FISHERY ASSESSMENT REPORT

TASMANIAN ABALONE FISHERY

1999

Compiled by Rick Officer and David Tarbath

May 2000

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This assessment of the Tasmanian abalone resource uses input from the abalone fishery assessment working group (AbFAWG).

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Abalone Fishery Assessment: 1999

Summary

The 1999 assessment of the Tasmanian fishery for blacklip abalone (*Haliotis rubra*) and greenlip abalone (*H. laevigata*) was derived primarily using commercial catch-effort statistics and size-composition data.

The assessment suggests that blacklip abalone stocks are generally healthy. Size distributions of catches show no sign of knife-edge fishing. Effort has shifted from the East Coast, partly onto lighter fished stocks in the west, but also into the heavily fished South East. Catch-rates in the east are below those of the previous year, but are stable in the South East and are rising in western Tasmania. The shift in catch away from northern areas and the west coast has been so marked that these areas could now be considered under-exploited when present catches are compared with those sustained in the past.

Assessment of greenlip abalone stocks has been affected by recent changes to the way in which the fishery is regulated. These changes include localised closures, daily catch-limits, regional TACs and increased size-limits. Increased size-limits reduce the number of abalone available to the fishery implying that catch-rates may be expected to fall. The response by divers to these management changes means that catch and catch-rates reflect a variety of factors apart from abalone abundance. It is therefore difficult to draw firm conclusions about greenlip abalone stocks. A recent study suggested that current measures are appropriate to ensure sustainability of the greenlip abalone fishery.

This is the last assessment of the Tasmanian abalone fishery in its current form. From 2000, the abalone fishery is to be managed with zonal TACs. The greenlip fishery is to be separated from the blacklip fishery. These changes provide an opportunity to limit the concentration of effort into vulnerable parts of the fishery, and make the fishery more robust. They will also change the way in which divers operate, and make comparisons with the past under different management conditions less meaningful.

Table of Contents

1. Introduction

1.1 Abalone Biology

1.1.1 Distribution and habitat

Abalone are marine archaeogastropods that inhabit rocky substrata sub-tidally and feed on macro-algae. Two species are fished commercially in Tasmania: the blacklip abalone, *Haliotis rubra* Leach, and the greenlip abalone, *Haliotis laevigata* Donovan. Blacklip abalone occur throughout southern Australia and are fished commercially in Tasmania, Victoria, South Australia, New South Wales and Western Australia (Harrison, 1983; Prince and Shepherd, 1992; Shepherd, 1973). Blacklip abalone live at depths ranging from 0 to at least 50 m, although abundances are highest at 0 to 15 m depth in most areas. Greenlip abalone occupy a more limited distribution and are only fished commercially in Tasmania, Victoria, South Australia and Western Australia. Within its distribution greenlip abalone are constrained to areas of strong tidal flow. The species occurs at depths ranging from 0 to 30 m.

1.1.2 Reproduction

The sexes are separate, and external fertilisation of gametes occurs by synchronous broadcast spawning of eggs and sperm into the water column. Whilst individual abalone can produce million of gametes each reproductive season (Shepherd *et al*., 1992), fertilisation success is influenced by the distance between spawning adults. Highest rates of fertilisation are achieved when male and female adults are within 2 metres of one another. Experimental studies have demonstrated that fertilisation success is less than 5 % at separations greater than 16 metres (S. Shepherd, pers. comm.).

Reproduction of blacklip abalone is reported to occur at different times of the year in different places, although in southern Tasmania spawning intensity is maximal in late winter and early spring, with minor spawning throughout much of the rest of the year (Nash *et al*., 1994). Spawning of greenlip abalone appears to be epidemic, occurring over a period of 2-3 days in late spring/early summer (Rodda *et al*., 1997). There is also evidence that greenlip abalone aggregate before and during spawning, possibly as an adaptive response to maximise fertilisation success (Shepherd, 1986).

Abalone eggs are lecithotrophic, so there is no feeding during the planktonic larval phase, although Manahan and Jaeckle (1997) have demonstrated significant absorption of dissolved organic nutrients through the integument. The larval phase is temperature-dependent but short (a few days) compared with that of species that have planktotrophic larvae (eg., oysters and fish), which have a planktonic larval duration of two weeks or more.

Abalone larvae settle preferentially on crustose coralline algae (McShane, 1996). Chemical cues for settlement include gamma-aminobutyric acid (GABA), a constituent of coralline algae (Morse *et al*., 1979), the mucous grazing trails of conspecific abalone (Seki and Kan-no, 1981) and the bacteria that grow on the surfaces of coralline algae.

1.1.3 Feeding

Small abalone feed on coralline algae until a few mm shell length, then feed for the rest of their lives on macroalgae. Preferred food species of *H. rubra* have been identified using gut analysis (Foale and Day, 1992) and laboratory trials (Fleming, 1995a; Fleming, 1995b). In southern Australia *H. rubra* primarily feeds on fleshy red macroalgae, although a variety of brown algal species are also eaten.

Abalone feed on either attached or drift algae. The relative importance of these two dietary components apparently depends on availability, which in turn depends on the degree of wave action and the species composition of algae growing where the abalone are living (Shepherd, 1973).

1.1.4 Growth and size

Growth rates have been estimated using both mark-recapture and direct ageing methods. Most mark-recapture studies have been of abalone larger than about 60 mm, and the data fitted by various methods to the von Bertalanffy growth function. When abalone smaller than ~60 mm have been tagged it has been shown that growth rate (in absolute terms, such as mm/yr) is maximal at a size greater than zero (Nash, 1995a), indicating that the age-length relationship is a sigmoid one. The use of the von Bertalanffy growth function is therefore not valid for fitting growth data when small sizes are included; these data may be fitted to the Gompertz growth function.

Worthington et al. (1995) have fitted New South Wales *H. rubra* mark-recapture data to several growth functions using the computer program GROTAG. Growth rates of small (10-60 mm) *H. rubra* have been measured by modal progression analysis (Nash, unpublished data).

Following the work of Prince et al. (1988b), who demonstrated the deposition of one shell layer per year, direct ageing of *H. rubra* has been an important part of the assessment of the Tasmanian abalone fishery (Nash, 1992; Nash *et al*., 1994). Nash (1994b) provided additional evidence of one growth ring per year in both adult and juvenile *H. rubra* in southern Tasmania. More recent work supports the assumption of annual growth rings in blacklip abalone from the northern part of the west coast, and at two sites on the east coast – one in the north and the other on Maria Island (Tarbath, 1999a).

Growth rates vary greatly between areas, although there is a trend towards faster growth and larger maximum size from north to south in Tasmanian waters (James, 1981; Nash, 1992; Nash *et al*., 1994; Tarbath, 1999a).

Maximum age of *H. rubra* is probably at least 20 years. This is difficult to estimate from mark-recapture data because blacklip abalone can live for several years with no growth; thus, age-at-95%-of-L_∞, as is sometimes used to estimate longevity, is therefore of little use. Direct ageing using shell growth rings suggests a maximum age of about 25 years (Nash, 1992; Nash *et al*., 1994)

1.1.5 Age and size at maturity

Size at maturity varies considerably around the State (Nash *et al*., 1994, unpublished data). Size at maturity tends to increase from north to south, although there is considerable variation at small spatial scales. There is some evidence that maturation is related primarily to age, not size (Nash, 1990).

1.1.6 Stock structure

Prince et al. (1987; 1988a) have postulated that *H. rubra* larvae may disperse no more than tens or hundreds of metres from the natal source, although the evidence is not conclusive (Sasaki and Shepherd, 1995). Even if the conclusions of Prince et al. are not generally correct, it is very likely that larval dispersal is no more than a few kilometres. Adult movement is at least as extensive as that postulated by Prince et al. for the planktonic larval phase (Nash, 1995a); movements of tagged blacklip abalone have been recorded over distances up to half a kilometre (Tarbath, 1999a).

Population genetic studies do not convincingly support the limited dispersal hypothesis, nor do they preclude it. Using enzyme electrophoresis, Brown (1991) found that measures of genetic distance between sites in southern Australia (including Tasmania) suggest an isolation-by-distance model, although significant genetic heterogeneity was found over small spatial scales (<3 km). Some of the four possible population/larval dispersal scenarios listed by Brown to explain this do not include limited larval dispersal. Population genetic studies of this sort are unable to discriminate between these scenarios (Brown, 1991).

Using mitochondrial DNA methods, Barrett (1989) found little genetic variation between sites extending from northern to southern Tasmania, and suggested that gene flow may be sufficient to maintain a homogeneous distribution of mitochondrial DNA genotypes throughout Tasmanian waters.

1.2 Fishery background

1.2.1 Commercial fishery

The Tasmanian abalone fishery has been reviewed by Harrison (1983) and Prince and Shepherd (1992). Abalone have been exploited commercially in Tasmania since the mid-1960s. Management measures introduced for the fishery (size limits, limited entry, total allowable catch, area restrictions, etc.) have been summarised by Nash (1994a; 1996).

A minimum size limit was first introduced in 1962. It has been changed several times to reflect the perceptions of the condition of the fishery and size at onset of sexual maturity. A state-wide increase from 127 to 132 mm occurred in 1987, followed in 1990 by a further increase to 140 mm in the west and south-west (between Wild Wave River and Whale Head). The most recent changes were an increase in size limit for greenlip abalone in 1999 from 132 to 140 mm in the North West and from 140 to 150 mm in all other greenlip-producing areas.

Entry to the fishery was limited in 1969 to the number of divers in the fishery in 1968 (120). A further five licences were created for the Furneaux group in 1972. The catch increased steadily since the commercial fishery began, peaking in 1984 before a total allowable catch (TAC) and individual transferable quotas (ITQs) were introduced in 1985. Each of the 120 mainland Tasmanian divers were allocated 28 units of quota, and the five Furneaux divers 20 units. Each unit was equivalent to 1.1 tonnes of abalone (live weight). The Furneaux divers were each granted an additional eight quota units in 1990, giving a total of 3,500 units in the entire Tasmanian abalone fishery.

Because of concerns held both by members of the fishing industry and the Fisheries Department, quota was reduced in the four years following the introduction of quotas until, in 1989, a quota unit was equivalent to 600 kg live weight of abalone (a reduction of 45 percent over four years). The TAC (for blacklip and greenlip abalone combined) remained at 2,100 tonnes from 1989 to 1996. Between 1997 and 1999, the TAC was set at 2520 tonnes.

A recurring feature of previous stock assessments has been high catch-rates of above-average size abalone on the West Coast. It was concluded that in this region, blacklip abalone abundance is relatively high and fishing pressure is low. The 1999 Stock Assessment Group decided that the West Coast could sustain a higher level of fishing. A regional TAC of 1400 tonnes was set for the western part of the Tasmanian coast between Port Sorell in the north and Whale Head in the south (subsequently known as the Western Zone). The TAC of the remaining part of the blacklip fishery (the Eastern Zone) was capped at 1190 tonnes. Catch from the greenlip abalone fishery was reduced to 140 tonnes. The Tasmanian TAC for the entire abalone fishery for 2000 is the sum of these regional TACs i.e. 2730 tonnes.

1998 saw the introduction of the Abalone Fishery Management Plan. Major changes included new requirements for:

- pre-fishing telephone reports from divers,
- post-fishing telephone reports of catch by divers and processors,
- processors to maintain daily balances of stocks on hand, received and dispatched,
- telephone reports from processors prior to dispatch of stock and on receipt of stock,
- greenlip abalone fishing, including regional monthly limits on catch, thus capping landings of greenlip whilst allowing catches throughout the year.

Following a review of the Management Plan in 1999, the blacklip abalone fishery was divided into eastern and western zones, and the greenlip fishery made a distinct entity. Each zone and the greenlip fishery were allocated a separate TAC. The total blacklip catch was increased, and the greenlip catch was reduced. Increased size-limits were adopted in the greenlip fishery. The zone allocation was reflected in each quota unit, with 400 kg, 340 kg and 40 kg being from the west, east and greenlip fisheries respectively.

1.2.2 Recreational fishery

Recreational divers who hold a fishing licence (recreational abalone) may harvest abalone. This licence is obtainable for a fee, and allows a daily catch limit of ten abalone of legal size. There are also possession limits of 20 abalone per person holding a recreational abalone licence and 5 abalone per person for those who do not hold recreational or commercial abalone licences.

Recreational fishing licences endorsed for abalone are issued on an annual basis for the period 1 November to 31 October. There is no limit on the number of recreational abalone divers. Surveys of recreational fishing have been undertaken by the Department of Primary Industry and Fisheries (Lyle, 2000).

1.3 Impact of the Fishery on the Marine Environment

Abalone are prised from rock surfaces individually by divers using a knife-like tool. There is a negligible deleterious effect of this fishing method on the habitat.

Because of the ecological interactions that occur between abalone and other organisms in their environment (competition and predation), it is almost certain that reductions in abalone abundance caused by fishing have a corresponding effect on the ecosystem which may alter the habitat in some way. It has not been established, however, that these changes are deleterious to the environment, or whether they fall outside the range of habitat variation that occurs in response to fluctuations in environmental factors not related to or caused by abalone fishing.

2. Management Objectives and Strategies

The Review of the Management Plan of the Tasmanian Abalone Fishery (Anonymous, 1999) specifies management objectives and strategies under several headings. These objectives are listed below. The strategies employed to achieve these objectives are also listed where they are relevant to the stock assessment.

2.1 Maintain Biomass and Recruitment

Objectives

- To maintain fish stocks at sustainable levels by constraining the catch and size of individual abalone taken by the commercial and non-commercial abalone sectors. In particular, to ensure that:

  a) abalone are harvested at sustainable levels, and,

  b) biomass and egg production do not decrease below the chosen proportion of pre-fishing egg production and that reasonable levels of egg production are maintained in all regions of the fishery.

- To allow abalone to grow to a size were they have had two breeding seasons through the use of appropriate size limits.

Strategies

- Limit the catch of the commercial sector and restrict catching potential of the non-commercial sector.

- To prohibit the taking of abalone at a size below which the fish have not had adequate opportunity to reproduce through the enforcement of minimum legal sizes, whilst ensuring that the minimum size limits reflect differences in both growth rates and harvesting rates around Tasmania.

2.2 Sustaining Yield and Economic Return

Objectives

- To take abalone at or above a size likely to result in the best use of the yield from the fishery.

- To protect abalone below the minimum legal size.

- To maintain economic returns by restricting the level of catch and the number of participants in the commercial fishery.

Strategies

- To prohibit the taking of abalone below the minimum legal size limits.

- Restricting the number of divers in the fishery and limiting their catches within the Total Allowable Catch.

2.3 Commercial Fishing Interactions

Objective

- To separate the activities of abalone divers from those of other commercial divers and the rock lobster fishery, and to limit the harvesting of seaweeds until there is a better understanding of the ecological implications of such a harvest.

2.4 Access to Fish Stocks by Non-Commercial Fishers

Objectives

- To provide reasonable access to abalone stocks for recreational fishers and Aboriginal people.
- To restrict the daily catch of recreational fishers such that it is not a cover for illegal fishing.

2.5 Marine Farming Interactions

Objective

- To enable both the farming of abalone and the harvesting of wild stocks to co-exist without posing a threat to the other.

2.6 Environmental Interactions

Objectives

- To maintain the marine ecosystems upon which Tasmania's abalone stocks depend and minimise the impact of other fisheries on the ecosystems.
- To maintain a robust abalone stock around Tasmania.

Strategies

- Set the TAC for the commercial abalone quota fishery at a conservative level, thereby minimising the impact of population declines on the ecosystems.
- Establish a series of Marine Resources Protected Areas so that representative Tasmanian marine ecosystems are reserved under a no-take policy.
- Set minimum legal size limits to reduce the potential for local depletion and disruption of community structure.

2.7 Enforcement

Objectives

- To prevent the combined take of abalone by licensed commercial and recreational divers, Aboriginal people and unauthorised persons from exceeding the sustainable productivity of the Tasmanian abalone stocks.
- To prevent recreational divers, Aboriginal people and unauthorised persons from selling abalone.
- To prevent unauthorised persons from taking and possessing abalone.
- To prevent any person from possessing commercial quantities of abalone without suitable documentation.

2.8 Cost Recovery and Return to the Community

Objectives

- To recover the Government's operating costs for the abalone fishery (commercial and recreational) from the participants through the fees agreed in the Abalone Deeds of Agreement, and licence fees from holders of abalone quota, commercial abalone divers and recreational licences.
- To recover a proportion of the resource rent generated by the commercial abalone fishery through the fees agreed in the Abalone Deeds of Agreement and licence fees from holders of abalone quota licences.

2.9 Quality Assurance

Objectives

- To maintain the high level of quality assurance for abalone.
- To promote best practice in the handling and processing of marine resources for human consumption.

2.10 Greenlip Abalone

The Review of the Management Plan also revises measures to manage the greenlip abalone fishery. These include

- Limiting the state-wide greenlip catch to 140 tonnes;
- Participation in the fishery is by quota management, 40 kg of which is attached to each quota unit of the Tasmanian abalone fishery.

- Increased size-limits to be adopted in each of the four greenlip regions; King Island: 155 mm, North West: 140 mm, North East: 150 mm, Furneaux Group: 150 mm.
- Block 35 in the Furneaux Group is to be open for a limited period each year starting 1 April, closing 1 October to protect spawning abalone.

3. Performance Indicators and Trigger Points

There are three performance indicators currently specified in the Review of the Management Plan of the Tasmanian Abalone Fishery: changes in catch-rate and catch, egg production and size composition (Anonymous, 1999).

Changes in catch and catch-rate may reflect changes in the abundance of abalone. Catch and catch-rate trigger points (specific changes in catch or catch-rates compared with particular reference years) were described in the Draft Tasmanian Abalone Fishery Policy Document (Anonymous, 1997). The regions used in relation to trigger points were the statistical blocks and regions currently used for the reporting of abalone fishing activity (Fig. 1).

It was noted in the previous Stock Assessment Report (Officer, 1999b) that in many parts of the State, 1997/98 catch and catch-rates were outside the levels specified by trigger points. The use of a single reference year did not make allowances for inter-annual variability, and differences were heightened when the reference year was unusually high or low.

It was subsequently proposed that the use of arbitrary levels of change be abandoned in favour careful consideration of all catches and catch-rates with respect to those from reference periods.

The first reference period adopted the average of 1992 to 1995. These years represent a period when fishing pressure was at a low level, and the fishery is assumed to have been in healthy state.

Because of increases in TAC, current catch levels are correspondingly higher than in the 1992-95 reference period, and comparisons may reflect little apart from the change in TAC. Current catch and catch-rates are therefore also compared with the average of a second reference period: 1979 to 1982. This period was prior to the introduction of a TAC, and catches unfettered by management restrictions, were amongst the highest in the history of the fishery.

Monitoring abalone stocks by assessing levels of egg production is the second performance indicator described by the management plan for the Tasmanian abalone fishery (Anonymous, 1999). Unfortunately, it has never been determined at what level egg production should be maintained, or how egg production is related to abundance. Intuitively, some level of egg production is required to maintain an abalone population. However, the develoment of eggs from within the gonad to recruitment of the mature animal to the fishery is an enormously complex process. Even at post-settlement stages, there is little evidence to relete abundance to future levels of recruitment to the fishery (McShane, 1996).

Nash (1992) has stressed the importance of reliable site-specific estimates of natural mortality in egg-per-recruit analyses, and discounts the value of such analyses where variations in natural mortality are not accounted for. The other parameters used in per-recruit analyses (growth, size at 50% maturity, size-fecundity relationship) vary widely, both spatially and with stock density (Breen, 1992; Nash, 1992; Tarbath, 1999b). Generally per-recruit analyses rely on assumptions of population equilibrium that are unlikely to be fully satisfied. Egg-per-recruit reference points are at best suggestions rather than indicators of future recruitment levels (Breen, 1992; McShane, 1995; Shepherd *et al*., 1991).

Gathering data about the size composition of commercial catches has resumed in 1998 after a break of several years. It is intended that change in the size composition reflect change in stock structure caused by fishing. At present, this data set is small, and much higher levels of sampling need to be undertaken before it can be used to reliably indicate performance of the fishery.

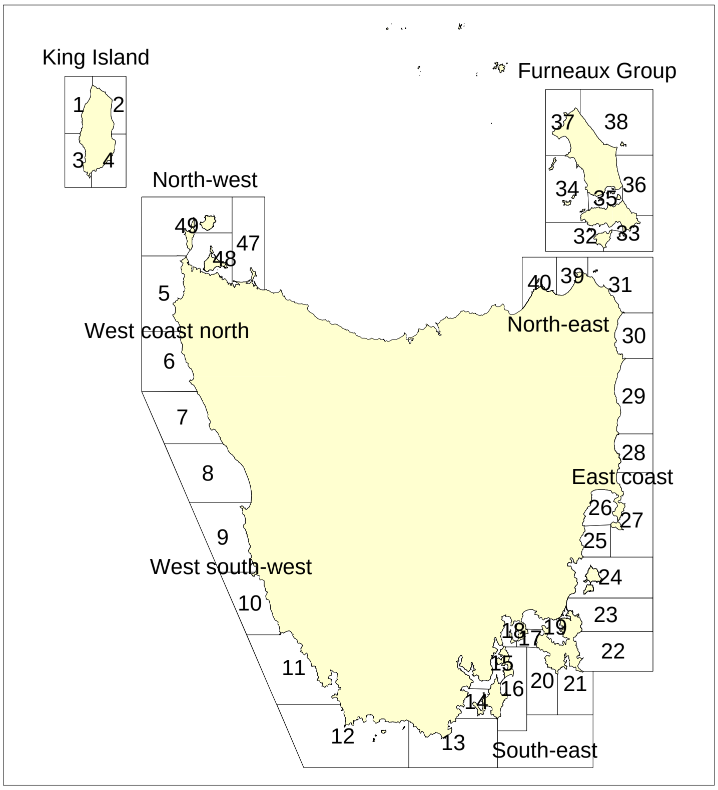

Fig. 1. Statistical blocks used in the Tasmanian abalone fishery. Statistical blocks are commonly grouped for analysis into eight regions.

4. Previous Assessments

Using data on the size composition of the catch to assess the impact of fishing Witherspoon (1975) demonstrated a reduction in size composition of the catch between 1968 and 1975 in two selected statistical fishing blocks. In all cases the modal length class was above the legal minimum length.

Harrison (1983) carried out surplus production analyses of Tasmanian abalone populations to provide estimates of sustainable yields and optimum levels of fishing effort. He concluded that catches for 1980-81 exceeded the long-term sustainable yield in most areas. It is noted that the catch for 1983 and 1984 exceeded the 1981 catch. The validity of surplus production analysis relies on the assumption that catch-rates may be used as an index of abundance. This assumption has been questioned because of the aggregating behaviour of abalone, the targeting of these aggregations by divers, and the catch-rate threshold of individual divers, who will move to another site rather than continue fishing at a site when the catch-rate drops below this threshold (Breen, 1992; Prince, 1987; Prince, 1989).

Prince and Shepherd (1992) demonstrated that catch per unit effort (CPUE) becomes an increasingly sensitive index of abundance as fishing mortality increases. In collaboration with Philip Sluczanowski of the South Australian Fisheries Department, Prince prepared a computer model of an abalone population, called AbaSim. The model could be used by fishers, fisheries researchers and managers to explore the effects of different rates of exploitation, TAC levels and size limits on the age composition of the stock, its biomass, and rate of recovery after depletion. As an educational tool it is very useful, but it does not necessarily portray the status and dynamics of the Tasmanian abalone fishery.

More recent assessments used some of the evidence that was used in previous years and provided explicit documentation of the evidence used in the assessment process (Nash, 1996; Officer, 1997; Officer, 1999b). These fishery assessments were based on evidence derived from:

- commercial catch/effort/catch-rate statistics,
- commercial catch-at-length (market-measuring) data,
- yield- and egg-per-recruit analyses,
- strip transect estimates of abundance (at sites sampled on several occasions), and
- trends (or changes) in age composition (obtained from repeated population surveys at selected sites, using shell growth rings as an index of age).

A steady increase in catch-rate was noted in most areas (with some exceptions), accompanied by a change in the distribution of catch and fishing effort. Whilst catch-rates were regarded as a poor index of abundance, the catch-rate increases generally observed were taken to signify that, in general, there was little evidence of overfishing.

4.1 Yield-per-recruit and egg-per-recruit analyses

Yield-per-recruit analyses have been carried out for blacklip abalone (Nash *et al*., 1994, unpublished data) to determine the combinations of minimum size limit and fishing pressure that maximise the yield per recruit from the resource. Officer (1999a) undertook similar analyses for greenlip abalone. This latter study was the basis for raising size limits in some greenlip fishing regions to ensure that adequate egg production would be maintained.

