Fishery Assessment Report to PIRSA

Northern Zone Rock Lobster (*Jasus edwardsii*) Fishery 2006/07

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This fishery assessment updates the 2005/06 report for the Northern Zone Rock Lobster Fishery (NZRLF) and is part of SARDI Aquatic Sciences ongoing assessment program for the fishery. The report provides a synopsis of information available and assesses the current status of the resource. The report also identifies both current and future research needs for the fishery.

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EXECUTIVE SUMMARY

1 This fishery assessment updates the 2005/06 report and assesses the current status of the Northern Zone Rock Lobster Fishery (NZRLF) against the performance indicators detailed in the new Management Plan for the resource (Sloan and Crosthwaite 2007).

2 In 2006/07, a total of 569,869 potlifts landed a catch of 491.5 tonnes. This was 28.5 tonnes below the TACC (520 tonnes) but represented an increase of 15.1 tonnes from 2005/06 (476.4 tonnes). This is the second successive season that catch has increased in the NZRLF. The effort in 2006/07 reflected a decrease of 2.6% from 2005/06 (585,389 potlifts). This is the first season since 1999/00 where total catch increased despite a decrease in effort.

3 The zonal Catch-Per-Unit-Effort (CPUE; November to April inclusive) for 2006/07 was 0.88 kg/pot lift which was above the limit reference trajectory (LRT) of 1 kg/potlift over 12 years as per the Management Plan for the resource. In 2006/07, regional CPUE estimates were above the target limit trajectories (TLTs) in Regions A and B but below the LRTs in Regions C and D.

4 The zonal pre-recruit index (PRI) for 2006/07 (calculated from voluntary catch sampling data) was 0.37 undersized/potlift, which represents a decrease from 2005/06 (0.49 undersized/potlift). In 2006/07, the 3-year average zonal PRI (2004/05-2006/07) was 0.38 undersized/potlift, which is above the long-term limit reference point (LRP) for the NZRLF. The 3-year average regional PRI (2004-2006) was above the long-term LRP in Region B and below it in Regions C and D.

5 The mean weight of lobsters in 2006/07 (calculated from season totals of catch in numbers and weight) was 1.0 kg. Mean weight has generally decreased over the last five seasons in the NZRLF.

6 In 2006/07, the puerulus settlement index (PSI) was 0.08 puerulus/collector, which is the lowest settlement index since sampling began in the NZRLF. Given that 2005/06 and 2006/07 were two of the highest PSIs on record, this highlights the sporadic nature of settlement in the NZRLF.

7 There is close agreement from both qR and LenMod models in relation to the current status of the NZRLF. Both models estimate that biomass in the zone has decreased considerably since the late 1980's reaching a historical low of between 1700–2000 tonnes in 2004/05. Current levels of biomass are estimated to be in the range of 1800-2000 tonnes representing exploitation levels of between 23–27%. Current estimates put egg production at between 12-17% of virgin levels.

8 In conclusion, while the status of the NZRLF remains at a historically low level, some positive signs for the fishery were observed in 2006/07. Namely, both catch and catch rate increased for the second successive season, most likely reflecting the high puerulus settlement of 2002, which was predicted to enter the fishable biomass in 2006/07. However, given the level of variation in recruitment to the NZRLF and the degree of uncertainty associated with puerulus settlement data, careful consideration should be given as to how pulses of recruitment are conserved. Specifically, during periods of low recruitment, pulses may be required to sustain catches for extended periods within the NZRLF resource. Data from 2007/08 will reveal if the current increase in both catch and catch rate can be sustained through the expected periods of low recruitment in 2007/08 and 2008/09 (due to poor settlement in 2003 and 2004). If this fails to materialize, then it may be necessary for management arrangements to be employed that afford greater levels of protection for recruitment pulses during the stock-rebuilding phase.

1 GENERAL INTRODUCTION

1.1 Overview

This Fishery Assessment Report updates the 2005/06 report for the Northern Zone Rock Lobster Fishery (NZRLF) and is part of SARDI Aquatic Sciences ongoing assessment program for the fishery. The aims of the report are to provide a comprehensive synopsis of information available for the NZRLF and to assess the current status of the resource in relation to the performance indicators provided in the new Management Plan (Sloan and Crosthwaite 2007).

The report is divided into eight sections. The first section is the General Introduction that: (i) outlines the aims and structure of the report; (ii) describes the environmental characteristics and history of the NZRLF; (iii) outlines the management arrangements for the fishery and identifies the current biological performance indicators and reference points; (iv) provides a synopsis of biological and ecological knowledge of the southern rock lobster, *Jasus edwardsii*; and (v) details the data sources from which the current assessment is made.

Section two provides a synopsis of the fishery dependent statistics for the NZRLF for the fishing seasons between 1970/71 and 2006/07. This section examines inter-annual, and within-season trends in catch, effort and catch-per-unit-effort (CPUE) of both legal and undersized lobsters at zonal and regional spatial levels. This section also analyses mean weight and length frequency data.

The third section presents fishery independent outputs from the puerulus monitoring programme. It also compares inter-annual variations in the settlement rates of puerulus with pre-recruit indices lagged by three years.

The fourth section presents estimates of fisheries indicators obtained from the qR model (McGarvey et al. 1997; McGarvey and Matthews 2001) while the fifth section presents outputs from the newly developed length structured model for the fishery. Outputs from both models are compared and discussed in this section of the report.

The sixth section uses information provided in sections two, three, four and five to assess the status of the fishery against the biological performance indicators and reference points defined in the NZRLF Management Plan (Sloan and Crosthwaite 2007).

Section seven is the General Discussion. It synthesises the information presented, assesses the status of the fishery and identifies future research priorities.

The eight section is the bibliography, which provides a list of research papers and reports that are directly relevant to research and management of the NZRLF.

1.2 Description of the Fishery

1.2.1 Location and Size

The NZRLF includes all South Australian marine waters between the mouth of the Murray River and the Western Australian border and covers an area of 207,000 km^2 (Figure 1-1). The NZRLF is comprised of 42 Marine Fishing Areas (MFAs), but most of the fishing is conducted in ten MFAs (7, 8, 15, 27, 28, 39, 40, 48, 49 and 50).

1.2.2 Environmental Characteristics

Geology

Geologically, the NZRLF can be divided into two subregions. From Gulf St Vincent to the South Australia/Western Australia border, the marine substrate is comprised mainly of a vast basement of granitic rocks (Lewis 1981). Reef communities and habitats for lobsters are confined to relatively small patches where this basement of granite projects through the overlying sands. Some additional small areas of limestone reef occur off Elliston. The remainder of the NZRLF (i.e. from Gulf St Vincent to the Murray Mouth) is comprised of a metamorphosed basement with intrusions of igneous rocks, particularly granites. These intrusive granites produce peaked reefs that provide discrete localised habitats for lobsters that are interspersed by large expanses of sand. Granite does not erode as easily as the limestone reefs in the Southern Zone Rock Lobster Fishery and granite reefs thus lack the numerous ledges, crevices and undercuts which provide ideal habitats for lobsters. Densities of lobsters on the granitic reefs of the NZRLF are generally lower than those on the limestone reefs of the SZRLF

Oceanography

The southern Australian continental shelf is storm-dominated with high (>2.5 m) modal deep-water wave heights. Winds are predominantly south-easterly during summer and north-westerly during winter.

During summer, currents flow westward along the coast of the eastern Great Australian Bight and eastward over the shelf break (Herzfield and Tomczak 1997; Evans and Middleton 1998; Herzfield and Tomczak 1999). The Flinders Current (Bye 1972) flows from east to west along the continental slope, and is the source of cold, nutrient rich water that upwells onto the continental shelf from depths of around 600m (Figure 1-2). The mean summer wind direction over the shelf from Robe to the head of the Great Australian Bight is favourable for upwelling. South-easterly winds transport warm surface water offshore and cold, nutrient rich water is upwelled from below (Middleton and Platov 2003). The water layer above the thermocline is characterised by medium salinity (35.6 parts per thousand, i.e. ppt), low nutrient levels (NO_3 <0.1 μg/l) and high temperatures (18 to 19°C). Water below the thermocline has lower salinity (< 35.5 ppt), higher nutrient levels (NO_3 >0.2 μg/l) and lower temperatures (~14°C). Sea surface temperatures during summer are lower near the coast (e.g. 14-15^{o}C), especially along the western Eyre Peninsula and off the western tip of Kangaroo Island, and higher offshore (18-20^{o}C) (Figure 1-2).

During winter, water over the continental shelf is vertically homogeneous, well mixed and characterised by low nutrient levels (NO_3 <0.25 μg/l), high salinities (> 36 ppt) and medium temperatures of ~17°C. Westerly, downwelling-favourable winds lead to the formation of an eastward coastal current along the shelf break from Cape Leeuwin to the east coast of Tasmania (Cirano and Platov 2003). The presence of this coastal current suppresses the upwelling of water from the Flinders Current, which flows underneath the coastal current at a depth of around 600m, onto the shelf (Cirano and Middleton 2004). Sea surface temperatures are lower inshore than offshore at this time.

1.2.3 Commercial Fishery

The southern rock lobster, *J. edwardsii*, has been fished in South Australian waters since the 1890s, but the commercial fishery did not develop until the late 1940s and early 1950s when overseas markets for frozen tails were first established (Copes 1978; Lewis 1981). Since then there has been a gradual change to live export. Currently over 90% of the commercial catch is exported live to overseas markets. More recently, efforts have also been made to export live into the United States market.

Commercial fishers predominantly harvest lobsters using steel-framed pots covered with wire mesh and incorporating a moulded plastic neck (Figure 1-3). Pots are generally set overnight and retrieved the following day. The catch is initially stored live in holding wells on boats and then transferred to live holding tanks at the numerous processing factories around the State.

1.2.4 Recreational Fishery

There is an important recreational fishery for lobsters within the boundaries of the NZRLF. Recreational fishers are allowed to take lobsters by diving, or by using hoop nets, drop nets or pots (pot numbers restricted by limit on registrations), during the same season as commercial fishers. All recreational lobster pots must be registered.

Recreational potters (with registered pots), drop netters and divers were estimated to have harvested 118 tonnes of rock lobsters, across South Australia, during the 2001/02 fishing season (Venema et al. 2003). In 2003, this equated to 4.7% (by weight) of the combined catch of commercial and recreational fishers across both Zones in South Australia. This was considered to be an underestimate of the total recreational catch of rock lobsters in South Australia as it does not adequately address the harvest of drop/hoop netters without registered pots, fishers using other gear types or the catches of charter boats.

The most recent survey of recreational fishers was undertaken during the 2004/05 season (Currie et al. 2006). Based on data from registered pot fishers only, the estimated State recreational catch in the 2004/05 season was 83.17 tonnes of which 74.62 came from the SZRLF and 8.56 from the NZRLF. The number of recreational pot registrations in the South Australian Rock Lobster Fishery for 2004/05 was 5,656.

The number of individual pots in use was 9,827. Future estimation of the total rock lobster catch would be enhanced by the establishment of a comprehensive database that monitors the recreational catch of fishers rock lobster by all methods of capture (Currie et al. 2006).

1.2.5 Illegal fishing

Some illegal lobster fishing has, and is, undoubtedly undertaken in the NZRLF. However, as in most fisheries, the size of the illegal catch has not been quantified. The implementation of systems for monitoring the Total Allowable Commercial Catch (TACC) combined with the prior reporting system has reduced opportunities for the disposal of illegal catches.

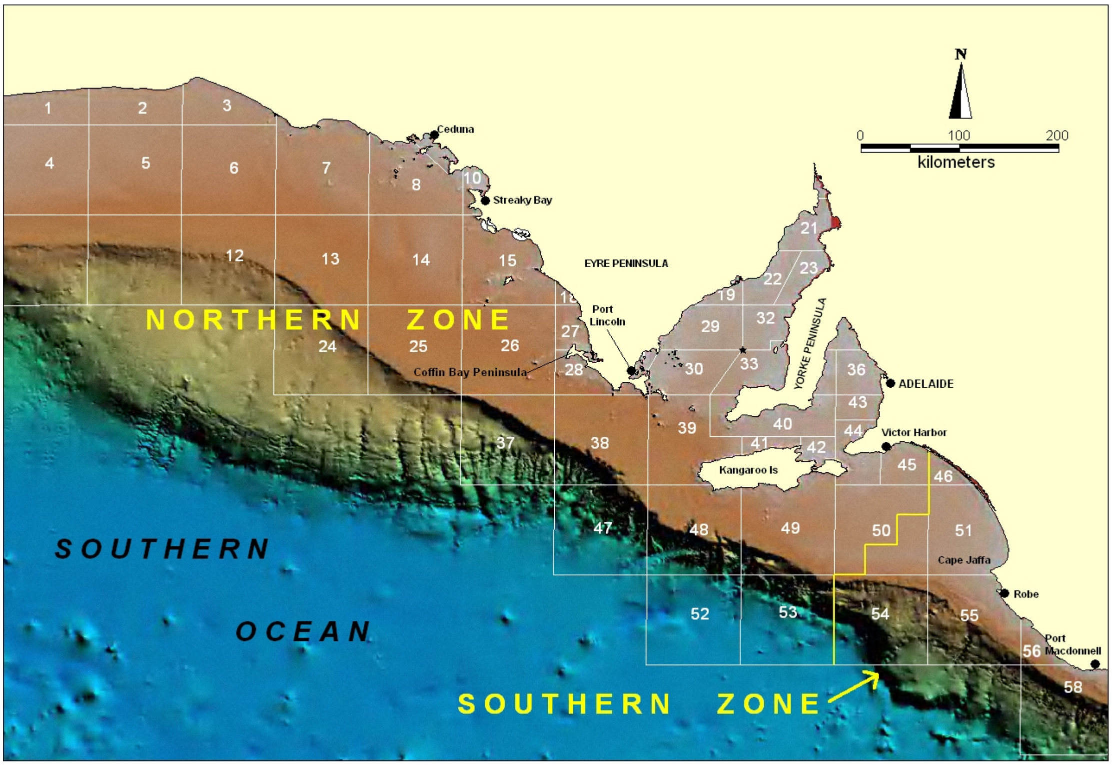

Figure 1-1 Marine Fishing Areas in the Northern and Southern Zones of the South Australian Rock Lobster Fishery.

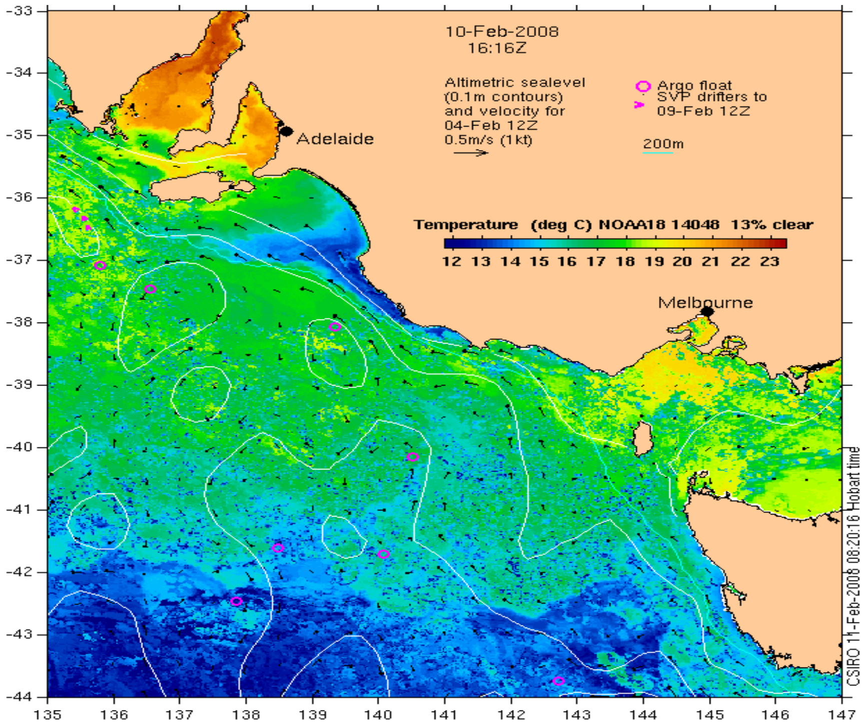

Figure 1-2 Sea-surface temperatures over the continental shelf of South Australia during February 2008. An upwelling can be seen where cooler water (dark blue) has moved onto the inner continental shelf (source: CSIRO).

Figure 1-3 The most commonly used pot in the NZRLF.

1.3 Management of the Fishery

The commercial NZRLF is a limited entry fishery with a total of 68 licences. The majority of boats fish from Port Lincoln (Figure 1-1). The statutory framework for ecologically sustainable management of this resource is provided by the *Fisheries Management Act 2007*. General regulations that govern the NZRLF are described in the *Fisheries Management (General) Regulations 2007* and the specific regulations are established in the *Fisheries Management (Rock Lobster Fisheries) Regulations 2006*. The policy, objectives and strategies to be employed for the sustainable management of the NZRLF are described in the *Management Plan for the South Australian Northern Zone Rock Lobster Fishery* (Sloan and Crosthwaite 2007). Recreational fishers are regulated under the *Fisheries Management (General) Regulations 2007.*

1.3.1 Management Milestones

Management arrangements have evolved since the inception of the fishery with the most recent review being in 2007 (Table 1-1).

Table 1-1 Major management milestones for the South Australian Northern Zone Rock Lobster Fishery.

Date	Management milestone
1968	Limited entry declared
1985	10% pot reduction; max number of pots 65
1992	10% pot reduction; max number of pots 60
1993	1 week closure during season
1994	LML increased from 98.5 to 102 mm CL; further "1 week" closure
1995	Further "1 week" closure added
1997	Flexible closures introduced. Management Plan for the fishery published (Zacharin 1997)
1999	Extra 3 days of fixed closure added Ballot to determine if size should increase to 105 mm – affirmed for 2000 season
2000	LML increased from 102 to 105 mm CL
2001	7% effort reduction
2002	8% effort reduction
2003	TACC implemented for the 2003/04 season at 625 tonnes; VMS introduced.
2004	TACC reduced to 520 tonnes vessel length and power restrictions removed.
2007	New Management Plan for the fishery published (Sloan and Crosthwaite 2007)

1.3.2 Current Management Arrangements

Details of the management arrangements for 2006/07 are provided in Table 1-2. The commercial fishery is currently managed by a combination of input and output controls. The season extends from November 1st to May 31st of the following year. There is a minimum legal size of 105 mm carapace length, prohibition on the taking of berried females, and several sanctuaries within which lobster fishing is prohibited. The dimensions of lobster pots, including mesh and escape gap size, are also regulated. Fishers may use up to 100 of the total number of pots endorsed on their licence at any one time to take lobster.

The TACC is set each year and is divided proportionally between licence holders as individual transferable quotas (ITQ's). Each licence holds one quota unit entitlement for each pot entitlement held. If a pot entitlement is transferred, a quota unit must also be transferred at the same time to the same licence, and vice versa. The daily catch of individual boats is monitored via catch and disposal records. The quota in 2006/07 was 520 tonnes.

Table 1-2 Management arrangements for the South Australian Northern Zone Rock Lobster Fishery in 2006/07.

Management tool	Current restriction
Total Allowable Commercial Catch	520 tonnes
Closed season	1 June to 31 October
Total number of pots	3,950
Minimum size limit	105 mm CL
Maximum number of pots/licence	100 pots
Minimum number of pots/licence	20 pots
Maximum quota unit holding	Unlimited
Minimum quota unit holding	320 quota units
Spawning females	No retention
Maximum vessel length	None
Maximum vessel power	None
Closed areas	Gleeson Landing Reserve
Catch and effort data	Daily logbook submitted monthly
Catch and Disposal Records	Daily records submitted upon landing
Landing times	Landings permitted at any time during the season
Prior landing reports to PIRSA	1 hour before removing lobster from boat
Escape gaps	2 gaps per pot
Vessel Monitoring System (VMS)	Operational VMS units required on all vessels during the season
Bin tags	All bins must be sealed with a lid and an approved tag prior to lobster being unloaded from the vessel. Tags are sequentially numbered.

1.3.3 The Management Plan

Goals, Objectives and Strategies

The newly developed Management Plan for the NZRLF identifies biological, economic, ecological and social goals, objectives, and strategies for the resource. The biological and environmental objectives and strategies are particularly relevant to this report and are described below in Table 1-3. Given the recent performance of the NZRLF, the primary goal of the Management Plan is biomass rebuilding. This is to be achieved through the setting of an annual TACC in accordance with decision rules identified in the Plan.

