. These settlers possessed commercial fishing gear (seine nets, hook and lines (Bradley, 1792)) and snapper were reported to be in great abundance along the entire New South Wales coast (Cohen, 1892). The earliest reports on fishing in New South Wales predicate the commercial and recreational value of snapper (Oliver, 1871; Smith-Hill, 1874). Commercial snapper fishing was well established by the 1880's and by the turn of the century New South Wales had an annual catch of about 100 tonnes. Snapper were to hold their position of importance into the twentieth century being regarded as "the premier sporting fish of New South Wales" (Ogilby, 1893), "the most important commercial species" (Stead, 1910) and "the choicest fish of our markets" (McCulloch, 1914).

In recent years the snapper fishery has constituted between 9-14% of the value of the declared commercial scale fish catch in New South Wales (Table 1), and between 3-7% of the commercial catch by weight (Table 2). The high value and relatively high abundance of this species, have resulted in snapper being the most valuable New South Wales commercial fish. The current value of the New South Wales snapper fishery at the point of first sale is about $6m annually. The retail value of snapper is considerably more with a restaurant table value of $30/kg.

Snapper is a popular New South Wales sport fishing species because of its fighting ability, eating quality and large maximum size. Surveys of recreational fishermen in New South Wales (Anon, 1981; Henry, 1984) have shown that large numbers of juvenile snapper are taken by anglers. Indeed, the quantity of snapper taken by anglers in Sydney metropolitan estuaries was greater than that taken by commercial fishermen. Similarily, the offshore recreational snapper

catch is thought to be large. As the number of anglers increase, this group may be expected to have a significant effect on the recruitment of fish to the commercial fishery.

Speculation concerning the abundance of fish is common to most commercial and recreational fisheries. Because snapper constitute a large and valuable common property resource, conflict over fishing access and levels of exploitation are inevitable. In recent years the number of disputes concerning these issues has increased along with renewed claims of a resource decline. Complex regulations governing fishing activities, fishing areas and gear types have been developed over a long period. These regulations were intended to prevent overexploitation of the fish stocks, but they usually had the important secondary objective of making appropriate adjustments between conflicting claims of different groups of fishermen. However, a perceived recent decline in snapper numbers in conjunction with increased recreational and commercial fishing effort has resulted in increased disputation frequently of a bitter nature.

Fisheries scientists and managers require estimates of catch to assess the claims made by fishermen and to recommend appropriate management strategies. The allegation of a decline in the snapper resource was addressed by New South Wales Agriculture and Fisheries by initiating a three year, Fishing Industry Research and Development Council (FIRDC) funded, research programme. This study examined the available fishing effort, catch, catch per unit of effort (CPUE) and fish size data to determine whether suggestions of a recent resource decline were correct.

The biology and fisheries of snapper have been comprehensively studied in New Zealand where this species forms the basis of an extensive commercial fishery. Cassie (1956a, 1956b, 1956c) studied the early development, spawning and

age and growth of snapper in the Hauraki Gulf. The reproductive cycle of snapper, fecundity and egg dispersal was investigated by Crossland (1977a and b, 1980a and b). General information on the commercial snapper fishing industry in New Zealand is summarised by Paul (1976, 1977). Australian snapper research has been less intense despite snapper being one of this countries most valuable species. The fisheries and biology of snapper has been studied in Western Australia by Bowen (1961) and Moran (1985, 1988, 1989), in South Australia by Jones (1980, 1984, 1987), and in Victoria by Sanders (1974, 1979) and Winstanley (1983). This report is the first study of the commercial snapper fishery in New South Wales and will be followed by reports on the biology of snapper in this State.

Materials and Methods

New South Wales commercial snapper catch and effort data were drawn from three sources;

1). The mandatory fishermen's returns to the Department of Agriculture and Fisheries,

2). The Sydney Fish Marketing Authority(SFMA) and the New South Wales Fishermen's Co-operative market data, and

3). The collection of catch and effort data from vessels at the main port of landing.

All New South Wales commercial fishermen are required to submit information on their fishing activities to the Department of Agriculture and Fisheries. These returns include information on area of operation, fish catch

(kg), species composition, fishing method and crew size. The information so collected is complied, summerised and published annually. These reports provided information on the annual and seasonal snapper catch, and catch by area for the period 1949-84.

The marketing of seafood in New South Wales is controlled by the Sydney Fish Marketing Authority (SFMA), a statutory corporation operating under the Fisheries and Oyster Farms Act (1935). Commercial fishermen are required to sell their catch through a registered fishermen's co-operative or fish market. Information on snapper catches may be obtained by examining the records of individual co-ops or the SFMA. This information includes trends in annual and seasonal snapper catch and catch by area. Information was obtained from 1972 to 1989. However, as some New South Wales fishermen, (on the recommendation of the Authority), are permitted to sell their catch to the general public, co-op and SFMA data can not be used to estimate total catch.

Coffs Harbour is the major New South Wales snapper producing port, it is located at the centre of snapper fishing activities and commercial catches are readily sampled as these fishermen have a common point of landing. Thus, commercial fishermen berthing their vessels at Coffs Harbour were interviewed and their snapper catches examined on 7 days/month for two years (1986 and 87). Fishermen were asked to provide information on their snapper catch (dressed weight $\pm$ 1kg and length $\pm$ 1mm), units of fishing effort (vessel days, traps, hooks or fishing hours), their area of work (depth) and sea conditions (current speed and direction). All fisherman arriving at the wharf during the survey period were so interviewed.

The mean monthly snapper catch, fishing effort and CPUE were plotted for the two year sampling period. A two-way, orthogonal analysis of variance

was used to partition variation in catch, effort and CPUE between years (1986 and 1987), and seasons (Summer, Autumn, Winter and Spring). The Kolmogorov-Smirnoff two-sample test was used to examine the size of fish taken in consecutive years.

Results

The mean annual New South Wales commercial snapper catch from 1949 to 1984 was 716 tonnes ranging from 484 tonnes (1956) to 980 tonnes (1975)(Figure 1). Fluctuations of the order of 200 tonnes frequently occurred within a few years. Periods of declining catches (1950-56) and (1961-69) were followed within a few years by a recovery phase. Each recovery phase culminated in a greater annual catch than had previously been recorded. Although the regression of catch on year over this 35 year period (+4.94 tonnes) indicates an increasing trend, there appears to have been a sharp decline in recent years (1982 to 1986).

Annual catch data from the Department of Agriculture and Fisheries and the SFMA were correlated (r=0.8285). SFMA data supported the trend observed in departmental data of a sharp reduction in the snapper catch from 1982 to 1987 (Figure 1). SFMA data also indicates that the decline in catch ceased in 1987 and remained stable (but at a low level) during 1988 and 1989. Annual snapper catch data from the main snapper producing ports support an apparent decline in catch since 1982 (Figure 2).

The number of commercial fishing licences issued in New South Wales was less than 1000 prior to 1900 (Figure 3). This then rose to about 3,000 by 1914, and has remained steady (apart from temporary increases in the mid 1940's and early 1980's) to the present time. The average annual number

of commercial fishermen in New South Wales from 1914 to 1989 was 3,129.

The bulk of the commercial snapper catch is landed through 30 main fishing ports along the New South Wales coast (Figure 4) The largest snapper catches are made in northern waters with catches decreasing toward southern New South Wales. Coffs Harbour, Wooli, Forster, Crowdy Head and Laurieton are the most productive snapper fishing ports (Table 3).

Point of landing data covered 646 vessel days and the measurement of approximately 20 tonnes of fish. This sample represented 13.32% of the total snapper catch landed at Coffs Harbour during the survey period. There was considerable variation in the efficiency of the different forms of snapper fishing gear and of the size of fish taken. For this reason the different fishing techniques were treated separately. Of the 646 vessel days sampled, 436 (67%) represented trapping, 134 (22%) setlining and 76 (11%) handlining. Trap fishermen had an average catch of 38 kg of snapper per vessel per day compared to 21 kg and 10 kg for setline and handline fishermen, respectively.

The size of snapper taken by Coffs Harbour fishermen was significantly larger in 1987 than 1986, (K-S test, $D_{max} = 0.034$, $p<0.05$; Figure 5). The mean size of snapper taken by setline fishermen (414 mm, LCF) was larger than that taken by trap fishermen (297 mm) or handline fishermen (300 mm).

Although large fluctuations in the catch and CPUE of trap fishermen occurred throughout the survey period (Figure 6), fishing effort was less variable. The mean monthly snapper catch ranged from a low of 15 kg/day (January, 87) to a high of 77 kg/day (November, 86). Trap fishermen lifted an average of 15.08 traps per vessel day over the survey period (Figure 6). Effort ranged from 13 traps/vessel/day (December, 87) to 19.33 traps/vessel/day (July, 87) (Figure 6).

The catch rate for trap fishermen ranged from 0.90 kg/trap to 5.94 kg/trap with an average over the survey period of 2.75 kg/trap (Figure 6).

There were no significant differences in snapper trap catch, effort or CPUE between years (Table 4) or in catch or effort among seasons. A significant difference was found for trap CPUE among seasons (Table 4). CPUE was larger in winter, 1986, than in autumn and summer, 1987 (Student-Newman-Keuls tests). The mean size of snapper taken by trap in 1987 (299 mm, LCF) was greater than in 1986 (295 mm, LCF) (K-S test, $D_{max} = 0.034$, $p<0.05$; Figure 7).

Setline catch and CPUE data show large fluctuations throughout the survey period, but fishing effort was less variable (Figure 8). The mean monthly setline catch ranged from a low of 3.2 kg/day (July, 86) to a high of 52.6 kg/day (September, 86). Setline fishermen set an average of 357 hooks per vessel per day over the survey period. Effort ranged from 138 hooks/vessel day (July, 86) to 540 hooks/vessel day (July, 87). The catch rate for setline fishermen ranged from 1.4 to 13.2 kg/100 hooks with an average over the survey period of 5.5 kg/100 hooks (Figure 8).