A comparison of egg production levels with those of fished abalone stocks elsewhere has been used to indicate the risk of recruitment failure. Nash (1992) and Nash et al. (1994) used egg-per-recruit analysis to estimate current levels of egg production of blacklip abalone, relative to virgin stock egg production, at several sites around Tasmania. These analyses indicated that levels of egg production were relatively high (> 40 percent of virgin stock egg production) and provide little cause for concern that recruitment failure is imminent for blacklip abalone (Koslow, 1992).

4.2 Fishery-independent estimates of abundance

Fishery-independent abundance monitoring using strip transects has previously been attempted by the Abalone Assessment Section at a small number of sites. Data gathered over a period of more than two years did not show any significant changes in abundance. However, because abalone generally live in aggregations it is difficult to obtain accurate and precise estimates of abundance or density. Highly variable numbers of abalone in low population density areas require that excessive numbers of replicates be done to achieve a acceptable level of sensitivity. Furthermore, abalone move in response to disturbance (Nash *et al*., 1994) and re-aggregate after stock density has been reduced by fishing (McShane and Smith, 1989; Nash *et al*., 1994). This movement further complicates abundance estimation. For these reasons Tasmanian transect survey work has lapsed.

During the last few years however, Victorian researchers have adopted a different approach to transect surveys, and are able to detect relatively small changes in abundance while maintaining realistic costs. An evaluation of methods for assessing the abundance of blacklip abalone in Victoria found transect surveys to be the best of five methods assessed (Gorfine *et al*., 1996; Hart and Gorfine, 1997; Hart *et al*., 1997). The study concluded that including methods to evaluate the spatial distribution of abalone would enhance results.

4.3 Commercial catch sampling data

The collection of commercial abalone catch-at-length data through the market-measuring program lapsed in 1995 and recommenced in 1998. Analyses of size-composition data undertaken to 1996 (Nash, 1996) concluded that:

(i) Sampling has been uneven around the State, and to some extent reflects the contribution of each statistical block to the total catch. The most extensive sampling has been from blocks 9 on the West Coast, 13 and 14 in the South East, and 23, 24 and 27 on the East-Coast.

(ii) There has been a reduction in the size composition of the catch between 1984 and 1995 in most areas, but in none of the areas does this approach knife-edge fishing (in which case the fishery would be composed primarily of the annual recruits through the size limit). This reduction in size composition may reflect either a true reduction in size composition or an increase in selective targeting of smaller abalone (which the market generally prefers), or a combination of the two factors. This may be resolved using length-frequency data gathered by research personnel; these data should represent true size composition.

(iii) Size composition trends must be viewed in combination with catch-rate trends if there is to be any chance of a useful assessment of the stocks using commercial size-composition data. This is because the average size of fish in the catch may increase at high levels of fishing pressure if recruitment rates are declining. The slight decline in size composition of the catch, coupled with the (increasing or stable) catch-rate trends in most statistical blocks, provides no evidence of either growth overfishing or recruitment overfishing.

(iv) The market measuring data therefore provide no evidence that the Tasmanian abalone stocks are presently in a state of either growth overfishing or recruitment overfishing.

A commercial catch- sampling program was reinstated in 1998. These measurements are likely to prove an invaluable source of information when computer-modelling Tasmanian abalone stocks. Whilst such an analysis is not yet possible, continuation of the commercial catch-sampling program will improve both the immediate and ultimate utility of the data.

5. Assessment Methods

5.1 Commercial catch-effort statistics

Like its predecessors, the 1999 assessment is based principally on an analysis of trends in the catch and catch-rate of the commercial fishery. These data are provided by licensed abalone divers on dockets submitted with all abalone landed. Catch and effort are reported by statistical block (Fig. 1) on these dockets. Catch and effort are estimated by block when the catch occurs over multiple blocks or days. Commercial catch and effort data are not standardised and therefore include variations due to factors such as season, weather, and diver experience. Catch-rates for the main statistical blocks and regions have been calculated for each diver-day by dividing the catch (in kg) by diving effort (in hours) to yield catch per unit of effort (CPUE) in kg/hour.

5.2 Commercial catch sampling data

The collection of size-composition data from the commercial fishery was recommenced in 1998. Licensed abalone divers collect these data. The divers photograph a portion of their catch against a calibrated background and note the location at which the abalone were caught. The photographs are subsequently scanned and the abalone are measured from the scanned image using a computer. Data collected by this project up to 1/1/00 are included in the 1999 assessment. These data are compared with those obtained by the previous market measuring program from 1984 to 1995, and, where possible, with size-composition data collected in 1997 by research divers. Research data includes measurements of fish below the legal minimum length. These data can therefore better indicate the true modal length of the population sampled and the proportion of the population not yet recruited to the fishery.

Size-composition data was also provided by Tasmania’s largest abalone processor: Tasmanian Seafoods Pty Ltd. These data describe the proportion of factory production made up of large abalone. These data were provided from July 1995 to December 1999. Production figures were also provided for days in 1997-99 where the catch was obtained exclusively from the west coast.

5.3 Recreational fishing surveys

The recreational catch reported in the 1999 assessments were derived from the preliminary results of recreational fishing surveys undertaken by the Department of Primary Industry and Fisheries (J. Lyle, pers. comm.). These surveys used a combination of diary and recall methods to obtain estimates of the recreational fishing catch in Tasmania.

6. Fishery Assessment: 1999

6.1 Blacklip Fishery Assessment: 1999

6.1.1 Evaluation of catch and catch-rate with reference to previous periods.

The previous stock assessment evaluated 1998 catches with respect to the trigger points specified in the Draft Tasmanian Abalone Fishery Policy Document (Anonymous, 1997). However, these trigger points were deficient, in that they made no allowance for normal inter-annual variation in catches or exceptional catches in 1995. Subsequently, the 1998 catches in each region and block were evaluated against alternative trigger points. These new trigger points were set at the average catches from 1992 to 1995 inclusive and 1981 to 1984 inclusive (for statistical blocks only).

Using the 1992-95 averages compared 1998 catches with those from a period where the fishery had had time to respond to a period of progressive quota reductions and size limit increases. Using the 1981-84 averages compared 1998 catches with those from the period immediately prior to quota introduction where fishing pressure was at its greatest.

Following discussion with industry representatives in 1999, it was realised that the years 1981-84 may reflect unusually high fishing activity prior to management of the fishery by ITQ and a TAC. Therefore, the period 1979-82 is used for the 1999 assessment.

The 1997/98 assessment recognised that trigger points failed to accommodate changes in catches caused by changes in TACs, or re-distribution of effort caused by closure of parts of the greenlip fishery. This 1999 assessment reviews catch and catch-rate by comparing current catch information with the two reference periods. The significance of any change is considered with respect to the quantity of abalone coming from the region or block, and its catch history.

The review of catch and catch-rates is in two parts – the first deals with blacklip abalone catches, the second covers the greenlip fishery.

Blacklip abalone - catch reference points: Regions

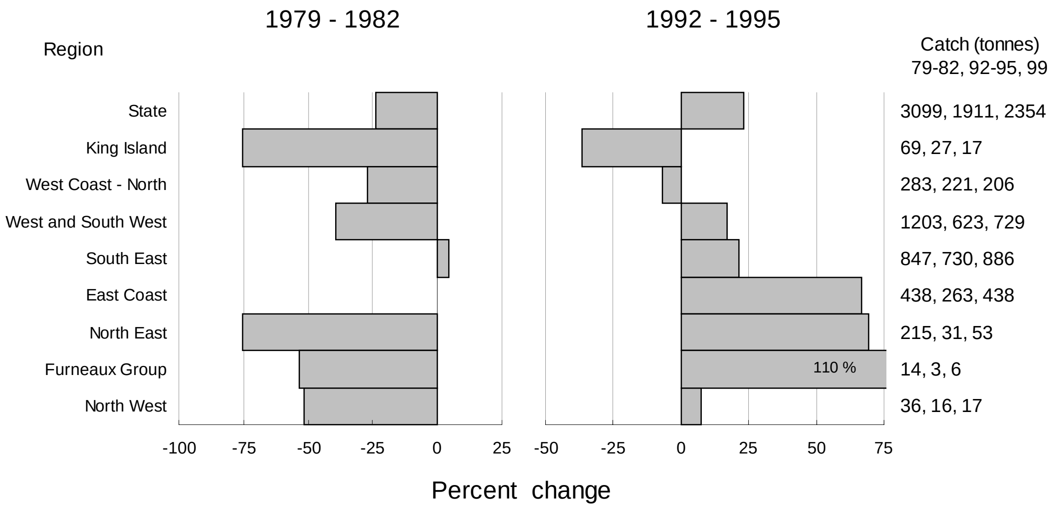

Fig. 2. The 1999 blacklip abalone catch by State and region, showing the deviation of the 1999 catch from two reference periods in the history of the fishery. The left-hand chart shows the change in catch compared with the average catch of 1979-82, and the right-hand chart compares the catch with that of 1992-95 average. The average catches (in tonnes) for 1979-82 and 1992-95 and the 1999 catch are shown on the right-hand side of the chart. In 1999, the blacklip abalone catch in the Furneaux Group was 110% greater than the 1992-95 average (the chart is truncated).

- Statewide, blacklip abalone catches have increased 23% on the 1992-95 average.
- Blacklip catches have continued to fall on King Island.
- Catches from the two west coast regions are well below those of the early reference period.
- On the East Coast, catches are still at very high levels, although they have dropped from 583 tonnes in 1998 to 438 tonnes in 1999.
- Catches in the North East are 25% of the1979-82 catch.
- The change in size of catch at the Furneaux Group is not significant as it refers to an increase in catch to 6 tonnes from 3 tonnes in the later reference period.

Blacklip abalone - CPUE reference points: Regions

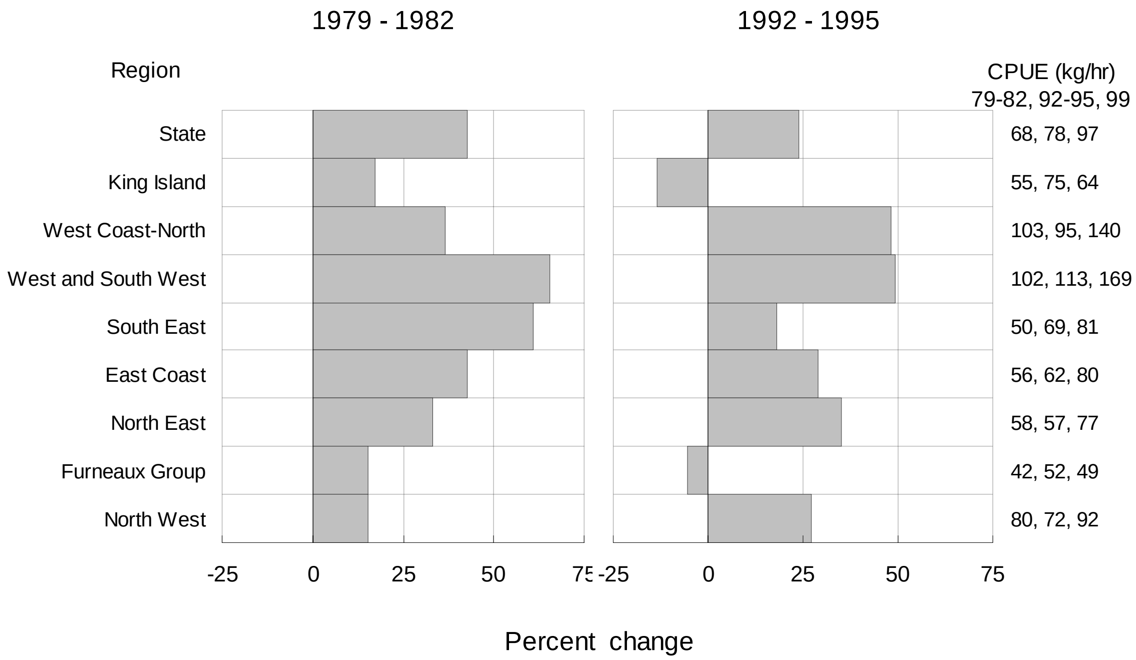

Fig. 3. The 1999 catch-rate (CPUE) by region, including the State, expressed as percent change from the average catch-rates of the periods 1979-82 and 1992-95. Catch-rates from King Island, the Furneaux Group and North West Tasmania are calculated using effort data which includes a significant component of effort from greenlip abalone catches.

The following points are noted with respect to the regional blacklip catch-rate reference points (Fig. 3):

- The chart was produced using data that contained greenlip effort. In some regions (particularly the Furneaux Group, and King Island), the major part of the annual blacklip catch is caught incidentally to greenlip fishing operations. Where greenlip catches predominate, the information shown above may not reflect the reality of blacklip abalone fishing in those areas.

- The statewide catch-rate was 24% greater than the average catch-rate of 1992-95. However, the State catch-rate fell by 0.4 kg/hr from the 1998 high of 97.4 kg/hr (Appendix 1).

- Catch-rates fell only in regions where greenlip abalone form the major part of the catch i.e. at the Furneaux Group (by 5%) and King Island (by 13%).

- Regions where blacklip abalone catch predominated recorded increases in catch-rate. These increases were marked in the west coast regions, but much less on the East Coast and South East.

Blacklip abalone - catch reference points: Blocks

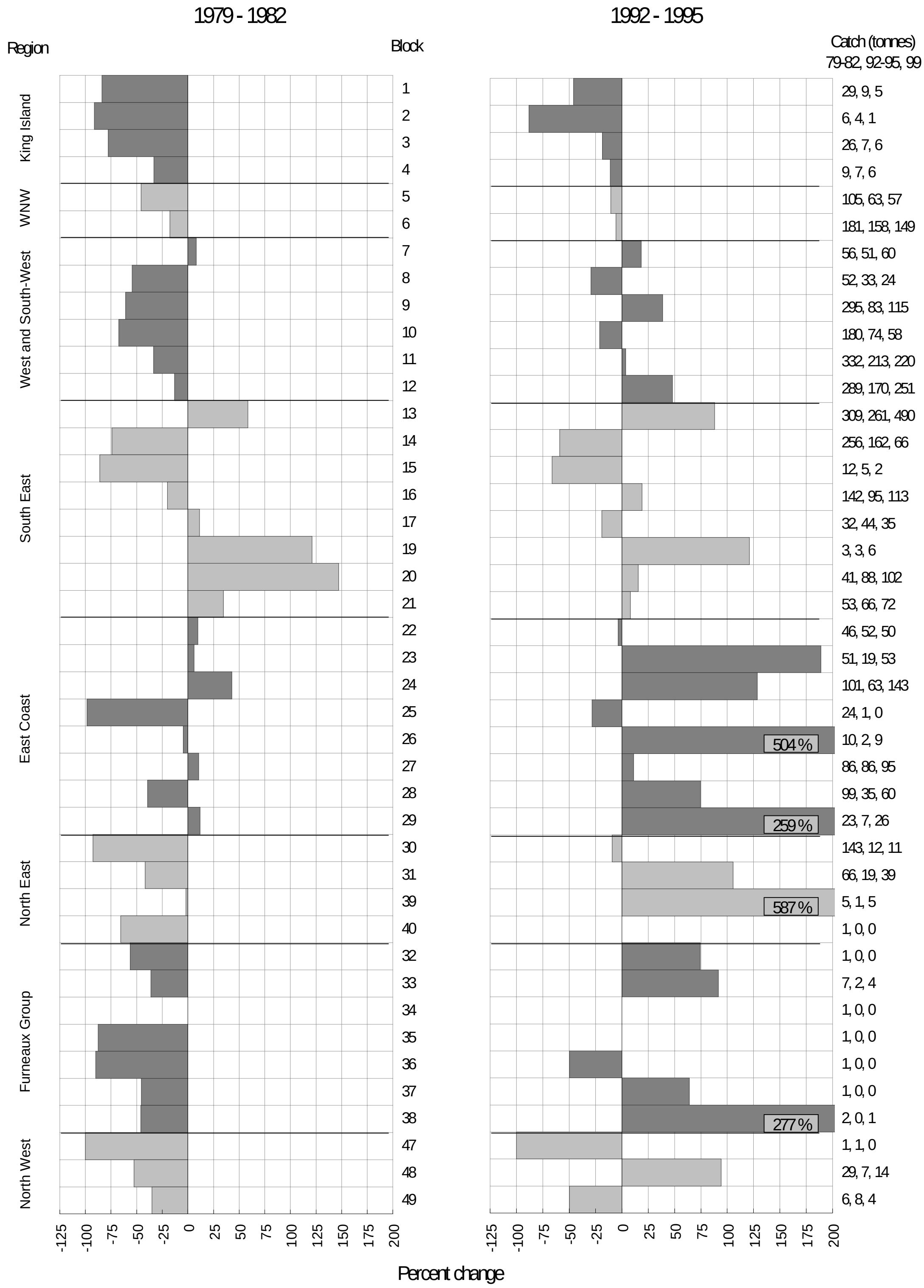

Fig. 4. The 1999 blacklip abalone catch by block, showing the deviation of the 1999 catch from two reference periods in the history of the fishery. The left-hand chart shows the change in catch compared with the average catch of 1979-82, and the right-hand chart compares the catch with that of 1992-95 average. The blocks (shown in the column between the two charts) are grouped by region (shown on the left-hand side of the page). The average catch in tonnes for the periods 1979-82 and 1992-95 and the 1999 catch are shown on the right-hand side of the page. Where the chart is truncated, percentage change is indicated.

Significant changes in the 1999 catch with respect to the two reference periods has occurred in the following blocks:

- Catches in Blocks 12 and 13 have shown a solid increase.
- Block 14 catch has declined.
- Catch in Block 20 has more than doubled compared with 1979-82.
- The East Coast blocks 23, 24, 28 and 29 show strong increases in catch over 1992-95. In recent years, Block 27 has performed at peak levels, but declined suddenly in 1999.
- Catches in the North East (particularly Blocks 30 and 31) have fallen with respect to the early reference period, but Block 31 is showing signs of a resurgence.
- Catches in several blocks that were previously important in the West Coast-North and West and South-West (Blocks 5, 6, 8, 10) have declined.

Blacklip abalone - CPUE reference points: Blocks

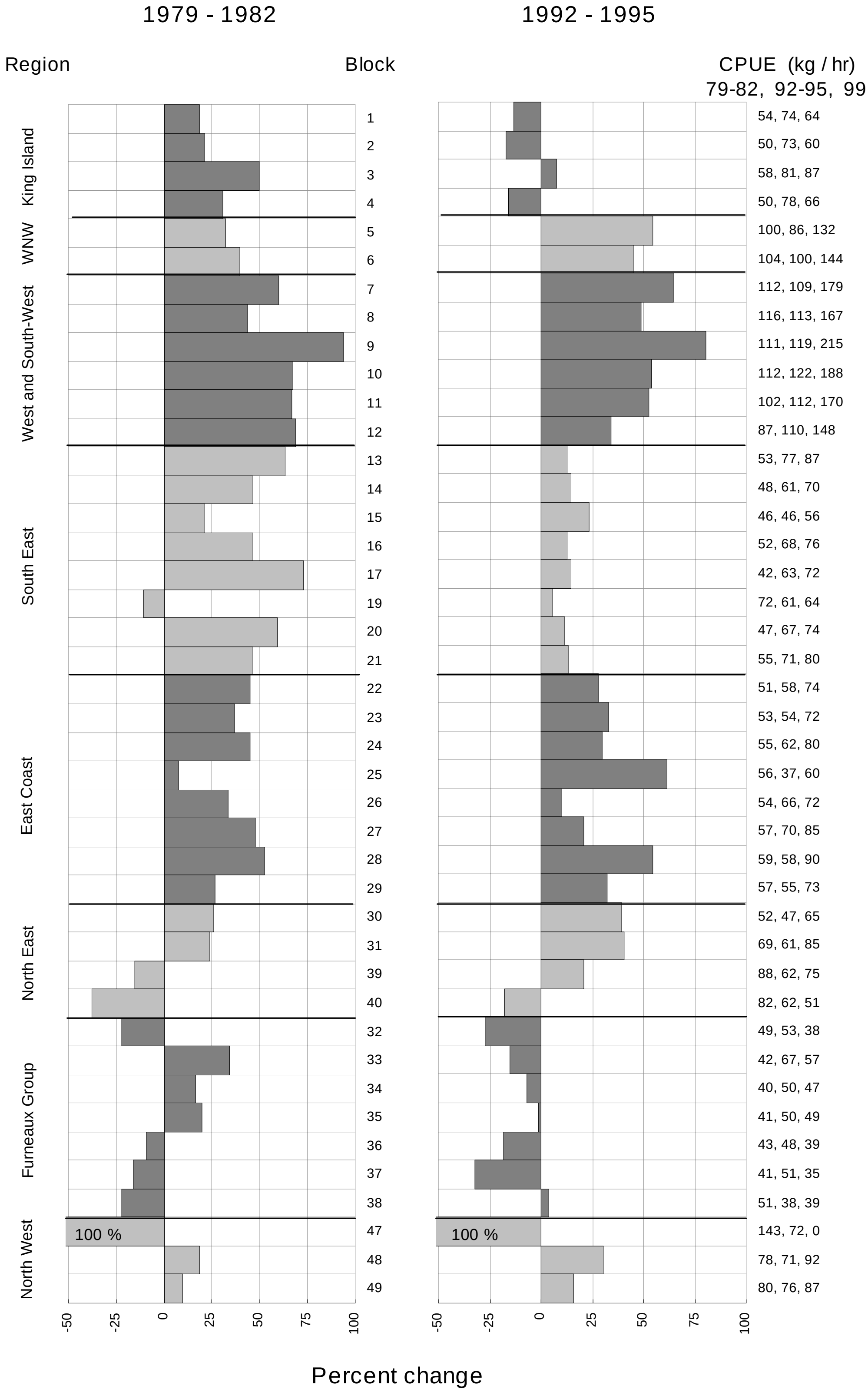

Fig. 5. 1999 catch per unit effort (CPUE) by block, expressed as percent change from the average catch-rates of the reference periods 1979-82 and 1992-95. Catch-rates from King Island, the Furneaux Group and North West Tasmania are calculated using effort data which includes a significant component of effort from greenlip abalone catches.

- Apart from Block 19, where annual catches are low (< 10 tonnes) and there is great inter-annual variability, the only blocks to record falls in CPUE are the greenlip catching blocks of the North East, the Furneaux Group and King Island.
- No catch was recorded in Block 47 in 1999.
- There was an increase in CPUE in all blocks where blacklip is predominant.
- Increases in catch-rates are still occurring in the West Coast blocks. Catch-rates in Block 9 averaged 215 kg/hr in 1999, the highest average recorded in the history of the fishery. West Coast blocks generally averaged over 150 kg/hr.
- In the important fishing blocks in the South East and East Coast, catch-rate increases are the least significant.

6.1.2 Blacklip abalone: commercial catch distribution

The statistical blocks for the abalone fishery are shown in Fig. 1. In order to show changes in the distribution of the catch around the State since 1975, the catch from each of the regions is shown for blacklip abalone in Fig. 6 to Fig. 9. The upper graph in each of these figures shows the catch in absolute terms (tonnes) and the lower graph shows the catch from each of these regions as a proportion of the total annual catch.

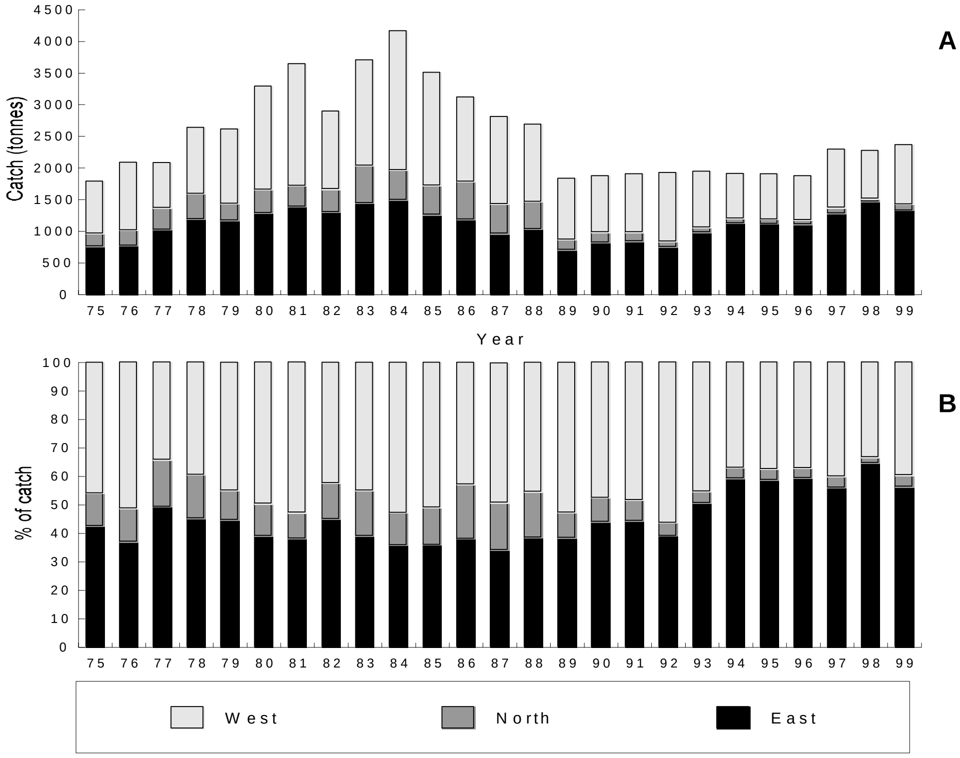

Fig. 6. The catch of blacklip abalone from the three main regions of Tasmania, by year from 1975-99. East: southeast & east coast (blocks 13-29). North: King Island, North West, North East & Furneaux Group (blocks 1-4, 30-40, 47-49). West: west coast north, West and South-West (blocks 5-12). Catches are expressed in absolute values (tonnes) (A), and as proportions of the total blacklip catch (B).