Table 1-3 Biological and environmental objectives of the Management Plan for the Northern Zone Southern Rock lobster fishery (Sloan and Crosthwaite 2007).

Goal	Objectives	Strategies
1. Maintain ecologically sustainable stock levels	*1a. Return the stock to a level that will support sustained catch rates within target and limit reference levels between now and 2016.*	▪ Set the TACC annually, in accordance with TACC decision rules in the harvest strategy. ▪ Maintain all other existing input and output controls.
	1b. Fishing is conducted at a level that provides protection from overfishing during extended periods of low recruitment.	▪ Monitor the number of pre-recruits in the fishery through the voluntary catch sampling program, as an index of future recruitment strength. ▪ Set the TACC annually, in accordance with TACC decision rules in the harvest strategy. ▪ Monitor larval settlement in the fishery, as an index of future recruitment strength. ▪ Use escape gaps to minimise pot-induced juvenile mortality rates.
	1c. Ensure sufficient biological and environmental information exists to inform management decisions.	▪ Collect fishery-dependent information through commercial logbooks. ▪ Maintain a voluntary catch sampling program to collect additional biological information. ▪ Develop and implement a fishery-independent data collection program. ▪ Undertake recreational survey to estimate catch and effort every three years. ▪ Assess the status of the stock through quantitative stock assessment. ▪ Review and update the strategic research and monitoring plan bi-annually. ▪ Monitor recreational catch and effort levels across the State every three years

1.3.4 Management Regions

The Management Plan (Sloan and Crosthwaite 2007) details key biological performance indicators that are to be assessed at both whole-of-fishery (zonal) and regional levels (Figure 1-4). Currently, the four specific regions are: “The West” (Region A), “Eyre Peninsula” (Region B), “Yorke Peninsula” (Region C) and “Kangaroo Island” (Region D). The aim of regional assessment is to refine management of the fishery to a finer spatial scale and ensure that greater precaution is factored into management arrangements. Regional assessment also allows known spatial variations in biological features such as growth rate (McGarvey et al. 1999a) and size of maturity (Prescott et al. 1996) to be taken into consideration. In addition, improved spatial management ensures that the performance of one region does not mask that of another. This is of particular importance during periods of low recruitment. Similarly, if the overall fishery is performing strongly, a downturn in one area may not necessarily lead to a TACC reduction for the whole fishery.

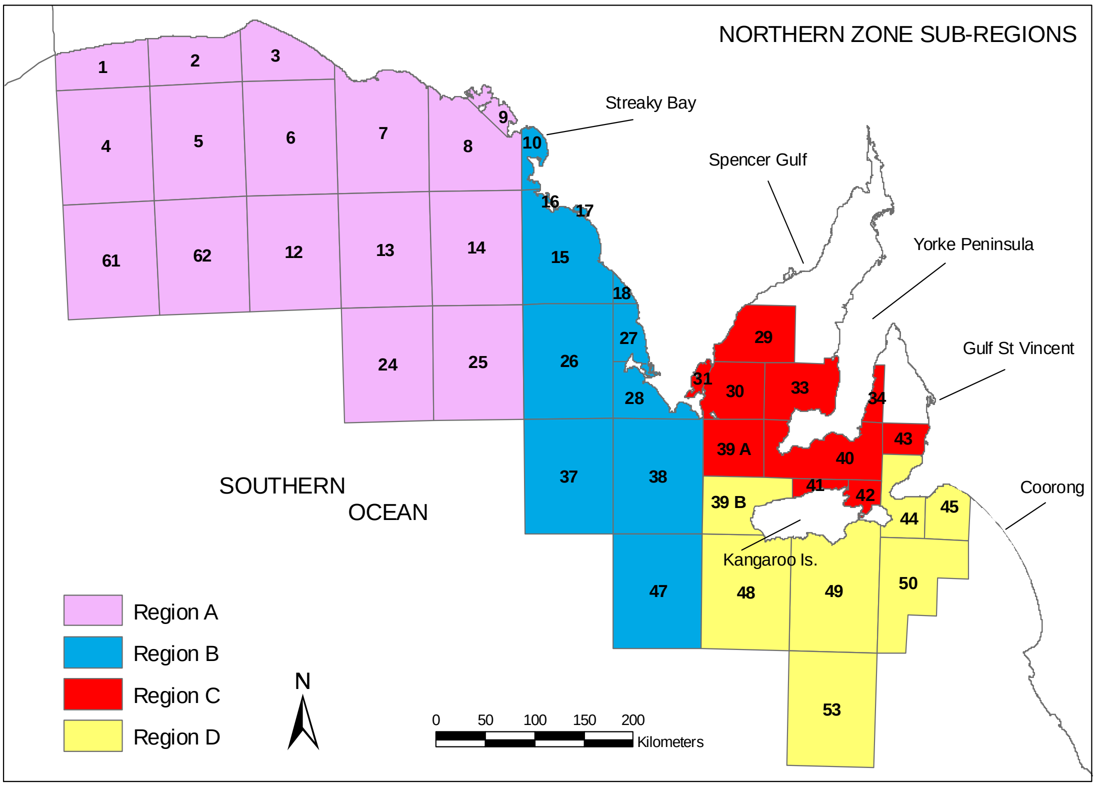

Figure 1-4 Key spatial regions as defined under the new Management Plan for the NZRLF.

1.3.5 Biological Reference points

The biological reference levels set out in the Management Plan (Sloan and Crosthwaite 2007) have been designed to provide clear guidance to the TACC setting process by defining how key performance indicator estimates should be interpreted and by explicitly linking them to a set of decision rules for TACC setting. The limit reference points (LRPs) represent unacceptable fishery performance that the fishery aims to avoid. Target reference pints (TRPs) represent desirable fishery performance that the fishery aims to achieve. Therefore, overall fishery performance will be measured by evaluating annual estimates of key performance indicators, relative to established limit and target biological reference levels.

A goal of the new Management Plan is to promote stock recovery within an agreed timeframe. This goal will be achieved by ensuring that fishery performance is maintained within the reference levels that have been developed for key performance indicators. Although the plan sets out a range of biological performance indicators, reference points have only been developed for two of these i.e. catch rate and pre-recruit index. Each of these will be assessed at both a zonal and regional level in order to assess the performance of the fishery in any one year. For further details of reference points, readers should refer to Sloan and Crosthwaite (2007).

Catch rate

LRPs for catch rate have been defined taking into account:

- Historical commercial catch and effort data
- Stakeholder expectations of biological and economic performance; and
- A long-term goal to achieve stock recovery.

For the purposes of setting LRPs for catch rate, the year 2004 has been chosen as a starting point, as this represents a point when the fishery is considered to have been at its lowest point in both a biological and an economic sense. A LRP recovery trajectory has been developed for the whole fishery and for each region to allow for gradual increase in the LRP over the recovery period.

TRPs have been defined taking into account:

- Historical commercial catch and effort data;
- Stakeholder expectations of biological and economic performance;
- A long term goal to maintain and improve stability in future catches; and
- A long-term goal to achieve a stock that will sustain a TACC of 600-700 tonnes.

Limit and target reference points have been established for both the fishery as a whole and each of the four regions, for the purposes of the TACC decision rules. Whilst the new Management Plan applies for a period of three years, the recovery trajectories relate to a twelve-year period. Details of zonal and regional LRPs and TRPs for catch rate are provided in Table 1-5.

Pre-recruit index

Only a LRP is set for pre-recruit index (PRI). Therefore PRI at any time is either above or below the reference point.

For the purposes of setting LRPs for PRI, a reference period between 1995 and 2004 (inclusive) has been chosen. This ten-year period is representative of recent fishery performance. In order to set reference points for pre-recruit abundance, the average over this period has been taken for the whole fishery and each regional area.

As set out in the decision rules of the Management Plan, the relevant measure for any particular year is the average of the most recent three years. For example, for calculating the PRI for 2006/07, the average of 2004/05, 2005/06 and 2006/07 will be used to determine whether PRI is considered to be above or below the reference levels. Zonal and regional LRPs for pre-recruit index are provided in Table 1-4.

Table 1-4 Zonal and regional limit reference points for pre-recruit index for the NZRLF.

Region	Pre-recruit index (Pot sampling data)
Northern Zone	0.33
A	0.03
B	0.19
C	0.42
D	0.61

Table 1-5 Zonal and regional limit and target reference points for catch rate based on a 12-year recovery time period.

Rock Lobster Season	Year number	Whole Zone		Region A		Region B		Region C		Region D	
		Target	Limit	Target	Limit	Target	Limit	Target	Limit	Target	Limit
2004 (*data*)	0	0.82	0.82	0.94	0.94	0.75	0.75	0.78	0.78	0.87	0.87
2005	1	0.86	0.84	0.98	0.95	0.79	0.76	0.81	0.79	0.90	0.88
2006	2	0.89	0.85	1.02	0.97	0.83	0.78	0.83	0.79	0.93	0.89
2007	3	0.93	0.87	1.06	0.98	0.86	0.79	0.86	0.80	0.97	0.90
2008	4	0.96	0.88	1.09	0.99	0.90	0.80	0.89	0.80	1.00	0.91
2009	5	1.00	0.90	1.13	1.01	0.94	0.81	0.91	0.81	1.03	0.92
2010	6	1.04	0.91	1.17	1.02	0.98	0.83	0.94	0.82	1.06	0.94
2011	7	1.07	0.93	1.21	1.03	1.01	0.84	0.97	0.82	1.09	0.95
2012	8	1.11	0.94	1.25	1.05	1.05	0.85	0.99	0.83	1.12	0.96
2013	9	1.14	0.96	1.29	1.06	1.09	0.86	1.02	0.83	1.16	0.97
2014	10	1.18	0.97	1.32	1.07	1.13	0.88	1.05	0.84	1.19	0.98
2015	11	1.21	0.99	1.36	1.09	1.16	0.89	1.07	0.84	1.22	0.99
2016	12	1.25	1.00	1.40	1.10	1.20	0.90	1.10	0.85	1.25	1.00

Additional performance indicators

The Management Plan also sets additional performance indicators to supplement the key performance measures used in the decision rules (Table 1-6). These performance measures provide supplementary information for fishery assessment. They will also provide information for periodic review to ensure that they performance indicators are adequate indicators for fishery assessment. These additional performance measures do not trigger a specific response. They only require that a management issue be considered, without dictating what the response should be.

Table 1-6 Table of additional performance indicators for the NZRLF.

Goal	**Objective**	**Performance Indicator**	**Description**	**Limit reference point**
1. Maintain ecologically sustainable stock levels	*Rebuild lobster biomass*	Biomass	Reflects the sum total weight of the breeding population and is used to determine the reproductive capacity of the population.	Monitored annually and reported in stock assessment.
		Egg production	Reflects the reproductive capacity of the fishery by providing an estimation of the number of eggs produced by all mature females in the population, as a percentage of the virgin egg production.	Monitored annually and reported in stock assessment.
		Catch vs TACC	Provides an indicator of the relative abundance of lobster in the fishery.	Drops below 90%
		Mean weight	May reflect changes in the stock structure or changes in fishing practices. Higher mean weight values usually reflect a lack of newly recruited lobster in the population. Lower mean weight usually reflects a greater frequency of smaller lobster in the population due to increased recruitement.	Monitored annually and reported in stock assessment.
		Puerulus settlement index	Reflects larval (puerulus) settlement abundance and provides an index of future recruitment strength. Provides an indication of future catch in 4 - 5 years time.	Monitored annually and reported in stock assessment.

1.4 Biology of Southern Rock Lobster

1.4.1 Taxonomy and Distribution

For detailed information on all aspects of southern rock lobster *Jasus edwardsii* (Hutton 1875) biology, readers should refer to Phillips (2006). Southern rock lobster, *Jasus edwardsii* (Hutton 1875) (Figure 1-5), are distributed around southern mainland Australia, Tasmania and New Zealand (Smith et al. 1980; Booth et al. 1990). In Australia, the northerly limits of distribution are Geraldton in Western Australia and Coffs harbour in northern New South Wales, however the bulk of the population can be found in South Australia, Victoria, and Tasmania where they occur in depths from 1 to 200 m (Brown and Phillips 1994).

Figure 1-5 Southern rock lobster, *Jasus edwardsii,* in reef habitat.

1.4.2 Stock Structure

Few genetic or morphological differences that may indicate sub-structuring have been found in the *Jasus edwardsii* population from southern mainland Australia, Tasmania and New Zealand (Smith et al. 1980; Booth et al. 1990; Brasher et al. 1991). Similarly, mitochondrial DNA analysis has failed to detect any sub-division of the population on a smaller scale and it is likely that there is some exchange of genetic material from lobsters from south-eastern Australia to New Zealand (Ovenden et al. 1992). The long larval phase and widespread occurrence of larvae across the central and south Tasman Sea, in conjunction with known current flows, point to the likely transport of phyllosoma from south-eastern Australia to New Zealand providing genetic mixing between the two populations (Booth et al. 1990).

The above notwithstanding, it is often useful to define spatially discrete fish stocks for management purposes, i.e. Northern and Southern Zones of the Southern Rock lobster fishery in South Australia. In New Zealand, clustering techniques have been used to partition rock lobster statistical areas into groups based on some characteristic of the fishery, i.e. trends in catch rates, size frequency distributions and size of maturity (Bentley and Starr 2001). This is used to provide aggregations of statistical areas, that to some degree, reflect fish stocks for stock assessment purposes.

1.4.3 Life History

Southern rock lobster mate from April to July. Fertilisation is external, with the male depositing a spermatophore on the female's sternal plates (MacDiarmid 1988). The eggs are extruded shortly afterwards and are brooded over the winter for about 3-4 months (MacDiarmid 1989).

The larvae hatch in early spring, pass through a brief (10-14 days) nauplius phase into a planktonic, leaf-like phase called phyllosoma. Phyllosoma have been found down to depths of 60 m, tens to hundreds of kilometres offshore from the New Zealand coast (Booth et al. 1991; Booth and Stewart 1992; Booth 1994; Booth et al. 1999; Booth et al. 2002). They develop through a series of 11 stages over 12-23 months before metamorphosing into the puerulus stage (Figure 1-6) near the continental shelf break (Booth et al. 1991; Booth and Stewart 1992; Bruce et al. 1999). The puerulus actively swims inshore to settle on to reef habitat in depths from 50 m to the intertidal zone (Booth et al. 1991).

Geographic variation in larval production may be marked. In New Zealand, it has been suggested that this may be due to variations in: (i) size at first maturity, (ii) breeding female abundance and/or (iii) egg production per recruit (Booth and Stewart 1992). Additionally, phyllosoma are thought to drift passively which, coupled with the long offshore larval period, means that oceanographic conditions, particularly currents and eddies, may play an important part in their dispersal (Booth and Stewart 1992).

Geographic patterns in the abundance of phyllosoma may also be consistent with those in puerulus settlement (Booth and Stewart 1992; Booth 1994). Correlations between levels of settlement and juvenile abundance have been found at two sites in New Zealand (Breen and Booth 1989; Booth and Stewart 1993). In South Australia, it has been suggested that the strength of westerly winds, during late winter and early spring, may play a role in the inter-annual variation in recruitment to the NZRLF (McGarvey and Matthews 2001). In their study, both winds and recruitment were shown to exhibit a 10-12 year periodicity, with significant correlations between recruitment and westerly winds lagged by 5-7 years.

Using a combination of biological and hydrodynamic modelling, Bruce et al. (2007) simulated the planktonic early life history of *J. edwardsii* across its geographical range. In relation to sources of recruiting pueruli to the Southern Zone, the study predicted that while the most significant levels of recruitment occur from regions west of the zone, some degree of self-recruitment is predicted in most years. Importantly, the study found that the SZRLF had the highest levels of egg production in southern Australia and as a result, was an important source of pueruli for much of the overall south-eastern fishery of Australia.

Figure 1-6 Newly settled southern rock lobster puerulus

1.4.4 Growth and Size of Maturity

Lobsters grow through a cycle of moulting and thus increase their size incrementally (Musgrove 2000). Male and female moult cycles are out of phase by 6 months, with males undergoing moulting between October and November, and females during April to June (MacDiarmid 1989).

A tagging study undertaken between 1993 and 1996, in which over 61,000 lobsters were tagged and 16,000 recaptured, demonstrated that there was substantial variation in growth rates among locations in South Australia (McGarvey et al. 1999a) with a general trend of higher growth rates in the NZRLF compared to the SZRLF. Growth rates also varied throughout the life of individuals and the mean annual growth for lobsters at 100 mm carapace length (CL) ranged from 7-20 and 5-15 mm per year for males and females respectively. Growth rates tended to increase along the South Australian coast from south-east to north-west and were highest in areas of low lobster density and high water temperature (McGarvey et al. 1999a). Growth rates also appeared to be related to depth of habitat and declined at the rate of 1 mm per year for each 20 m increase in depth (McGarvey et al. 1999a).

The size at which 50% of females are sexually mature is spatially variable, ranging between 90 and 115 mm CL (Prescott et al. 1996).

1.4.5 Movement

In South Australia, movement patterns of the southern rock lobster *Jasus edwardsii* were determined from 14,280 tag-recapture events from across the State between 1993 and 2003 (Linnane et al. 2005a). In total, 68% of lobsters were recaptured within 1 km of their release site and 85% within 5 km. The proportion of lobsters moving >1 km in MFAs ranged from 13 to 51%. Movement rates were noticeably high in the SZRLF and at Gleesons Landing lobster sanctuary off the Yorke Peninsula in the NZRLF (refer to Figure 1-1) but patterns of movement differed spatially. In the SZRLF, lobsters moved distances of <20 km from inshore waters to nearby offshore reefs whereas off the Yorke Peninsula individuals moved distances >100 km from within the sanctuary to sites located on the north-western coast of Kangaroo Island and the southern end of Eyre Peninsula.

1.5 Stock Assessments: Sources of data

The first stock assessment for the NZRLF was conducted by Copes (1978), who plotted a yield curve of catch (tonnes) against effort (pot lifts) and applied the simplest version of the Schaefer Model to suggest that the stable catch-effort relationship for the fishery was about 600 t from 400,000 pot lifts.

Lewis (1981) superimposed additional data on the yield curves generated by Copes (1978) and suggested that the potential yield from the fishery was best described by curves that indicated a potential yield of between 550 and 650 tonnes. The stock assessment report produced by Prescott and Lewis (1992) used surplus production modelling to estimate the maximum sustainable yield and related parameters for the NZRLF. The report suggested that a prudent level of catch for the NZRLF based on information available was approximately 850 tonnes.

Since the mid-1990s, the qR model (McGarvey et al 1997; McGarvey and Matthews 2001) and a range of fishery dependent indices as detailed in the Management Plan by Zacharin (1997), have provided the basis for reporting against the performance indicators for the fishery. In 2005, outputs from the newly developed "Length-frequency Model" (Len Mod) were presented in addition to qR.

In 2007, a new Management Plan for the fishery was published (Sloan and Crosthwaite 2007) and in this current stock assessment report, the performance of the fishery will be assessed against the biological indicators detailed within.

SARDI Aquatic Sciences is contracted by PIRSA Fisheries Policy to: (i) administer a daily logbook program, (ii) collate catch and effort information, (iii) conduct pot-sampling, bycatch, puerulus and fishery independent monitoring programs and (iv) produce annual stock assessment and status reports that assesses the status of the NZRLF against the performance indicators defined in the Management Plan.

1.5.1 Catch and Effort Research Logbook

Licence holders complete a compulsory daily logbook that has been amended to accommodate changes in the fishery. During 1998, the logbook was modified to include specific details about giant crab (*Pseudocarcinus gigas*) fishing. In 2000/01, the logbook was amended so that the recording of numbers of undersize, spawning and dead lobsters, along with numbers of octopus became voluntary. Logbook returns are submitted monthly and are entered into the South Australian Rock Lobster (SARL) database.

Details currently recorded in the daily logbook include:

1. the MFA within which the fishing took place
2. depth at which the pots were set
3. number of pots set
4. weight of retained legal-sized lobsters - reported at the end of each trip or as a daily estimated weight
5. landed number of legal-sized lobsters
6. number of undersized lobsters caught
7. number of dead lobsters caught
8. number of spawning lobsters caught
9. weight of octopus caught
10. number of octopus caught
11. number of giant crab pots
12. depth of giant crab pots
13. landed weight of giant crabs
14. landed number of giant crabs
15. marine scalefish retained

1.5.2 Voluntary Catch Sampling

Since 1991, commercial fishers and researchers have collaborated in an at-sea pot-sampling program with the main aim of providing temporal and spatial data on pre-recruit indices, legal sized catch, length frequencies, female reproductive status, sex ratios and estimates of lobster mortality. During the life of this program there have been various levels of participation and changes to the sampling regime.