Generally, there were no significant differences in setline snapper catch, effort or CPUE between years or seasons (Table 5). However, a significant difference was found in the setline catch between seasons and in the interaction of year and season (Table 5). Catch in spring, 1986 and winter, 1987 were greater than autumn, 1986. Catches in other seasons were similar. The snapper taken by setline in 1986 (mean size = 445 mm, LCF) were considerably larger than in 1987 (mean size = 385 mm, LCF) (K-S test, $D_{max} = 0.272$, $p<0.05$; Figure 9).

Very little information was obtained from handline fishermen. Only 76 vessel days were sampled in the two year period so few analyses were possible.

The mean monthly handline snapper catch, effort and CPUE were highly variable with no obvious overall trends (Figure 10). Catches ranged from 3.0 kg/vessel/day (October, 1986) to 22.8 kg/vessel/day (September, 1987). The mean fishing effort was 11.3 fisherman hours with most vessels having two crew members. However, some vessels had crews of up to 8, which resulted in peak estimates of fishing effort as high as 60 fishermen hours/vessel/day (March, 1987). For handline fishermen, snapper catch per effort ranged from 0.1 kg/fisherman hour (March, 1987) to 2.9 kg/fisherman hour (September, 1987) with an average over the survey period of 1.4 kg/fishermen hour (Figure 10). Statistical analysis of these data was not possible due to the small and variable sample sizes.

The size of snapper taken by handline fishermen was similar for both 1986 and 1987 (K-S test, $D_{max} = 0.0592$, $p<0.05$) (Figure 11).

Although snapper catch, fishing effort and CPUE for trap, setline and handline fishermen varied by month and season, there were no statistical differences in these parameters over the term of the study (1986-87). It therefore cannot be concluded that snapper catch, fishing effort and CPUE in the Coffs Harbour commercial snapper fishery changed during the period January, 1986 to December, 1987.

Figure 12 examines the effect of current speed, depth and fishing effort on snapper catch rate (CPUE). CPUE tended to show a direct relationship with current speed and an inverse relationship with the number of traps set. However, CPUE did not appear to vary with depth (Figure 12).

Discussion

Although governmental snapper catch data have been collected since the 1880's, all but the most recent data were of minor interest. Catch data from the 1880's to the turn of the century only covered that part sold through the Wooloomooloo market and therefore was not representative of total statewide catch. From the turn of the century to the 1940's, trends in the catch data are confounded with socio-economic upheavals in the Australian society; changes in fishing techniques, technological improvements to vessels and gear, and advances in marketing and product development. Thus, fluctuations in catches are impossible to quantify as they were accompanied by changes in (unrecorded) fishing effort. Further complications in the interpretation of snapper catch data are due to the mutli-gear and multi-species nature of the fishery. Consequently, many of the fluctuations in the recorded commercial snapper landings during the 20th century may be attributed to socio-economic factors within the industry itself.

Only the catch data from 1949 to 1984 were considered sufficiently consistent to be comparable. However, there is some concern over the accuracy of these data because many self employed fishermen are reluctant to disclose their annual earnings for government scrutiny. Thus, the recorded landings could considerably underestimate the true catch. This possible bias was assumed to be constant each year with the 1940-84 data being used to describe catch trends. Departmental data from 1984 to the present are not available due to a reorganisation of the methods of collation and analysis, but, Sydney Fish Market data may accurately portray recent trends in annual catches.

Large fluctuations in annual, seasonal and monthly snapper catches were observed in Departmental, Sydney Fish Market, Fishermen's Co-op, and point of

landing data. This type of catch variability has also been observed in the New Zealand (Paul, 1977), Western Australian (Bowen, 1961), South Australian (Jones, 1984) and Victorian (Winstanley, pers. comm.) snapper fisheries. It appears to be a normal characteristic of snapper populations and has previously been observed in the New South Wales fishery (1950-56 and 1961-69). In each case the catches recovered and rose to record levels of production. However, in recent years the size and duration of the reduction is of concern to the fishing industry. Snapper stocks appear to have fallen at a greater rate and to a lower level than ever before. Commercial and recreational fishermen attest to the unusually low levels of production.

The apparent reduction in snapper abundance may be due to either overexploitation and/or natural causes. Overexploitation has been the assumption of many fishermen who cite the expansion of prawn trawling, the growth in the number of anglers and/or a surge in commercial fishing effort due to an increase in the number of fishermen and gear efficiency. These factors may play a role in the reduction of catches. However, it is unlikely that overexploitation of a long lived, mutliple year class fishery based on a fecund, highly mobile, oceanic and widely distributed species would be so dramatic, or that this decline would level out as has occurred in 1987-89. Changes in abundance of this sort are more likely due to the failure of several annual recruitments.

The study of the dynamics of the abundance and reproduction of fish from the New South Wales coast is in its initial stages. Consequently, even for the main commercial species there is no definite information on variations in stocks or on the factors influencing them. Paul (1976, 1977), analysed the fishery and biological statistics of *C. auratus* over several decades. He concluded that strong annual recruitments of this species originated from warm spawning seasons.

Similar trends in the dynamics of abundance of a number of fish from the continental slope of New Zealand have been reported by soviet scientists (Shuntov et al, 1980).

A relationship between air temperature and commercial landings was not evident for New South Wales coastal waters but may be true for water temperature. Unfortunately, no water temperature information is available prior to 1987. A strong upwelling has been reported on the New South Wales coast during spring, but this phenomenon was not observed during this study. While the possible relationship between warm springs and strong year classes requires more investigation, variable features of the environment other than temperature must also be investigated. It is unlikely that spawning season temperature alone influences year class strength. Temperatures during the first few months after spawning may also be critical. Much of the snappers success must be its ability to exploit a wide range of habitats and take a wide variety of food organisms. The factors influencing year class strength will probably be related to some aspect of spawning and subsequent larval and early juvenile development. There is a lack of information on optimal conditions for gonad maturation, spawning behaviour, egg survival, hatching and larval development and the subsequent survival of larvae and early juveniles.

The snapper resource has always been considered to be particularly resilient because of the high fecundity and wide distribution of the species. High levels of productivity are expected to be sustained in the long term even though unfavourable environmental factors may have exerted an influence on short term yields. The recent poor catches probably reflect a normal fluctuation in abundance and thus should recover. It is relevant that the decline in catches during the 1950's and 1960's were followed by a recovery in landings to higher levels than had been previously achieved. Commercial snapper catches from

other parts of Australasia have exhibited this annual variability and have recovered from low levels of productivity. If this decline in abundance is due to natural factors, then recovery should occur. However, the New South Wales commercial snapper catch appears to be at its lowest level for the last 40 years and has not as yet exhibited any sign of recovery.

As some estimate of fishing effort is essential to understand and manage the exploitation of a fish stock, it was hoped that this information would be acquired during this study. However, New South Wales commercial fishermen are not required to indicate fishing effort expended on a particular species. Their estimates of days fished each month (required on their monthly statistical returns) may apply to the use of several different fishing techniques and to the capture of many different species. Therefore, it has never been possible to estimate effort or catch per effort directed solely on snapper. This is a serious failure of the data collection techniques, exacerbated by the claim of some snapper fishermen that they have greatly increased their fishing effort in terms of the quantity and efficiency of gear set, the hours worked each month, their vessel size, engine horsepower and the improvement in fish finding and position fixing technology.

Some of the increase in commercial fishing effort is probably due to a recent fisheries regulation allowing the transfer of licences from small estuarine net boats to 7m coastal vessels for the exploitation of snapper stocks. However, no information on the magnitude or effect of this management regulation is available. There have also been frequent claims of an increase in the number of recreational fishermen exploiting coastal waters in recent years. These claims usually attribute this increased angler fishing effort to increased affluence and mobility, shorter working hours and increased leisure time of the general community. An increase in recreational fishing effort per capita can be

anticipated, irrespective of demographic forcasts, since the socio-economic trend is toward shorter working hours and increased leisure. Commercial fishermen claim that all the above changes have led to a more efficient industry and increased pressure on fish stocks. In the longer term they are probably correct.

However, the point of landing data obtained in this study failed to detect an increase (or decrease) in commercial fishing effort, catch or CPUE. There is some evidence (Figure 1) that the real changes in the New South Wales snapper catch (and possibly fishing effort) occurred from 1982 to 1986 and that the fishery has been relatively stable since that time. Also there is some evidence (Figures 6,8 and 10) that the great variability in snapper catches and fishing effort hinder the detection of short term changes in these factors. For this reason a longer study is necessary to determine trends in the New South Wales commercial snapper fishery. The small annual changes in fishing effort may become significant when examined over many years. Thus, this information will be of great value in future years. Despite the failure of this study to detect significant changes in catch, effort or CPUE, the possibility of undetected increases in fishing effort exists. It is recommended that the Division of Fisheries strongly resists further increases in commercial fishing effort in view of the low production levels and the limited prospect of immediate increase in snapper abundance.

Size of fish has been used as an indicator of the fishing mortality applied to a fishery. Since fishing reduces survival rate and so changes the age structure of a stock, the intensity of fishing should be estimable from observed changes in age (Gulland, 1978). A steady decline in mean size of fish may be indicative of a reduction in age and therefore of overfishing. However, as the mean size of snapper taken by commercial fishermen in 1987 was larger than in 1986, overfishing does not appear to be occurring.

The size of snapper taken by each fishing group differed both in mean size of fish and in size changes over time. Snapper size increased, decreased, and remained constant for trap, setline and handling fishermen, respectively. Since trap fishermen caught the bulk of the catch, their size change influenced the result for the total fishery. The different fishing techniques were probably responsible for the different size of fish taken. The major part of the trap catch consists of smaller fish which had recently entered the commercial fishery. Fish traps tend to target a narrower size range than do setline and handline fishing gear. Information from trap caught fish may be biased due to this selection. Setline and handline catches may be more indicative of the variations in size of the population, and thus, may more accurately portray the effect of fishing.