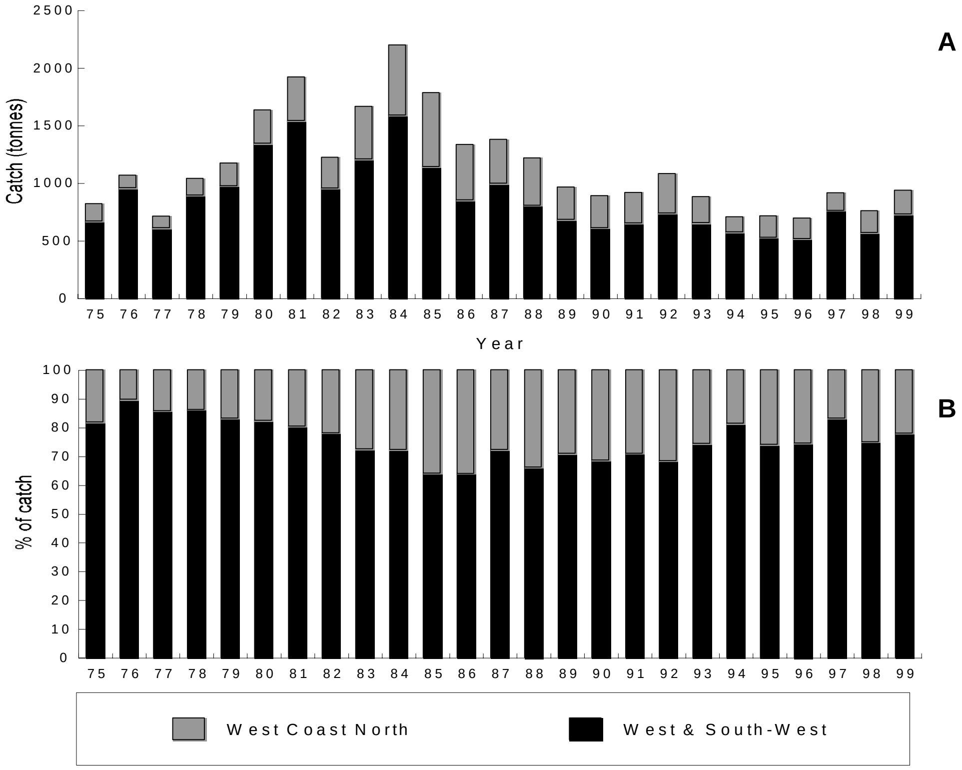

Fig. 7. The catch of blacklip abalone from the west of Tasmania, by year from 1975 to 1999. The catch from each region is expressed in (A) absolute values (tonnes), and (B) as a proportion of the total blacklip catch.

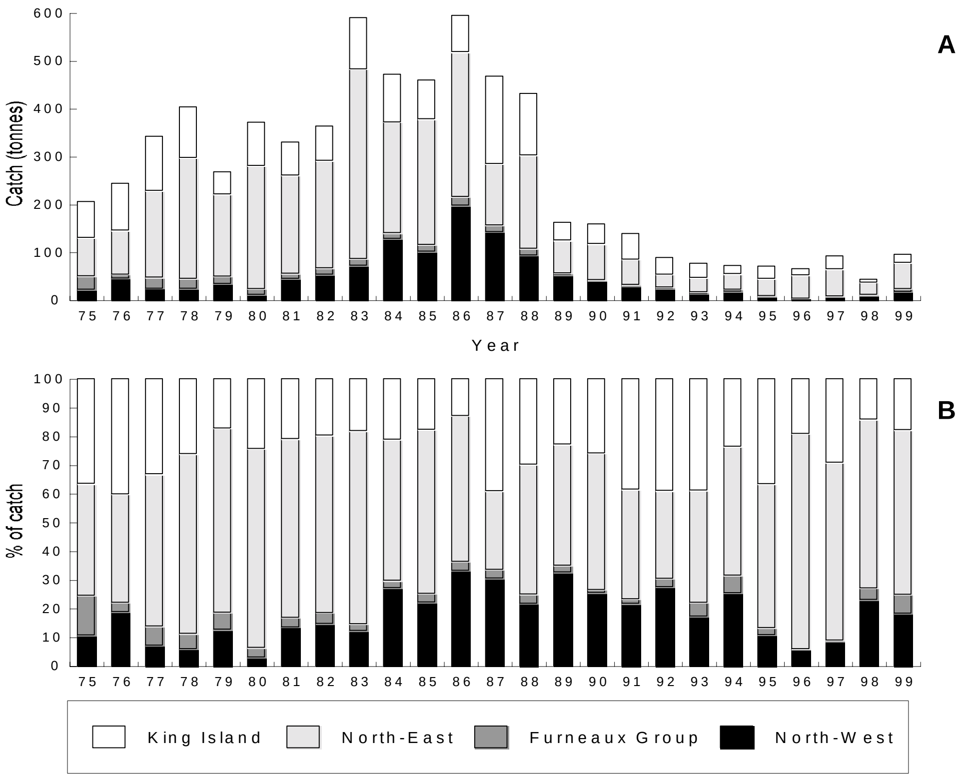

Fig. 8. The catch of blacklip abalone from the north of Tasmania, by year from 1975 to 1999. The catch from each region is expressed in (A) absolute values (tonnes), and (B) as a proportion of the total blacklip catch.

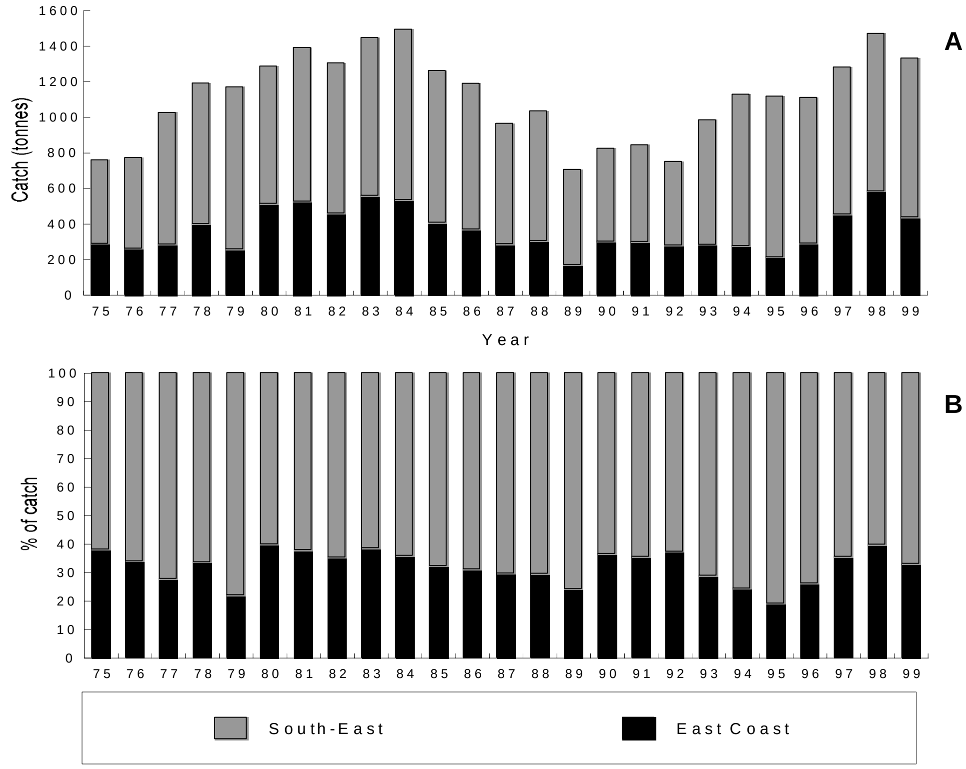

Fig. 9. The catch of blacklip abalone from the east and southeast of Tasmania, by year from 1975 to 1999. The catch from each region is expressed in (A) absolute values (tonnes), and (B) as a proportion of the total blacklip catch.

The following points are noted with reference to these graphs:

(i) The bulk of the blacklip catch has traditionally been taken from the west of the state (blocks 5 to 12) (Fig. 6).

(ii) Since 1993 the East Coast and South East have produced the greatest proportion of the catch, reaching a peak in 1998 when 60 percent of the total Tasmanian abalone catch was taken here (Fig. 6). Recent catches on the East Coast now exceed those prior to the introduction of quota (Fig. 9).

(iii) There was a small increase (170 tonnes) in the catch from the west in 1999, compared with the previous year, and a corresponding fall (140 tonnes) in the catch from the East Coast (Fig. 6, Fig. 7, Fig. 9).

(iv) The decline in catch from the north of the state continues (Fig. 6 and Fig. 8 A).

6.2 Greenlip Fishery Assessment: 1999

A detailed assessment of the greenlip abalone fishery was published in 1999 (Officer, 1999a), and from this, a number of structural changes were made to the way in which the fishery was managed. The effects of these changes are discussed below.

6.2.1 Evaluation of catch and catch-rate with reference to previous years

For the sake of applying uniform processes to the assessment of both the blacklip and greenlip fisheries, the greenlip abalone fishery catch information for 1999 is evaluated here against the same two reference periods applied to the blacklip fishery. However, this method of assessment is not particularly appropriate for the greenlip fishery. In response to perceived reduction in abundance by industry, in 1998 and 1999, the Tasmanian Government introduced management changes to the greenlip fishery. In response, the divers changed their fishing practises in a variety of ways, many of which were not anticipated by managers. Changes in catch and catch-rate are therefore less likely to reflect changes in abundance than in the blacklip fishery, and more likely to reflect the management changes recently introduced to the fishery.

More than the blacklip fishery, the greenlip fishery is driven by market demand. A number of processors, mostly in the north of the State and offshore islands, supply a premium product (i.e. large abalone) to a live fish market in Sydney, for which they receive a higher price than the blacklip beach price. Because the greenlip stocks are limited, there is competition between divers and processors for the resource, and the stocks were possibly fished at levels higher than could be sustained.

In 1998, the changes introduced by the Tasmanian Government to manage the resource in a sustainable manner were:

1. Annual greenlip TAC of 148 tonnes statewide,

2. Annual Furneaux Group TAC of 42 tonnes, which was subdivided into monthly TACs of 3.5 tonnes,

3. Allowing fishing on only two days a week. Originally these days were fixed, but after complaints by divers that they were being forced to work on days when weather conditions made diving hazardous, the divers were allowed to nominate any two days in the week.

4. A 200 kg per day bag limit was introduced, as was a 200 kg per day landing limit. This effectively meant that catch could not be held on board a mother ship overnight.

These measures were of limited success. They achieved a reduction in catch. However there were monthly catch overruns (because of the difficulty of closely monitoring and accounting for catch). Consequently the Furneaux Group was closed in August when the regional TAC was met. Greenlip were caught in other parts of the State, although the statewide TAC was also overrun.

In 1999, the catch and landing limits were dropped, and other changes introduced:

1. The greenlip fishery was divided into east (Furneaux Group and North East) and west (King Island and North West) with quarterly TACs of 17 tonnes and 20 tonnes respectively.

2. New size-limits were adopted to better protect stocks and increase yield. In all areas the size-limit was increased by 10 mm except in the North West, where it was increased by 8 mm.

Once again, competition for the resource led to overrun of TACs and the entire greenlip fishery was shut down early in the final quarter of 1999.

These management changes, especially the introduction of TACs, increased the degree of competition among participants of the fishery, a result of which was changes in catch and catch-rates that had little to do with abalone abundance. As well, changes in level of catch compared with the reference periods are more likely to reflect the implementation of TACs, and not necessarily changes in abundance.

Considering these covenants, the 1999 catch and catch-rate information compared with the reference periods is presented without further comment.

Greenlip abalone – catch reference points: Regions

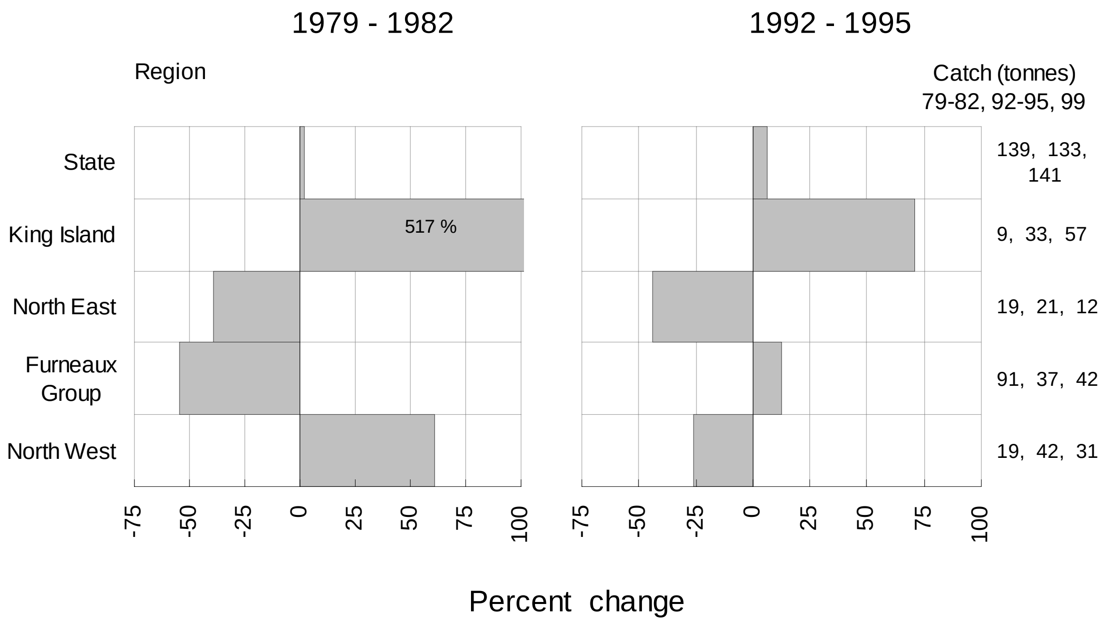

Fig. 10. The 1999 greenlip abalone catch by region, showing the deviation of the 1999 catch from the average catches of the 1979-82 and 1992-95 reference periods. The average catch in tonnes for the periods 1979-82 and 1992-95 and the 1999 catch are shown on the right-hand side of the page. The 1999 catch from King Island is 517% of the average catch from 1979 – 1982.

Greenlip abalone – CPUE reference points: Regions

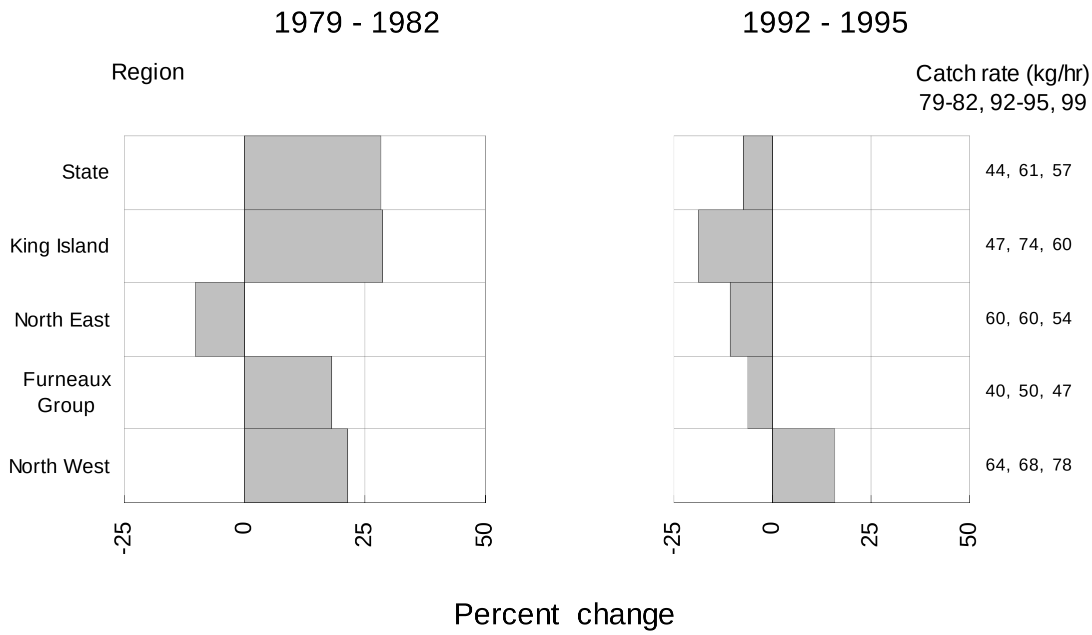

Fig. 11. The 1999 greenlip catch-rate (CPUE) by region, showing the difference in catch-rates between 1999 and the average of catch-rates for the periods 1979-82 and 1992-95. The catches from which these catch-rates were calculated are greenlip only catches i.e. no blacklip abalone were landed.

Greenlip abalone – catch reference points: Blocks

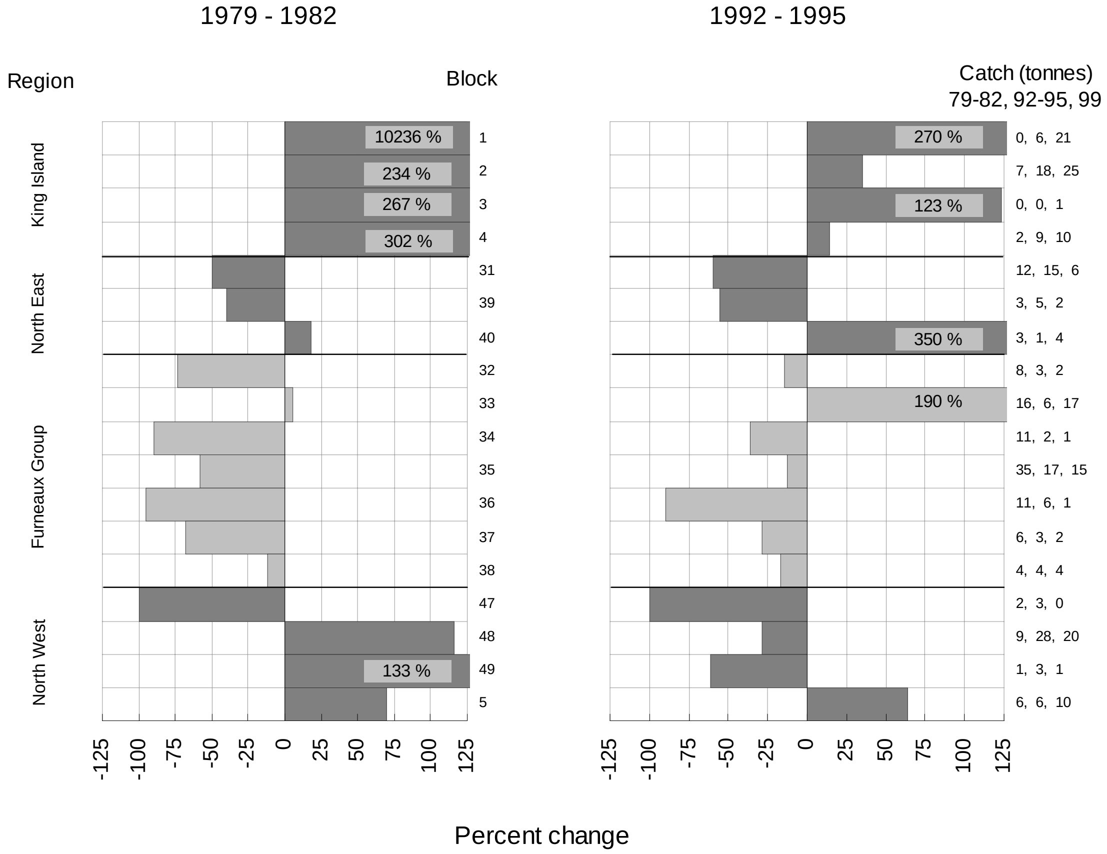

Fig. 12. The 1999 greenlip abalone catch by block, showing the deviation of the 1999 catch from the average catches of the 1979-82 and 1992-95 reference periods. The blocks (shown in the column between the two charts) are grouped by region (shown on the left-hand side of the page). The average catch in tonnes for the periods 1979-82 and 1992-95 and the 1999 catch are shown on the right-hand side of the page. Where the chart is truncated, percentage change is indicated.

Greenlip abalone – CPUE reference points: Blocks

Fig. 13. The 1999 greenlip catch-rate (CPUE) by block, showing the difference in catch-rates between 1999 and the average of catch-rates for the 1979-82 and 1992-95 reference periods. The catches from which these catch-rates were calculated are greenlip only catches i.e. no blacklip abalone were landed. In block 40, during the period 1992-95, no greenlip-only catches were landed. The blocks (shown in the column between the two charts) are grouped by region (shown on the left-hand side of the page). The average catch-rate in kilograms per hour for the periods 1979-82 and 1992-95 and the 1999 catch-rate are shown on the right-hand side of the page.

Greenlip abalone – regional catch

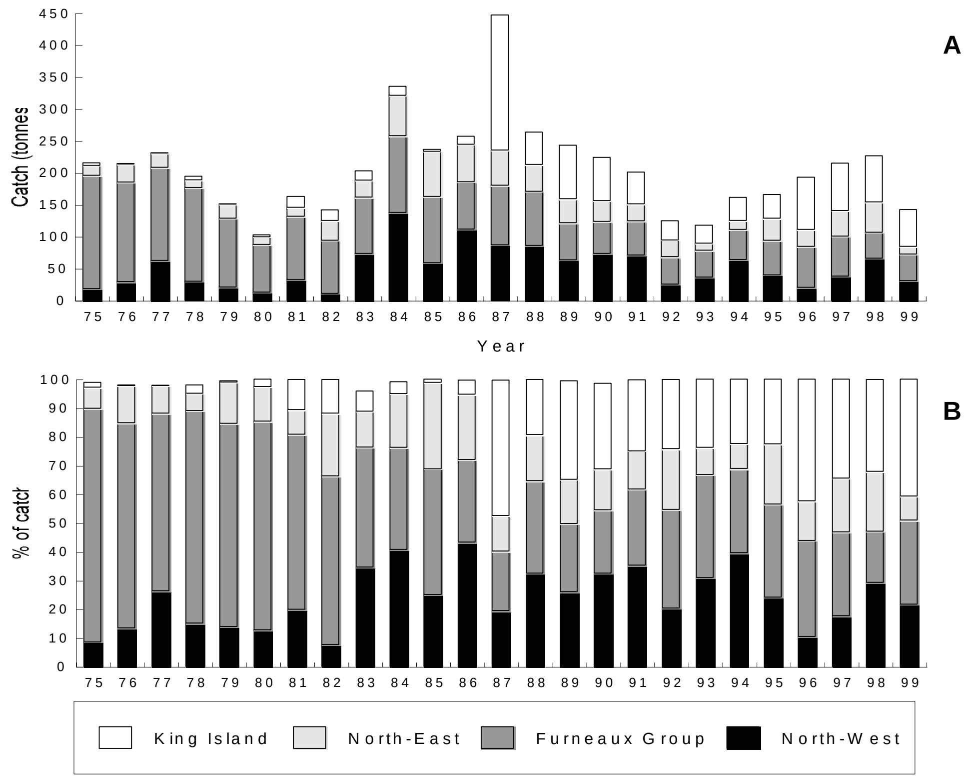

Fig. 14. The catch of greenlip abalone from the four main greenlip-producing regions of Tasmania, by year from 1975 to 1999. King Island includes blocks 1-4. North East includes blocks 30, 31, 39 and 40. The Furneaux Group includes blocks 32-38. North West includes blocks 5, 6, 47, 48 and 49. The catch from each region is expressed in (A) absolute values (tonnes), and (B) as a proportion of the total greenlip catch. Proportions do not sum to 100 % in some years due to minor catches in other blocks or misreported catches in areas that do not produce greenlip abalone**.**

The following points are noted with reference to these graphs:

(i) The annual greenlip catch peaked in 1987 when large catches were taken from eastern King Island (Fig. 14A). The 1999 greenlip catch was capped by the 148 tonne TAC.