The program started with commercial fishers sampling from several (usually 3) pots each day, for the duration of the fishing season. During the 1995 season, sampling was reduced to one week per month over the period of the third quarter of the moon. During the following season, sampling was done as part of an FRDC project that aimed to determine the optimal sampling strategy required to produce quantifiable and minimum variances in the mean lengths and catch rates (McGarvey et al. 1999b; McGarvey and Pennington 2001). This study demonstrated that the optimal design should incorporate a high percentage of boats, with sampling done on as many days as possible from a small fraction of the pots from each boat. As a result, fishers are now encouraged to sample from up to 3 research pots per trip where the escape gaps are closed. They are supported by research staff who undertake trips to sea on commercial vessels to encourage more fishers to participate in the program and to demonstrate the methods to new participants.

Participation in the program is neither random nor systematic and can vary among areas. Overall participation in the program has decreased over the last number of seasons (Figure 1-7) with only 20% of the fishery participating in 2004/05. During a series of port meetings in 2006/07, the importance of participation in the catch sampling programme was emphasised by both SARDI personnel and industry representatives. In particular, it was highlighted that future management decisions for the fishery will rely heavily on pre-recruit indices that are directly estimated from voluntary catch sampling data. In 2006/07, the participation level was 38% of licence holders. It is imperative that this participation level is at least maintained to ensure that future management decisions for the fishery are based on reliable and accurate data.

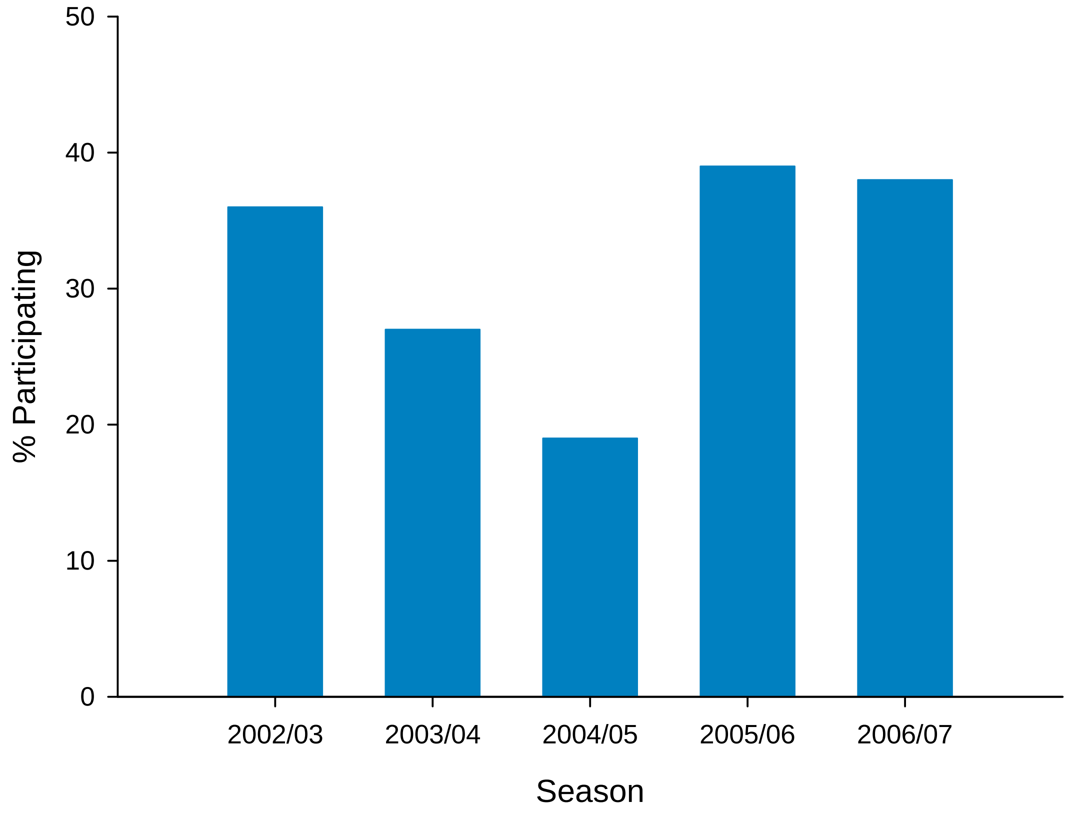

Figure 1-7 Percentage of licence holders in the NZRLF participating in the voluntary catch sampling program over the last 5 seasons.

1.5.3 Puerulus Monitoring Program

Larval recruitment processes may be related to changes in breeding stock abundance and seasonal, annual and geographic variation in recruitment to the fishery (Booth et al. 2002). As a result, knowledge of these processes may ultimately improve the usefulness of fishery assessment models.

Rates of puerulus and post-puerulus settlement have been monitored in the NZRLF since 1996. The four puerulus collector sites in the NZRLF are located at McLaren Point and Taylor Island (Port Lincoln) and Marion Bay and Stenhouse Bay (Yorke Penninsula). The annual Puerulus Settlement Index (PSI) is calculated as the mean monthly settlement on these collectors. Results from the puerulus monitoring program are presented in Section 3 of this report.

2 FISHERY DEPENDENT STATISTICS

2.1 Introduction

This section of the report summarises and analyses fishery statistics for the NZRLF for the period between 1 January 1970 and 31st May 2007. For ease of reference, figures and text in this section refer to the starting year of each season year e.g. 2006 refers to the 2006/07 fishing season.

The scale of spatial analyses undertaken with respect to various fishery dependent data reflects their importance as performance indicators within the Management Plan for the NZRLF. For example, both CPUE and PRI (the two primary indicators) are presented by zone, region, MFA and depth. Other indicators e.g. length frequency, not directly contribute to the decision making process are presented at zonal scales only.

Estimates presented in this section are calculated from daily data and differ slightly from estimates based on season totals that are presented in other sections of this report. Daily data are used to describe the inter-annual and within-season patterns in catch (kg), effort (potlifts), catch-per-unit-effort CPUE (kg/potlift) and mean weight (kg/lobster) across both the entire zone as well as key MFAs. This section also presents statistics on important indices such as pre-recruits and means weights. Finally, estimates of inter-annual variations in settlement rates of puerulus are compared with pre-recruit indices lagged by three years.

2.2 Catch, Effort and CPUE

2.2.1 Zonal trends

Catch

Total catch for the NZRLF remained relatively steady at around 600-700 tonnes during the 1970s and early 1980s (Figure 2-1). The highest catch recorded during this period was 750 tonnes in 1972, i.e. the fishing season beginning in November 1972. The lowest was 560 tonnes in 1978.

The annual catch increased from 657 tonnes in 1985 to 1,221 tonnes in 1991. Between 1991 and the mid-1990s, catches declined to around 900 tonnes, before increasing again to over 1,000 tonnes in 1998 and 1999. Since 1998, the catch has declined each year to reach 446 tonnes in 2004, which is the lowest reported annual catch in the history of the fishery. The decline in the catch for the 2000 season partly reflected the increase in the minimum legal size from 102 mm to 105 mm (~5%). The further reduction in the catch for the 2001 and 2002 seasons partly reflects reductions in fishing effort. In 2006, catch in the NZRLF was 491.5 tonnes. This reflects an increase in catch of 15.1 tonnes from 2005 and is the second successive season that total catch has increased in the fishery.

Effort

Like catches, nominal fishing effort remained relatively constant throughout the 1970s at around 450,000 pot lifts per season (Figure 2-1). However, effort almost doubled from 411,939 pot lifts in 1977 to 805,139 pot lifts in 1991. Since the peak in 1991, effort was reduced gradually to around 720,000 pot lifts per season during the mid-1990s and to 553,701 pot lifts during the 2004 season. In 2006, effort was 569,869 potlifts, which reflected a decrease of 2.6% from 2005 (585,389 potlifts). This is the first season since 1999 where total catch increased despite a decrease in effort.

Whilst inter-annual changes in nominal effort in the NZRLF are well documented, the associated changes in effective effort are poorly understood. Both Copes (1978) and Prescott and Xiao (2001) presented analyses that suggest the catching power of (some) pots increased during the 1970s, 1980s and 1990s. However, the detailed data on the uptake and utilisation of technological advances by individual licence holders that are required to quantify changes in fishing efficiency are not available for the NZRLF and this issue may never be resolved completely for the fishery.

CPUE

Catch-per-unit-effort (CPUE) in the early 1970s was over 1.40 kg/pot lift (Figure 2-2). After the mid 1970s, it declined steadily to 1.07 kg/pot lift in 1984. During the late 1980s, CPUE increased and reached a peak of 1.50 kg/pot lift in 1990 before declining to 1.23 kg/pot lift in 1995. CPUE rose to 1.42 kg/pot lift in 1999, but then declined rapidly over the next 5 seasons. The CPUE in 2004 of 0.80 kg/pot lift was the lowest in the history of the fishery. Since 2004, CPUE has marginally increased and in 2006 was 0.86 kg/potlift. This represents the second successive season that CPUE has increased in the fishery.

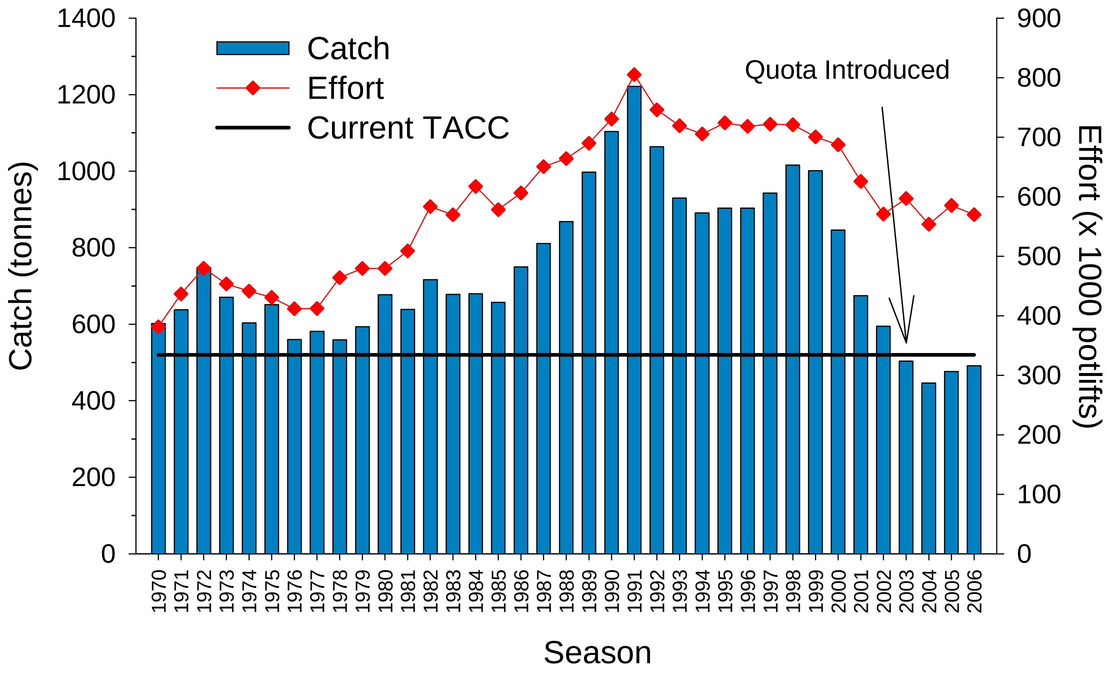

Figure 2-1 Inter-annual trends in catch and effort in the South Australian Northern Zone rock lobster fishery between 1970 and 2006. TACC=Total Allowable Commercial Catch (Currently 520 tonnes).

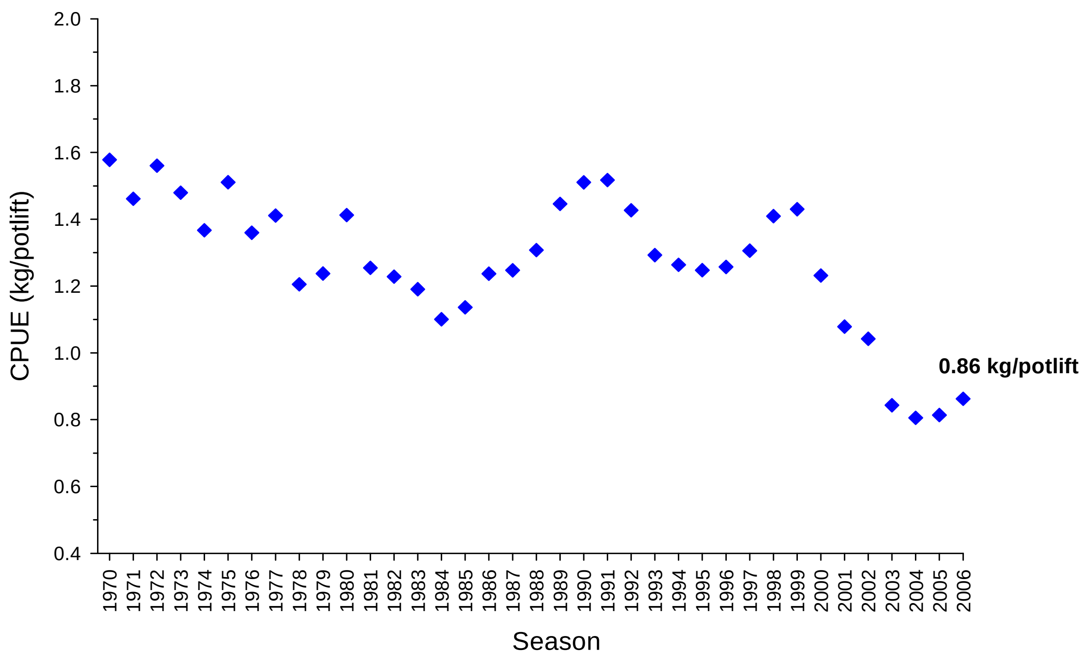

Figure 2-2 Inter-annual trends in CPUE in the South Australian Northern Zone rock lobster fishery for seasons between 1970 and 2006.

2.2.2 Within-season trends

Catch and effort

Within-season trends in catch and effort in the NZRLF between 1970 and 2005 are presented in Linnane et al. (2006) and Linnane et al. (2007). In the 1970s and 1980s, monthly catch and effort levels were highest during the first five months of each season (November to March), with the largest catch often taken during January. During this period, monthly catch and effort levels during April and May were generally relatively low. During the 1990s, effort was expended more evenly across the entire season, and monthly catches in April and May were higher than in the previous two decades (but still generally lower than catches in the previous five months of each season).

In the 2006 season, 87.5% of the total catch was taken from November to March inclusive (Figure 2-3). The highest catch was taken in February (95.6 tonnes) with the lowest catch taken in May (11.9 tonnes). Trends in effort generally reflected monthly trends in catch.

CPUE

The within-season trend in CPUE was similar for the 1970s, 1980s and 1990s (Linnane et al 2007). The highest CPUEs were recorded during December, January and February. Mean monthly CPUEs for all months were highest during the 1970s and lowest during the 1980s, with the estimates for the 1990s lying between the two extremes.

Within season trends in CPUE have been consistently similar over recent seasons (Figure 2-4). CPUE has generally increased from November to January before decreasing as the season progressed. In 2006, CPUE increased from November to February before decreasing thereafter. CPUE was highest in February at 1 kg/potlift and lowest in May at 0.52 kg/potlift.

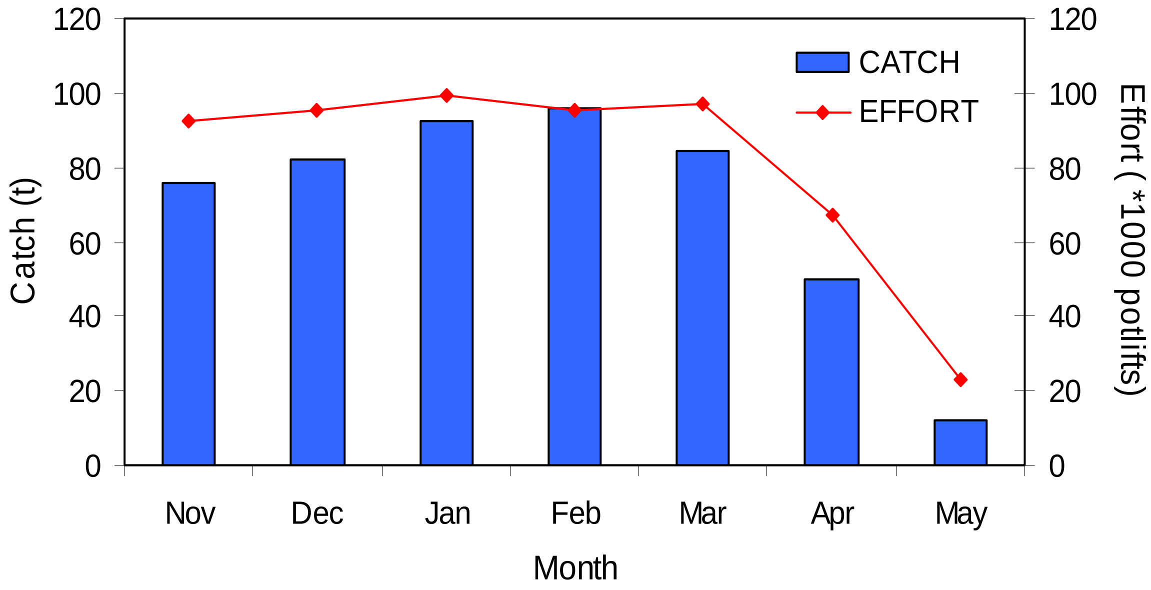

Figure 2-3 Within-season trends in catch and effort in the NZRLF for the 2006 fishing season.

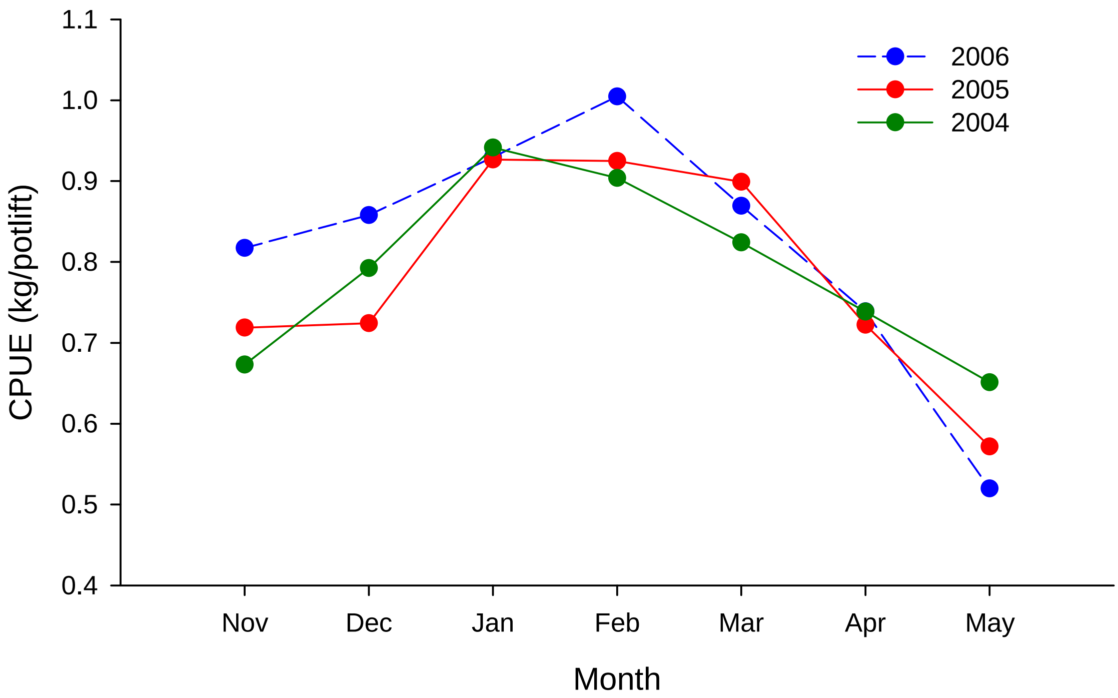

Figure 2-4 Within-season trends in CPUE in the NZRLF for the 2006 fishing season.