The size range of snapper taken by setline fishermen declined significantly from 1986 to 1987. This fishing technique was considered to be less size selective than other methods and therefore more likely to be indicative of the level of commercial fishing intensity. The reduction in size of fish was a source of concern and may indicate a problem in the fishery. But, size variations over successive years may have a number of contributing factors. Commercial samples will always to some extent be biased samples of the whole. The landings are only representative of the stock on the grounds being fished. The size of fish may vary from ground to ground, it being claimed that the smaller fish are most abundant on the shallower grounds and the bigger fish in deeper water. The restriction of setline fishermen to deeper water (outside state waters) may have led to the disparity in size of fish taken by each group. The variation in size of setline fish from year to year may have resulted from fish movements between grounds. Differences in year class strength, recruitment and natural mortality also contribute to size variability. A continuous reduction in fish size over a much longer period (to negate the above factors) is required before claims of overfishing are sustainable. Indeed, either a much longer study or a repetition of

this work is needed to better understand these changes in the New South Wales snapper fishery.

As fishing vessels berthing at Coffs Harbour were surveyed, the frequency of encounter would indicate the relative pressure applied to the resource by each fishing group. These data show that fish trapping was the principal snapper catching technique accounting for more than two thirds of the fishing activity. This is understandible as trap vessels were generally larger, more powerful and thus able to work in more adverse conditions and further from home. Another reason for the prevalence of trap vessels was the disparity in CPUE. Trap vessels had a CPUE of 38 kg/vessel/day compared to 21 kg and 10 kg from setline and handline vessels, respectively. Whether this disparity in CPUE was converted into greater profit lay with the efficiency of these vessels and the costs involved. Trap fishing appeared to be more expensive than the other methods due to higher running costs associated with larger vessels, traps, bait and lost gear. The relative profitability of each technique probably has as much to do with the operator as it has the technique. There are many instances where the physical inputs (horsepower, fleet capacity) are less important than those relating to the skill utilised by the fishermen in making managerial decisions (Rothschild, 1978).

Commercial fishing effort, particularly of trap vessels, has been a source of discontent within the snapper fishing industry in recent years. Allegations concerning the number of traps, their efficiency, ghostfishing and environmental effects are common issues with fisheries researchers and managers. The data obtained in this study, and in a survey done by the West Australian Department of Fisheries (Moran and Jenke, 1989) should dispel a number of arguments. Commercial trap fishermen in New South Wales did not set excessive numbers of traps with the average number lifted each day being 15.

It was common for fishermen to have two sets of traps so the average number of traps was about 30 per vessel. Traps are frequently lost or damaged and their replacement is seen by some people as evidence of an increase in effort rather than maintaining the status quo.

The trapping technique is not as efficient as has been claimed. A common assumption has been that a trap set on a school of fish will inevitably catch a high proportion of that school. While the average CPUE for traps was 2.7 kg/day, this CPUE was not uniform among traps. It was common to find a few traps with the bulk of the days catch and the majority of traps with no fish at all despite having being set where fish were showing on the echo sounder. Certain environmental conditions appear to be necessary for trapping to be successful. Water temperature, clarity, current speed and direction were claimed by fishermen to be the most important.

Traps that were not lifted for several days (usually due to bad weather) rarely had fish. Presumably once the bait had been eaten, the fish escaped. This indication of free movement into and out of traps was confirmed by the Department of Fisheries in Western Australia by attaching an waterwater video camera to traps. Their observation of snapper moving freely between traps confirm that traps do not catch everything in their vicinity and that ghostfishing was not an issue (Moran and Jenke, 1989). While lost traps are intuitively undesirable, they probably contribute to the reef on which they were set and provide more habitat for fish. Artifical reefs have long been accepted as fish attractors.

Conclusions

The catches and catch rates (CPUE) of snapper fishermen in New South Wales were found to be highly variable with large daily, monthly, seasonal and annual fluctuations being observed. The extremes of catch and CPUE over the two year survey period were often only a few months apart, thereby reflected the variable nature of the fishery. Fishermen and managers must accept the variability of animal populations and view large changes as a characteristic of this fishery. It is reasonable to expect annual changes in catch when it varies so dramatically by day and month.

Some evidence of a substantial decline in snapper catches over the period 1982 to 1986 has been obtained from Departmental and SFMA data. However, SFMA catch data, the analysis of catch, effort and CPUE and the size distribution of fish indicated that the fishery was in a relatively stable condition in 1986 and 1987, despite catches remaining at a low level.

However, caution must be exercised in the interpretation of these data because of the inadequacies of the data base. Data on commercial fishing effort applied to the snapper fishery was only available for the period covered by this survey. Thus, the allegation by the fishing industry that the true fishing effort has greatly increased due to technological improvements in fish finding, position fixing and gear efficiency remains an unsubstantiated possibility. Also, the effect on snapper abundance of prawn trawling and recreational fishing remains largely unrecorded. A more accurate estimate of trends in commercial snapper catches would be possible if the data collection techniques allowed the reporting of these factors. But, at this point, we can only conclude that the snapper catches, fishing effort and CPUE have stabilised. Since large fluctuations in catch have been a part of the history of this fishery, the recent downturn may

be a cyclic event related more to environmental factors than fishing pressure. Should the present low catches be a result of environmental factors then an improvement in catches may be expected in the near future.

However, the present low level of the annual catch, the limited prospect of discovering unexploited snapper grounds, the possibility of real growth in fishing effort and further adverse environmental effects oblige managers to maintain careful watch over the New South Wales snapper fishery. Even a small further decline in future catches from the present low level would be critical for this fishery. Some critical managerial decisions may be required in the near future.

It is recommended that no further growth in snapper fishing effort be permitted until catches improve and that ways of reducing fishing effort be formulated for consideration in the event of a further reduction in snapper catch. A limited-entry fishing regime for snapper, a limit on the amount of gear to be used and catch quotas for both commercial and recreational fishermen are regulations that have been proposed by industry itself. In recent years, commercial snapper fisheries in Australia and New Zealand have been subjected to a range of management regulations to reduce fishing effort. There is an acceptance by the New South Wales fishing industry that there is a danger of overfishing the snapper resource. It is generally agreed that should catches continue to decline some limits will have to be imposed either by government regulation or by the industry itself.

It is recommended that a more accurate technique for estimating fishing effort applied to the commercial snapper fishery be established. An estimate of fishing effort is essential to understand and manage the exploitation of a fish stock. Present methods do not allow for the determination of fishing effort and

this has been a serious deficiency in the management of this fishery. Steps are being taken to remedy this problem. A more detailed fishermen's data return sheet has been introduced. Also, improved data collation and analysis procedures are being introduced and the database staff at the Fisheries Research Institute have been increased. The monitoring of the reliability of these governmental data by a second "market based" technique is also being introduced.

It is recommended that careful monitoring of the snapper fishery be continued. This may be accomplished by monitoring the present governmental and SFMA data until a more reliable data base is established. As many of the problems associated with the intrepretation of these data were due to the short term of the survey, it is recommended that this work be repeated.