(ii) The King Island greenlip catch was very small until 1987; catches since 1987 are higher than in these earlier years (Fig. 14A).

(iii) There has been a steady decline in the annual greenlip catch from the Furneaux group, from 175 tonnes in 1975 to about 40 tonnes in both 1998 and 1999.

(iv) The greenlip catch from the North West peaked in 1984 and has declined since then. Increases since 1996 have not been maintained in 1999.

(v) The greenlip catch from the North East (blocks 30, 31, 39 and 40) has varied in both absolute and relative terms, with no readily apparent trend.

6.3 Blacklip and Greenlip Abalone: trends in catch and catch-rate

The statistical blocks have been grouped into eight regions (Fig. 1) to show broad regional trends in catch, effort and catch-rate (CPUE) (Appendix 1). The statewide trend is also shown in Appendix 1. Catch, effort and catch-rate data for most of the individual statistical blocks for the period 1975 to 1996 are shown in Appendix 2. Statistical block 18 (the Derwent River estuary) and block 41 to 46 (central north coast) have been excluded for brevity; the catch in these blocks is very small or zero.

The following points are noted with reference to these catch-effort graphs:

(i) Statewide, high catch-rates are continued, although there is a reduction in catch-rate of 0.4 kg/hr from the previous year (Appendix 1).

(ii) On a regional basis, catch-rates remain high. They continue to climb in the West and South-West, have leveled off or fallen slightly in the West Coast-North and South East, and have fallen by 10 % on the East Coast (Appendix 1).

(iii) Of blocks producing significant quantities of blacklip abalone, catch-rates generally fell from the record highs of 1998. Falls were usually small and within the range of variation seen in previous years. Larger falls occurred in Block 27 (12%) and Block 29 (27%) (Appendix 2).

(iv) The decline in catch in Block 14 that started in 1996, continued in 1999 (Appendix 2).

(v) While past assessments have tracked the movement of trends in catch and catch-rate by block, even at a regional level there is considerable inter-annual variation that cannot reasonably be interpreted as change in abundance. Interpreting catch and catch-rate trends on a smaller spatial scale (i.e. at block level) without reference to other information has therefore been discontinued.

(vi) Catch-rate trends must be interpreted in association with trends in catch and effort. Where effort and catch are relatively low, the presence (or absence) of particular divers with local knowledge can have a significant effect on catch-rates. Changes in catch-rate alone may not necessarily reflect changes in abundance. The need to use information on both the catch and catch-rates when attempting to interpret catch-effort trends is discussed further below.

(vii) In blocks where both blacklip and greenlip abalone are harvested, fishing effort is often supplied for both species combined; it is therefore generally impossible to calculate catch-rate figures for these species separately. However, in blocks where only one of these species is the sole or predominant component of the catch, the catch-rate figures may better represent the trends for that species.

Among regions, King Island has experienced a decline in both catch and catch-rate. The region was under pressure to fill the gap left by the closure of the Furneaux Group greenlip fishery. In 1999, it was also fished at a substantially higher size-limit, which meant that the total number of legal-sized abalone declined, thus reducing catch-rates (Appendix 1).

At the other extreme, catches and catch-rates generally rose in the West and South-West. This region is lightly exploited because of limitations imposed by weather. In 1999, conditions were favourable, and divers landed larger catches at higher catch-rates than during previous years **(**Appendix 1**)**.

The performance of the other regions was at a level between these two extremes. Catches and catch-rates behaved erratically on the East Coast, after rising rapidly for several years. Capped greenlip catches and the response of divers to management changes saw catches fall in the greenlip regions of the Furneaux Group and the North East. In the North West and northern part of the West Coast, catches and catch-rates were stable. In the South East, catches have stabilised between 800 and 900 tonnes since 1994. Catch-rates have been stable here since 1996 **(**Appendix 1**)**.

6.3.1 Commercial catch sampling data

The measurement of abalone caught commercially recommenced in 1998. This project has yielded length measurements from over 22,500 abalone to the end of 1999 and includes samples from about half of the statistical blocks (1, 2, 4, 7, 12, 13B, 14, 16, 17, 19 to 24, 26 to 30, 32, 35 and 39). However, the level of sampling at many of these blocks is low and insufficient to make meaningful comparisons with earlier years. Good samples have been obtained from some of the more heavily fished blocks (Fig. 15 to Fig. 22).

These data suggest an apparent increase in the mean size of abalone sampled recently compared to 1995 in most areas. In no areas does the size-composition of the commercial catch show knife-edge fishing indicative of growth overfishing. In all blocks where size-composition data from research samples is available the large proportion of the population below the legal minimum length suggests that recruitment to the populations sampled will be maintained in the immediate future.

It must be noted that the catch-sampling data presented in this report has not been validated. The samples obtained from divers may not be representative of the fishing blocks from which they were obtained or there may be systematic biases in the measurement system used to generate the size-composition data. Such biases are considered unlikely but will nevertheless be considered in a separate validation study of the commercial catch sampling project.

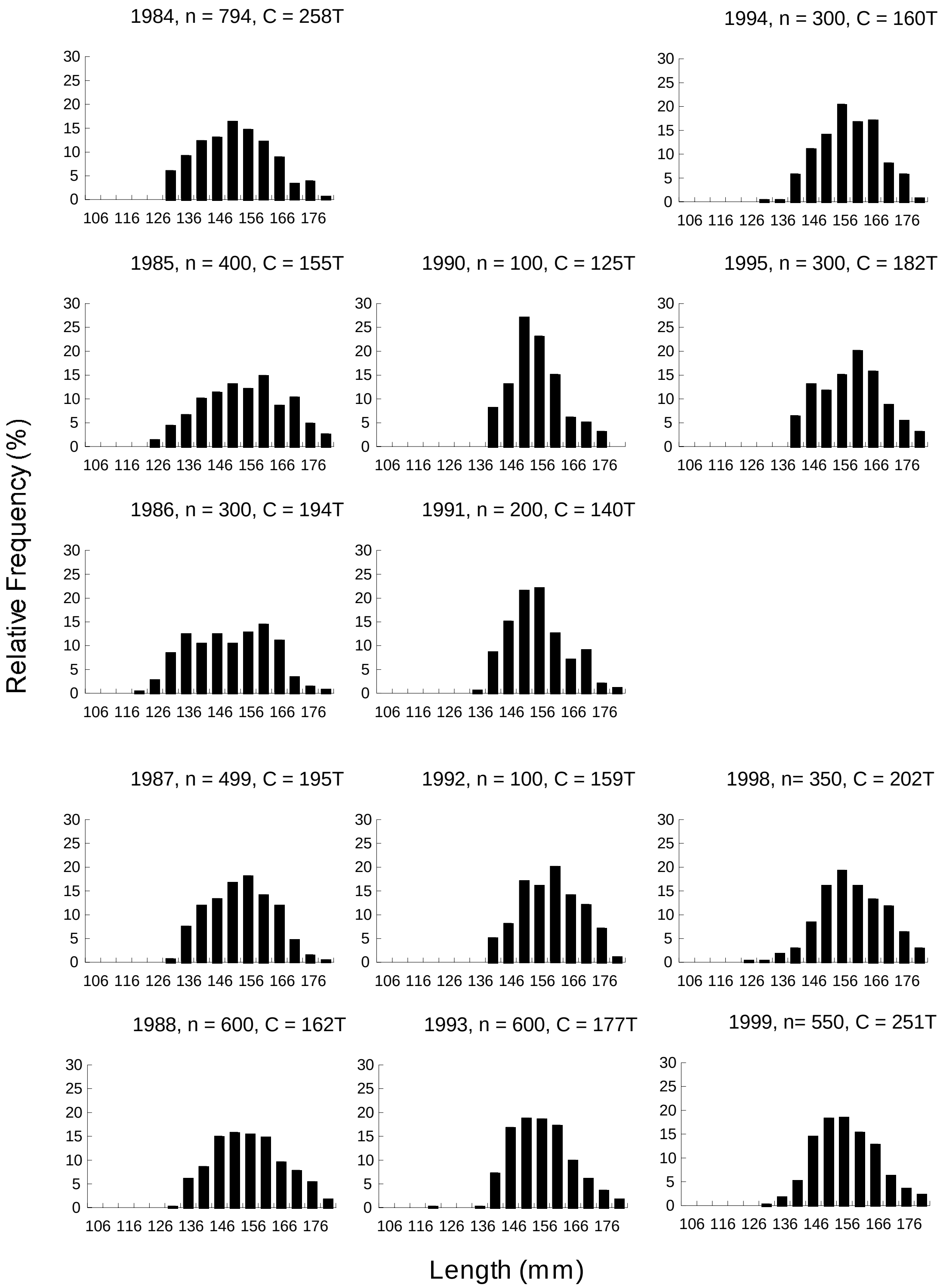

Fig. 15 Size-composition of the commercial catch from statistical block 12. Samples were measured at processing factories from 1984-95 and supplied by divers in 1998-99. The number of abalone sampled (n) and the annual catch in tonnes (C) is given for each year.

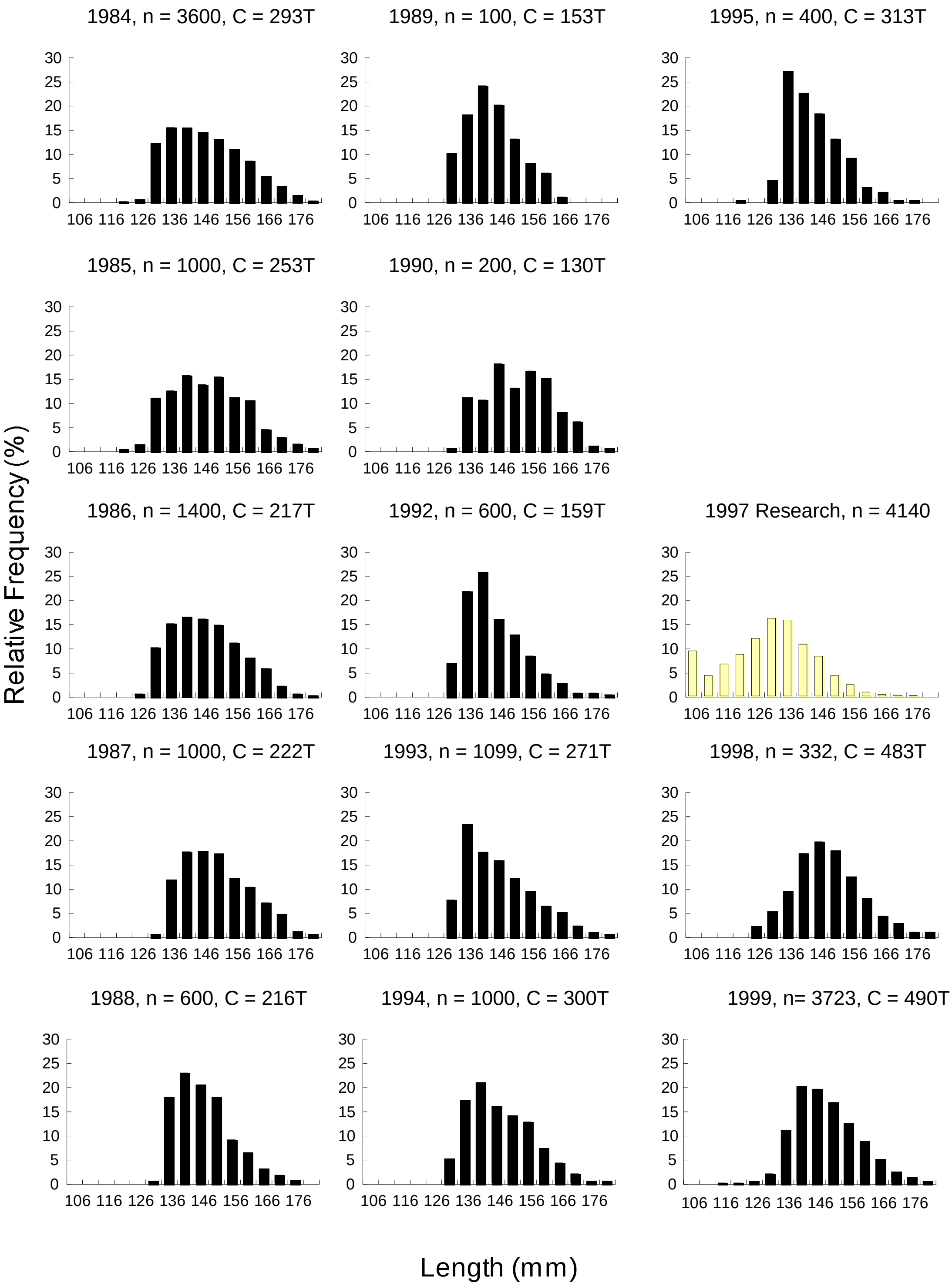

Fig. 16. Size-composition of the commercial catch from statistical block 13. Samples were measured at processing factories from 1984-95 and supplied by divers in 1998-99. The size composition of samples taken by research divers in 1997 is also shown for comparison. The number of abalone sampled (n) and the annual catch in tonnes (C) is given for each year.

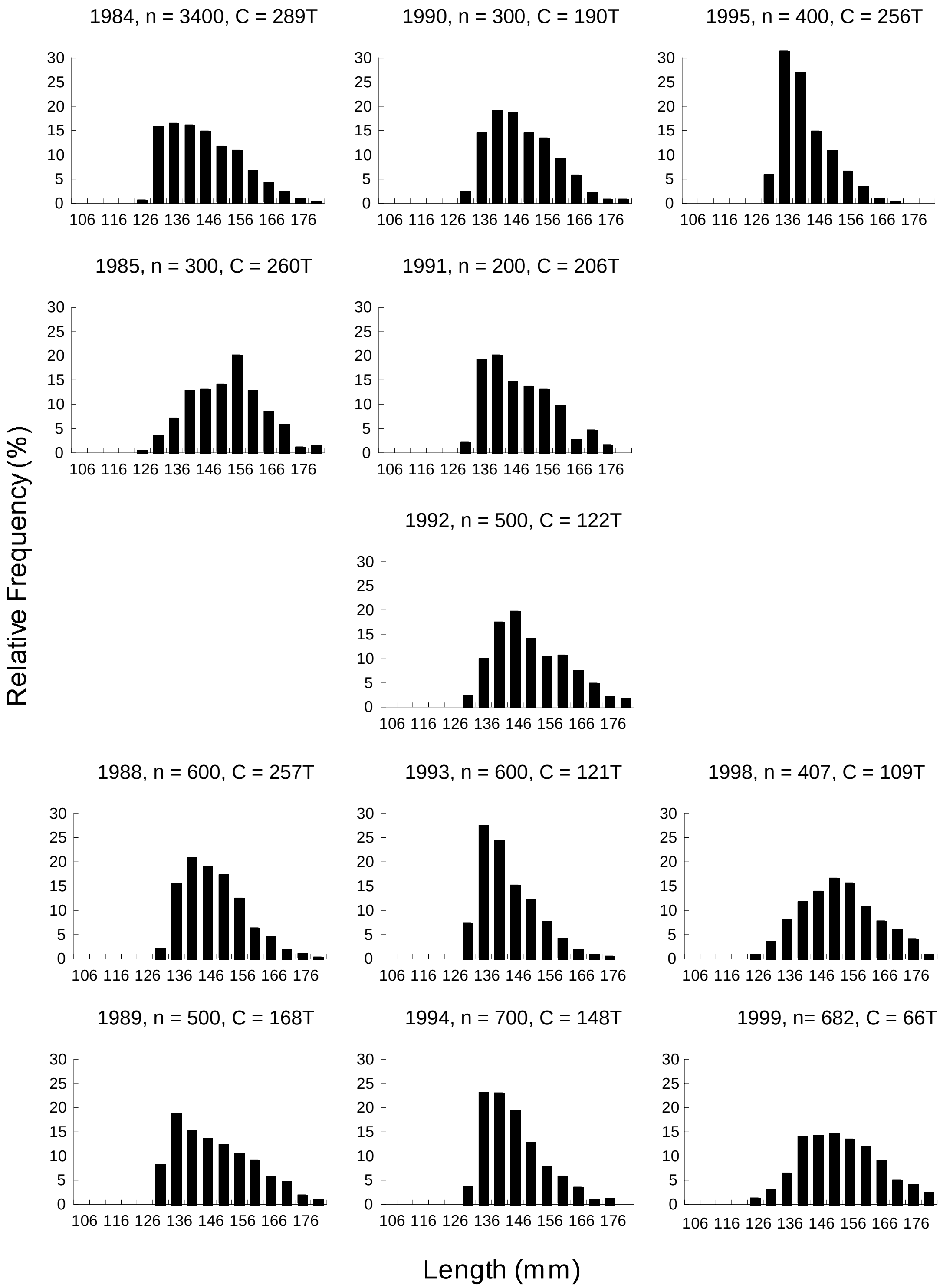

Fig. 17. Size-composition of the commercial catch from statistical block 14. Samples were measured at processing factories from 1984-1995 and supplied by divers in 1998-99. The number of abalone sampled (n) and the annual catch in tonnes (C) is given for each year.

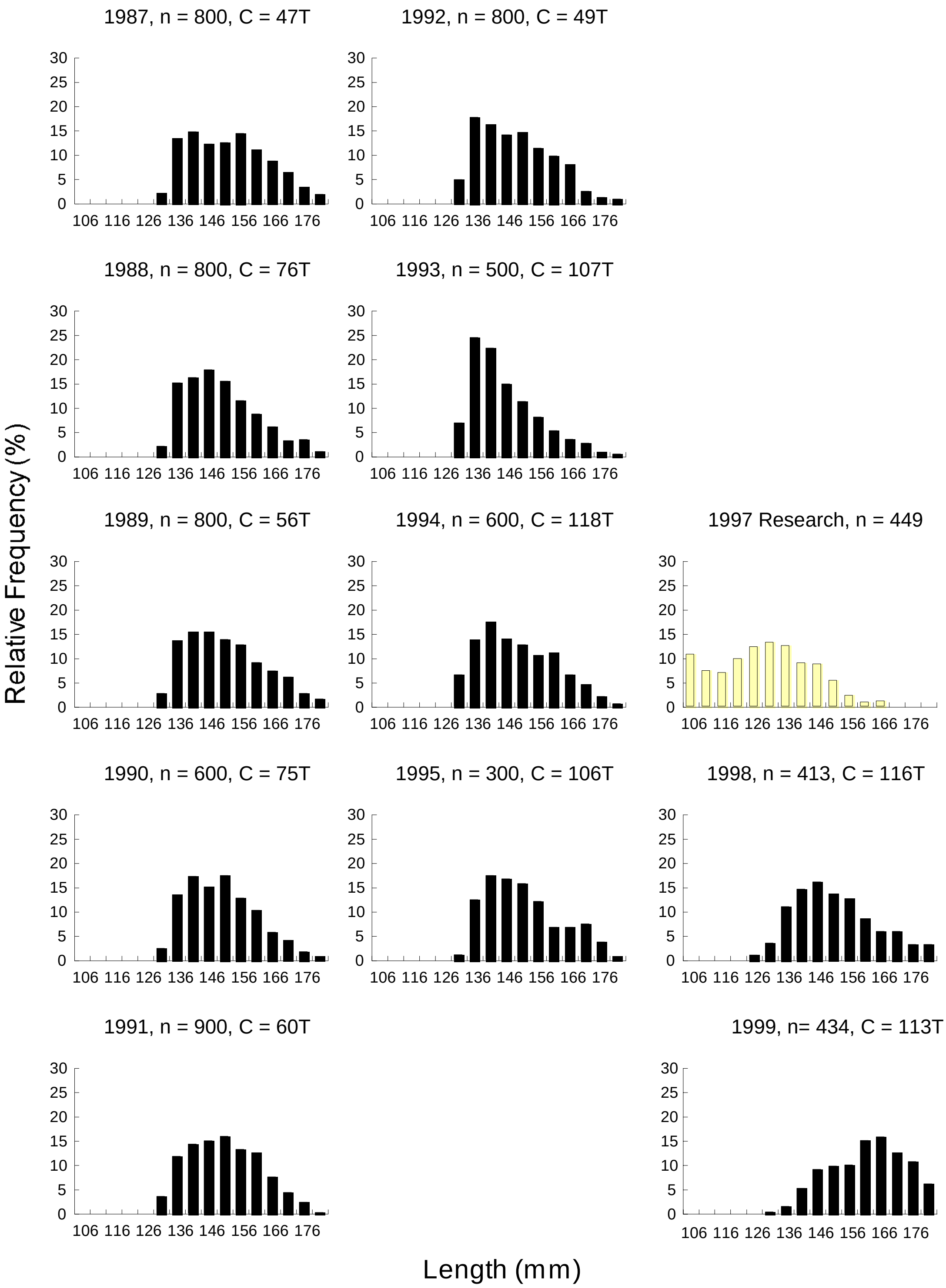

Fig. 18. Size-composition of the commercial catch from statistical block 16. Samples were measured at processing factories from 1984-1995 and supplied by divers in 1998-99. The size composition of samples taken by research divers in 1997 is also shown for comparison. The number of abalone sampled (n) and the annual catch in tonnes (C) is given for each year.

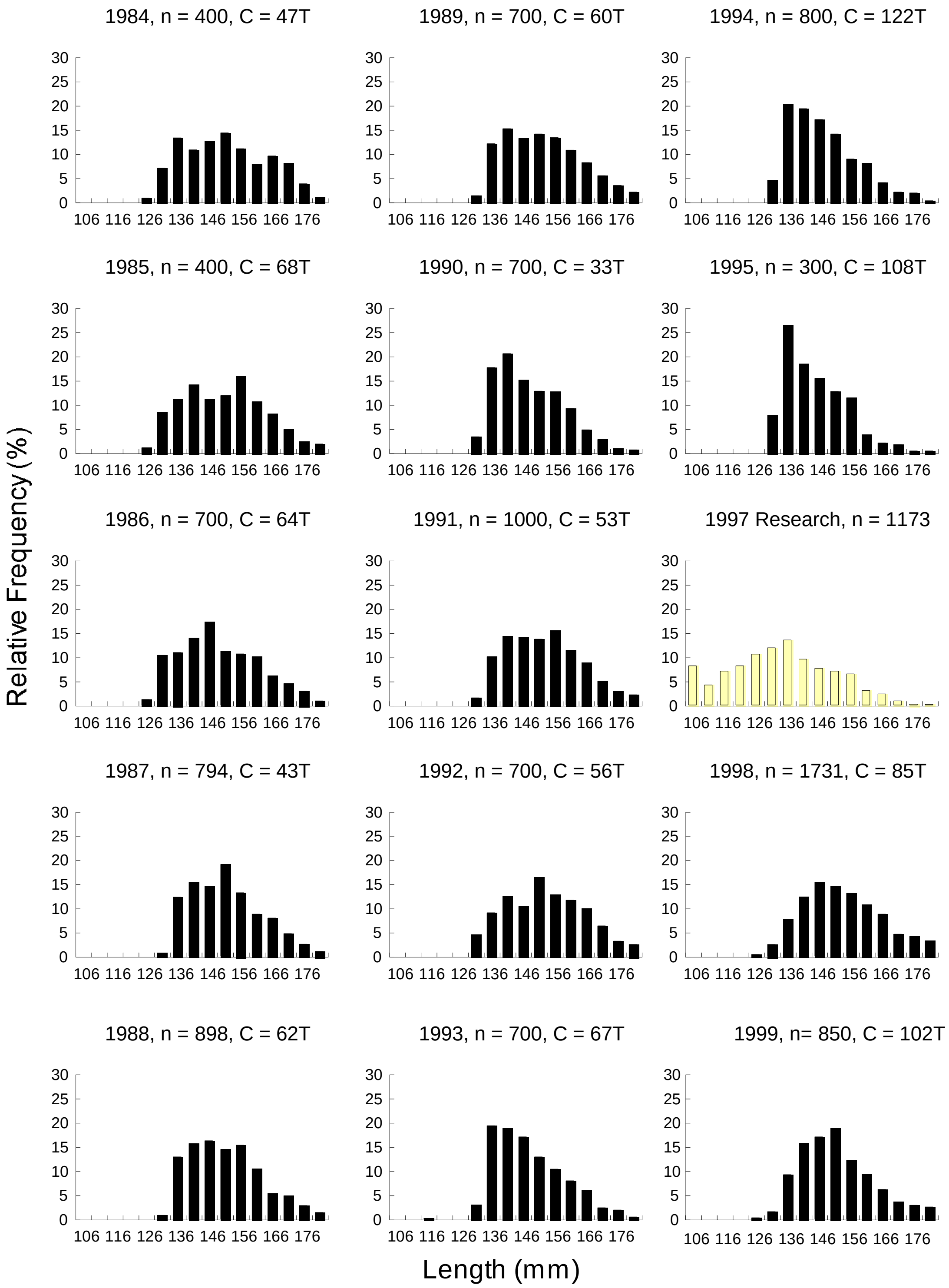

Fig. 19. Size-composition of the commercial catch from statistical block 20. Samples were measured at processing factories from 1984-1995 and supplied by divers in 1998-99. The size composition of samples taken by research divers in 1997 is also shown for comparison. The number of abalone sampled (n) and the annual catch in tonnes (C) is given for each year.