2.2.3 Trends across key MFAs

Catch

Figure 2-5 shows inter-annual catch and effort data for the 10 main MFAs (7, 8, 15, 27, 28, 39, 40, 48, 49 and 50) (refer to Figure 1-1 for location of MFAs) in the NZRLF from 1970 to 2006. In 2006, over 90% of the catch came from these MFAs with over 70% taken in MFAs 28, 39, 40, 48 and 49 (Table 2-1; Figure 2-7). In 2006, catch decreased marginally (< 3 tonnes) in MFAs 7, 27, 39, and 40. More substantial decreases were observed in MFA 8 (17.9 tonnes) and MFA 48 (16.5 tonnes). Increases in catch were observed in MFAs 15 (6.6 tonnes) and MFA 49 (10.2 tonnes). However, the most notable increase was observed in MFA 28 where catch increased by 37.3 tonnes in 2006. The catch of 124.7 tonnes in 2006 in MFA 28 represents a 98.9% increase since 2004 when the catch was 62.7 tonnes.

Effort

As in inter-annual patterns (Figure 2-1), effort across MFAs has closely reflected trends in catch (Figure 2-5). In 2006, the majority of effort occurred in MFAs 28, 39, 40, 48 and 49. Most notable was MFA 28, where effort has increased by 61% since 2004.

CPUE

The ten major MFAs in the NZRLF show similar inter-annual trends in CPUE, with peaks in CPUE during the 1970s, early 1990s and late 1990s and low CPUEs in the early 1980s (Figure 2-6). Since the late 1990's, the CPUE has generally declined in most MFAs. In 2006, CPUE increased in MFAs 15, 27, 28, 39, 40, 49 and 50. This represents the second successive season that CPUE has increased in MFAs 15, 27 and 28. Catch rates decreased in MFAs 7, 8, and 48.

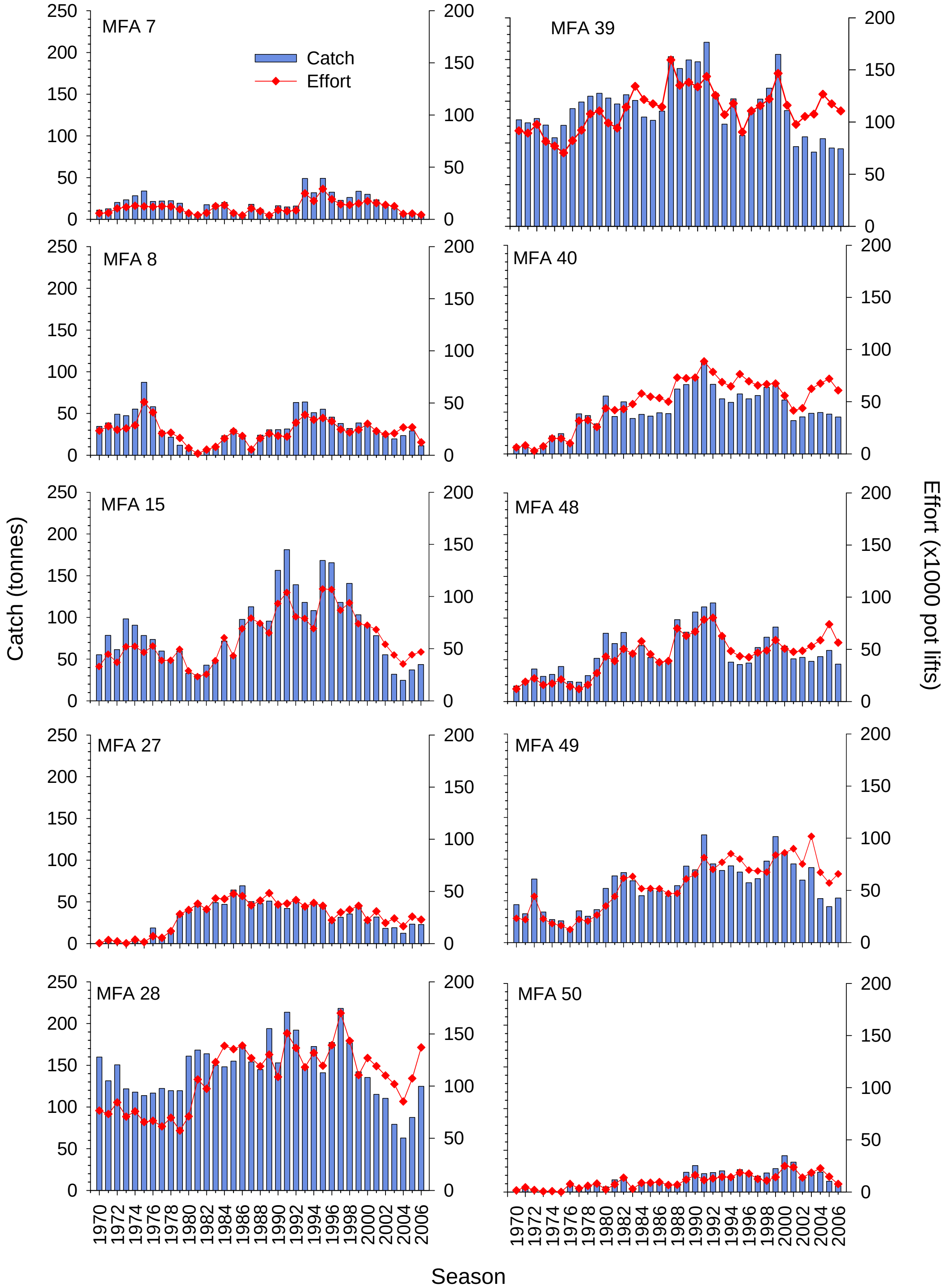

Figure 2-5 Inter-annual trends in catch and effort in the 10 main MFAs (from north-west to south-east) of the NZRLF for the fishing seasons between 1970 and 2006 (note: alternate seasonal ticks on X axis).

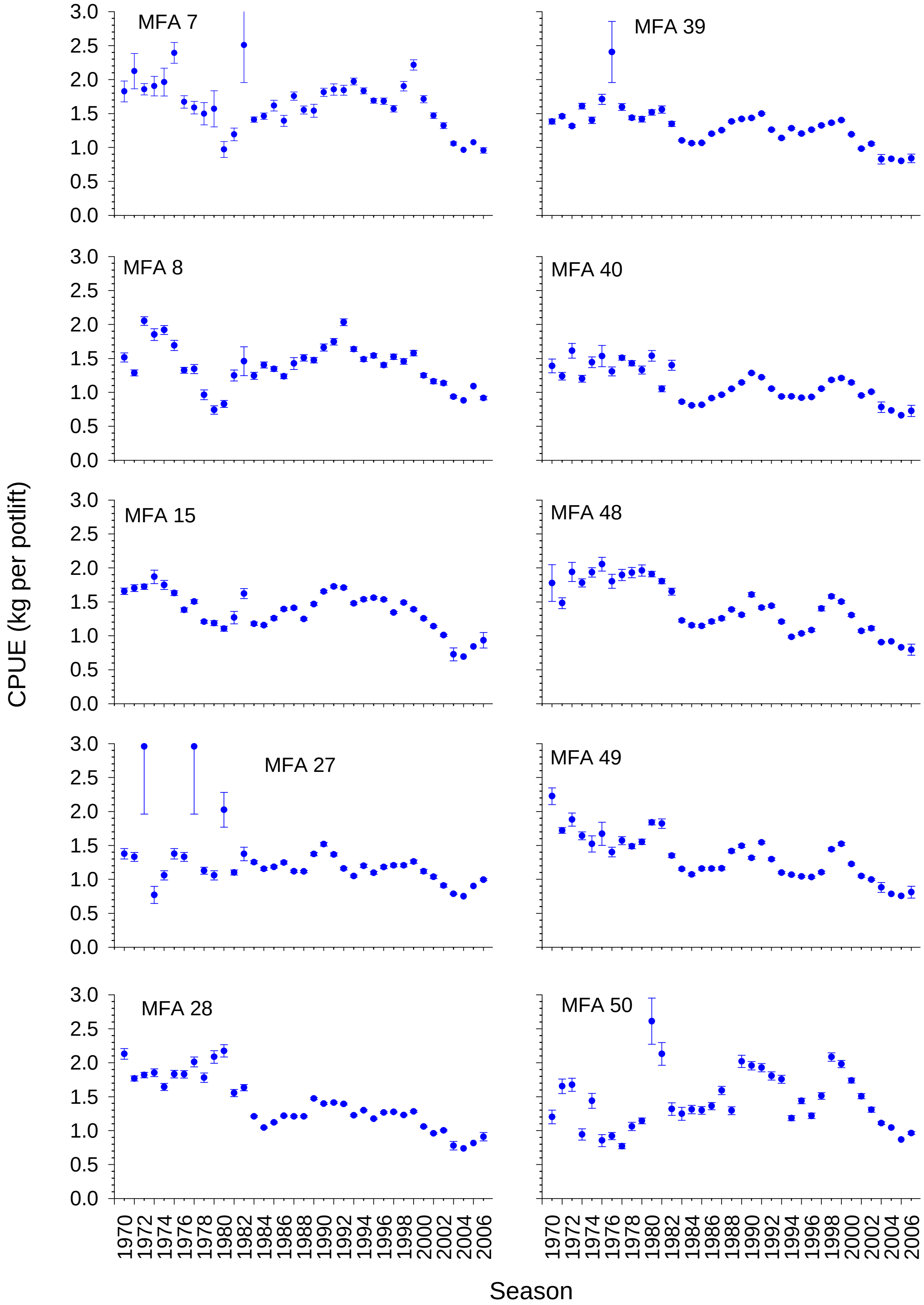

Figure 2-6 Inter-annual trends in CPUE (± SE of the mean) of the 10 main MFAs (from north-west to south-east) of the NZRLF for the fishing seasons between 1970 and 2006 (note: alternate season ticks on x axis).

Table 2-1 Total catch taken from the 10 main MFAs in the NZRLF in 2006.

MFA	Catch (t)	% Total Catch
7	4.06	1
8	11.24	3
15	43.63	10
27	22.73	5
28	124.71	27
39	92.94	20
40	44.24	10
48	44.77	10
49	53.26	12
50	7.4	2

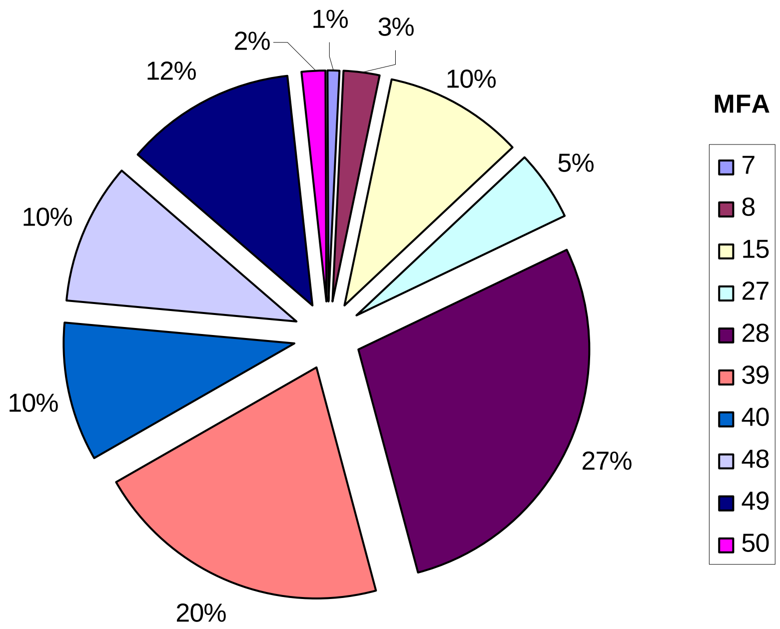

Figure 2-7 Proportion of total catch taken from the 10 main MFAs in the NZRLF in 2006.

2.3 Trends by Region

2.3.1 Catch

Trends in catch within the newly proposed Regions of the NZRLF (refer to Figure 1-4) between 1970 and 2006 are presented in Figure 2-8. While up to 172 tonnes were taken in Region A in 1993, catches in this Region are now <50 tonnes with just 20.1 tonnes landed in 2006. The majority of the catch is taken in Regions B, C and D. In recent seasons, catch in all Regions (with the exception of Region B) has decreased, reflecting zonal trends presented in Figure 2-1. In 2006, catch continued to decrease in Regions C and D with 76.2 (down 4.86 tonnes from 2005) and 176.3 tonnes (down 11.1 tonnes from 2005) recorded in these areas respectively. In Region B, catch increased for the second successive season. In 2006, a total of 218.7 tonnes were landed representing an increase in catch of 55.5 tonnes from the 2005 season.

2.3.2 Effort

In 2006, trends in effort reflected trends in catch in all Regions (Figure 2-8). Of particular note is the increase in effort in Region B over the last two seasons. Effort in this areas has increased by 50% from ~157,000 potlifts in 2004 to ~235,000 in 2006.

2.3.3 CPUE

Trends in CPUE in all Regions between 1970 and 2006 are presented in Figure 2-9. Historically, catch rate tended to be highest in Region A, reaching >2 kg/potlift in 1990, 1992 and 1993. However, as with zonal trends in CPUE (Figure 2-2), catch rate decreased in all Regions over the period 1999 to 2004. In 2006, CPUE increased for the first time since 1999 in Regions C and D reaching 0.76 and 0.84 kg/potlift, respectively. CPUE also increased for the second successive season in Region B reaching 0.95 kg/potlift.

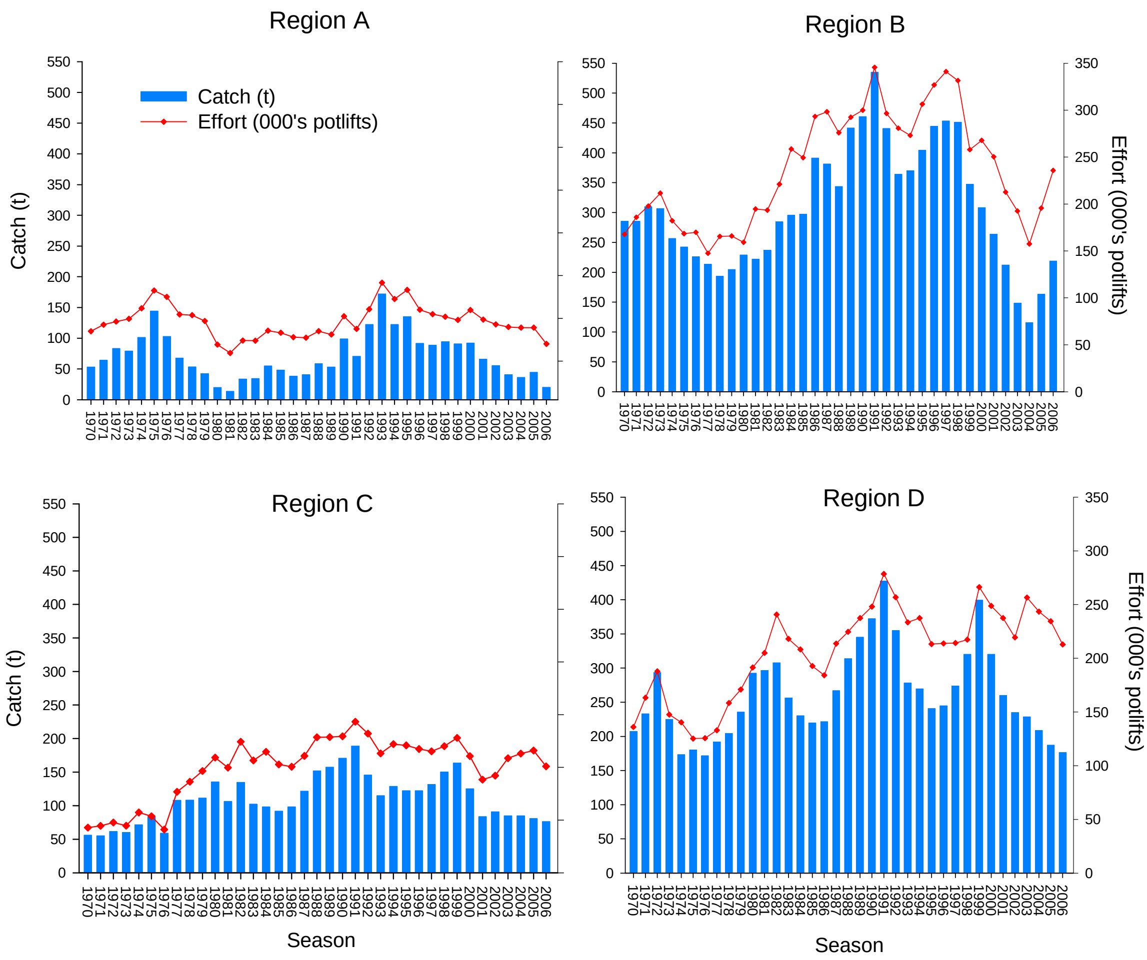

Figure 2-8 Catch and effort by region in the NZRLF from 1970 to 2006. Note that catch and effort from MFA 39 (Figure 1-1) has been apportioned 30:70 between Regions C and D.

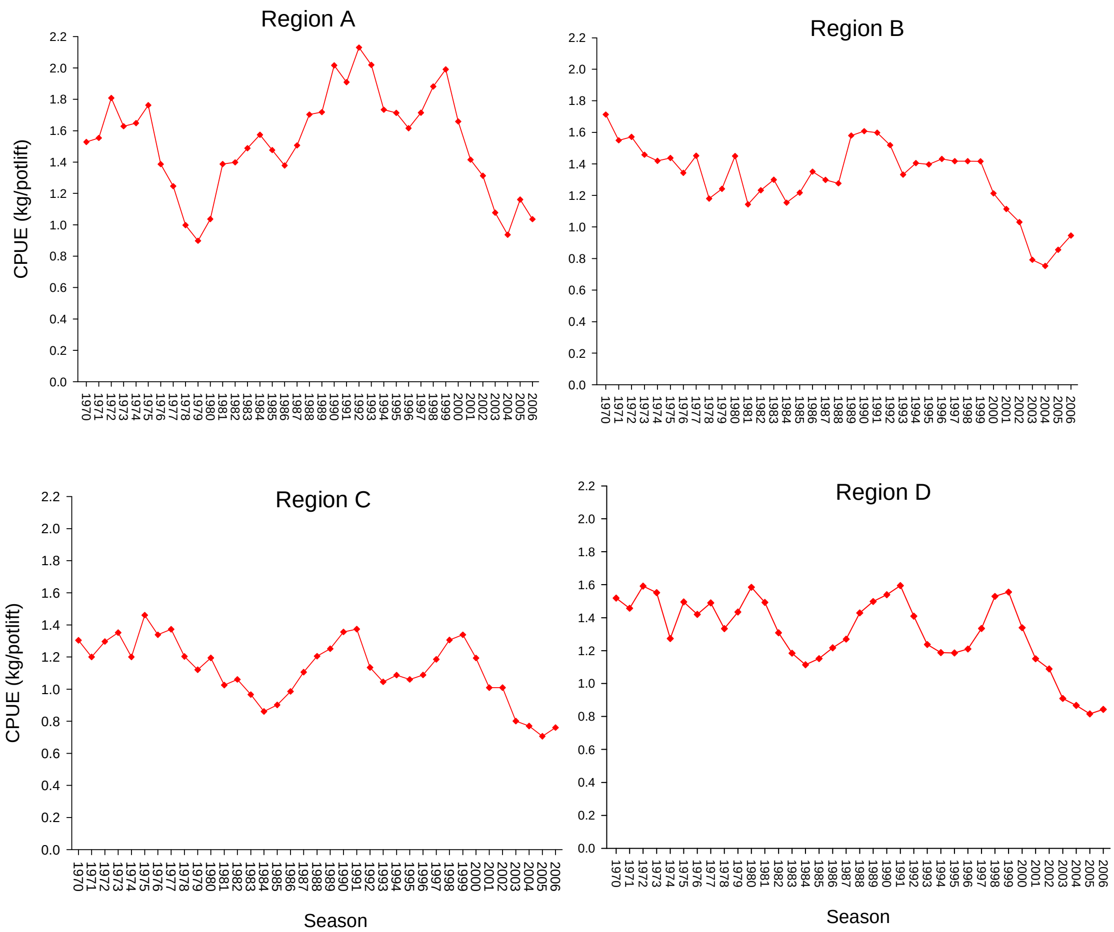

Figure 2-9 CPUE by region in the NZRLF from 1970 to 2006. Note that catch and effort from MFA 39 (Figure 1-1) has been apportioned 30:70 between Regions C and D to calculate catch rate.