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FIGURE 1 ANNUAL COMMERCIAL SNAPPER CATCH FROM NSW

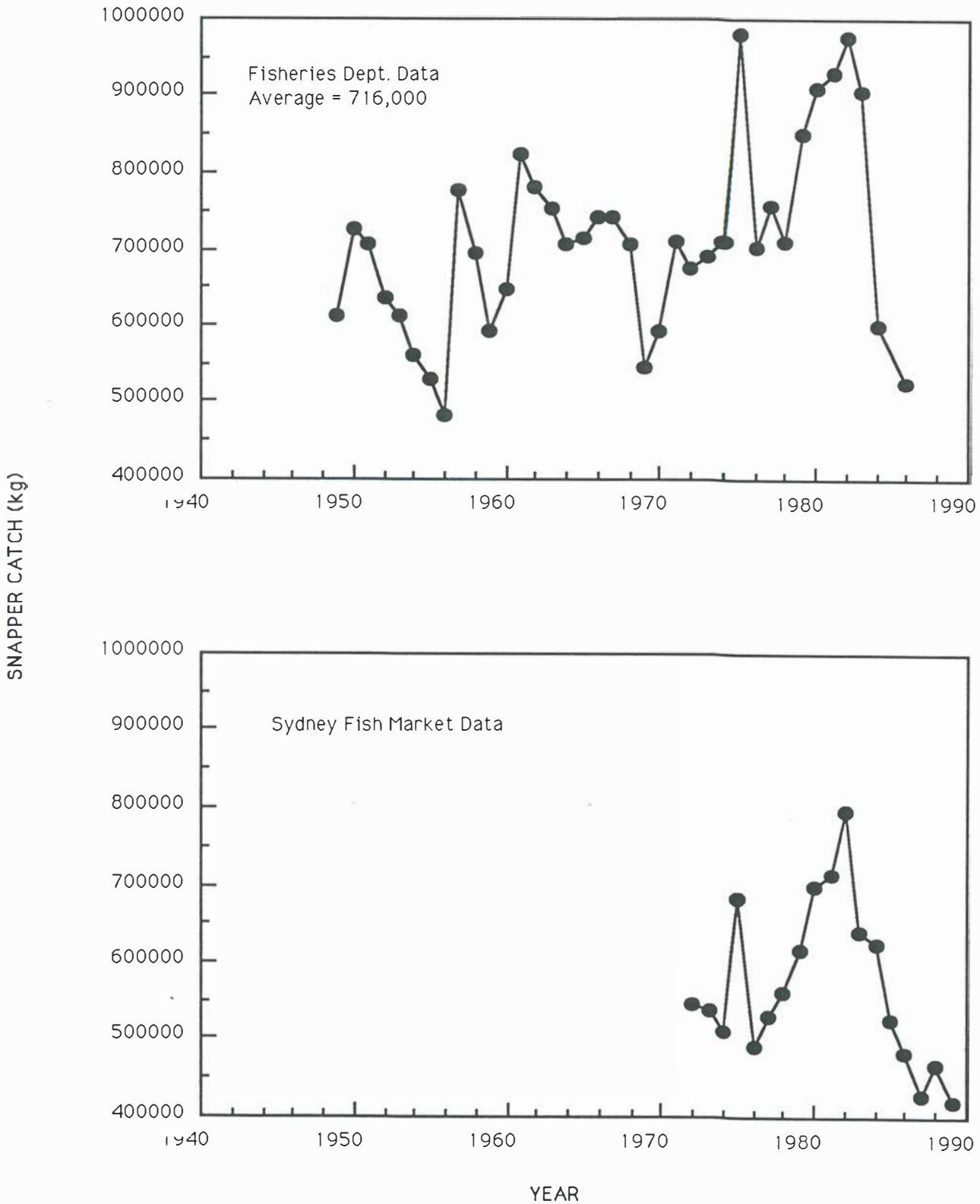


FIGURE 2 COMMERCIAL SNAPPER CATCH FROM THE MAIN SNAPPER PRODUCING FISHERMEN'S CO-OPS

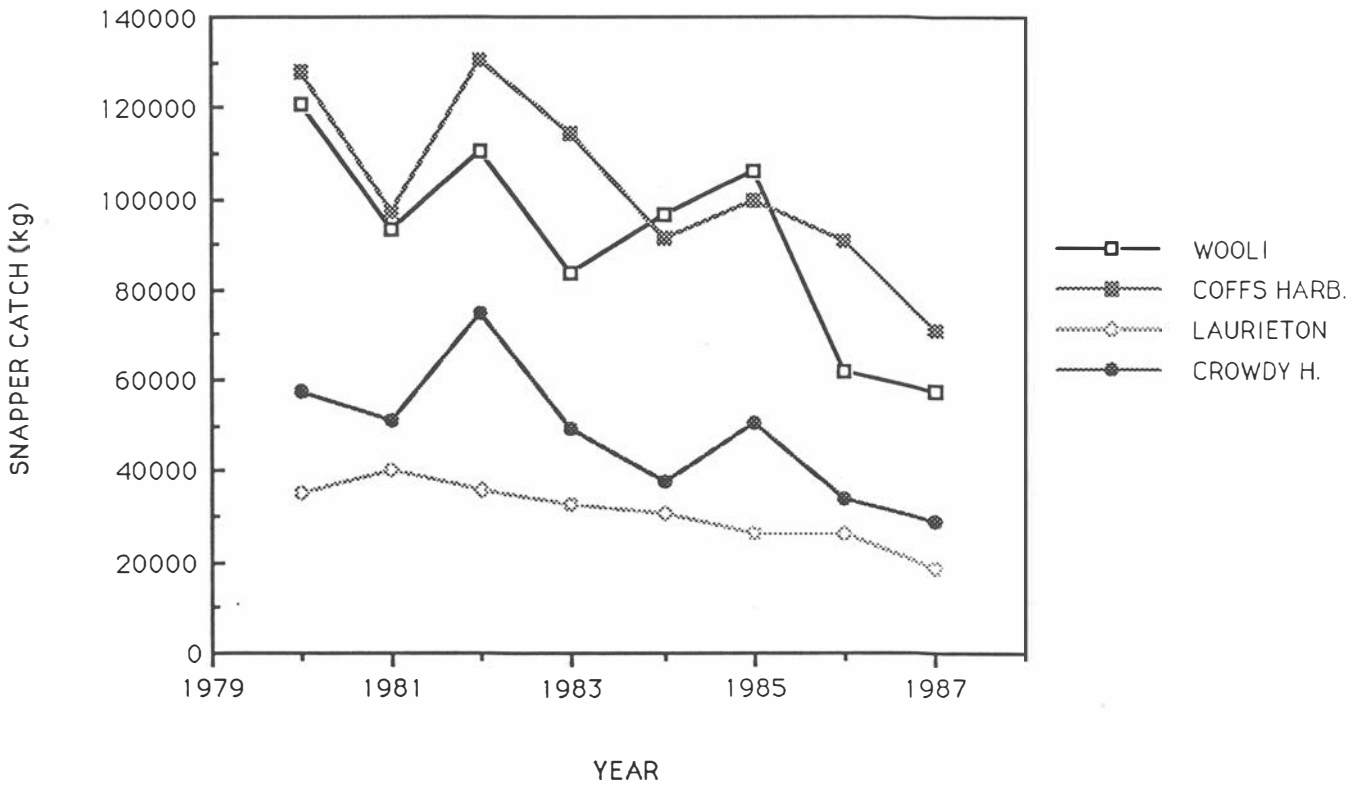


FIGURE 3 ANNUAL NUMBER OF COMMERCIAL FISHERMEN IN NSW

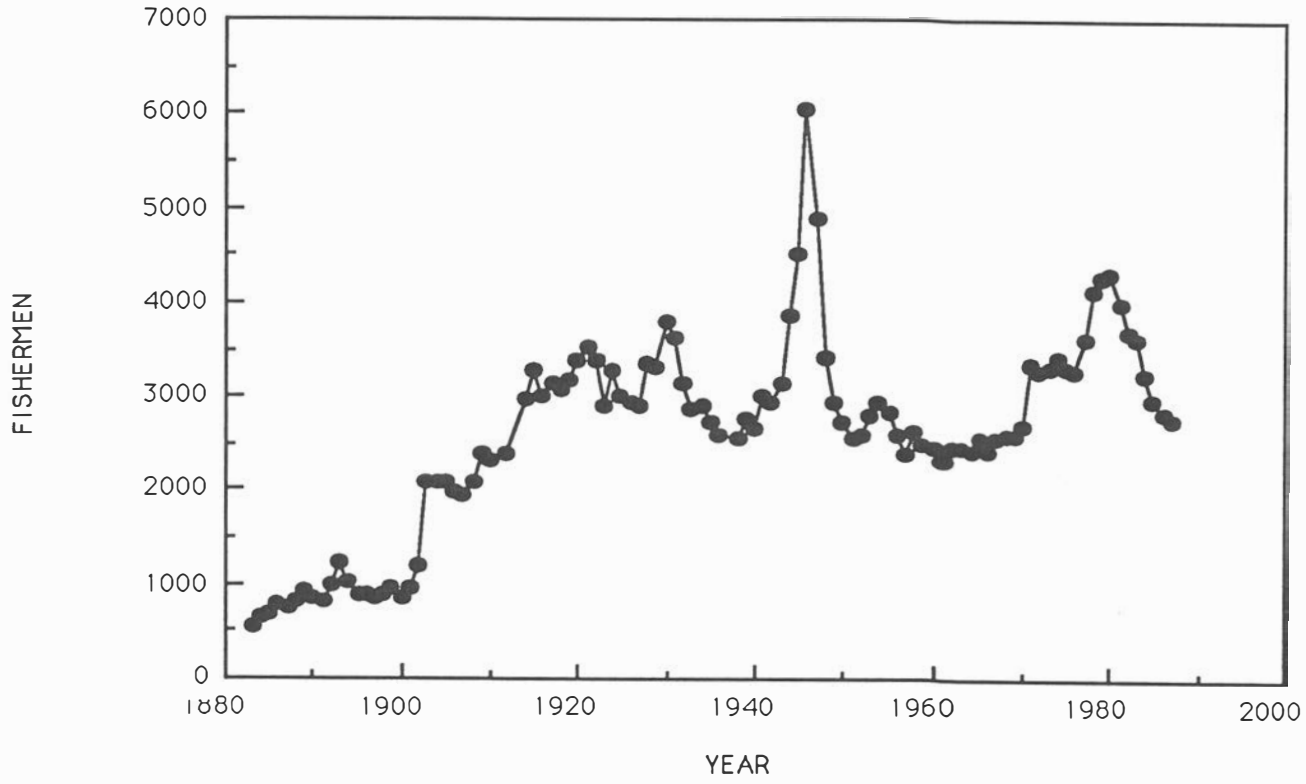


FIGURE 4 NEW SOUTH WALES COMMERCIAL SNAPPER CATCH FROM THE 30 MOST PRODUCTIVE PORTS

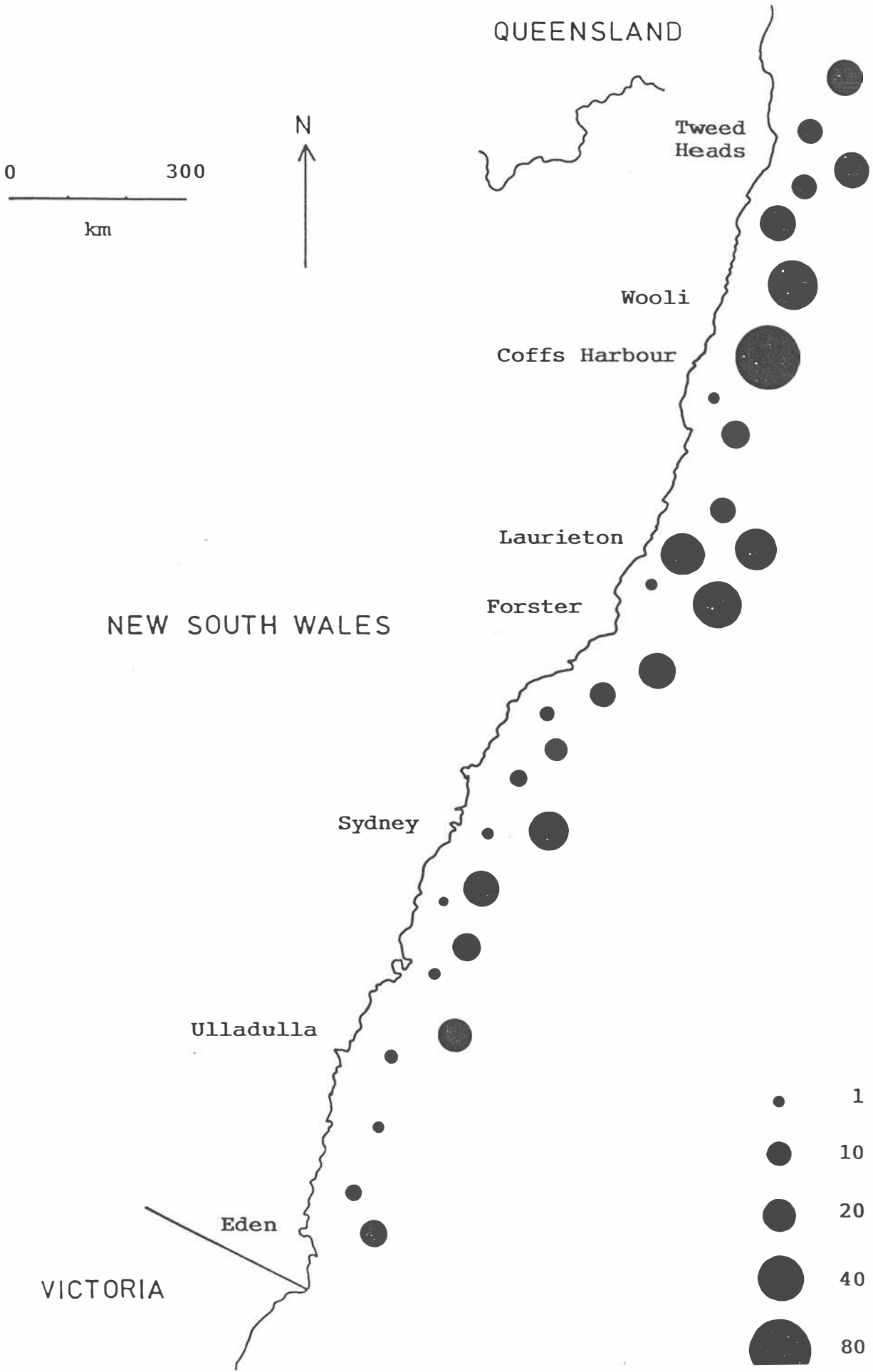


FIGURE 5 SIZE OF SNAPPER TAKEN BY COMMERCIAL FISHERMEN
(Coffs Harbour, 1986 and 1987)