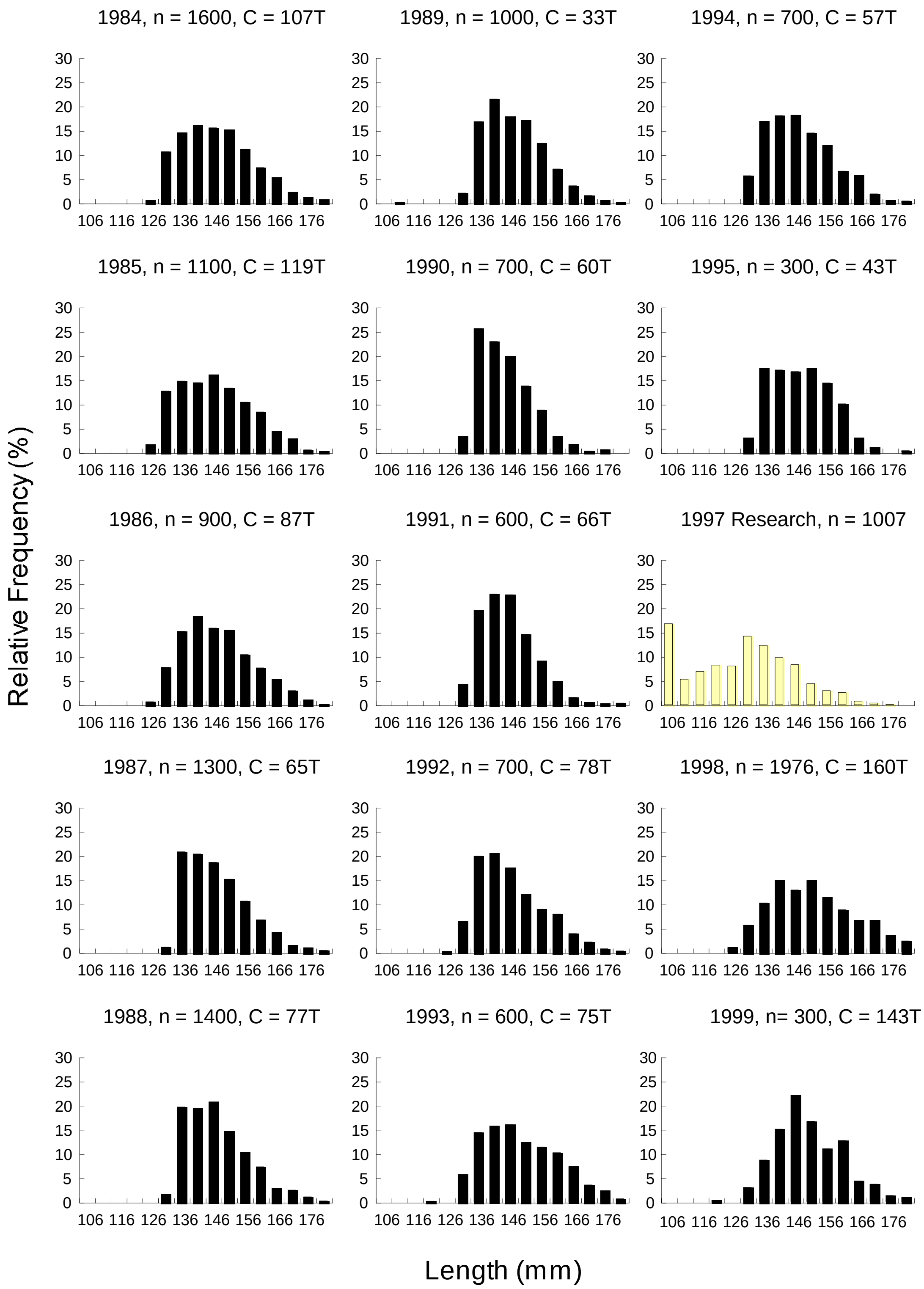

Fig. 20. Size-composition of the commercial catch from statistical block 24. Samples were measured at processing factories from 1984-1995 and supplied by divers in 1998-99. The size composition of samples taken by research divers in 1997 is also shown for comparison. The number of abalone sampled (n) and the annual catch in tonnes (C) is given for each year.

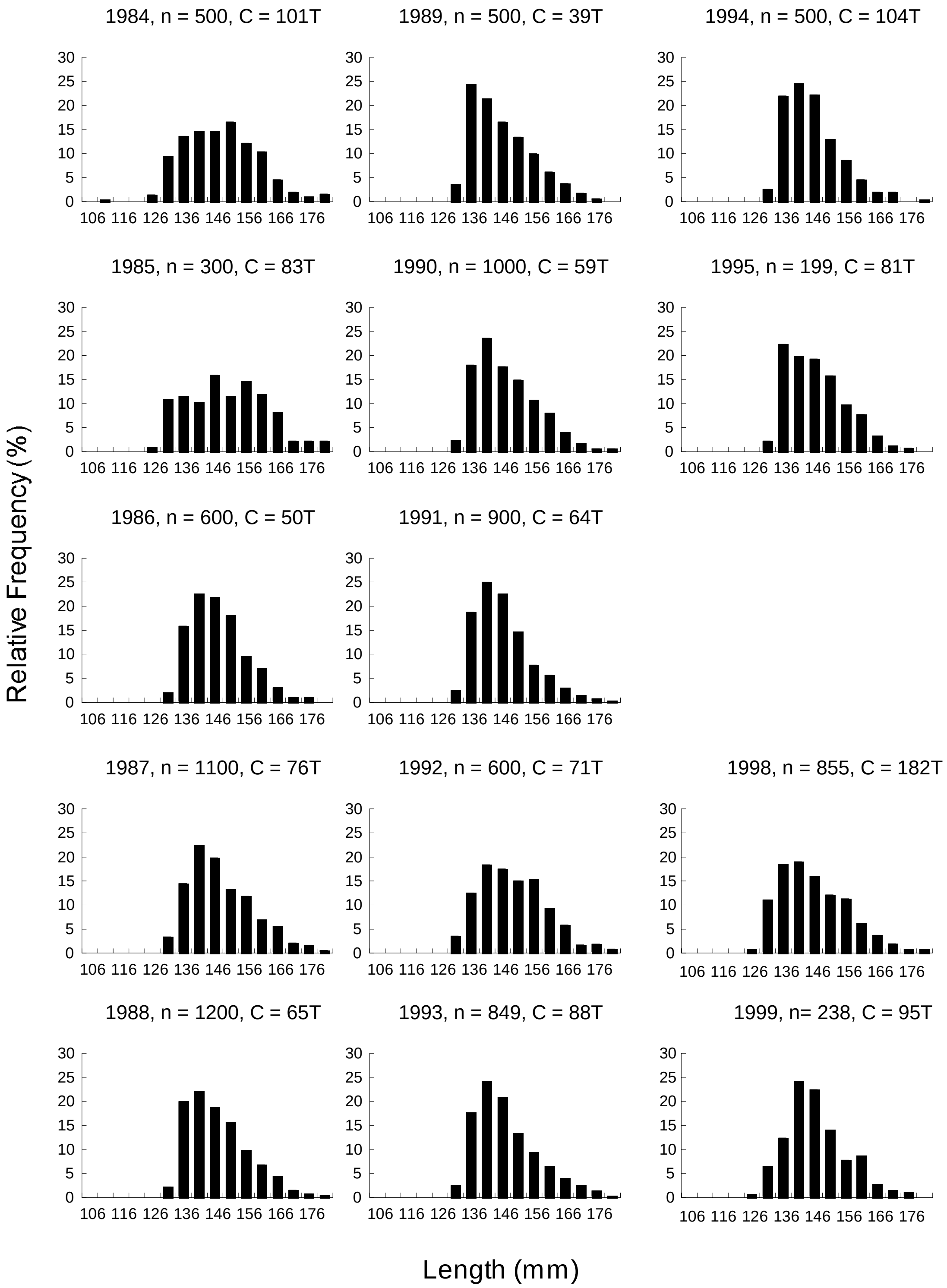

Fig. 21. Size-composition of the commercial catch from statistical block 27. Samples were measured at processing factories from 1984-1995 and supplied by divers in 1998-99. The number of abalone sampled (n) and the annual catch in tonnes (C) is given for each year.

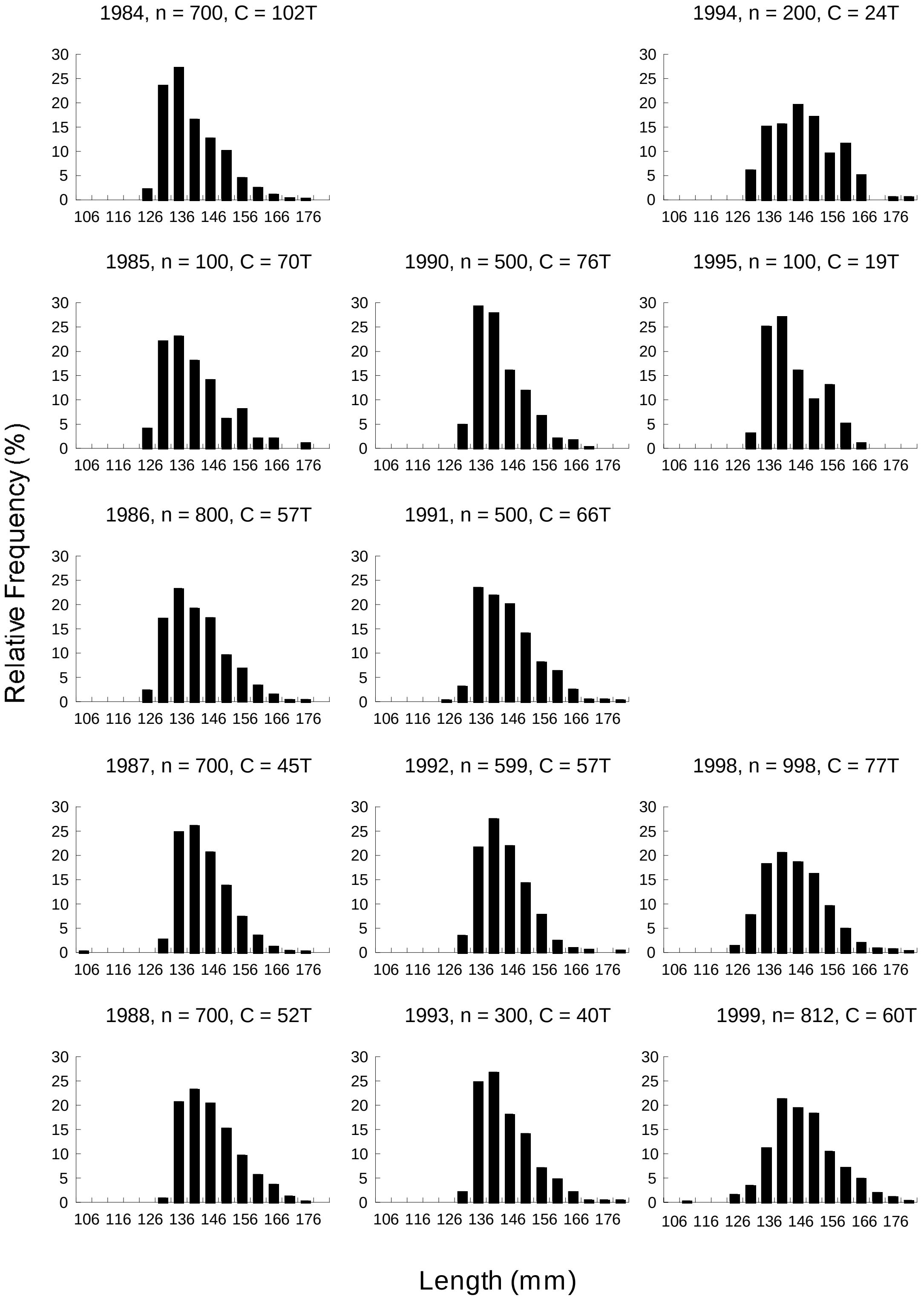

Fig. 22. Size-composition of the commercial catch from statistical block 28. Samples were measured at processing factories from 1984-1995 and supplied by divers in 1998-99. The number of abalone sampled (n) and the annual catch in tonnes (C) is given for each year.

Sampling from the west coast has been poor but the few samples collected from Block 12 suggest that about 50% of abalone measured at least 160 mm. An analysis of production data provided by Tasmanian Seafoods Pty. Ltd. strengthens this conclusion. These data analyse the proportion of production of cans containing one whole abalone or one abalone cut so as to fit it within a can. Such abalone would have a minimum length of 160 mm given the minimum bled meat weight within a can of 213 g, known rates of weight loss during processing (A. Hansen, pers. comm.) and bleeding (Nash, 1995b), and known length-weight relationships (Nash *et al*., 1994).

Overall production from fish sourced in all areas showed an increase from 1995 to 1999 of product canned one piece whole and larger (Table 1). There was some reduction in this percentage from 1997 to 1998, and an increase to 1999, corresponding with a shift in relative size of the catch from the east and west coasts during that period (Table 1).

Table 1. Production of large abalone from one Tasmanian Processor

Details from the total production July 1995 to December 1999, of all grades of abalone product canned by Tasmanian Seafoods (Margate), showing the percentage of cans produced containing one abalone, or one cut abalone.

Year	Month	One piece whole as % of production
1995	July-December	15%
1995	**Total**	**15%**
1996	January-June	19%
1996	July-December	14%
1996	**Total**	**16%**
1997	January-June	26%
1997	July-December	17%
1997	**Total**	**21%**
1998	January-June	17%
1998	July-September	16%
1998	**Total**	**16%**
1999	January-June	24%
1999	July-September	21%
1999	**Total**	**23%**

When catches from the west coast are analysed exclusively the proportion of very large abalone on the west coast becomes more apparent. These data show that 50% of the west coast abalone production was canned one piece whole in 1999, up 5% from the previous year, indicating an increase in the average weight of abalone (Table 2).

Table 2. Tasmanian Seafoods Pty Ltd size distribution data

Details the daily production of cans containing one (or one cut) abalone, as a percentage of all grades of abalone product canned by Tasmanian Seafoods Pty Ltd (Margate). On the days listed abalone caught on the west coast were processed exclusively.

Date	One piece whole as % of production
30-Jan-97	52%
2-Feb-97	45%
3-Feb-97	54%
4-Feb-97	57%
25-Mar-97	56%
9-Jul-97	52%
10-Jul-97	44%
1997 total	**51%**
13-Mar-98	36%
14-Mar-98	64%
18-Mar-98	33%
26-Apr-98	40%
8-May-98	38%
9-May-98	49%
18-May-98	60%
19-May-98	36%
20-May-98	60%
27-May-98	67%
22-Jul-98	45%
29-Jul-98	36%
5-Aug-98	47%
10-Aug-98	46%
19-Aug-98	46%
20-Aug-98	51%
21-Aug-98	49%
14-Oct-98	37%
15-Oct-98	45%
16-Oct-98	24%
7-Nov-98	51%
17-Nov-98	39%
25-Nov-98	46%
26-Nov-98	43%
1998 total	**42%**

Table 2 (continued)

Date	One piece whole as % of production
25-Feb-99	62%
26-Feb-99	53%
27-Feb-99	55%
2-Mar-99	70%
4-Mar-99	53%
5-Mar-99	44%
6-Mar-99	43%
8-Mar-99	66%
26-Apr-99	48%
27-Apr-99	34%
4-May-99	42%
24-May-99	60%
26-May-99	44%
7-Jun-99	80%
21-Jun-99	53%
1-Jul-99	44%
12-Jul-99	44%
13-Jul-99	48%
14-Jul-99	43%
16-Jul-99	47%
19-Jul-99	47%
20-Jul-99	59%
17-Sep-99	30%
24-Sep-99	52%
30-Sep-99	47%
1-Oct-99	48%
9-Oct-99	42%
18-Oct-99	38%
5-Nov-99	40%
6-Nov-99	43%
8-Nov-99	48%
9-Nov-99	54%
10-Nov-99	54%
22-Nov-99	55%
1-Dec-99	75%
2-Dec-99	44%
17-Dec-99	64%
1999 total	**50%**

6.3.2 Recreational fishery

The number of recreational abalone licences increased from about 4200 in 1995-96 to about 5800 in 1998-99, a rate of increase of about 10% per annum. Surveys of recreational fishing undertaken by the Department of Primary Industry and Fisheries suggest the recreational abalone harvest in 1997 was approximately 37.5 tonnes (about 1.5 percent of the commercial harvest) (Lyle, 2000). The distribution and magnitude of the recreational abalone catch in 1997 is shown in Fig. 23. These data suggest that the recreational fishery focuses on blacklip abalone and that 70% of the recreational catch comes from the south-east and east coast. The highest estimated recreational catch was in the north-west (5 % of the commercial catch). This percentage appears high not because the recreational catch itself was large, but because of the decline in the commercial catch from this region (Fig. 23).

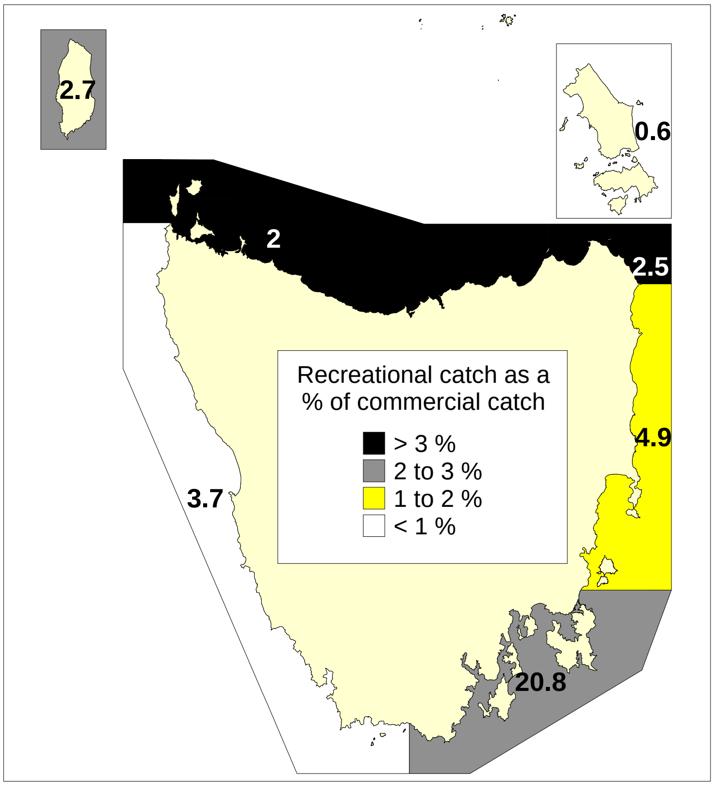

Fig. 23. The 1997 recreational catch in tonnes and as a percentage of the commercial catch for the seven regions used in surveys of recreational fishing in Tasmania (Lyle, 2000). Numbers indicate the catch in tonnes, shading indicates the value of these tonnages as a percentage of the commercial catch from each region. Regional boundaries are adjusted from those normally used in abalone assessment to better reflect the boundaries used in recreational fishing surveys.

Surveys of recreational fishing in Tasmanian suggest that the recreational catch of greenlip abalone is relatively small (Fig. 23) (Lyle, 2000). These data suggest that the recreational fishery in the two main greenlip abalone producing areas (King Island and the Furneaux Group) yielded 2.6 and 0.5 tonnes respectively in 1997.

7. Discussion

7.1 Comparison of catch and catch-rates with those from reference periods

This assessment provides a more informative approach to the comparison of catch and catch-rates with those from earlier key periods in the history of the fishery, than the earlier method that relied on firing of fixed trigger points to initiate the review process.

The first historical period (1979-82) featured unrestrained catches, and conversely during the second period (1992-95), catches were subject to their highest level of constraint. It follows that current catches, where levels are fixed at an intermediate level between the two, should generally appear at an intermediate position in charts, particularly those comparing blacklip catch (Fig. 2, Fig. 4). In particular, the comparison highlights the continuing shift in catch and effort to the South East, and of the decline in blacklip catch from King Island, the North West, West and South-West and North East.

Statewide, blacklip abalone catches have increased 23% on the 1992-95 average. This increase is due both to an increase in the State TAC and a capped catch of greenlip abalone in 1999, which shifted effort back onto the blacklip fishery. Note that the 1999 blacklip catch is considerably less (24%) than the 1979-82 catch (Fig. 2).

On King Island, blacklip catches are much reduced (Fig. 2, Fig. 8). This is partly due to a 5mm increase in size limit in 1987. The current size-limit is large compared with the average size of the blacklip stocks here and has made the blacklip fishery less attractive than areas with larger abalone. Additionally, there are no longer abalone divers resident on the Island. Abalone fishing that takes place is now undertaken by visiting divers, who go there with the express purpose of catching greenlip abalone. Until the closure of the greenlip fishery in November 1999, blacklip abalone was generally by-catch of greenlip fishing operations. Only after that date were blacklip abalone targeted, when one diver landed several tonnes. Catch-rates are generally down against the later reference period, but because they are derived mostly from greenlip catches, provide no information about blacklip catch-rates (Fig. 3). Around King Island there has been an almost complete shift in effort from blacklip to greenlip fishing. The decline of the blacklip fishery on King Island is due to the decrease in fishable biomass and catch-rates from the increase in size-limit in 1987 from 127 to 132 mm, and to strong market demand for greenlip abalone. Furthermore, prior to this period no significant targeted fishery for greenlip abalone existed and a substantial proportion of the greenlip catch was probably reported as blacklip abalone.

On the northern part of the West Coast, catches are down against the two reference periods, significantly so in the case of the first reference period. Catch-rates for the region are high though (140 kg/hr), and the lower annual catch is due to a shift in effort out of the region. For various reasons unconnected with abalone fishing, the number of divers living in this area has decreased. Divers living elsewhere are put off by the distances travelled, poor boat ramps and lack of accommodation.

Further south on the West Coast and along the South Coast, catch-rates are the highest recorded in the fishery. The catch is considerably less than that from the earliest reference period, when annual catches from this sector approached 1600 tonnes. The 1999 catch is greater than that from 1992-95 and reflects increases in TAC.

The size of the catch in the South East and East Coast is of concern. The size of the catch in both regions is similar to that of 1979-82, but much higher (approaching 70%) than 1992-95. It was noted in recent stock assessments that effort was progressively being transferred from the north and west of the State to the East Coast and South East. In part this is due to demographic changes (particularly a shift from country to city living) of divers. It can also be attributed to a preference for smaller abalone by processors, the proximity of the eastern and south-eastern regions to live-fish exporters, the difficulty of fishing more remote areas of the west and north and the prevalence of more suitable diving conditions in the east and south.

In 1998, the East Coast showed both rising catches and catch-rates, from which it could be concluded that fishable biomass was increasing. In 1999, catches dropped on the East Coast. This fall may be more closely associated with other factors such as the availability of motherships and weather conditions for fishing in the west of the State, instead of change in abundance in the east. For example, the halving of annual catch in Block 27 between 1998 and 1999 is closely associated with the rise to prominence of the live-fish market. Most live-fish buyers operate around Hobart, close to the airport, and blacklip effort has shifted to adjacent blocks in the South East, where there is also an abundance of small abalone favoured by that market.

The fall in catch from the East Coast in 1999 was compensated by rises in catch from the West and South-West, and to a lesser extent, the South East. Tasmanian Seafoods Pty Ltd's records reflect the increase in west coast catch in 1999 (Table 1).

Catch-rates also dropped on the East Coast in 1999. There was general agreement among divers that abalone could not be caught here at the same high levels of previous years. The decline in catch-rates in most East Coast blocks follows a meteoric rise in catch between 1995 and 1998. In recent years, catch in two of the more significant blocks doubled: over two years in Block 24 and one year in Block 27. Divers worked in areas that had been fished infrequently in earlier years, at high catch-rates. Eventually these areas were fished regularly, and the high catch-rates tapered off as abalone numbers decreased. There is however, little suggestion that the fall in abundance is cause for concern. Size composition data shows that the distribution of length classes remains stable, and suggests that recruitment decline is unlikely.