2.4 Trends by Depth

2.4.1 Catch

Over the last 6 seasons, the majority (>80%) of the catch in the NZRLF has been taken at depths of < 60 m (Figure 2-10). The greatest proportion (~50%) has been taken at depths of 31-60 m. Less than 10% of the catch is taken at depths > 90 m. For zonal estimates of catch by depth pre 2001, see Linnane et al (2007).

Most of the main MFAs follow a similar pattern in catch with depth to that described for the entire fishery, with more of the catch coming from shallower depths (0-30 and 31-60 m) in recent years (Figure 2-12). In 2006, MFAs 48, 49 and 50, located south and east of Kangaroo Island (Figure 1-1), were the only MFAs where a notable proportion of the catch (~10-31%) was taken in deeper waters of >60 m depth. For estimates of catch by depth pre 2001 in key MFAs, see Linnane et al (2007).

2.4.2 CPUE

CPUE generally increases with depth in the NZRLF. In 2006, CPUE was highest in February (Figure 2-11) in the lower depth ranges of 0-30 and 31-60 m and ranged from 0.44 kg/potlift (in May at 0-30m) to 1.0 kg/potlift (in February at 31-60 m). Catch rates in deeper waters >60 m were highest in January/February and ranged from 0.58 kg/potlift (in May at 61-90 m) to 1.19 kg/potlift (in February at 61-90 m). Trends in CPUE by depth in 2006 were consistent with those observed in recent seasons within the NZRLF (Linnane et al. 2007).

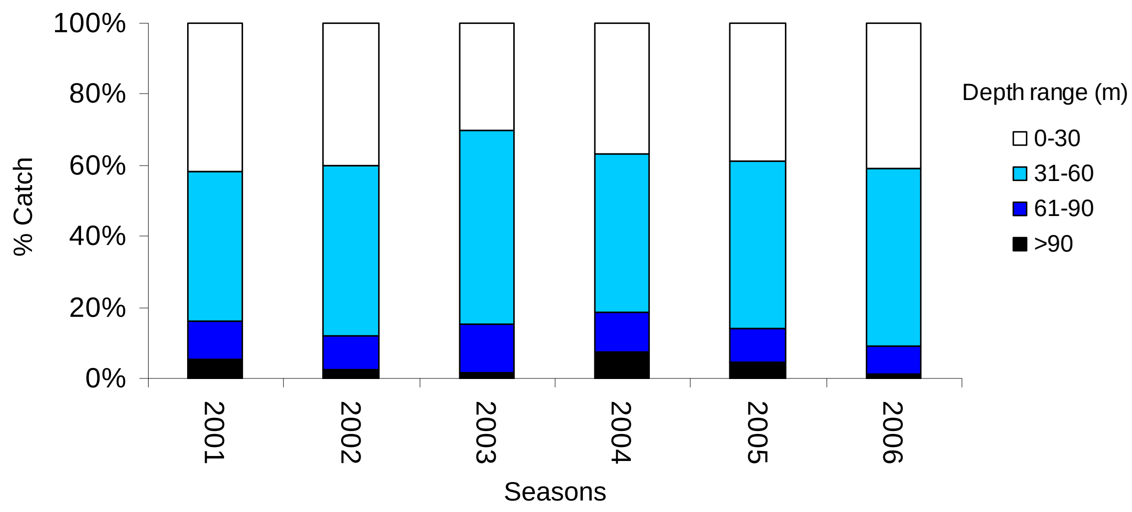

Figure 2-10 Percentage of the catch taken from four depth classes in the NZRLF during the last 6 fishing seasons.

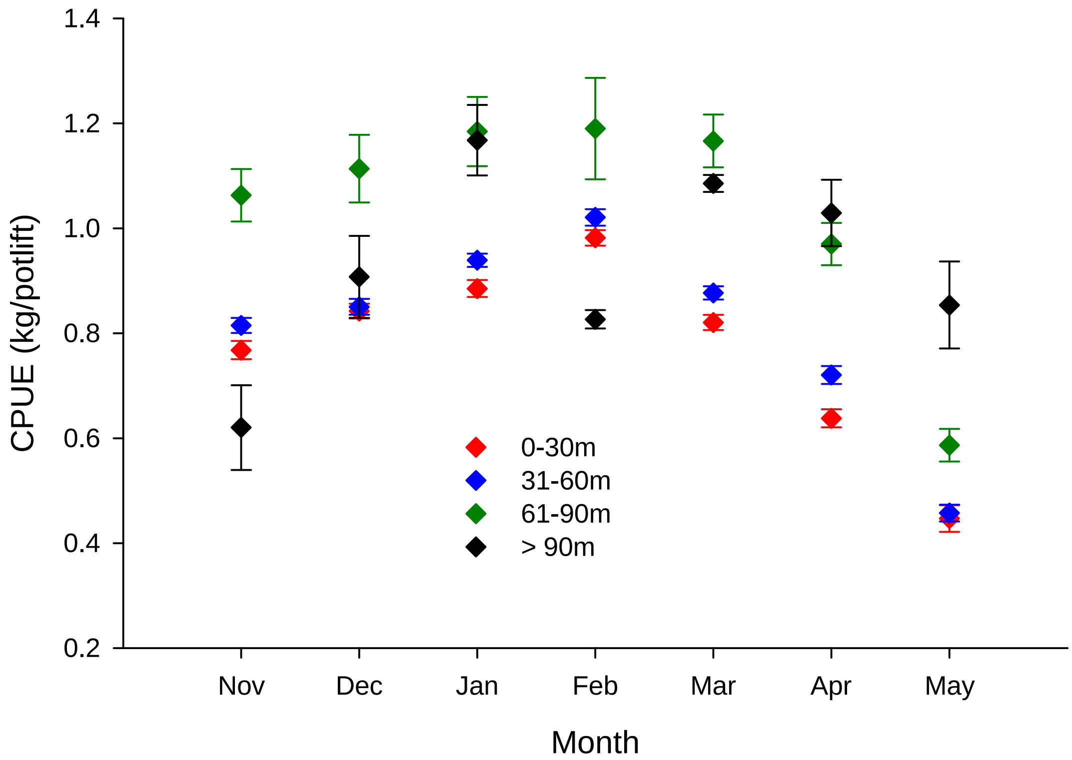

Figure 2-11 Mean monthly CPUE (+/- SE) in four depth classes in the NZRLF during the 2006 fishing season.

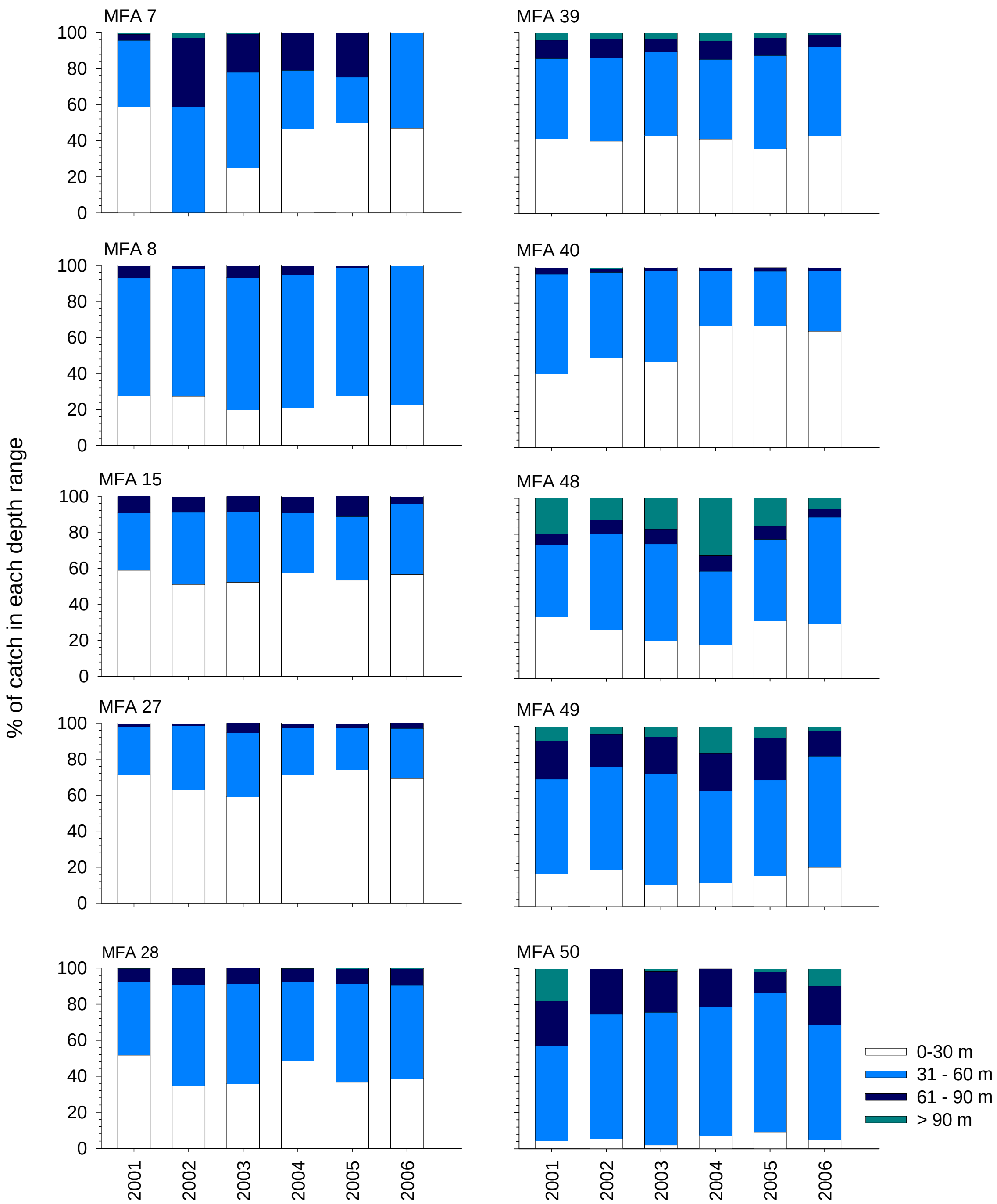

Figure 2-12 Percentage of the catch taken from four depth classes in the 10 major MFAs of the NZRLF over the last 6 seasons.

2.5 Pre-Recruit Index

2.5.1 Zonal trends

The mandatory introduction of escape gaps in the NZRLF in 2003 means that data required to calculate a pre-recruit index (PRI - mean number of undersize lobster per pot lift) is now dependent on voluntary catch sampling (where the escape gaps from up to 3 research pots are closed). PRI increased over the period 1994 to 1998 peaking at 0.51 undersize/potlift before decreasing to an all time low of 0.22 undersized/potlift in 2001 (Figure 2-13). Over the next four seasons, PRI increased to 0.49 undersized/potlift in 2005. In 2006, PRI decreased to 0.37 undersized/potlift.

2.5.2 Within-season trends

Within season trends in PRI over the last three seasons (2004, 2005 and 2006) have not been consistent (Figure 2-14). In 2006, PRI was highest in November at 0.65 undersized/potlift before decreasing to 0.14 undersized/potlift in May.

2.5.3 Trends across key MFAs

The PRI tends to be highest in MFAs located in the south of the NZRLF. Hence, the index is generally low in MFAs 7, 8, 15, 27 and 28 and high in MFAs 39, 40, 48, 49 and 50 (Figure 2-15). The zonal trends in the NZRLF index (Figure 2-13) are reflected in PRI for the individual MFAs although estimates for early years are probably negatively biased. The PRI in most MFAs increased between 1996 and 1998 before decreasing in subsequent seasons. In 2006, the index remained low in the MFAs to the north-west of the zone (i.e. 7, 8, 15, 27, 28). Patterns in remaining MFAs generally reflected the overall zonal trend with decreases observed in MFAs 39, 40, 48, 49 and 50.

2.5.4 Trends by Region

Patterns by Region broadly reflect observed patterns in key MFAs (Figure 2-16). PRI in Region A (refer to Figure 1-4) was considerably lower than Regions B, C and D. Peaks in PRI were observed in Regions C and D in 1998 but generally decreased thereafter to 2004. In 2005, PRI increased across all Regions before decreasing again in 2006.

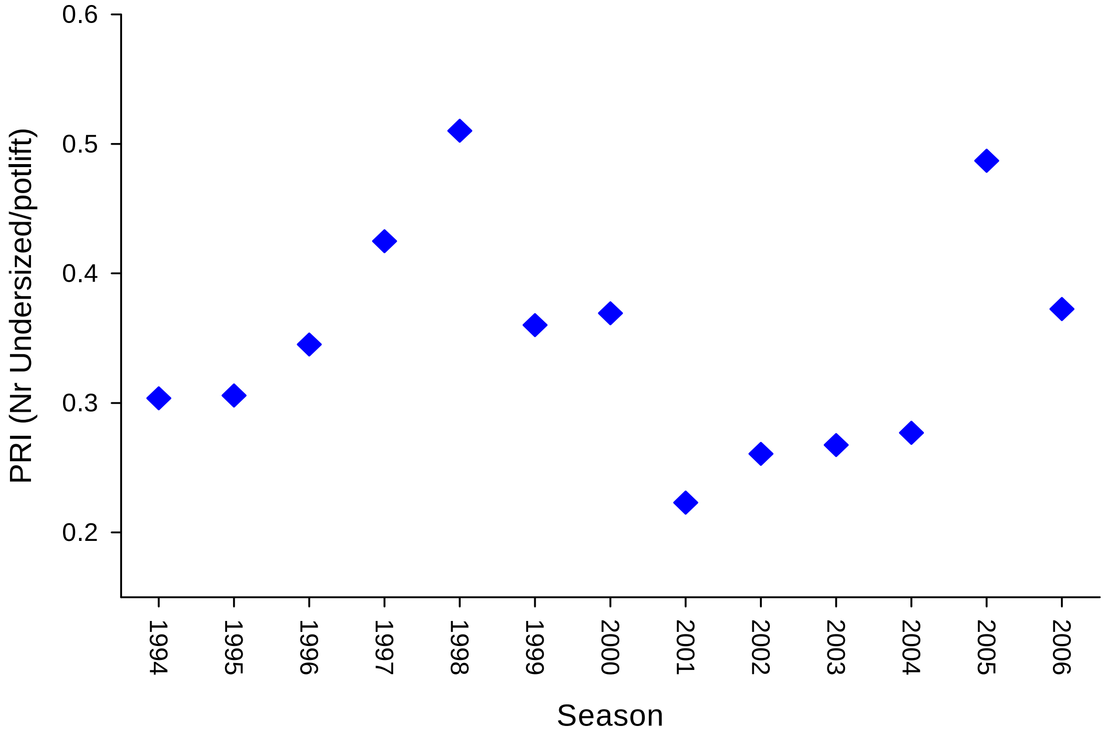

Figure 2-13 Inter-annual trends in pre-recruit index in the NZRLF from 1994 to 2006 as calculated using voluntary catch sampling data (November-March inclusive).

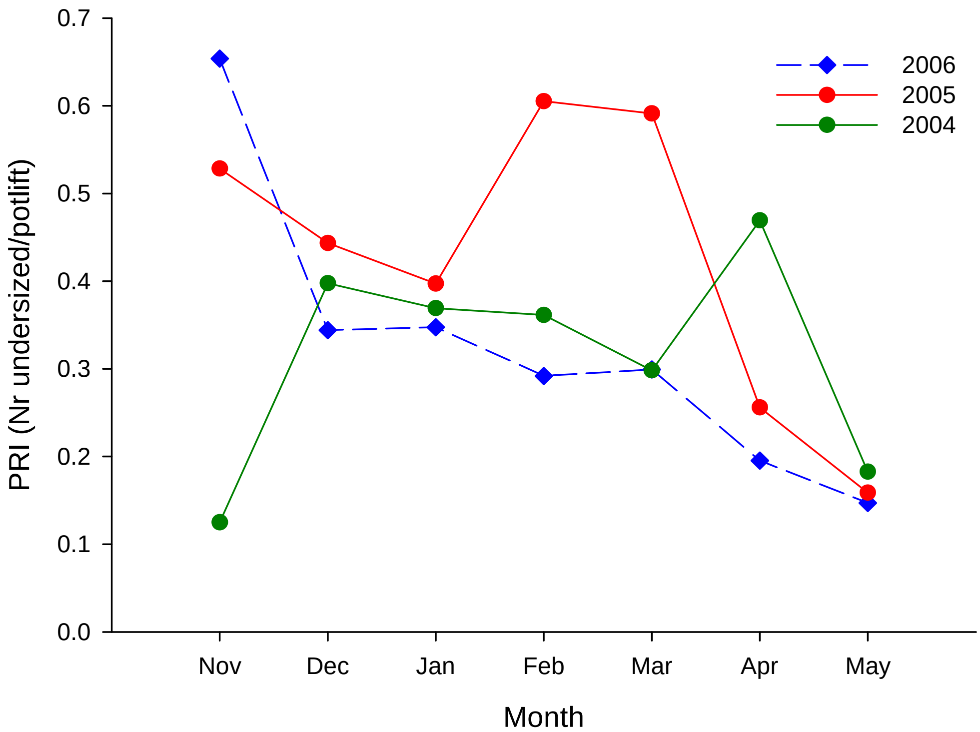

Figure 2-14 Within season trends in pre-recruit index in the NZRLF for the 2004, 2005 and 2006 fishing seasons as estimated from voluntary catch sampling data.

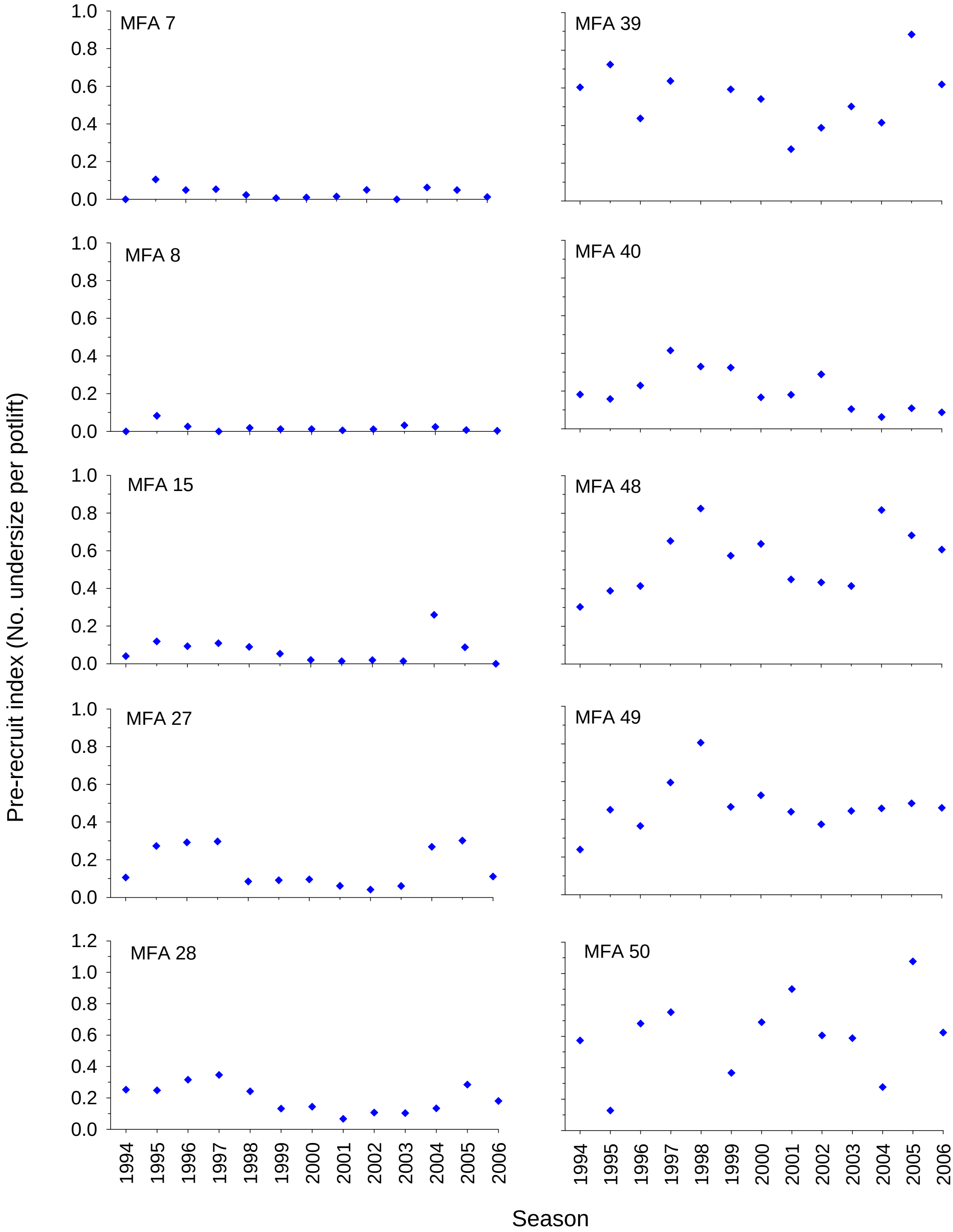

Figure 2-15 Mean pre-recruit index (catch sampling data) for MFAs in the NZRLF from 1994 to 2006. (Numerical order of MFAs is from north-west to south-east).