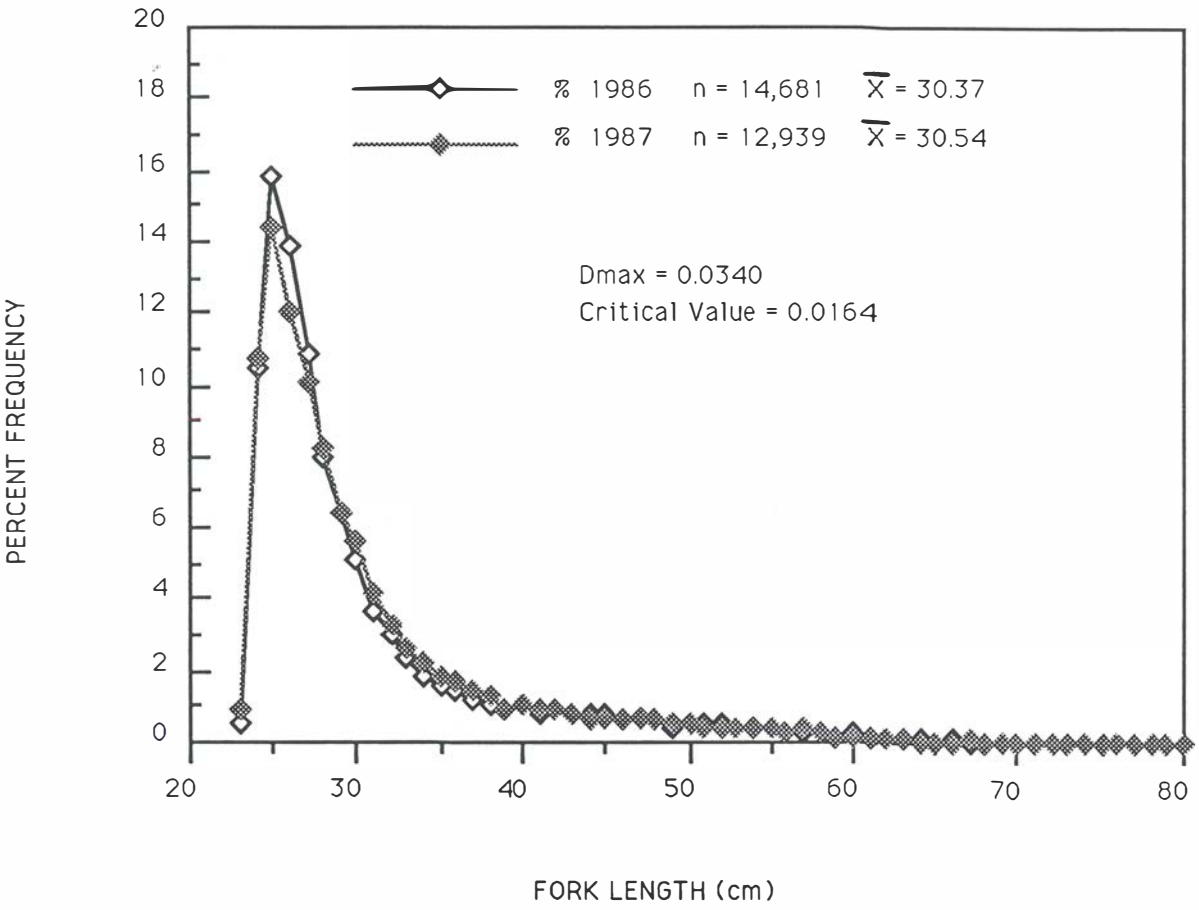


FIGURE 6 MEAN MONTHLY SNAPPER CATCH, EFFORT AND CPE.
(Coffs Harbour Trap Vessels, ± 1 SE)