In the South East, catches have fluctuated at high levels for the past six years, at relatively stable catch-rates. The decline in catch from Block 14 is enigmatic. Part of the decline is due to mis-reporting of block numbers (i.e. divers think that they are working in Block 13 when they are actually in Block 14). Effort (and catch) has increased in neighbouring Block 13, so the shift out of Block 14 may be due to divers working more productive reefs between Southport and Whale Head.

Assessment of greenlip abalone stocks is complicated by recent changes to the way in which the fishery is regulated. The response by divers to these changes means that catch and catch-rates reflect a variety of factors in addition to abalone abundance. Catch-rates in this fishery continue to decline, attributable to increased size-limits in all areas, which has decreased the amount of legal-sized abalone. Localised closures have shifted effort into areas in which divers would not normally work, where they feel compelled to stay and fish at marginal catch-rates. Market demand and increases in the beach price mean that divers can fish profitably at lower catch-rates than earlier years.

Correlating changes in catch and catch-rate with abundance may prove erroneous when there are reasons for shifts of effort between blocks not directly associated with fishing. Divers are reluctant to travel long distances to fish in remote areas, when they can catch their quota (albeit at lower catch-rates) locally. During the early 1990's, only six divers were listed with residential post-codes in the North East and East Coast, and between 1989 and 1992, catches were at their lowest levels here (Fig. 6A). Following an increase in the number of divers living in the area, annual catches have risen substantially.

Catch-rates are widely perceived as being insensitive to abalone abundance because of the aggregating behaviour of abalone and the fishing behaviour of abalone divers. The inaccuracy in the relationship between catch-rates and abalone abundance is the principal reason for the uncertainty in this assessment. Abalone tend to move (aggregate) to preferred habitat, and divers target these aggregations. Divers maintain high catch-rates by moving from aggregation to aggregation, and it is only when there are very small numbers of abalone remaining (too few to reform aggregations) that catch-rates show a marked decline.

Similarly, when catch and effort on the stock declines, catch-rates may increase because the abalone have more time between fishing events to aggregate. In such cases catch-rates may increase not necessarily due to an increase in abundance, but because the abalone are more easily caught in aggregations.

Increases in catch-rate may reflect increases in fishing power. Since the start of the fishery, divers have improved harvesting techniques, yet the method by which effort is determined has remained static. The interpretation of trends in catch-rate is confounded by improvement in the efficiency of divers (fishing power). It is likely that fishing power has continued to increase in the past 10 to 15 years. Most divers now use lines from the bottom to the boat to board their catches, instead of swimming to the surface with each net as it fills. This undoubtedly saves time, and enables divers to spend a greater proportion of time underwater catching abalone, thus increasing their fishing power. Recently too, divers have made been made more aware of safe diving practises through the diver training program run by the Tasmanian Abalone Council. They are now more conscious of time spent underwater, and either by the use of dive-tables or dive-computers, record their dive-time more accurately. Before the widespread use of dive-computers, effort often included the time spent travelling to and from the fishing ground. If effort had been recorded more carefully in the past, catch-rates would be higher and perhaps the difference between past and current catch-rates would be less. The marginal increases in 1999 catch-rates over those from the 1992-95 reference period in the South East may just reflect changes in fishing power, rather than increases in abundance (Fig. 3).

If, as some abalone divers have stated, divers' fishing power continues to improve, then the catch-rate trends may be optimistic with respect to changes in abundance. Thus, for example, a 20 percent increase in catch-rate would overestimate the increase in fishable biomass if there has been an increase in fishing power over the same period of time.

Standardisation of catch-rates for increasing diver efficiency (fishing power), or for other factors such as depth or diver experience, has yet to be done. It should be noted, however, that standardisation of fishing effort can only partially improve the relationship between catch-rate and abundance.

The stock assessment report of 1997/98 drew attention to the difficulty of correlating catch information with abalone abundance, and the need for an adequate index of abundance, and ideally a population model (Officer, 1999b). However, the present lack of such an indicator does not preclude the introduction of other performance indicators. These could include performance indicators that examine changes in size at maturity, proportion of stock in various size classes, and the productivity of other species that share abalone habitat. The high degree of variability in these parameters between locations would make a general application of these indicators difficult. A more appropriate evaluation could be achieved by the routine re-examination of these parameters at fixed sites. This approach would demand that the sites sampled are numerous and representative of important fishing areas. The present program of population surveys at the Tasmanian Aquaculture and Fisheries Institute is being adapted to achieve these objectives.

Fishery independent abundance estimation also holds promise as a better indicator of biomass change. It is proposed that a modified transect method, such as that suggested in Victoria, be tested in Tasmania. The new approach would provide all the information available from previous strip transect methods as well as additional information describing the spatial distribution of abalone. The efficacy of the proposed method would be tested by comparing it with other methods of estimating abundance. Temporal comparison of the spatial distribution of abalone aggregations and their density may provide another measure of the resilience of abalone populations to fishing.

7.2 Recreational catch

The recreational catch of abalone reported continues to represent a very minor proportion of the commercial catch. At such levels there is little danger of the recreational catch impacting upon the commercial fishery. However, this does not mean that the recreational catch should be disregarded. It was noted above that the number of recreational abalone fishing licenses is increasing at about 10% per annum, and whilst the recreational catch is small overall it is likely to be significant in areas that are close to population centres. Recreational divers are also more likely to continue taking abalone from reefs where the abundance would be insufficient to maintain acceptable commercial catch-rates. For these reasons the level of the recreational catch should continue to be monitored.

7.3 Implications for Management

This is the last assessment of the fishery prior to zoning. In future, the establishment of geographic zones and partitioning of the greenlip fishery from the blacklip fishery will inhibit the uncontrolled concentration of effort seen in recent years.

Zoning will make the current focus of assessment techniques that are dependent of catch information less reliable. It will bring changes to the way that divers operate, so that comparisons with the past under different catching conditions will have less meaning. These comparisons are most effective under a stable operating environment, and become ineffective when factors such as fishing power, market forces, regional closures and changes in size-limit have a greater effect on catch and catch-rates than stock abundance. The change in catch on the west coast will provide a one off massive perturbation that will be useful in assessing the relationship between CPUE and abundance.

The shift in catch away from northern areas and the west coast has been so marked that these areas could now be considered under-exploited when present catches are compared with those sustained in the past. The previous stock assessment report highlighted the low catch levels here, and work is currently under way at TAFI to determine an appropriate catch in the north of the State.

The status of the greenlip fishery remains clouded. Management controls introduced over the past two years and the response of divers to them make it difficult to interpret catch information. Several years of catch data under stable management and fishing conditions are required before they can provide useful information to managers. There is an urgent need to develop alternative abundance assessment techniques in this fishery.

7.4 Recommendations For Future Assessments

- Develop alternative means of fishery independent abundance estimation,
- Incorporate alternative biologically-based performance indicators,
- Construct a population model of the Tasmanian abalone fishery,
- Analyse catch and effort data on a finer spatial scale, and standardise data for increase in fishing power.
- Explore and develop alternative means of gathering representative size-composition data from the fishery.

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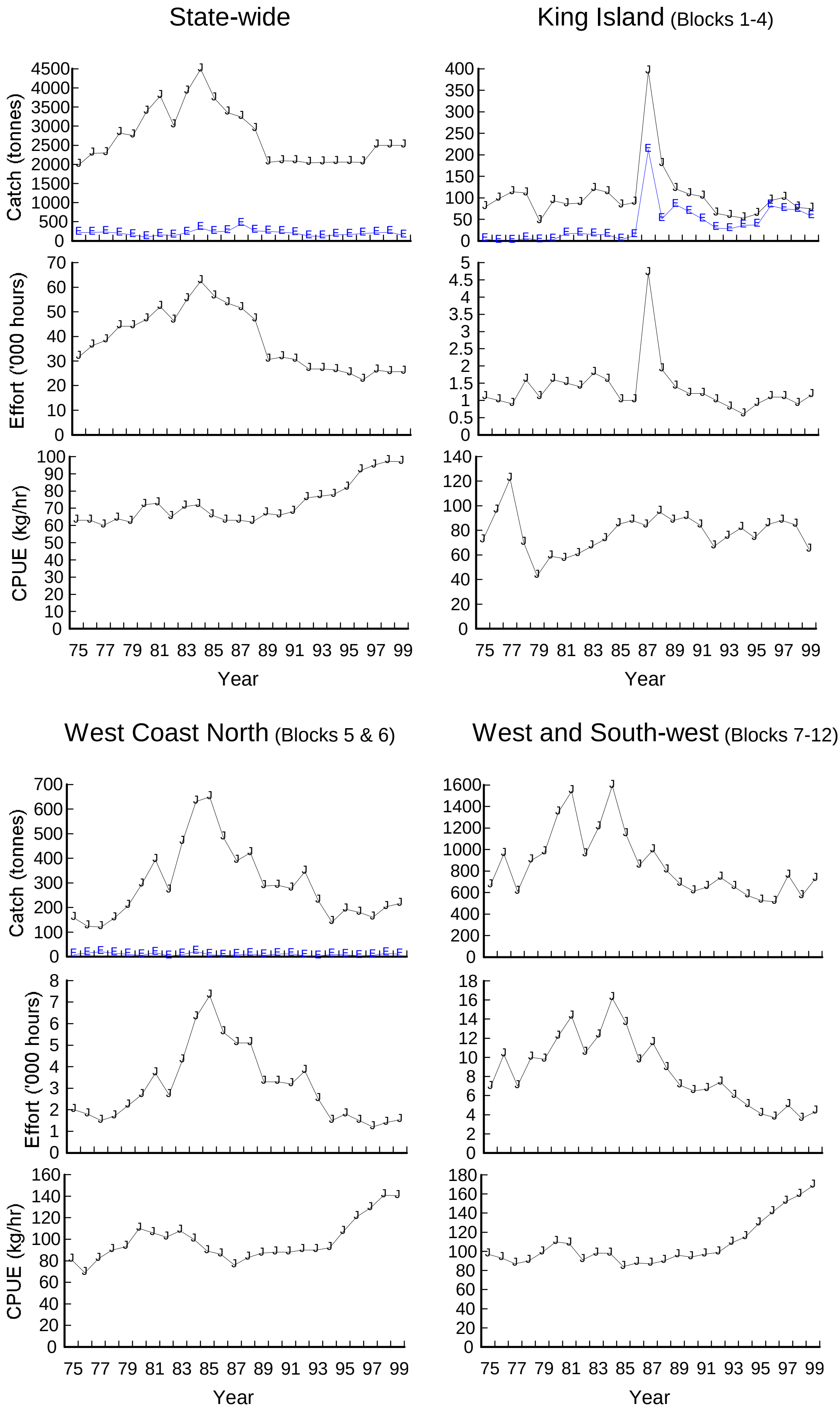
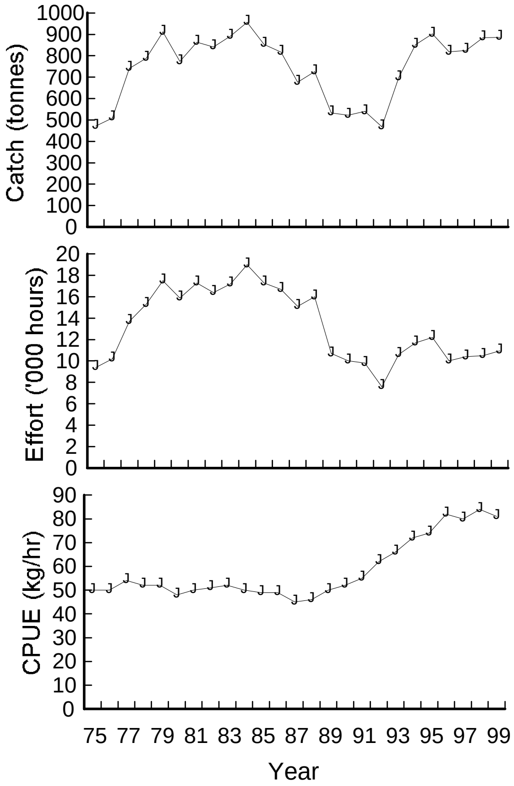
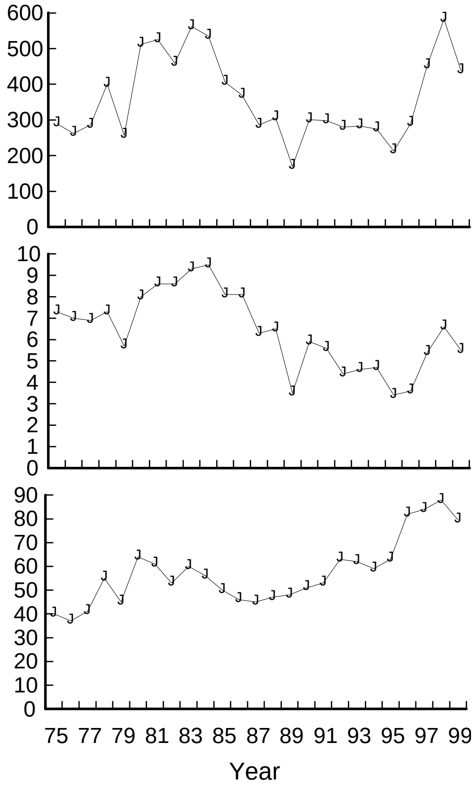


Appendix 1. Total abalone catch, effort and catch-rate (CPUE) by region and year. Greenlip catch is plotted (○) where it is an important part of the total catch.

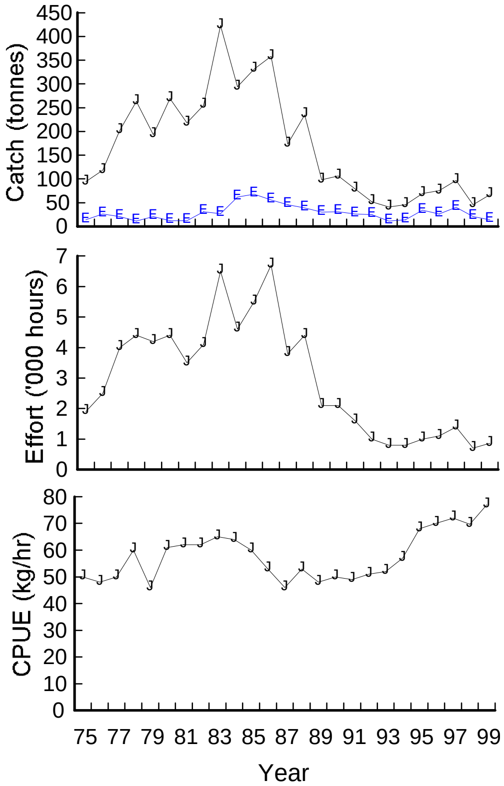
South East (Blocks 13-21)



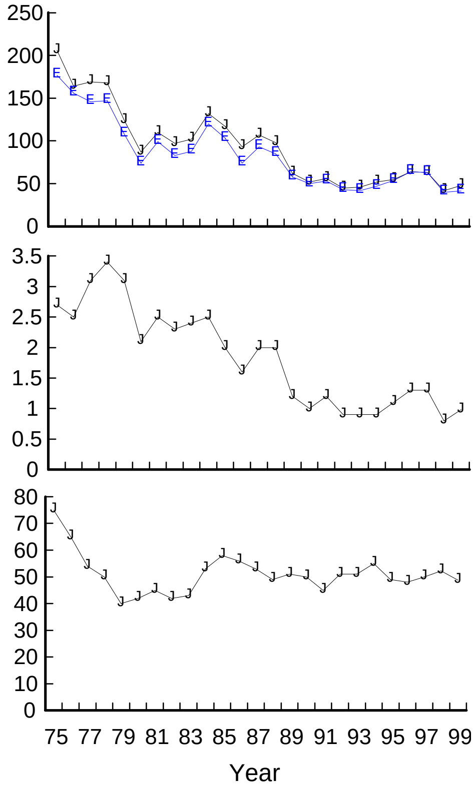
East Coast (Blocks 22-29)



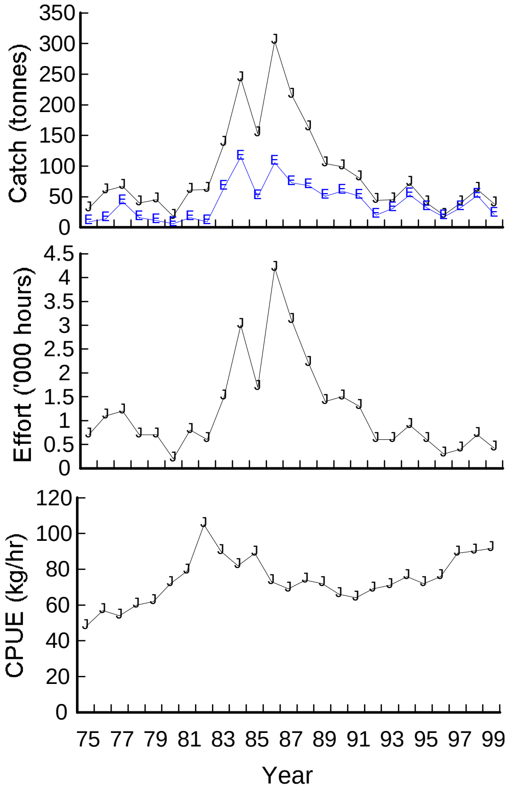
North East (Blocks 30, 31, 39 & 40)

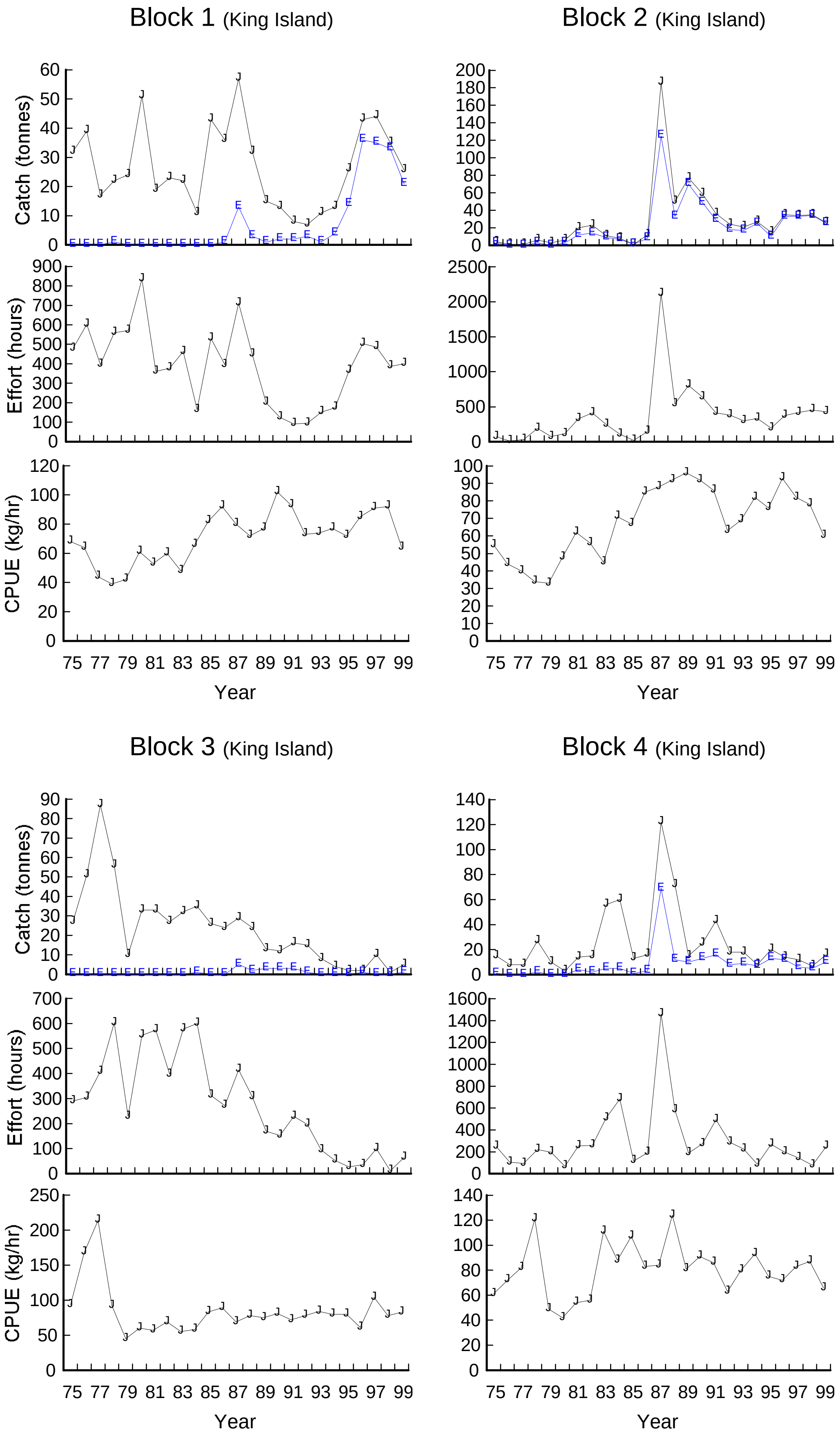


Furneaux Group (Blocks 32-38)



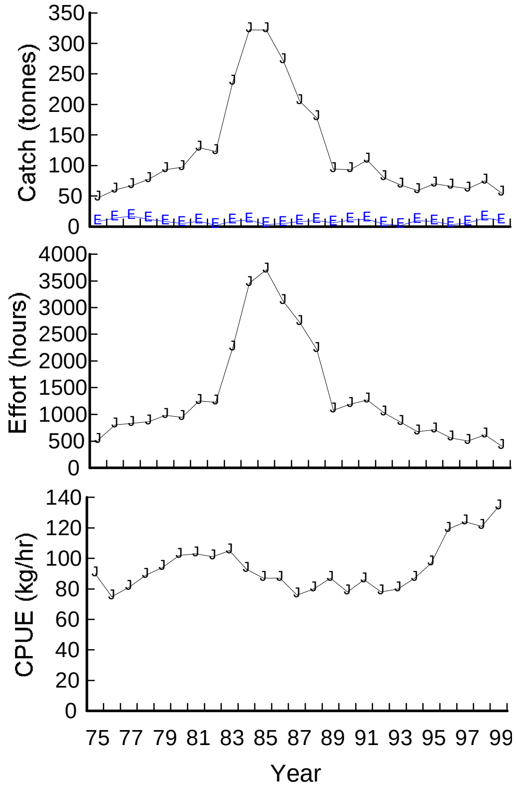
North West (Blocks 47-49)



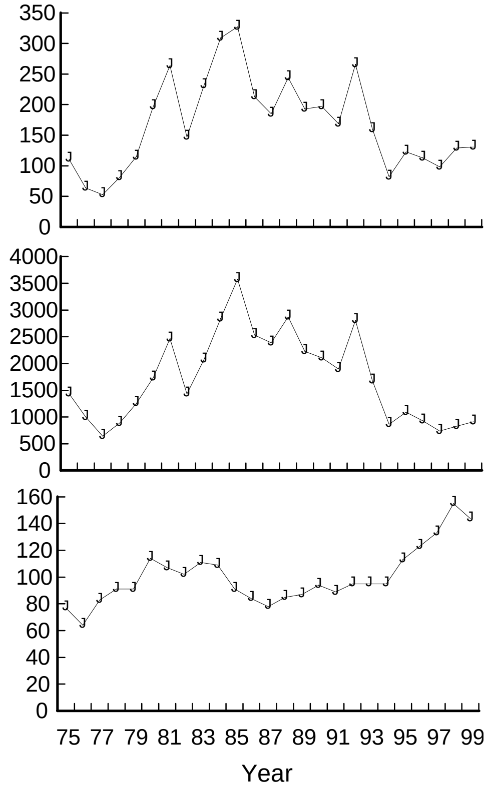


Appendix 2. Total abalone catch, effort and catch-rate (CPUE) by block and year. Greenlip catch is plotted (○) where it is an important part of the total catch.