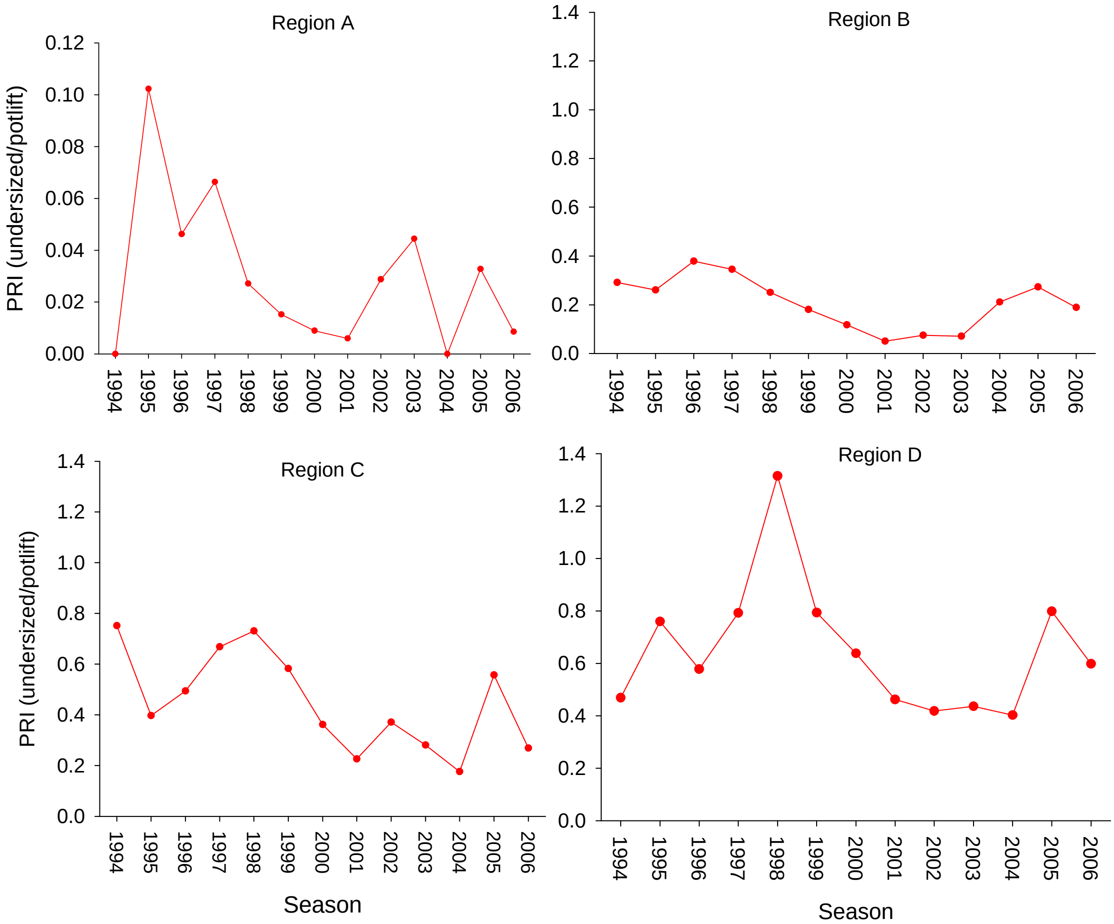

Figure 2-16 Pre-recruit Index (PRI number of undersized/potlift) by region in the NZRLF from 1994 to 2006. Note that PRI from MFA 39 (Figure 1-1) has been apportioned 30:70 between Regions C and D.

2.6 Mean Weights

2.6.1 Zonal trends

Since 1983, the mean weight of lobsters taken in the NZRLF has fluctuated between 1.00 and 1.21 kg (Figure 2-17). The lowest mean weight was recorded in 1988 and 1989. There were peaks in the mean weight of lobsters in 1984 (1.08 kg) and 1995 (1.16 kg), with the peak of 1.21 kg for the 2001 season being the highest mean weight recorded for the fishery. Over the next three seasons, mean weight decreased to 1.08 kg in 2004. In 2005, mean weight marginally increased to 1.09 kg before decreasing again to 1.0 kg in 2006. The pattern of rise and fall in mean size reflects long-term patterns of recruitment, with low mean weights resulting from influxes of small lobsters into the fishable biomass and high mean weights resulting from several consecutive years of low recruitment. The gradual increase in lobster mean weight observed from 1998 to 2001 probably also reflects the effects of the increases in minimum legal size from 98.5 mm to 102 mm in 1994 and from 102 mm to 105 mm in 2001. Since 2001, mean weight has generally decreased, which is a positive sign for the fishery and may reflect that the fishery is entering a period of higher recruitment.

2.6.2 Within-season trends

Since the 1970s, there has been a consistent trend of increasing mean weight as the fishing season progresses (Linnane et al. 2006). Lobsters caught early in the season (November to January) tend to be smaller than those taken later in the season (February to May). In 2006, mean monthly weight was similar to previous seasons being lowest in November at 0.87 kg and highest in May at 1.18 kg (Figure 2-18).

2.6.3 Trends across key MFA's

Mean weights of lobsters are highest in MFAs located in the north of the NZRLF (e.g. 7, 8, 15, 27; Figure 1-1), and lowest in MFAs located further south (e.g. 48, 49, 50) (Figure 2-19). Between 1983 and 1998, mean weights were relatively stable in most MFAs but tended to increase between 1998 and 2001, except in MFA 8. Since 2001, mean weight has generally decreased in most MFAs reflecting the zonal estimates of mean weight observed over the same period (Figure 2-17).

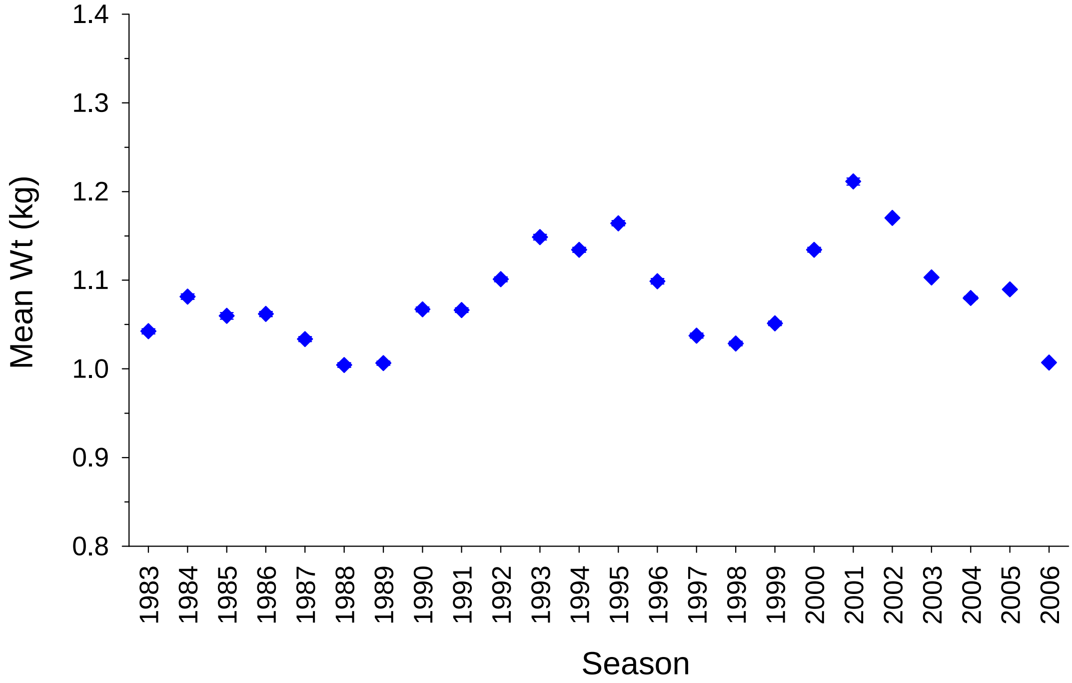

Figure 2-17 Inter-annual trends in the mean weight (± SE) of lobsters in the NZRLF for the fishing seasons between 1983 and 2006.

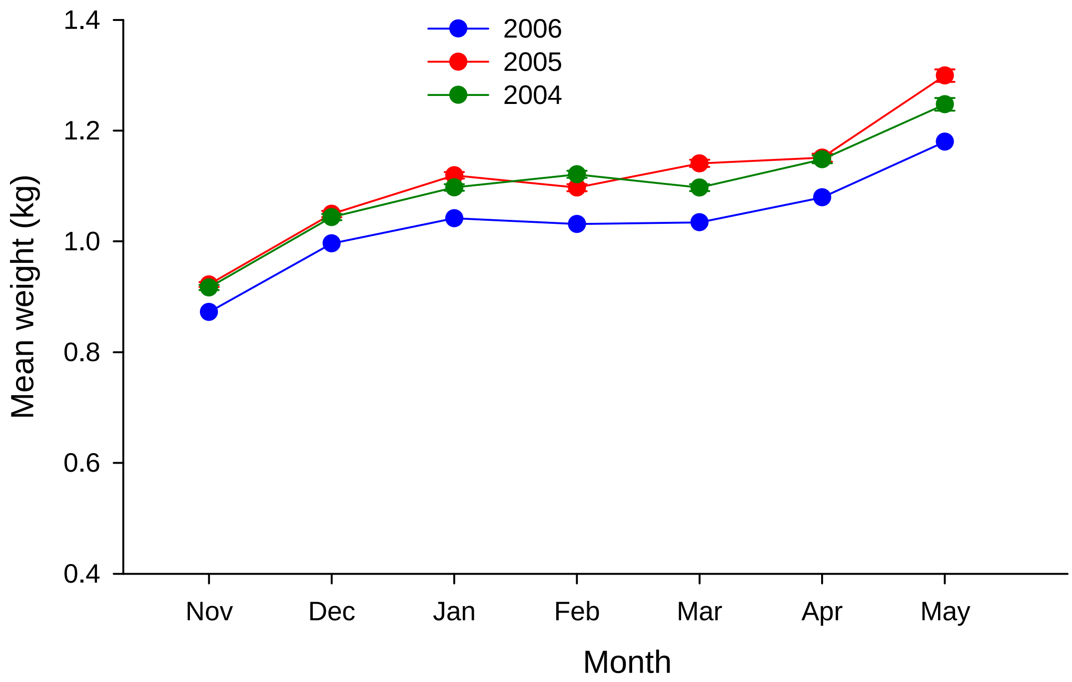

Figure 2-18 Within-season trends in the mean weight (± SE) of lobsters in the NZRLF during the 2004, 2005 and 2006 seasons.

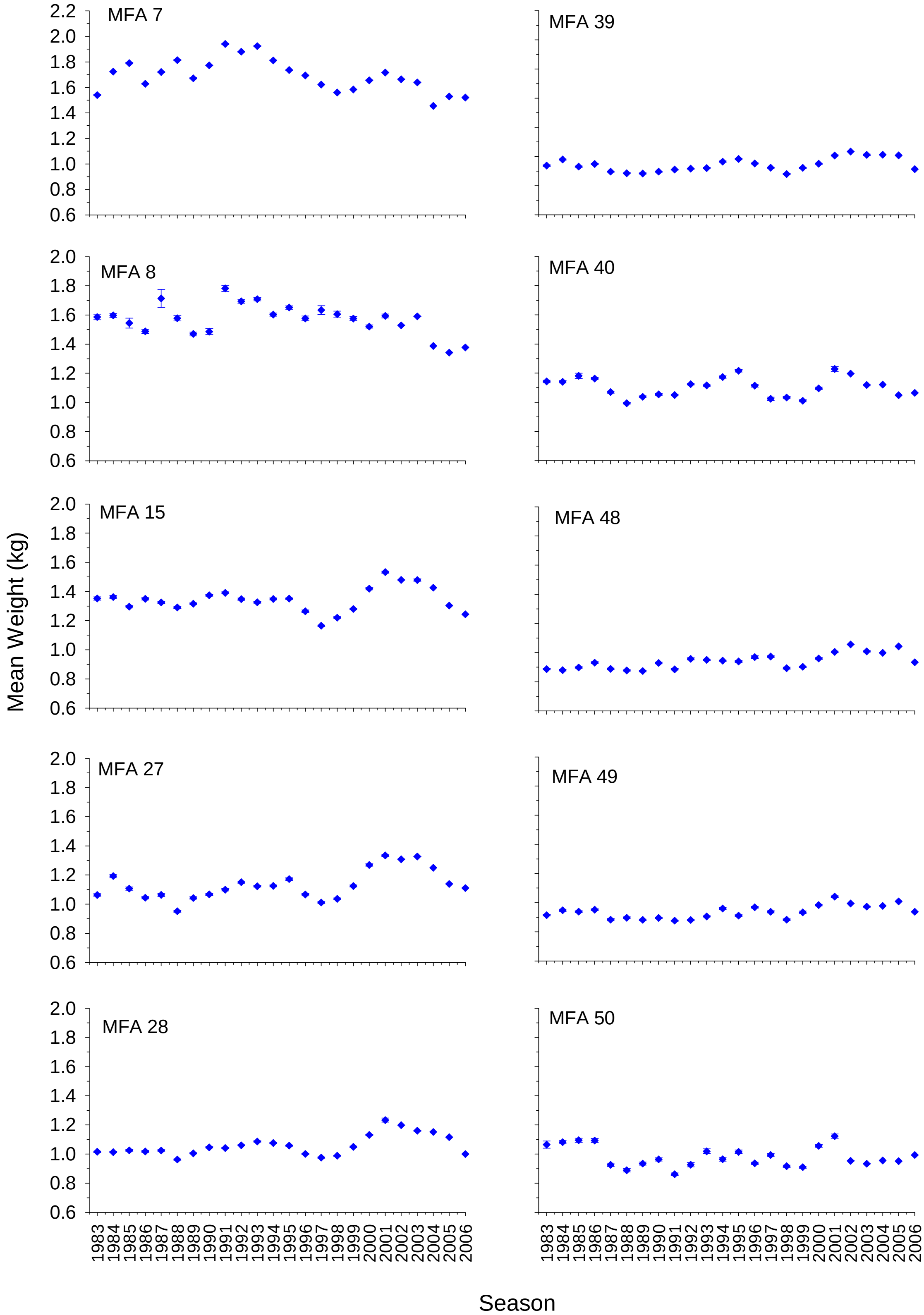

Figure 2-19 Inter-annual trends in the mean weights (± SE) of lobsters for the main MFAs of the NZRLF for the fishing seasons between 1983 and 2006.

2.7 Length Frequency

Since 1991, between 3,200 and 18,000 male lobsters and between 3,200 and 15,500 female lobsters, have been measured annually (refer to Linnane et al., 2006 for previous length outputs). Length frequency data provide important input for length transition matrices that are an integral component of the length structured model (LenMod) outputs (see Section 5 of this report). Male lobsters, which grow faster and reach larger sizes than females, range between 70 and 210 mm CL, whereas few females are larger than 150 mm CL. The median size for males ranges between 115 – 125 mm CL, whereas for females it ranges between 105 – 115 mm CL. A total of 8,948 lobsters were measured in 2006 (Figure 2-20). Of these, 79.2% of males and 65.9% of females were above the Minimum Legal Size (MLS) of 105 mm CL. Overall, there is no strong evidence from length frequency data to suggest that the size distribution of lobsters has changed markedly since sampling began (Figure 2-21).

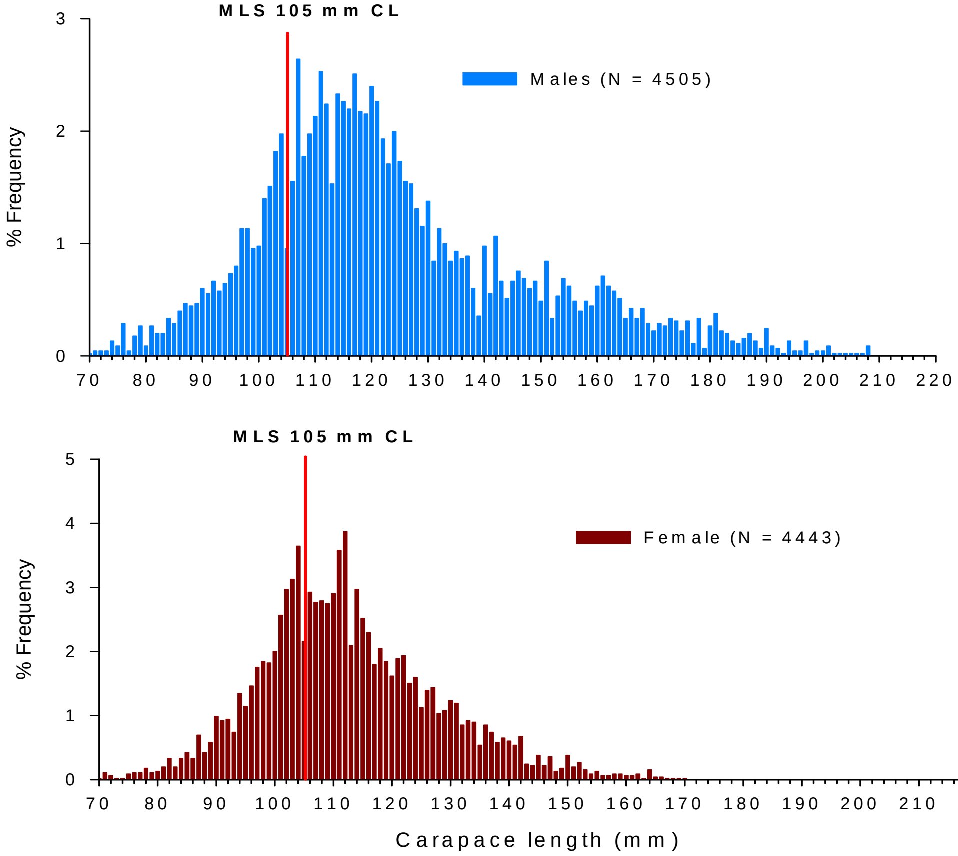

Figure 2-20 Length frequency distributions of male and female lobsters in the NZRLF 2006 fishing season.