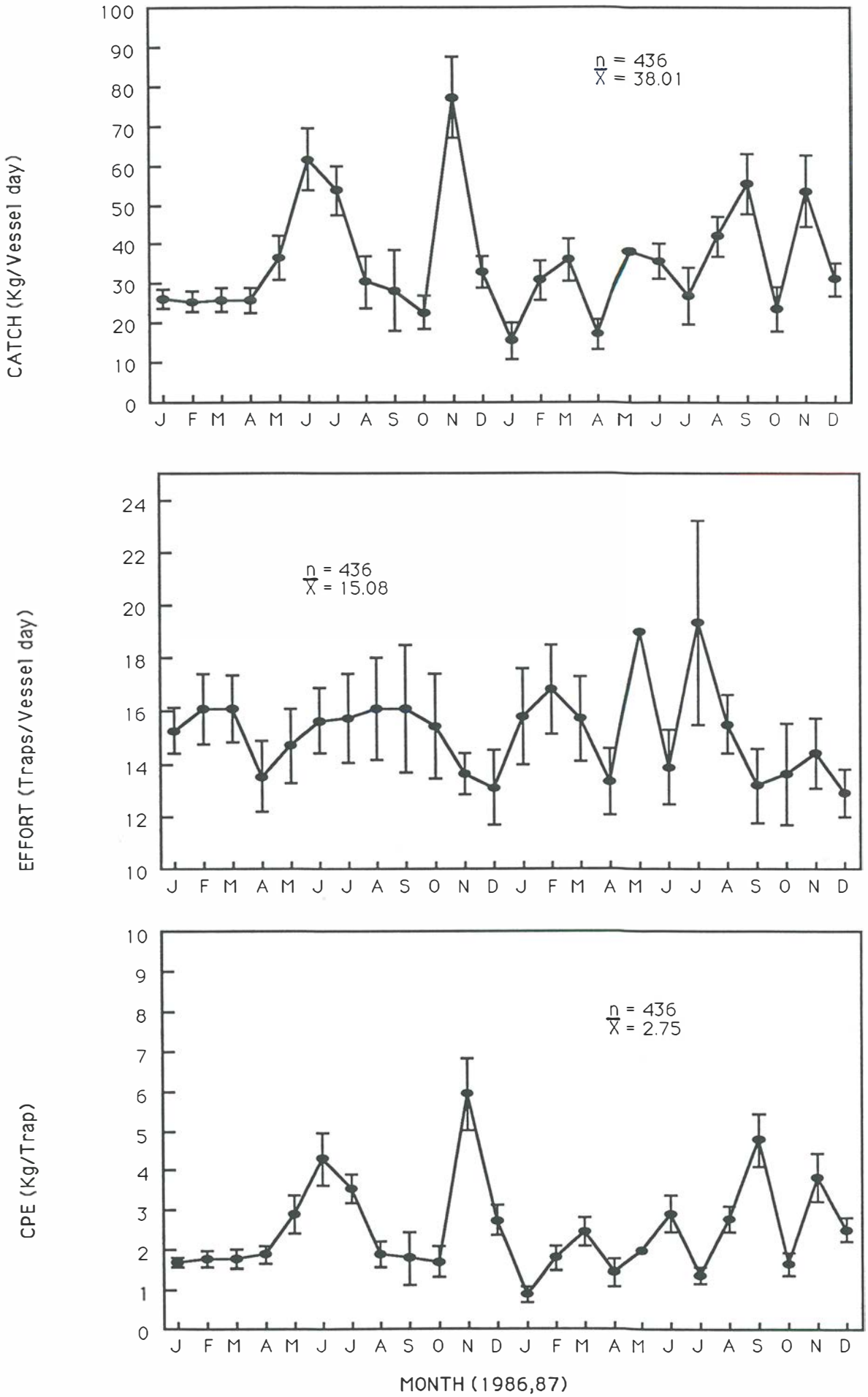


FIGURE 7 SIZE OF SNAPPER TAKEN BY COMMERCIAL TRAP FISHERMEN, 1986 AND 1987

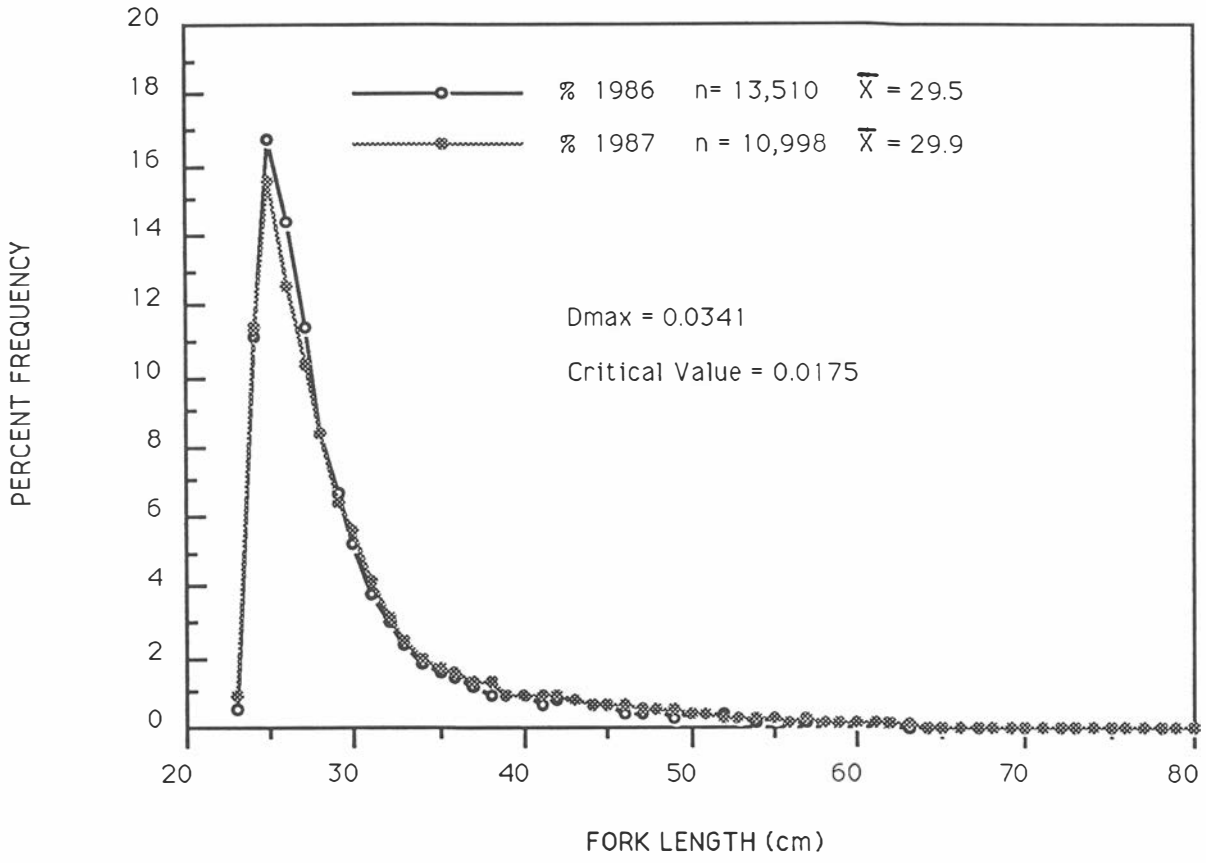


FIGURE 8 MEAN MONTHLY SNAPPER CATCH, EFFORT AND CPE
(Coffs Harbour Setline Vessels, ± SE)

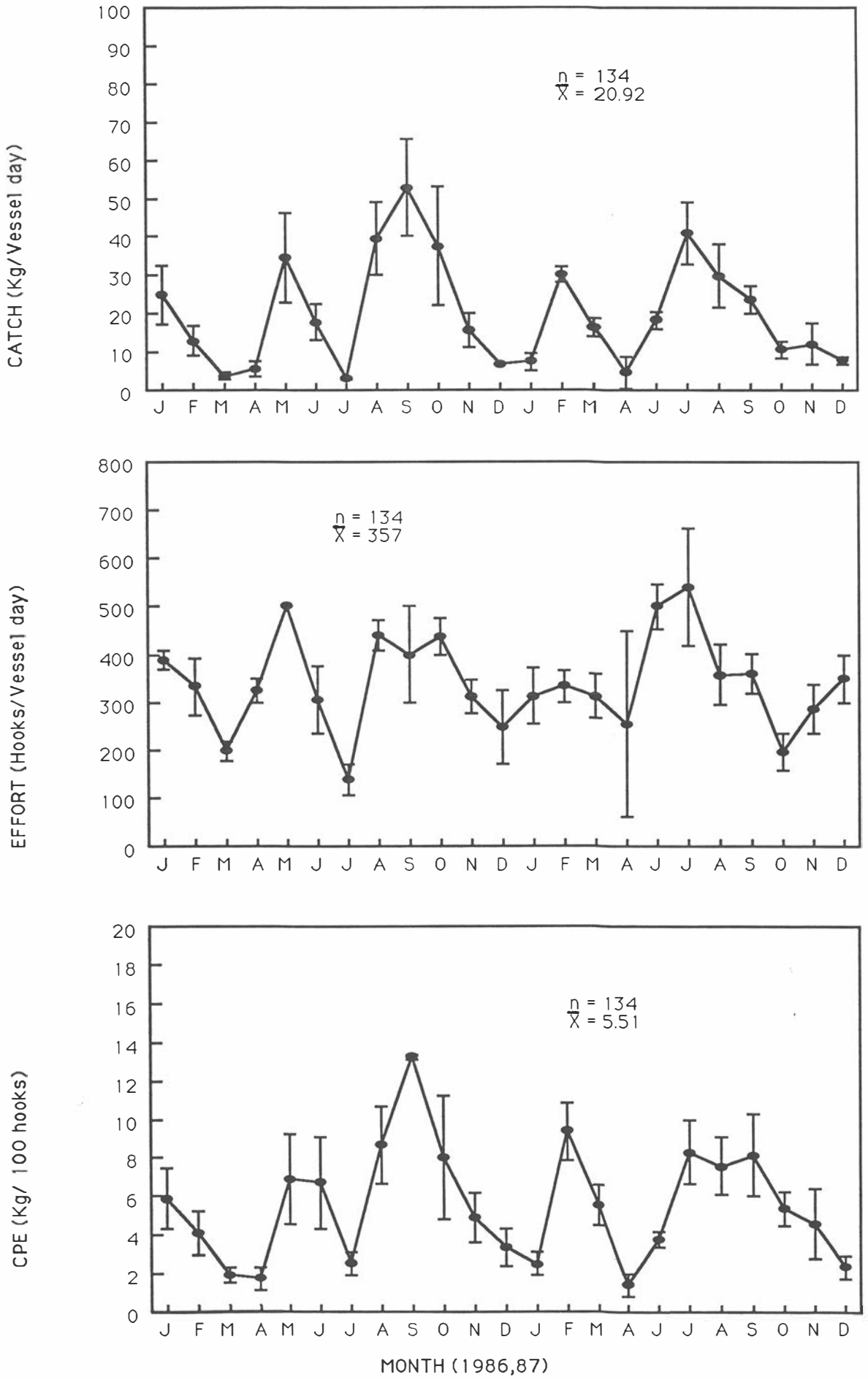


FIGURE 9 SIZE OF SNAPPER TAKEN BY COMMERCIAL SETLINE FISHERMEN, 1986 AND 1987

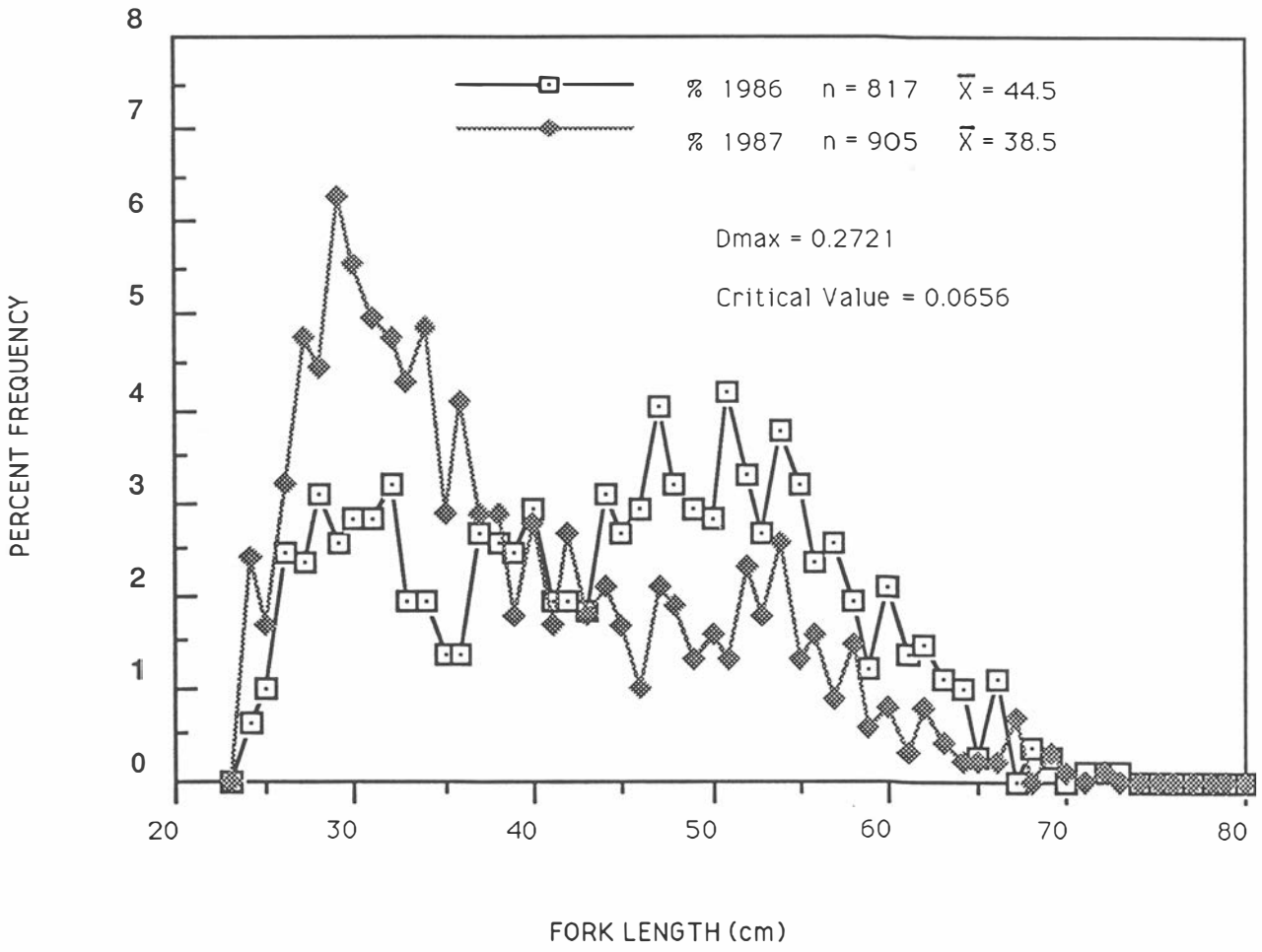


FIGURE 10 MEAN MONTHLY SNAPPER CATCH, EFFORT AND CPE
(Coffs Harbour Handline Vessels, ± SE)