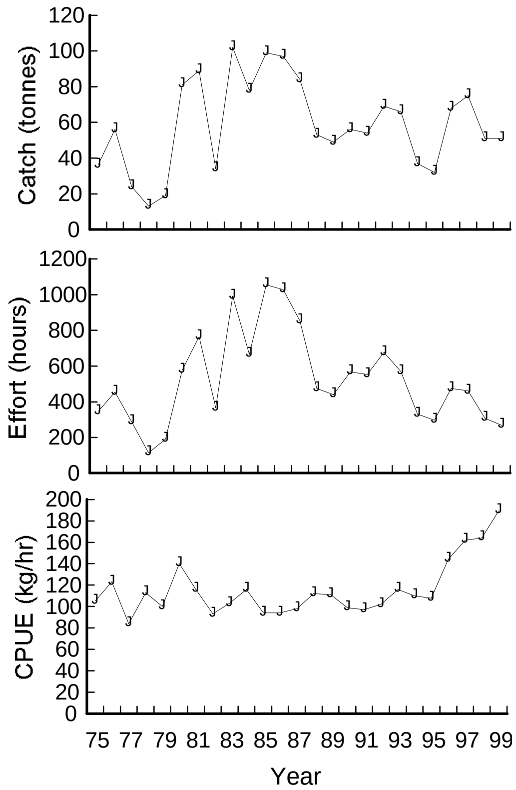
Block 5 (West Coast North)



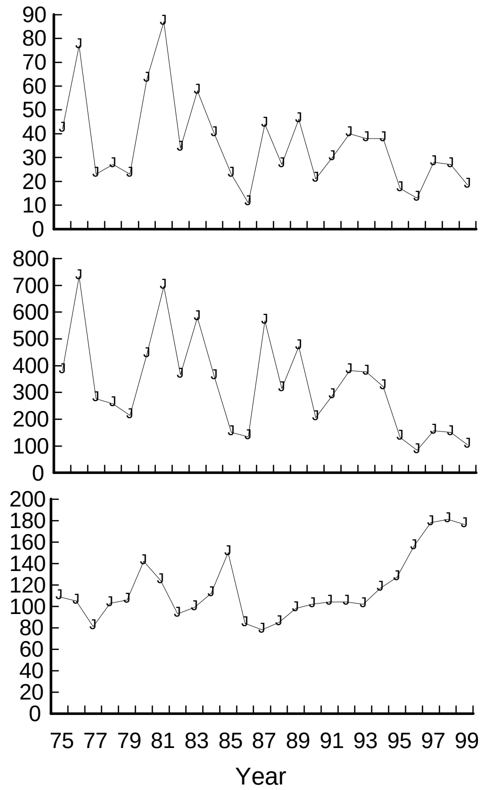
Block 6 (West Coast North)



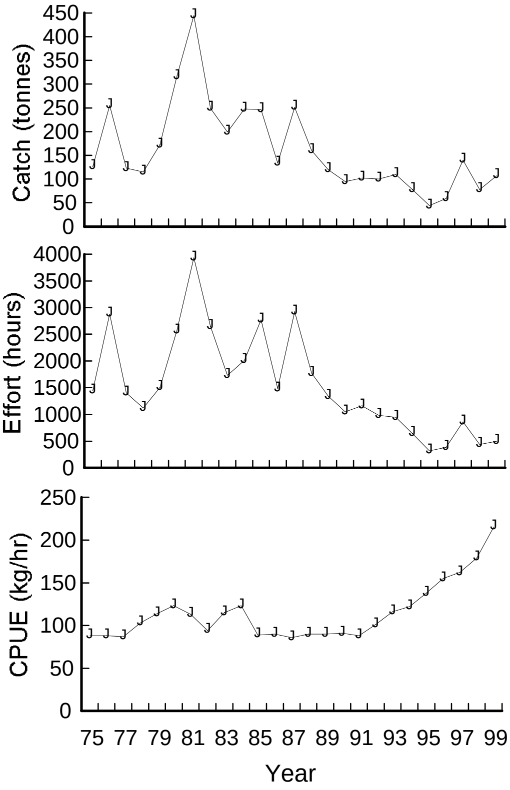
Block 7 (West & South-west)



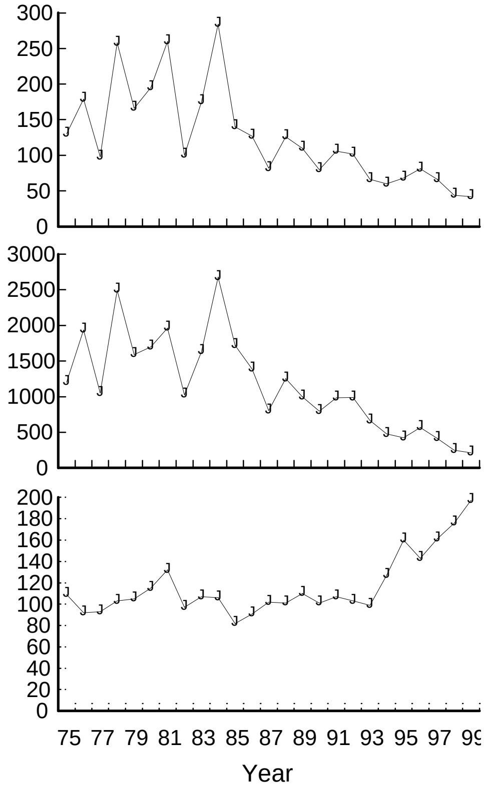
Block 8 (West & South-west)



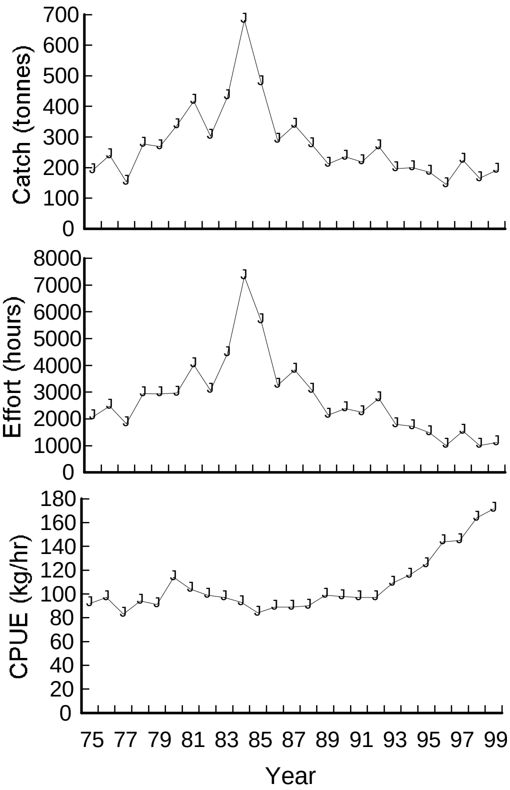
Block 9 (West & South-west)



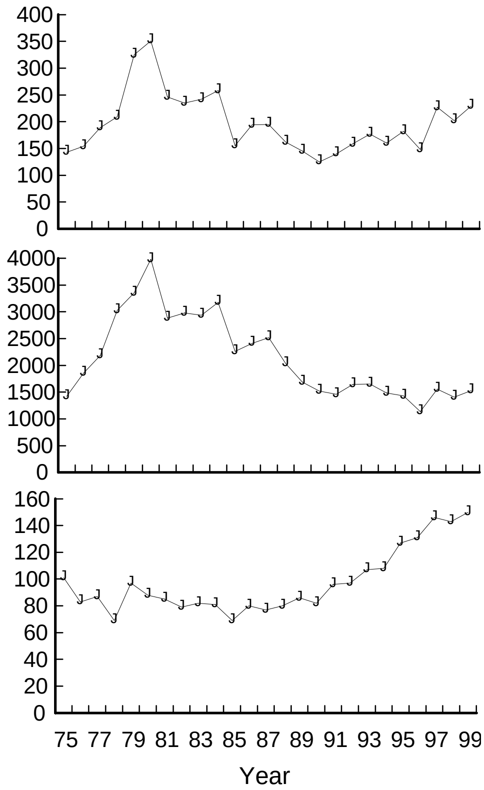
Block 10 (West & South-west)



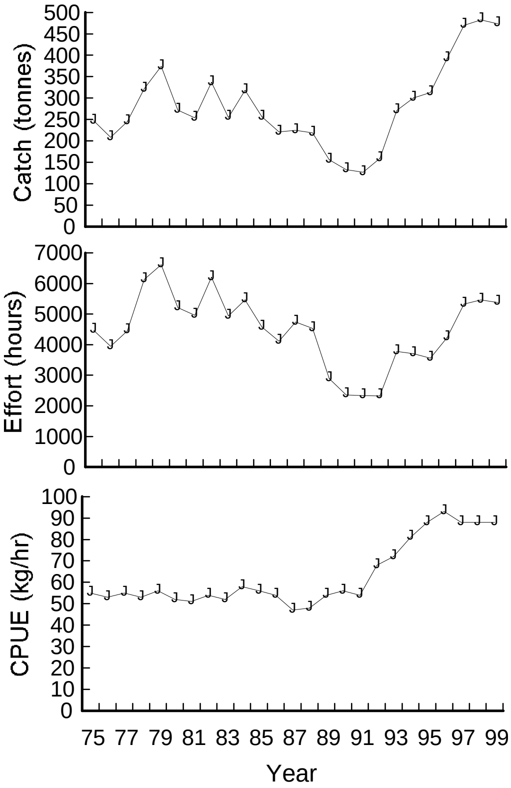
Block 11 (West & South-west)



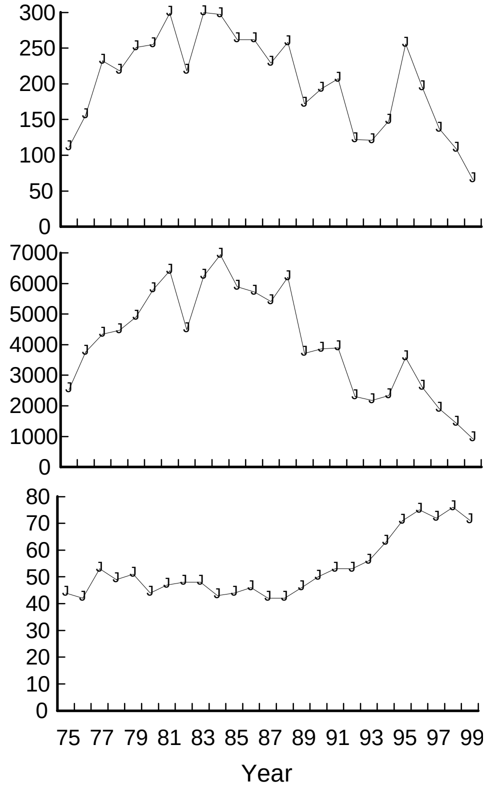
Block 12 (West & South-west)



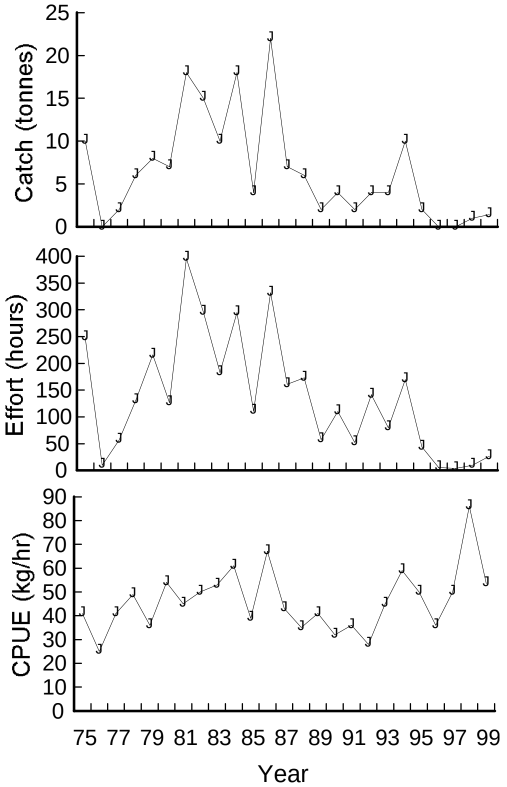
Block 13 (South East)



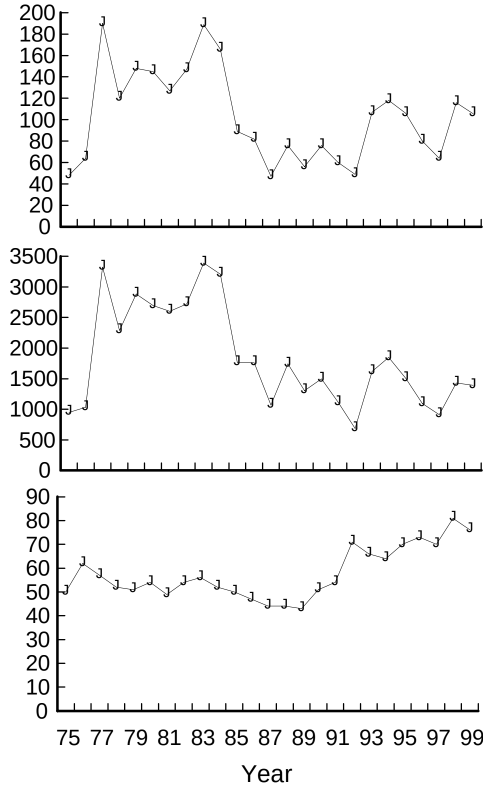
Block 14 (South East)



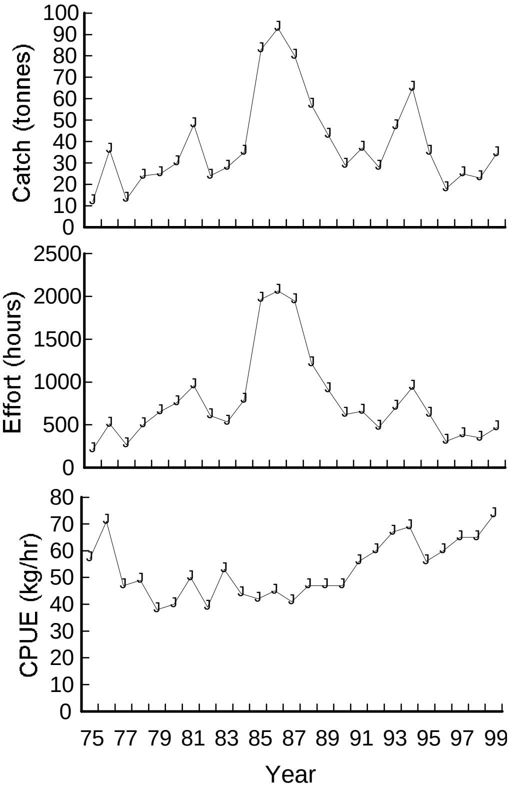
Block 15 (South East)



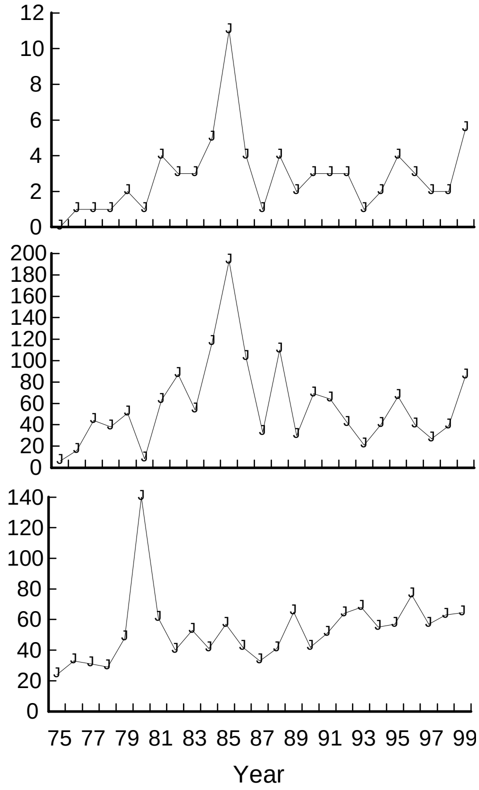
Block 16 (South East)



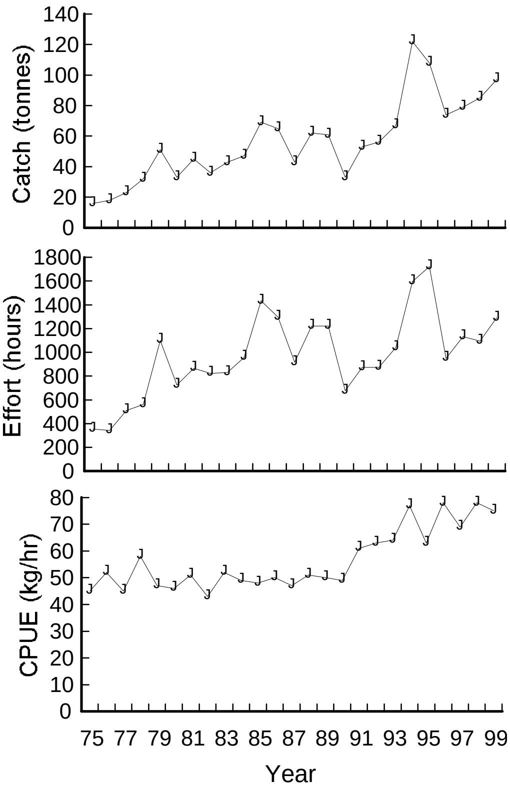
Block 17 (South East)



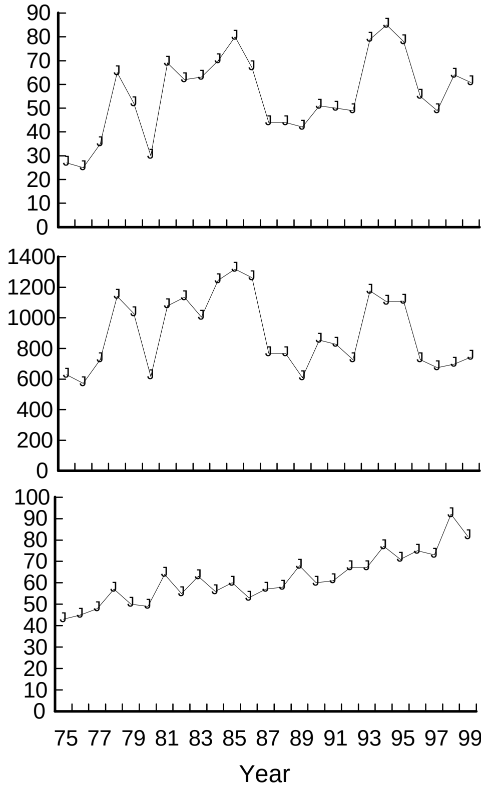
Block 19 (South East)



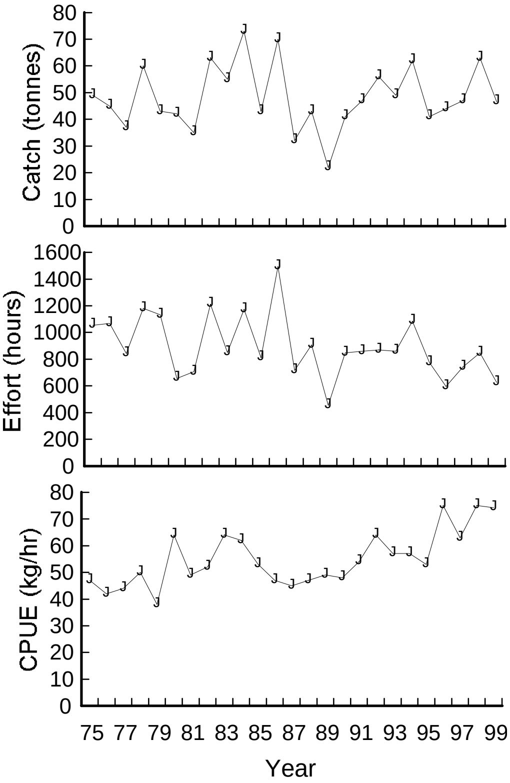
Block 20 (South East)



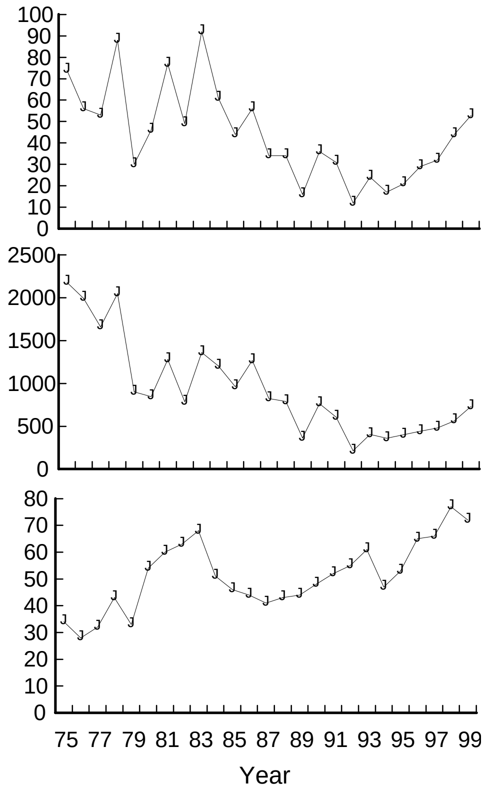
Block 21 (South East)



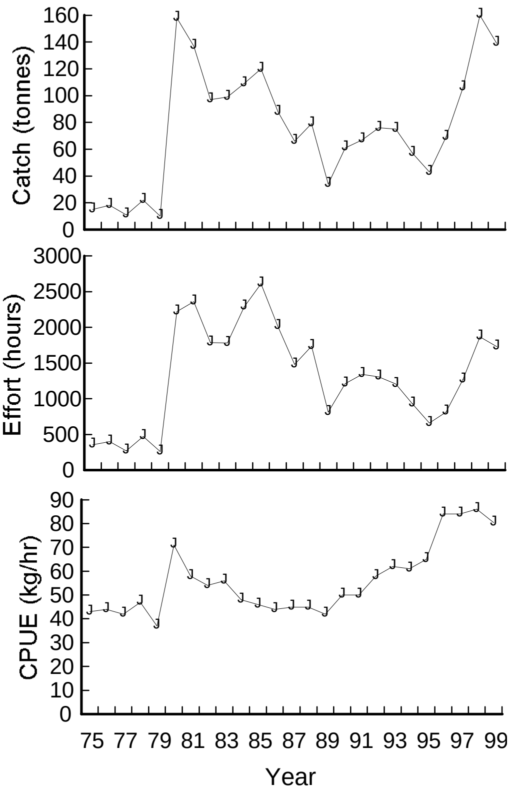
Block 22 (East Coast)



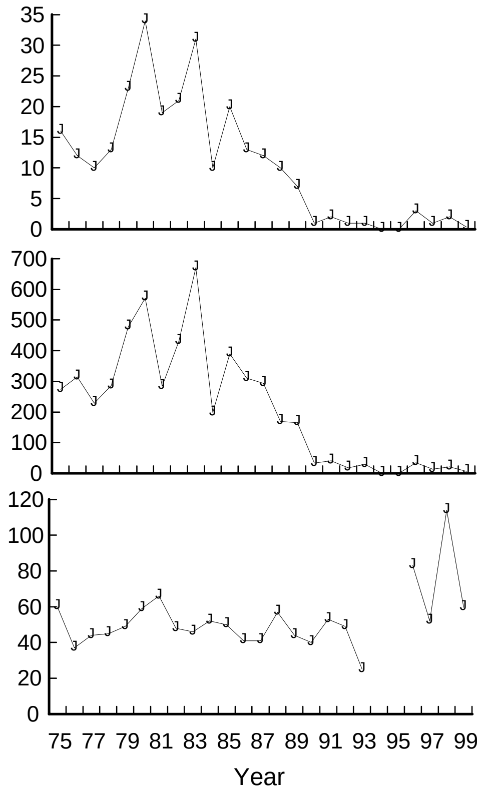
Block 23 (East Coast)