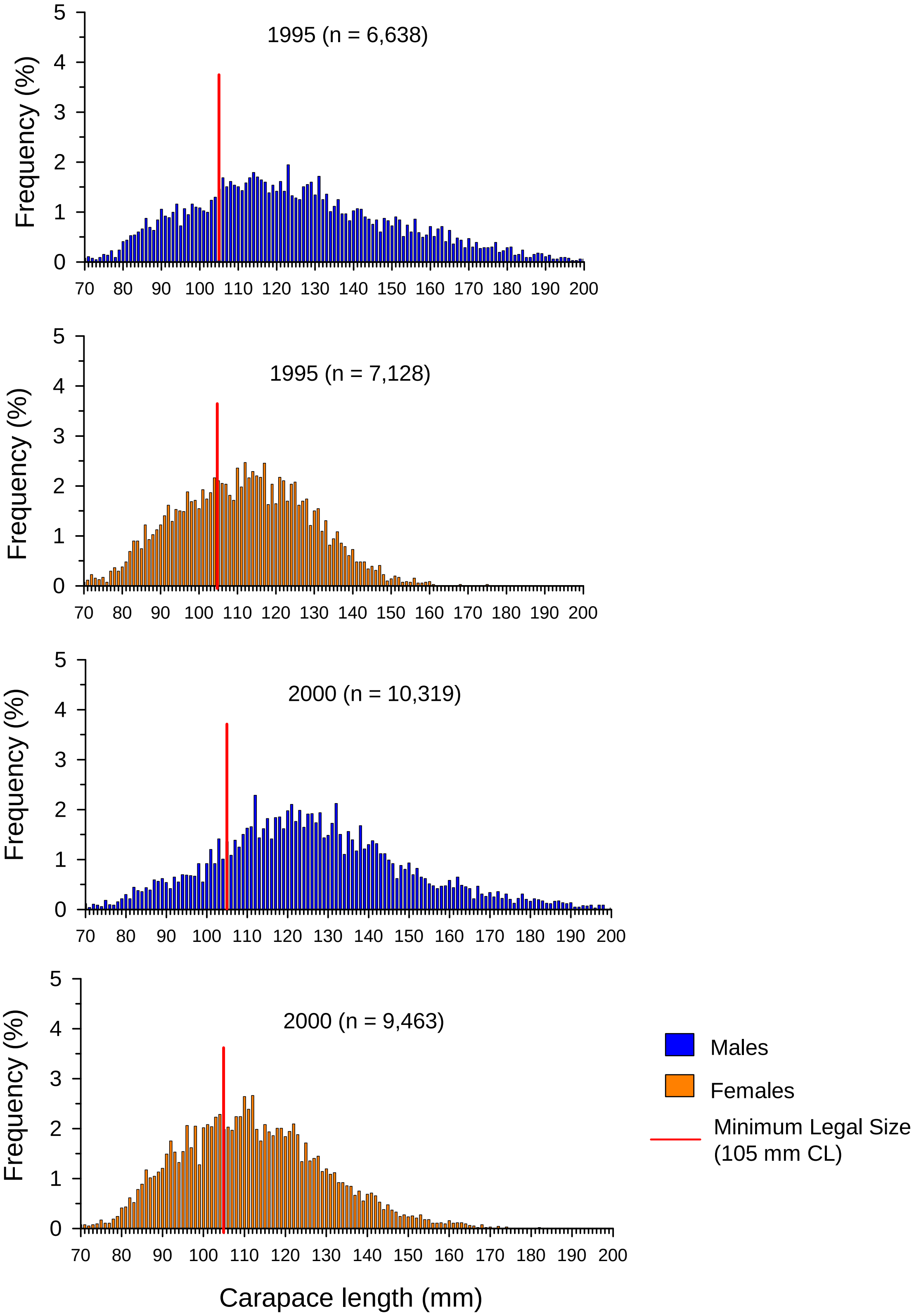

Figure 2-21 Length frequency distributions of male and female lobsters in the NZRLF during the 1995 and 2000 seasons fishing seasons.

3 FISHERY INDEPENDENT STATISTICS

3.1 Settlement Index

The annual estimates of puerulus settlement index (PSI) in the NZRLF are calculated from puerulus counts observed at McLaren Point and Taylor Island (Port Lincoln), Stenhouse Bay (Yorke Penninsula) and Marion Bay (Yorke Penninsula). The plots show that the settlement index remained relatively low from 1996 to 2001 (Figure 3-1). In 2002, the highest PSI on record was observed at 1.09 puerulus/collector. Indices over the next two seasons in 2003 and 2004 were again low but increased again in both 2005 and 2006. These two seasons represent the first time that back-to-back peak settlements have been observed. In 2007, the PSI decreased to 0.08 puerulus/collector, which is the lowest on record since monitoring began. Given that 2005 and 2006 were two of the highest PSIs on record, this highlights the sporadic nature of settlement in the NZRLF.

The PSI (lagged by 3 years) was plotted alongside pre-recruit index (PRI) as calculated from voluntary catch sampling in the NZRLF (Figure 3-2). Correlation analysis indicated that PSI was correlated to PRI over the period 1999 to 2006 ($R^2 = 0.53$) using a 3-year time lag. Future data points should substantiate this emerging relationship between puerulus settlement and recruitment.

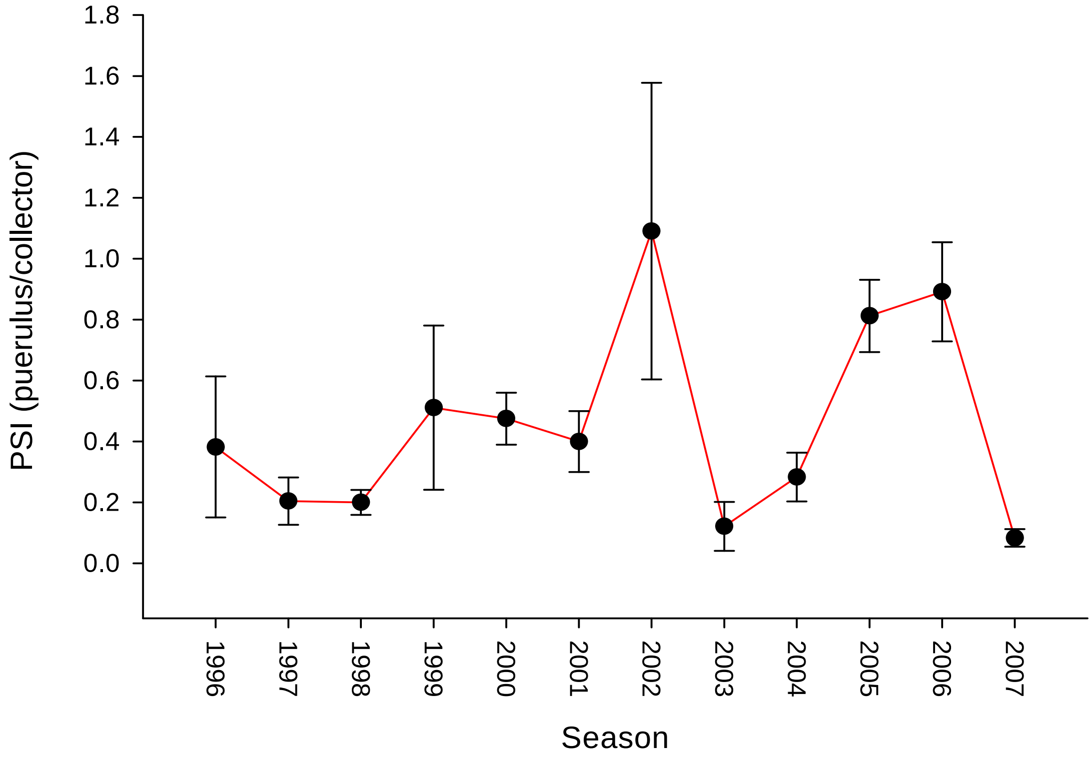

Figure 3-1 Puerulus settlement index (PSI; mean +/- SE) in the NZRLF from 1996 to 2007.

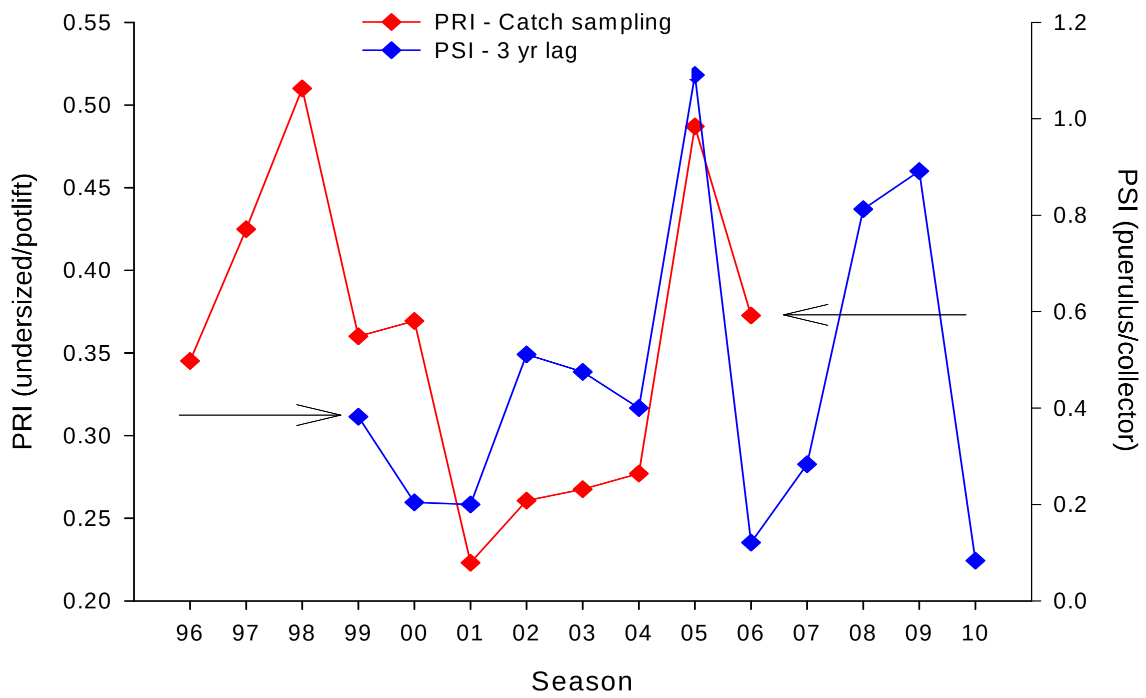

Figure 3-2 Puerulus settlement index (PSI) lagged by 3 years plotted against pre-recruit index (PRI) as calculated from voluntary catch sampling data. Arrows indicate overlapping period of correlation analyses.

4 THE QR MODEL

4.1 Introduction

The qR model (McGarvey et al. 1997; McGarvey and Matthews 2001) is used to generate estimates of important performance indicators for the NZRLF, namely biomass, exploitation rate egg production and recruitment.

A review of the stock assessment research conducted by SARDI Aquatic Sciences (Breen and McKoy 2002) concluded that the qR model is an appropriate tool for assessing exploitation rate and recruitment. The model has been refined over time, most notably during the peer review process for publication of McGarvey and Matthews (2001). Three recent changes to the model are: (i) the replacement of the least squares method by normal likelihoods for the fits to catches in both number and weight; (ii) the adoption of a Baranov, rather than a simple bi-linear Schaefer catch relationship (iii) the incorporation of a 3% annual increase in effective effort over the time period 1983 to 2000.

This section of the report has two objectives; (i) to use the 2006 version of the qR model to generate annual estimates of biomass, egg production, % virgin egg production and exploitation rate for the NZRLF using data to the end of the 2006 fishing season; and (ii) to compare estimates of recruitment obtained using the qR model with the independent measure of pre-recruit abundance from catch sampling.

4.2 Methods

A detailed description of the qR model is provided in McGarvey and Matthews (2001). In summary, the qR model fits to the yearly catches by weight (*Cw*, in kg) and number (*Cn*, in number of lobsters landed). Effort data (*E*) is also taken from logbook data and a Baranov survival model using a Schaefer catch relationship ($Cn=qEN$) is assumed. The model likelihood is written as a modified normal and fitted numerically. Catchability and recruitment in each year are estimated as free parameters, as is the likelihood coefficient of variation parameter, assumed to be the same for the two catch data sources, *Cw* and *Cn*.

Other stock assessment models (delay-difference and biomass dynamic) that fit to catch and effort data use only catch given in the weight landed (*Cw*), while employing *CwPUE* as a measure of relative fishable biomass. The qR model adds catch totals in number of lobsters landed to the fitted data set. Because catch-in-weight divided by catch-in-number gives the mean weight of an average lobster, the addition of the catch-in-number brings information about yearly mean size in the legal catch, otherwise available only from length-frequency data. Because catches in weight and number constitute a 100% sample, the quality of information obtained about yearly changes in *mean* size from catch data is more precise than that obtained from length frequencies alone, which typically constitute a 0.1% to 1.0% sample fraction. Thus, the qR model uses *CwPUE* as a measure of change in abundance and mean weight as a measure of change in size structure.

The pre-recruit index, (numbers of undersize lobsters), provides a direct measure of yearly recruitment that is independent of qR-inferred recruitment, which uses only legally sized landed lobsters. It therefore provides a means of assessing the recruitment outputs from the qR model. The pre-recruit index used in this section of the report is based on undersized lobster CPUE for November to March due to the fact that variability in the number of undersized lobsters is lowest during this period.

Two modifications were made to the 2005 version of the qR model. First, the 3% yearly rising effective effort was assumed to cease after 2000. Second, a selectivity parameter was included to account for a reduced level of recruitment in the first age that lobsters reach legal size. This models the partial recruitment of newly arriving year classes and assumes that the entire cohort does not reach legal size in the same year. This partial recruitment vulnerability was implemented from 2003 onward, yielding an estimated value of 67%.

4.3 Outputs

Goodness of fit

Estimates of catch in number and weight from the 2006 version of the qR model, based on the assumption of a 3% change in effective effort over the time period 1983-2000, fitted closely with measures of *Cn* and *Cw* obtained from the NZRLF (Figure 4-1 and Figure 4-2).

Biomass

Outputs from the qR model suggest that the biomass in the NZRLF have decreased considerably over the last 20-30 years (Figure 4-3). In 2006 it was estimated to be 2,086 tonnes, one of the lowest estimates on record. While biomass is currently at a historically low level the rate of decline was reduced in 2006. Specifically, the recent rapid decline from 1999 through to 2005 was arrested and in 2006 biomass was observed to have marginally increased.

Egg production

Similar to biomass, the qR model indicates that that total egg production has considerably decreased in the NZRLF (Figure 4-4). In 2006 it was 241 billion eggs, which equates to 17.5 % of virgin egg production (Figure 4-5).

Exploitation rate

The exploitation rate during 2006 decreased marginally to 23% but remains one of the lowest estimates since 1989 (Figure 4-6).

Comparison of estimates of recruitment from qR model and the pre-recruit index

Temporal trends in recruitment predicted by the qR model and estimated by the pre-recruitment index determined from catch sampling data are broadly similar (Figure 4-7). The recruitment estimates from the qR model suggest that recruitment levels over the last five seasons were among the lowest in the fishery's history. In 2006, the increase in qR recruitment was not reflected in a comparable increase in PRI.

4.4 qR Model Discussion

Details of the qR model, and simulation testing of its performance have been described in a number of peer-reviewed papers (McGarvey et al. 1997; McGarvey and Matthews 2001). The model estimates from simulated data yielded close agreement with 'true' fishery indicators from the simulated fishery for yearly varying recruitment, biomass, and exploitation rate. Moreover, these simulated data tests found that the model estimates were relatively insensitive to errors in natural mortality rate, and some other common assumptions. However, these estimates were relatively sensitive to assumed weights at age (McGarvey and Matthews 2001; McGarvey et al., 2005).

The qR model outputs estimate that biomass in the NZRLF has decreased considerably since the inception of the fishery. In 2006 it was estimated to be 2,086 tonnes, a marginal increase from 2005 (1,997 tonnes) but remaining one of the lowest estimates on record. Current exploitation rates (based on the current TACC of 520 tonnes) are estimated to be 23%. Similar to biomass, egg production in the NZRLF has decreased considerably since 1970, with the 2006 estimate of 241 billion eggs one of the lowest on record.

There is relatively close agreement between qR model yearly recruitment trends and pre-recruit estimates from voluntary catch sampling. The notably exceptions are 2001, where a decrease in PRI was not observed in qR recruitment and 2005 where a notably increase in PRI recruitment was not reflected in model estimated recruits. Given that the biological reference points for PRI in the Management Plan currently rely on catch sampling PRI, the robustness of this indicator needs to be closely monitored within the life of the plan.

Most of the uncertainty in the model estimates lies in the assumed values of input parameters, i.e. (1) natural mortality, (2) mean weights-at-age, and (3) CPUE as a measure of biomass. Steady-state analysis by McGarvey et al. (1997) showed that catch under-reporting has essentially no effect on the qR estimates of exploitation rate, while yearly estimates of biomass and recruitment are reduced by under-reporting. Similarly, McGarvey and Matthews (2001) and McGarvey et al. (2005) showed that (1) model estimates are relatively insensitive to errors in the assumed natural mortality rate, but that these estimates were, (2) like any size-based assessment, sensitive to the assumed growth inputs of weight-at-age.

Finally, it should be highlighted that the current version of the qR model for the NZRLF is exclusively reliant on fishery dependent data, namely catch by weight and catch by number. As a result, a current limitation to the model is that trends in biomass (Figure 4-3) mimic trends in legal-sized catch rate (Figure 2-2). Future development of the model will benefit from the inclusion of fishery independent data from annual fishery independent monitoring surveys that are currently being developed for the NZRLF. The inclusion of fishery independent data will improve the usefulness of the model as a management tool by a) providing a spatial component to the fishery assessment and b) allowing assessment of the overall resource rather than just areas fished.

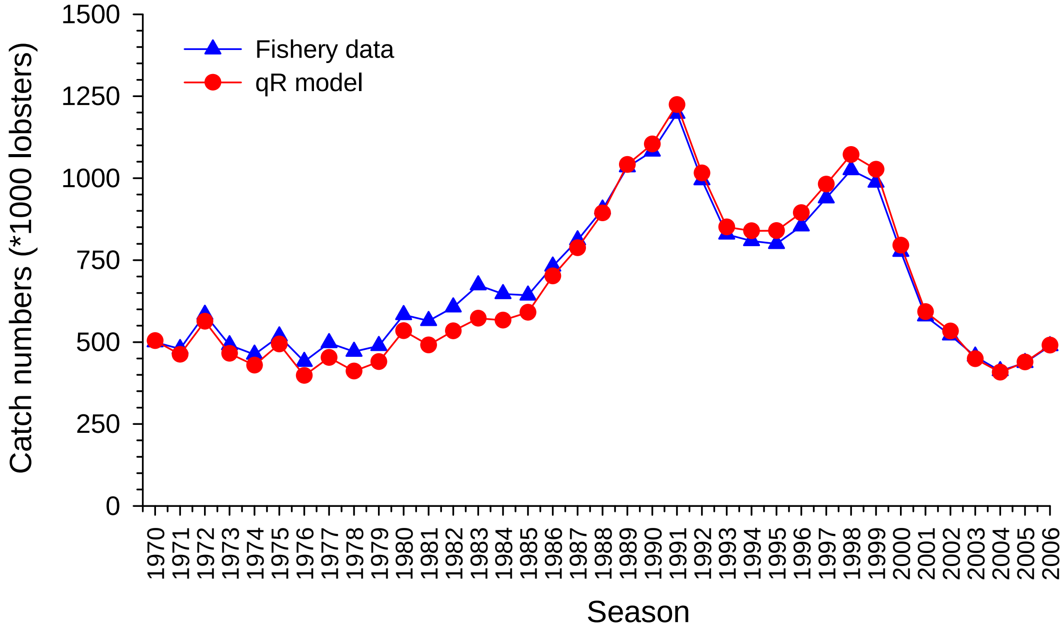

Figure 4-1 Fit of the qR model to catch in numbers for the NZRLF, based on annual catch totals from the fishery and estimates provided by 2006 version of the qR model.

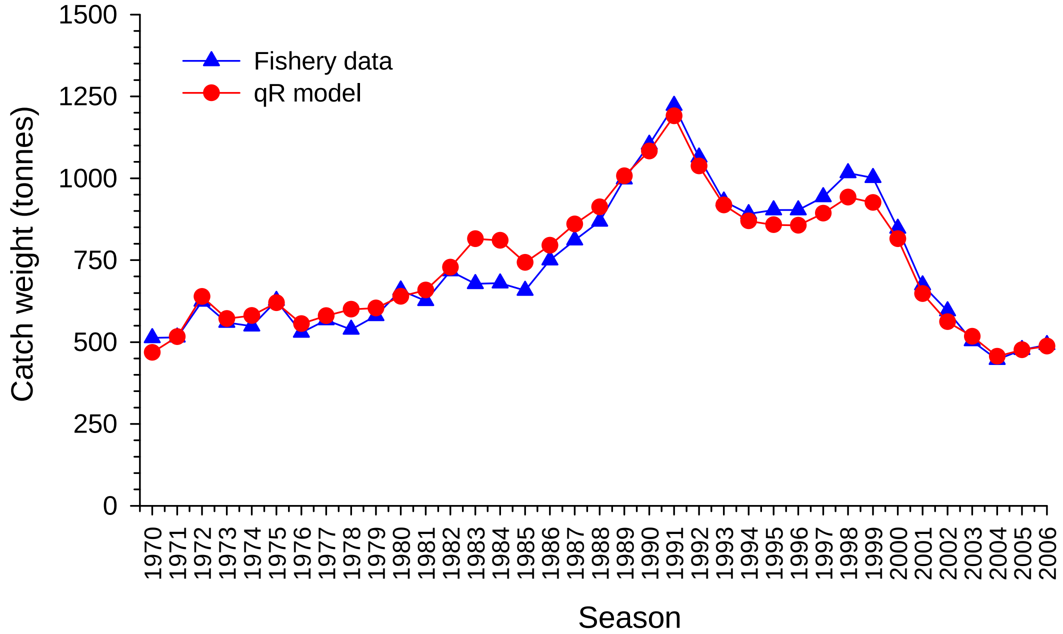

Figure 4-2 Fit of the qR model to catch by weight for the NZRLF, based on annual catch totals from the fishery and estimates provided by 2006 version of the qR model.