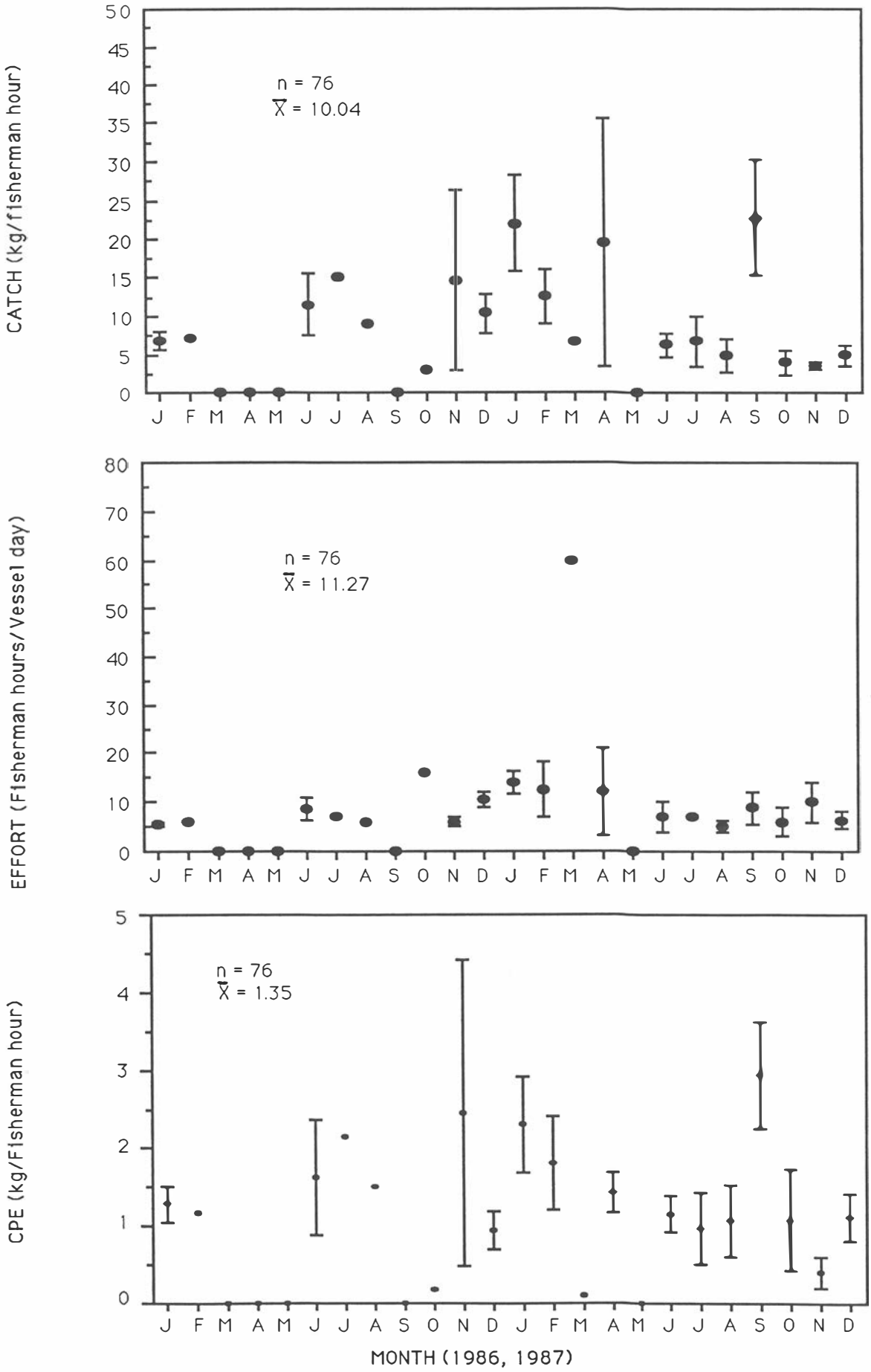


FIGURE 11 SIZE OF SNAPPER TAKEN BY COMMERCIAL HANDLINE FISHERMEN, 1986 AND 1987

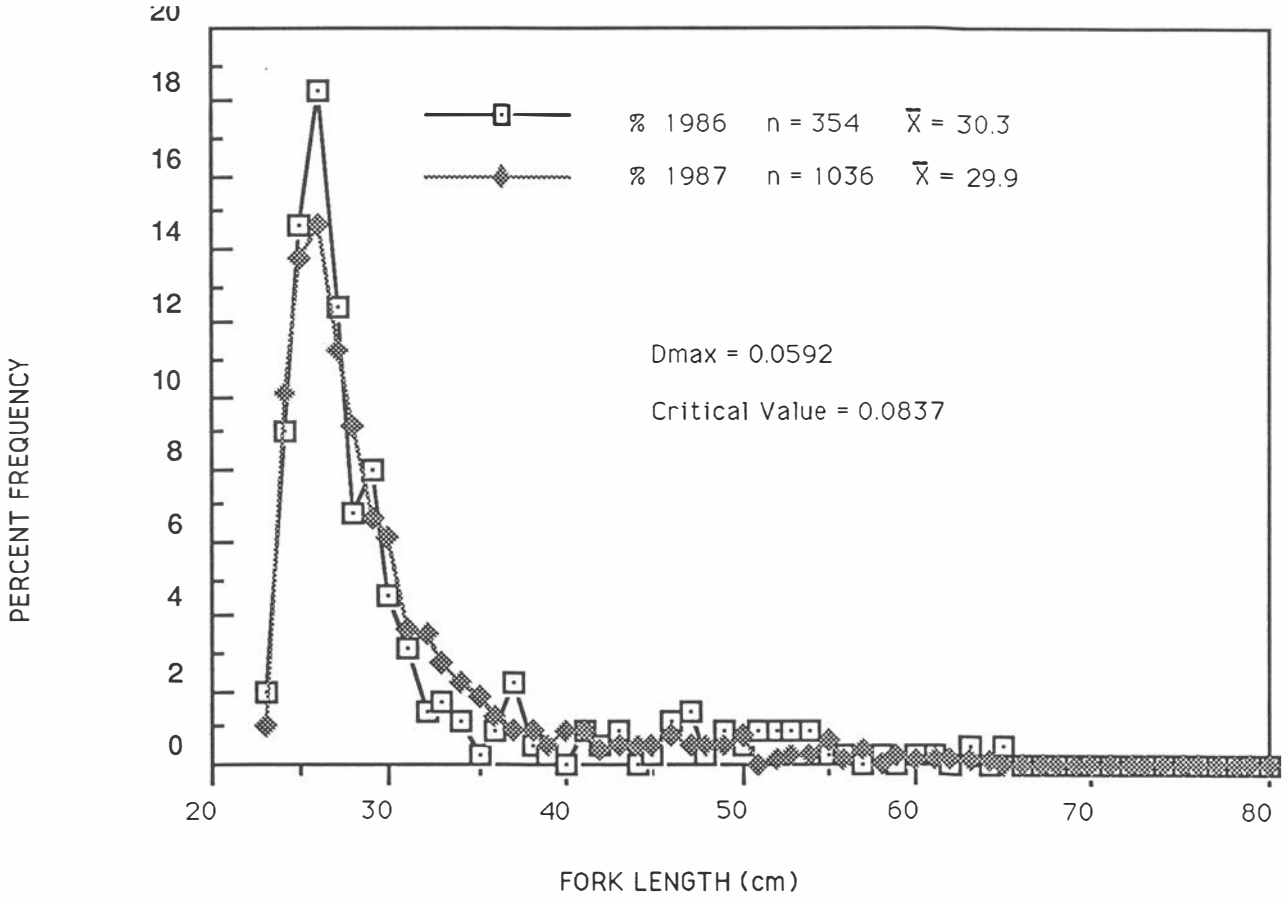
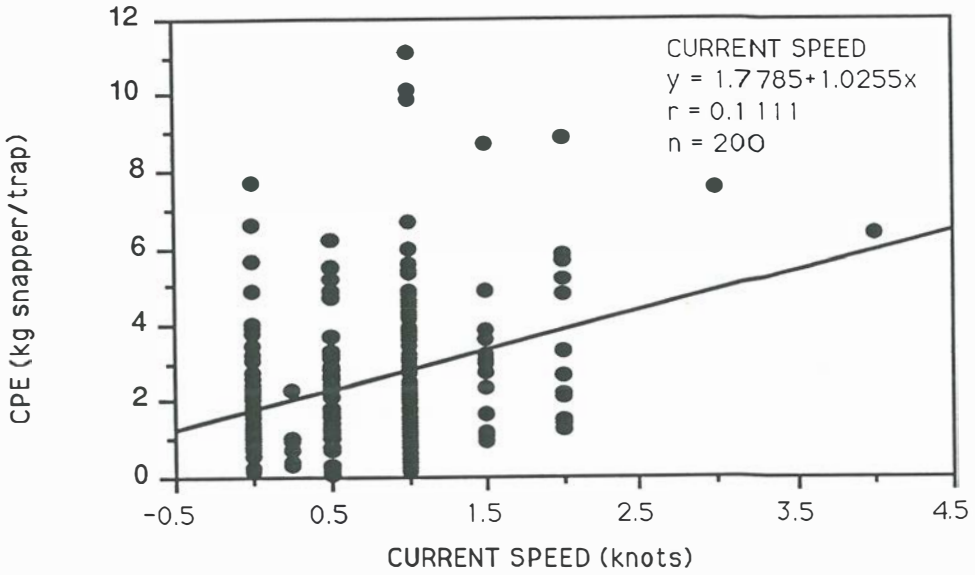
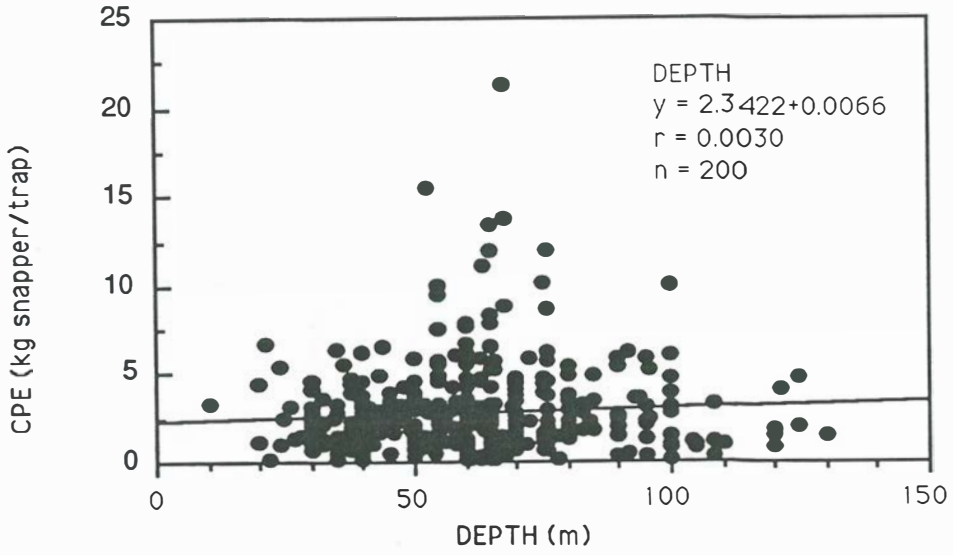