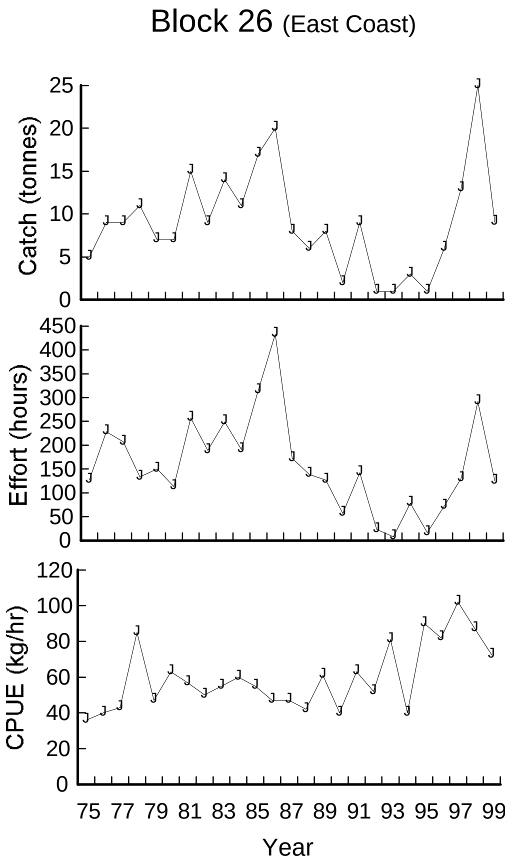


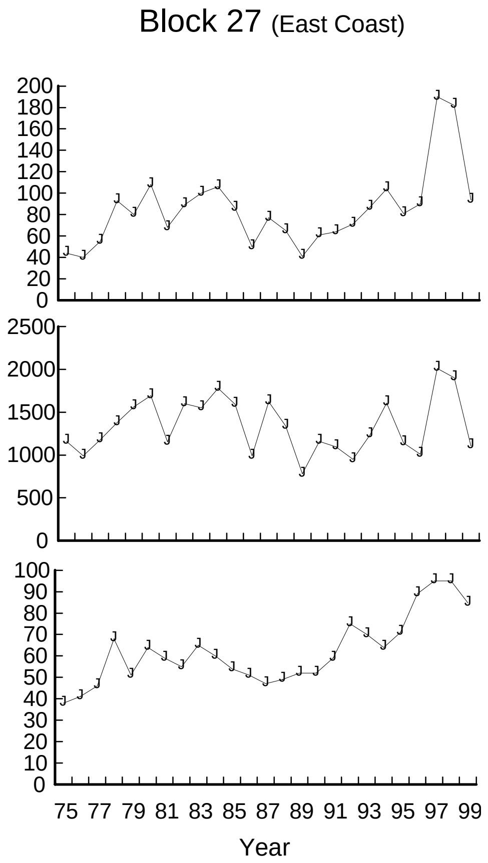
Block 24 (East Coast)

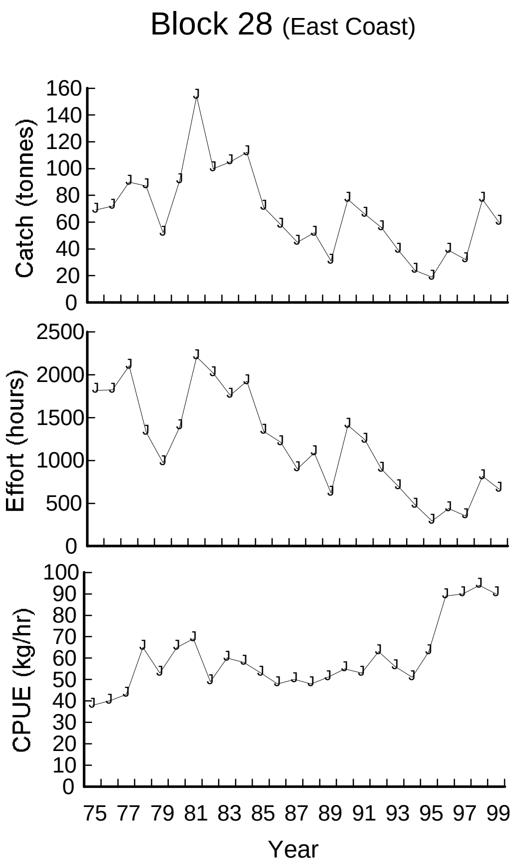


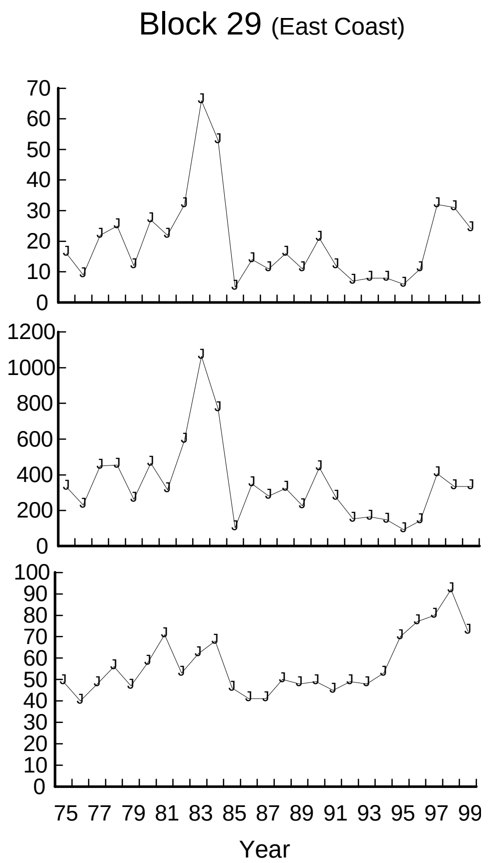
Block 25 (East Coast)

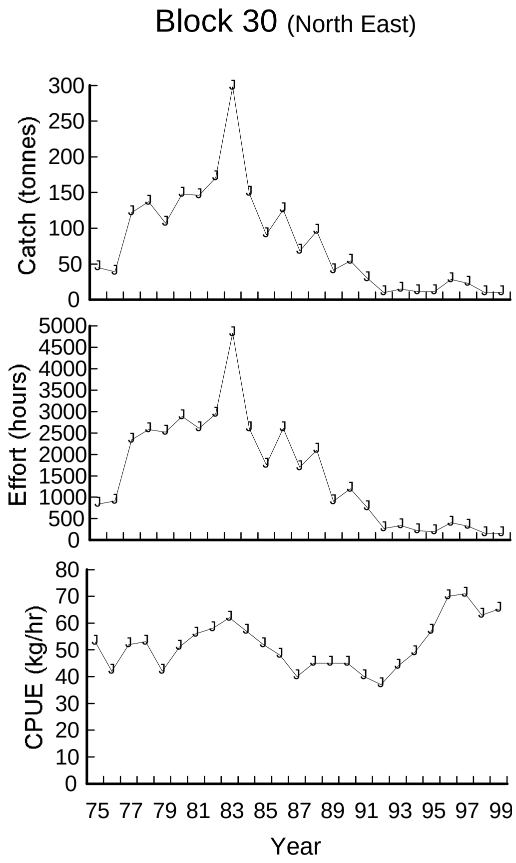


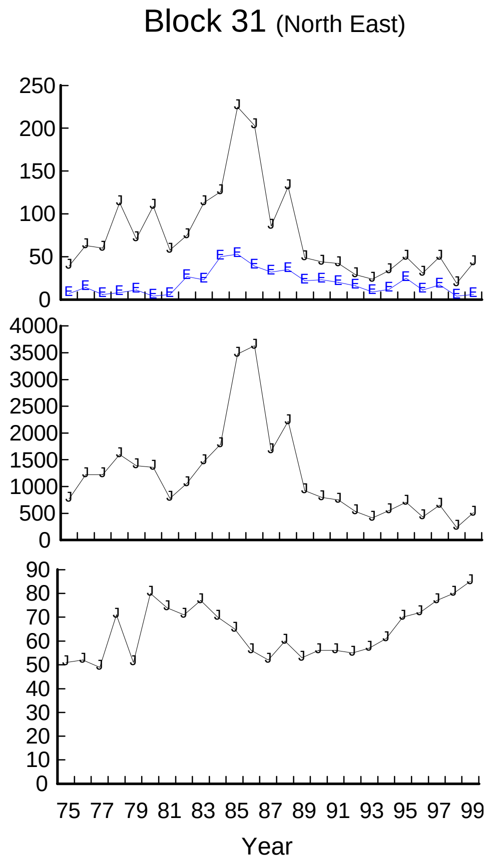

Block 26 (East Coast)
Catch (tonnes)
Effort (hours)
CPUE (kg/hr)
75 77 79 81 83 85 87 89 91 93 95 97 99
Year

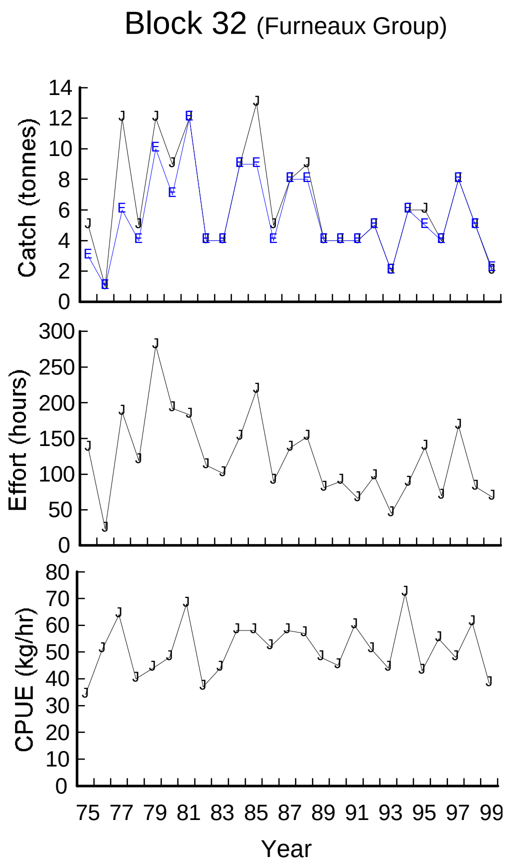

Block 27 (East Coast)
75 77 79 81 83 85 87 89 91 93 95 97 99
Year

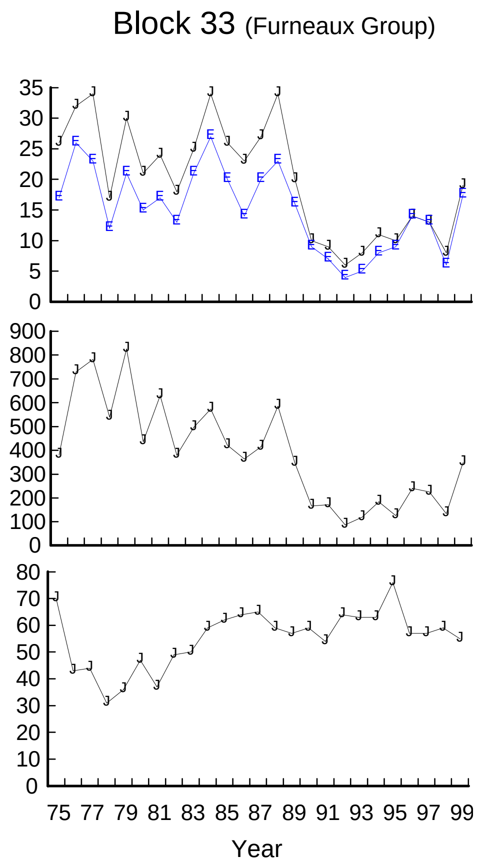

Block 28 (East Coast)
Catch (tonnes)
Effort (hours)
CPUE (kg/hr)
75 77 79 81 83 85 87 89 91 93 95 97 99
Year


Block 29 (East Coast)
75 77 79 81 83 85 87 89 91 93 95 97 99
Year

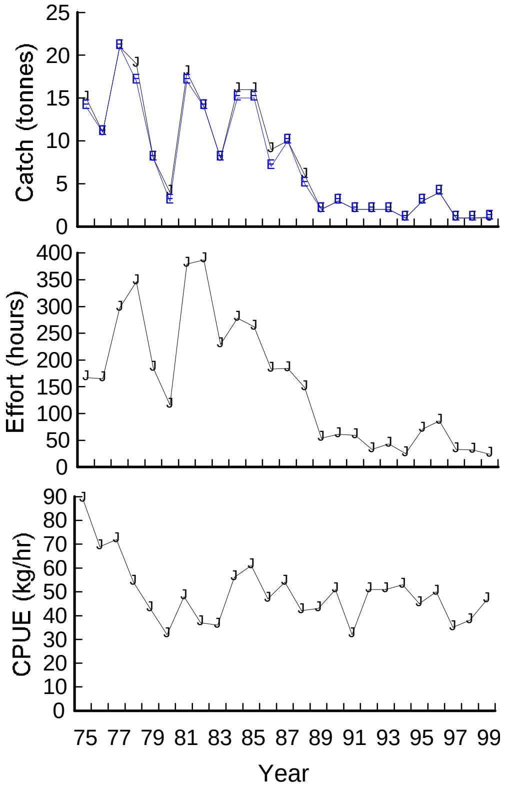

Block 30 (North East)
Catch (tonnes)
Effort (hours)
CPUE (kg/hr)
Year
75 77 79 81 83 85 87 89 91 93 95 97 99


Block 31 (North East)
Year
75 77 79 81 83 85 87 89 91 93 95 97 99

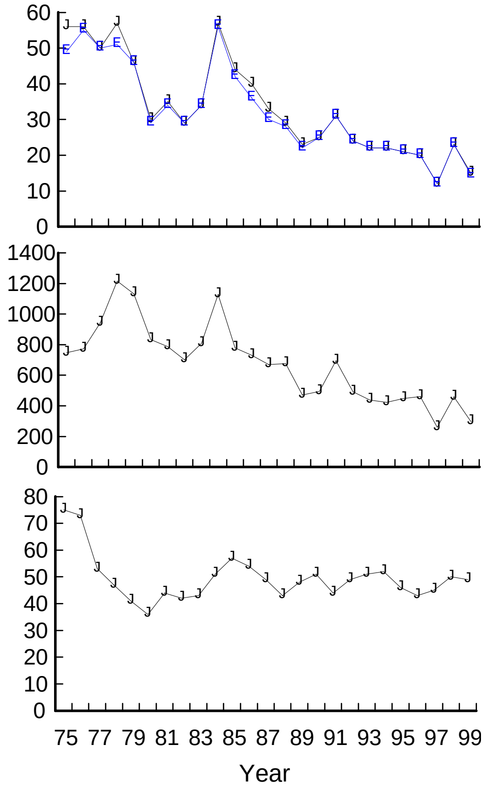

Block 32 (Furneaux Group)
Catch (tonnes)
Effort (hours)
CPUE (kg/hr)
Year
75 77 79 81 83 85 87 89 91 93 95 97 99


Block 33 (Furneaux Group)
Year
75 77 79 81 83 85 87 89 91 93 95 97 99

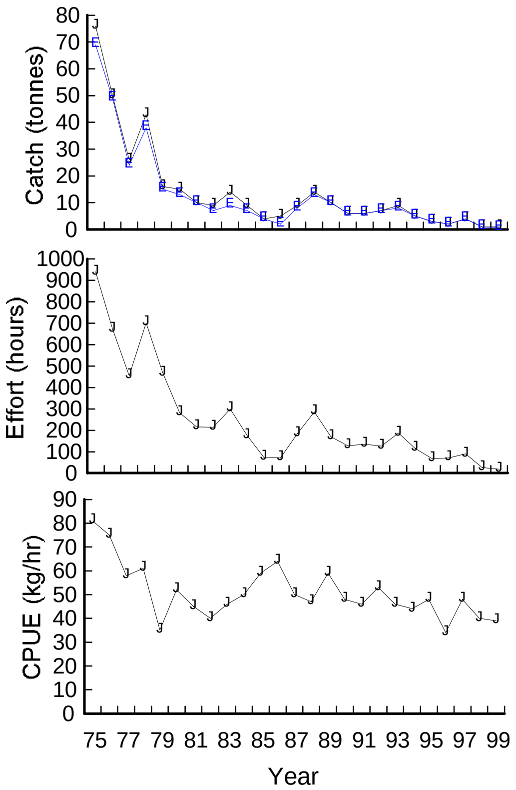
Block 34 (Furneaux Group)



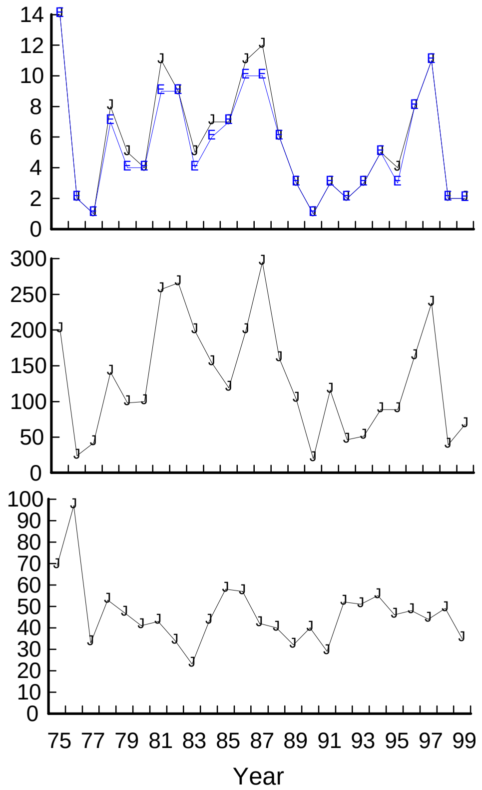
Block 35 (Furneaux Group)



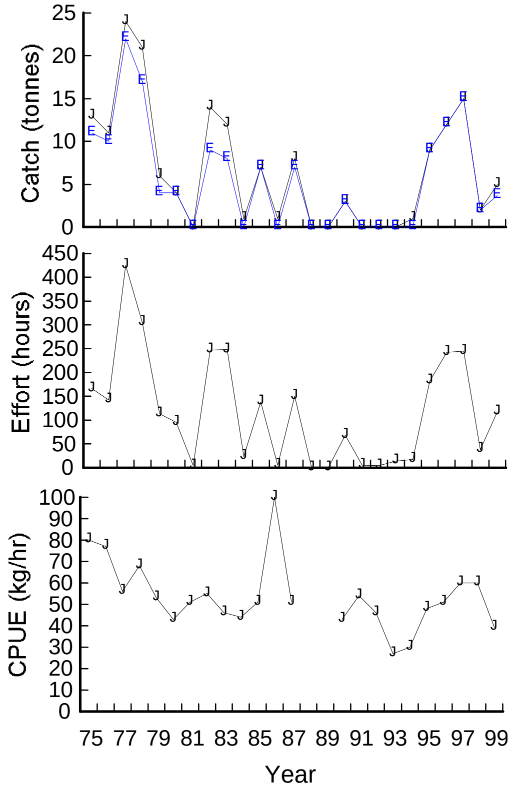
Block 36 (Furneaux Group)



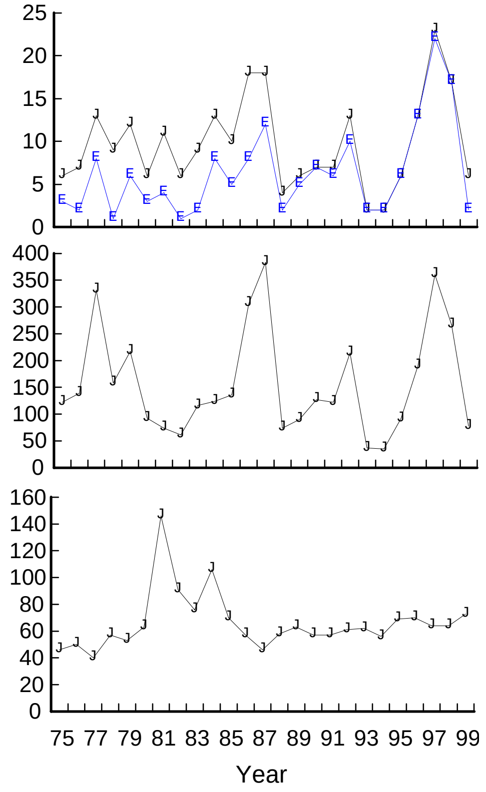
Block 37 (Furneaux Group)



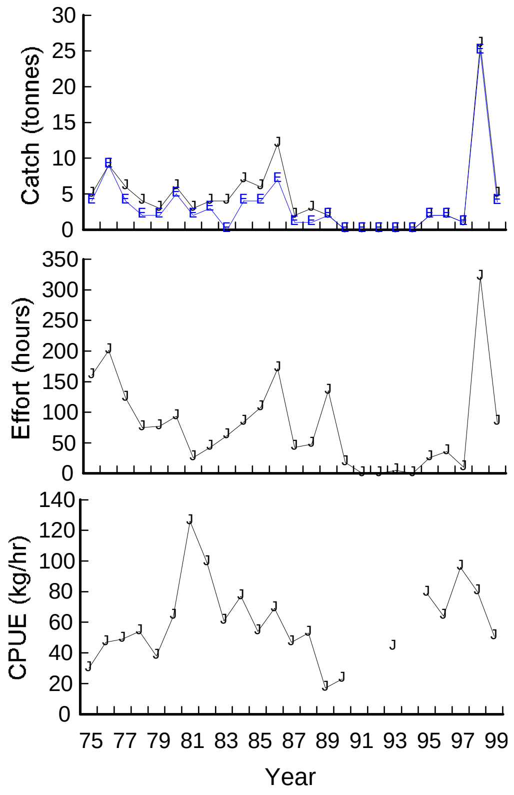
Block 38 (Furneaux Group)



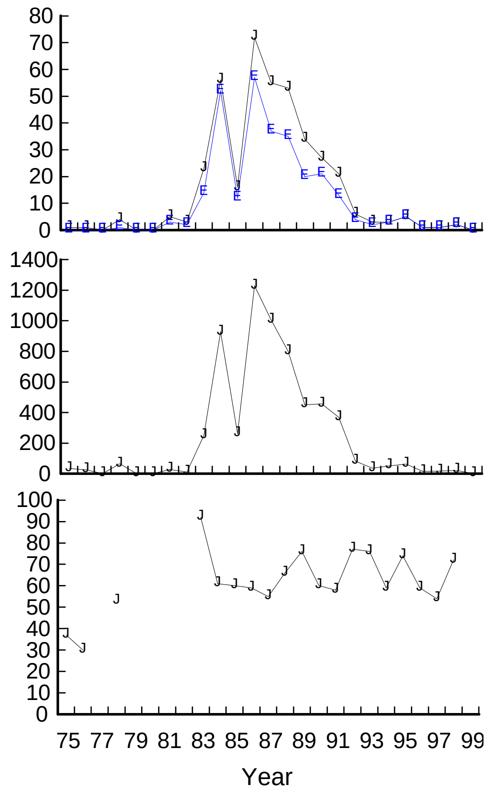
Block 39 (North East)

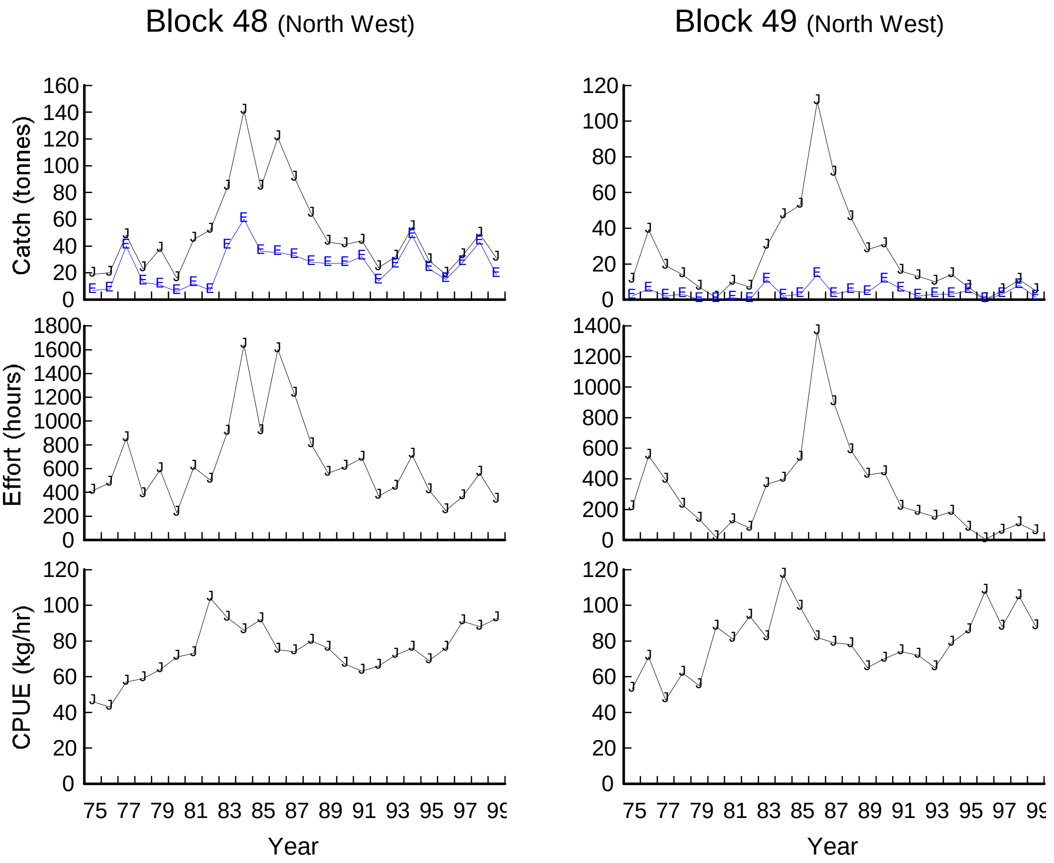


Block 40 (North East)



Block 47 (North West)




Block 48 (North West)
Block 49 (North West)
Catch (tonnes)
Effort (hours)
CPUE (kg/hr)
Year
Year