FIGURE 12 SNAPPER CATCH RATE (CPE) MEASURED AGAINST CURRENT SPEED, DEPTH AND FISHING EFFORT (Coffs Harbour, 1986-87)





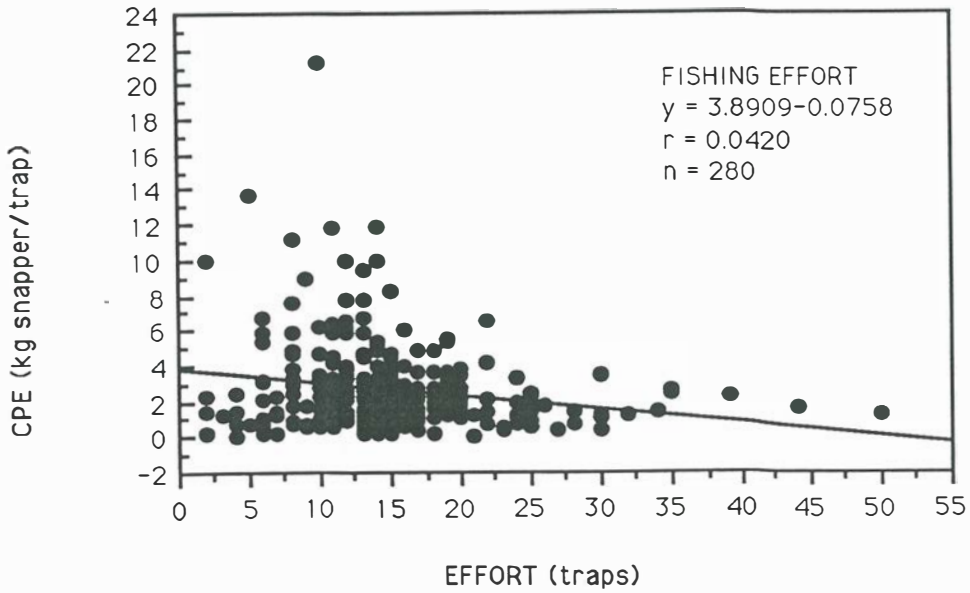


TABLE 1 VALUE OF THE NEW SOUTH WALES COMMERCIAL SNAPPER CATCH

Financial Year Ending 30th June	Total Value of all species ($m)	Snapper Value ($m)	Snapper Value per Kg ($)	Percent of Total	Rank of Importance
1972	6.777	0.621	0.92	9	2
1973	8.615	0.821	1.19	10	2
1974	8.104	1.077	1.52	13	1
1975	11.518	1.499	1.53	13	1
1976	12.187	1.505	2.15	12	1
1977	13.737	1.869	2.47	14	1
1978	15.484	1.922	2.70	12	1
1979	17.802	2.429	2.86	14	1
1980	23.118	3.025	3.32	13	1
1981	26.540	3.408	3.67	13	1
1982	28.570	3.833	3.92	13	1
1983	34.712	4.162	4.60	12	1
1984	*	2.904	4.83		
1985	*	*	5.74		
1986	*	*	6.48		
1987	*	*	7.70		
1988	*	*	7.90		
1989	*	*	8.39		

* Data not available for these years

TABLE 2 ANNUAL COMMERCIAL SNAPPER CATCH IN NEW SOUTH WALES

Financial Year Ending 30th June	Total NSW Fish Catch (kg)	Snapper Catch (kg)	Snapper Percent of Total	Rank of Importance
1954	13,220,010	561,710	4	7
1955	10,761,320	630,264	5	5
1956	9,253,395	483,953	5	6
1957	12,010,887	778,420	7	5
1958	11,538,713	695,954	6	5
1959	12,288,320	590,826	5	6
1960	12,356,252	647,830	5	5
1961	12,524,593	821,763	7	4
1962	12,069,745	778,604	6	5
1963	14,154,144	752,786	5	5
1964	14,792,408	706,282	5	6
1965	14,993,475	714,280	5	6
1966	13,499,712	739,585	5	5
1967	12,319,057	739,444	6	5
1968	12,883,065	707,719	5	5
1969	14,266,495	545,833	4	6
1970	14,611,185	592,929	4	8
1971	13,442,013	710,773	5	5
1972	13,342,479	675,440	5	5
1973	17,319,390	689,653	4	7
1974	16,353,645	708,680	4	5
1975	17,955,588	979,759	5	6
1976	15,794,105	700,070	4	9
1977	16,570,358	756,712	5	6
1978	16,720,950	711,679	4	7
1979	18,978,662	849,474	4	7
1980	20,696,596	911,166	4	6
1981	23,486,746	928,742	4	7
1982	22,320,374	977,897	4	5
1983	24,972,505	904,810	4	9
1984	20,452,038	601,159	3	8

TABLE 3 PRODUCTION OF SNAPPER FROM THE MOST PROMINENT NSW PORTS

Port	Rank	Mean Annual Catch 1969-84 (kg)
Coffs Harbour	1	87,470
Wooli	2	57,517
Forster	3	47,860
Crowdy Head	4	41,076
Laurieton	5	37,733
Port Jackson	6	32,778
Tweed Heads	7	30,833
Ballina	8	29,951
Wollongong	9	28,983
Clarence River	10	27,423
Port Stephens	11	25,862
Ulladulla	12	25,011
Eden	13	16,191
Greenwell Point	14	14,863
Evans Head	15	14,182
Port Macquarie	16	13,353
Newcastle	17	13,231
Byron Bay	18	10,780
Tuggerah Lakes	19	10,501
Bermagui	20	4,702
Broken Bay	21	4,693
Batemans Bay	22	3,875
Swansea	23	2,566
Botany Bay	24	1,997
Manning River	25	1,781
Jervis Bay	26	1,688
Narooma	27	1,598
Illawarra	28	1,214

TABLE 4 ANOVA TABLES FOR COMMERCIAL TRAP FISHERMEN IN COFFS HARBOUR

ANALYSIS OF VARIANCE ON SIN(X) OF CATCH

Source	D of F	Sum of Squares	Mean Squares	F-Test	P Value	Signi.
Year (A)	1	0.208	0.208	0.429	0.513	ns
Season (B)	3	0.762	0.254	0.523	0.667	ns
AB	3	1.188	0.396	0.816	0.486	ns
Error	272	131.981	0.485			

ANALYSIS OF VARIANCE ON SQRT(X) OF EFFORT

Source	D of F	Sum of Squares	Mean Squares	F-Test	P Value	Signi.
Year (A)	1	0.240	0.240	0.329	0.567	ns
Season (B)	3	1.397	0.466	0.637	0.592	ns
AB	3	1.225	0.408	0.558	0.643	ns
Error	272	198.939	0.731			

ANALYSIS OF VARIANCE ON LN(X) OF CPE

Source	D of F	Sum of Squares	Mean Squares	F-Test	P Value	Signi.
Year (A)	1	2.323	2.323	3.193	0.075	ns
Season (B)	3	12.345	4.115	5.658	0.001	Sig
AB	3	0.936	0.312	0.429	0.732	ns
Error	272	197.831	0.727			

TABLE 5 ANOVA TABLES FOR COMMERCIAL SETLINE FISHERMEN IN COFFS HARBOUR

ANALYSIS OF VARIANCE ON LN(X) OF CATCH

Source	D of F	Sum of Squares	Mean Squares	F-Test	P Value	Signi.
Year (A)	1	0.366	0.366	0.427	0.515	ns
Season (B)	3	8.579	2.860	3.337	0.024	Sig
AB	3	8.569	2.856	3.333	0.024	Sig
Error	72	61.706	0.857			

ANALYSIS OF VARIANCE ON (X) OF EFFORT

Source	D of F	Sum of Squares	Mean Squares	F-Test	P Value	Signi.
Year (A)	1	1175.658	1175.658	0.055	0.816	ns
Season (B)	3	13831.093	46105.364	2.140	0.103	ns
AB	3	289625.913	96541.971	4.482	0.006	Sig
Error	72	1550988.333	21541.505			

ANALYSIS OF VARIANCE ON SQRT(X) OF CPE

Source	D of F	Sum of Squares	Mean Squares	F-Test	P Value	Signi.
Year (A)	1	0.871	0.871	1.213	0.274	ns
Season (B)	3	5.618	1.873	2.609	0.058	ns
AB	3	4.402	1.467	2.045	0.115	ns
Error	72	51.676	0.718			