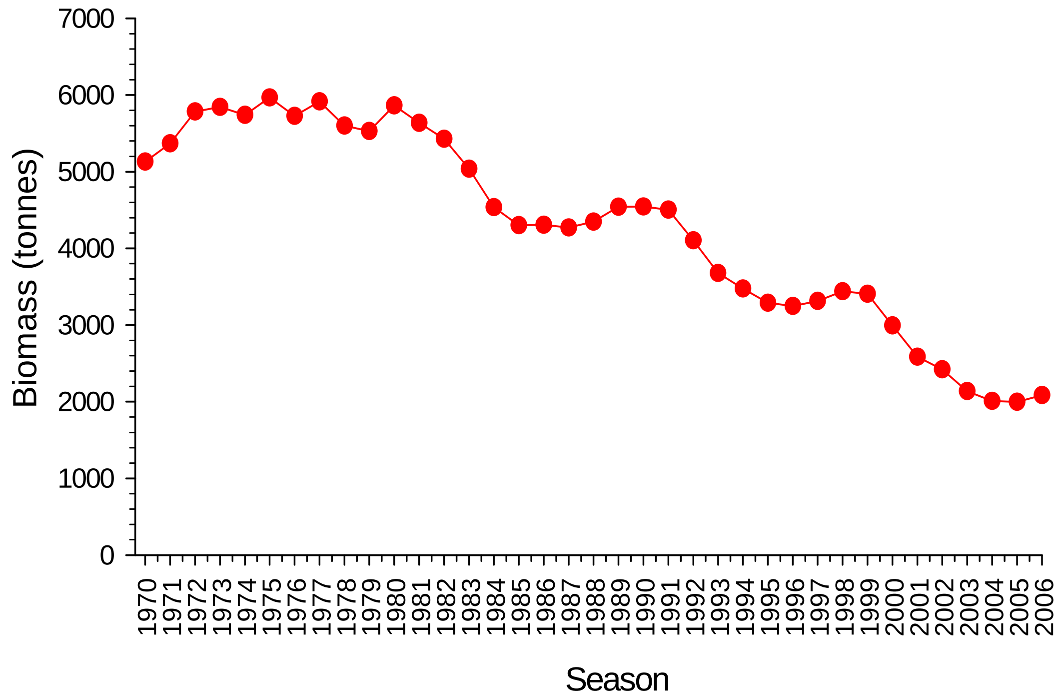

Figure 4-3 Estimates of biomass for the NZRLF, provided by the 2006 qR model.

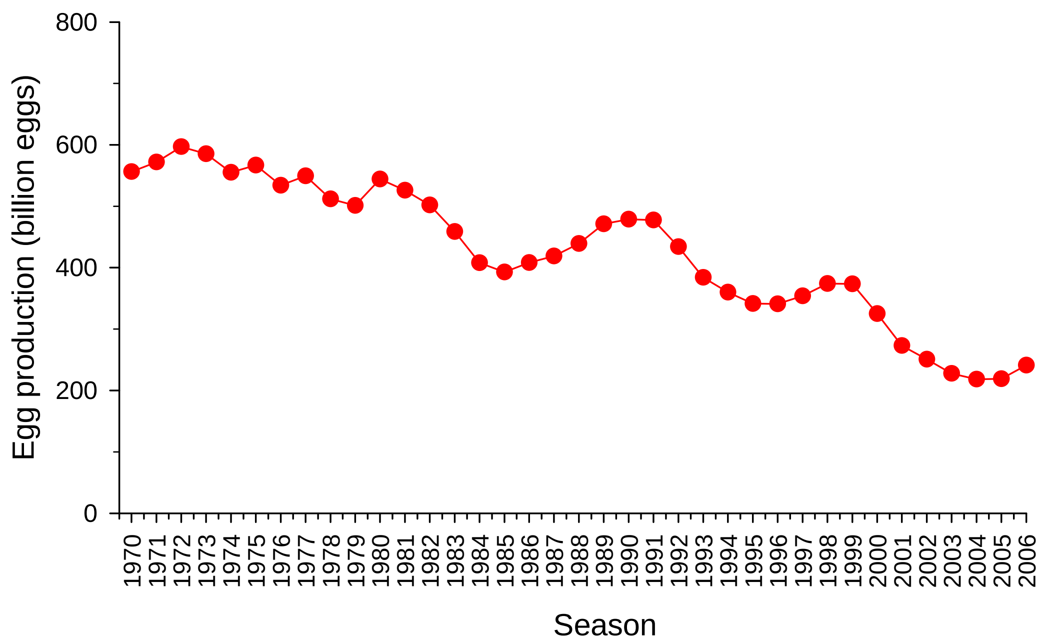

Figure 4-4 Estimates of egg production for the NZRLF, by the 2006 qR model.

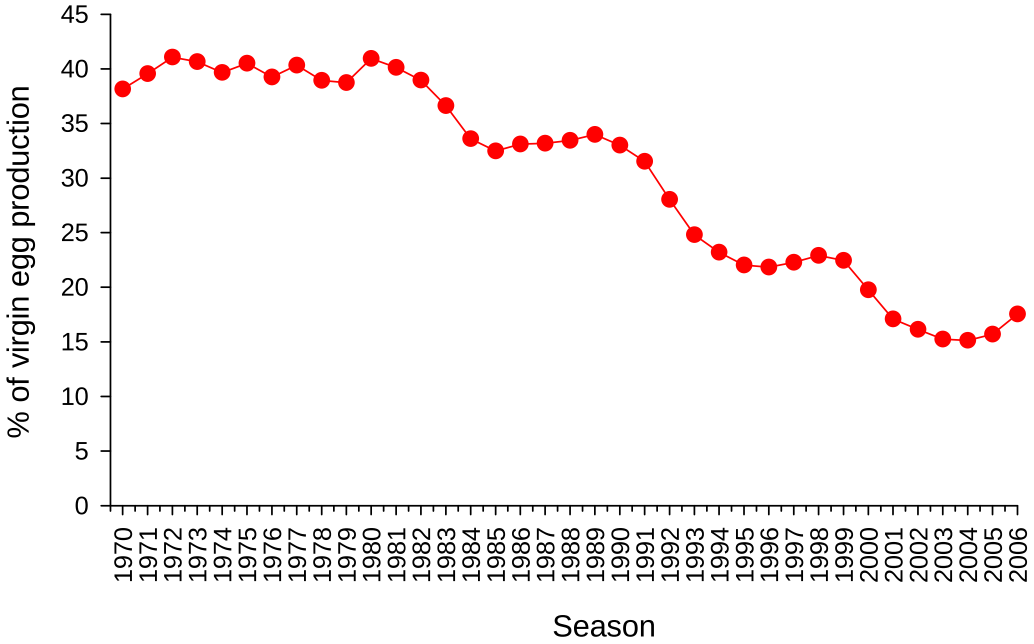

Figure 4-5 Estimates of % virgin egg production for the NZRLF, from the 2006 qR model.

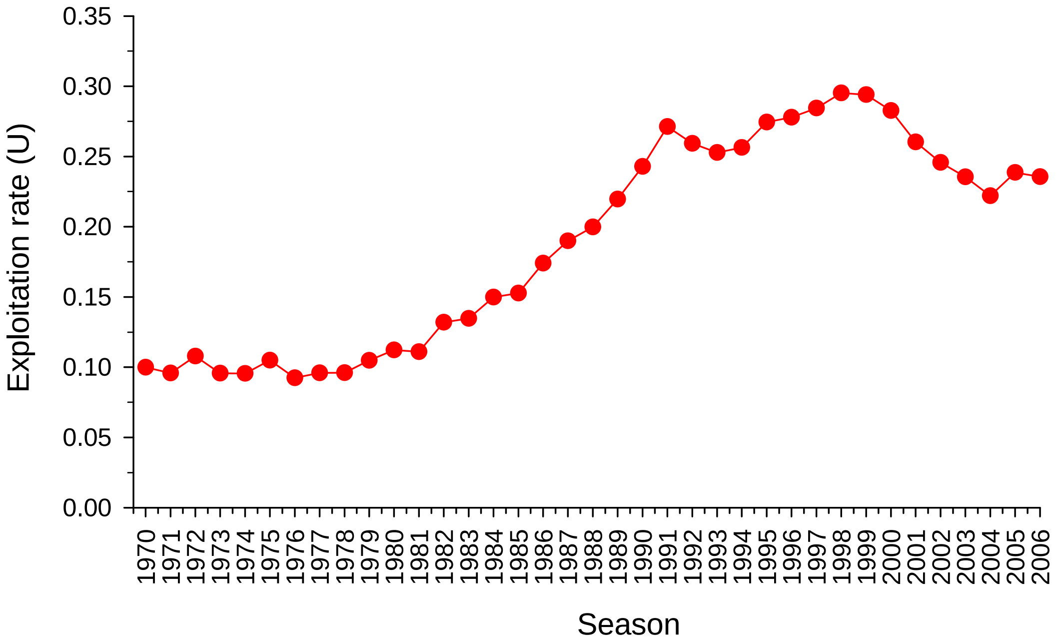

Figure 4-6 Estimates of exploitation rate for the NZRLF, obtained from the 2006 qR model.

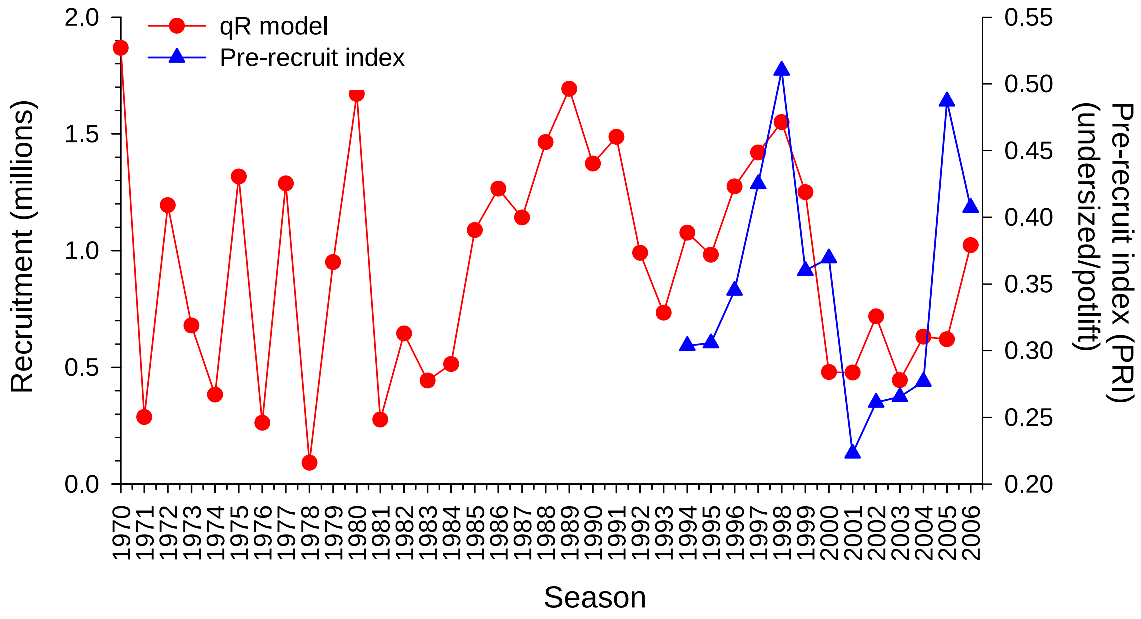

Figure 4-7 Estimates of annual recruitment for the NZRLF, obtained from the 2006 qR model, and pre-recruit index as undersized lobster per pot lift obtained from catch sampling data.

5 THE LENGTH STRUCTURED MODEL

5.1 Introduction

This section of the report provides the second published outputs from the newly developed length-frequency based model (LenMod) for the NZRLF. Previous reports provided estimates of yearly biomass, recruitment and exploitation rate inferred from catch and effort data, using the qR model. The newly developed model aims to incorporate all major sources of data from the fishery. André Punt first developed the basic model structure in the 1990's and a detailed description of the model is provided in Punt and Kennedy (1997). This length-structured model is now used for management and quota setting in most *Jasus edwardsii* fisheries, notably in New Zealand, Victoria and Tasmania.

5.2 Methods

The code for the South Australian LenMod has been adapted from the Victorian version of the model (Hobday and Punt 2001; Punt 2003). However, in order to incorporate all the available data from the South Australian fishery, a number of modifications to the model design have been implemented. These include: (1) accounting for seasonal changes in the fishery, notably of catchability and fishing effort, (2) accounting for mid-summer recruitment and growth achieved by implementing a monthly, rather than a yearly, time step, (3) acknowledging that the majority of lobster growth in South Australia occurs at moulting seasons in late autumn and early summer, rather than once yearly, (4) incorporating data on sex ratios among recruits and the catch as estimated using voluntary catch sampling data, (5) reducing the length class bin widths from 8 mm to 4 mm, and (6) substantially refining the growth descriptions.

LenMod uses information about changing and absolute levels of stock abundance principally from three data sources: (1) CPUE (see Section 2.2) to which biomass is assumed to vary in direct proportion, (2) catches in both weight and numbers (see Section 2.6), which supply a highly precise (100% sample) measure of mean weight of lobsters in the catch, and (3) length-frequency data (see Section 2.7), interpreted in combination with the length-transition matrices to yield estimates of mortality rate and relative recruitment.

In LenMod, growth differs by sex and a monthly rather than yearly model time step is used. Growth rates are known to differ substantially by sex once lobsters reach maturity, and catchability and effort levels vary through the fishing season.

In LenMod, growth is modelled using a length-transition matrix and is defined as the proportion of lobsters in each length category that grow into larger length classes during each seasonal moulting period. Growth matrices were derived for both sexes, in the two growth moulting seasons. The length-transition matrix has been created using the extensive tag-recovery dataset for the NZRLF, and incorporates known information on sex ratios as well as annual within-season moulting periods. The generalised polynomial method to estimate growth-transition matriices (McGarvey and Feenstra 2001) permits quanfication of a more flexibly wide range of growth trends. Thus, a key feature of LenMod is the ability to account for slower growth rates of females that have reached sexual maturity (McGarvey and Feenstra 2001) thus allowing a more accurate overall estimation of growth than previously assumed using a traditional von Bertalanffy mean growth curve.

5.3 Outputs

Goodness of fit

Estimates of catch in numbers and catch rate from the LenMod model fitted closely with reported *Cn* and *CPUE* obtained from the NZRLF (Figure 5-1, Figure 5-2). In addition, both male and female model estimates fitted well to commercial catch length frequency data, as shown in monthly fits from the 2006 season (Figure 5-3).

Biomass

Outputs from the LenMod model indicate that the biomass in the NZRLF has generally decreased since 1990, reaching a historical low of 1,766 tonnes in 2004 (Figure 5-4). Over the last two seasons biomass has marginally increased and in 2006 was estimated to be 1,879 tonnes.

Egg production

Similar to biomass, LenMod trends in egg production in the NZRLF have been generally decreasing since 1991, reaching a historical low of 227 billion eggs in 2004

(Figure 5-5). In 2006, egg production marginally increased to 231 billion, which equates to 12.4% of virgin egg production (Figure 5-6).

Exploitation rate

The exploitation rate has been decreasing in the NZRLF since 1999 reaching a low of 0.26 in 2004 (Figure 5-7). Since then it has marginally increased and in 2006 was 0.27.

Recruitment

The recruitment estimates from LenMod suggest that recruitment has fluctuated greatly since 1983 but that estimates over the period 2001 to 2004 have been the lowest in the history of the fishery (Figure 5-8). In 2006, recruitment increased and was estimated to be 0.74 million lobsters.

5.4 Model Discussion

Details of the length structured model including simulation testing of its performance have been described in two peer-reviewed papers (Hobday and Punt 2001; Punt 2003). The LenMod outputs estimate that biomass in the NZRLF has decreased considerably since the inception of the fishery. In 2006 it was estimated to be 1,879 tonnes, a marginal increase from 2005 (1,788 tonnes) but remaining one of the lowest estimates on record. Current exploitation rates (based on the current TACC of 520 tonnes) are estimated to be 27%. Given the current status of the fishery, the problem of high-grading that affects the SZRLF is not considered an issue in the NZRLF. As a result, biomass outputs are not likely to be affected by this practice. Similar to biomass, egg production in the NZRLF has decreased considerably since 1970, with the 2006 estimate of 231 billion eggs one of the lowest on record.

The current version of LenMod, like the qR model, utilises fishery dependent data, namely CPUE and catch by weight and number. As a result, similar limitations to the model exist, namely, that trends in biomass (Figure 5-4) mimic trends in legal-sized catch rate (Figure 2-2). As a result, the model is non-spatial, meaning that each fishery zone is modelled as a single population. In future versions of LenMod, the lobster population and fishery of each zone will be differentiated into subregions (based on Management Plan objectives), with movement rates among these subregions being estimated from tag-recovery data (McGarvey et al 2008 *in press*). Separate growth estimates (as length-transition matrices by sex) will be derived using (non-moving) tag recoveries from each subregion. In addition, future outputs will incorporate fishery independent data to provide (1) a measure of abundance not affected by market differentials or spatial differences in fishing effort, and (2) a resolved spatial breakdown of estimated population biomass, exploitation rate and other management indicators.

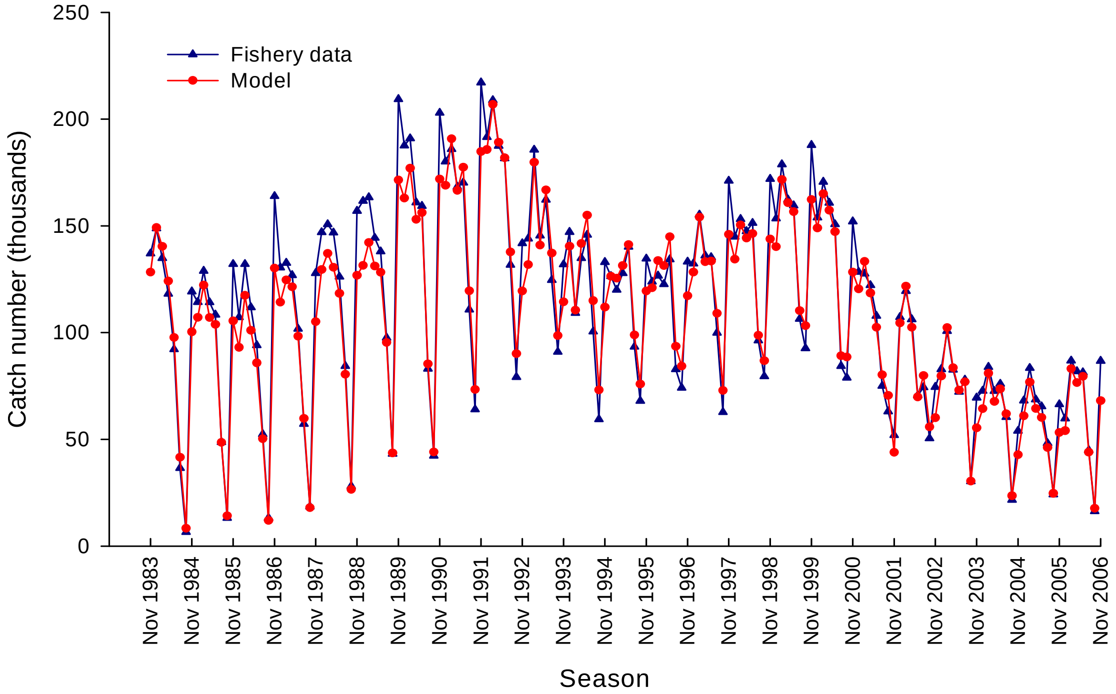

Figure 5-1 Fit of the LenMod model to monthly catch in numbers for the NZRLF, based on annual catch totals from the fishery and estimates provided by the 2006 version of the model.

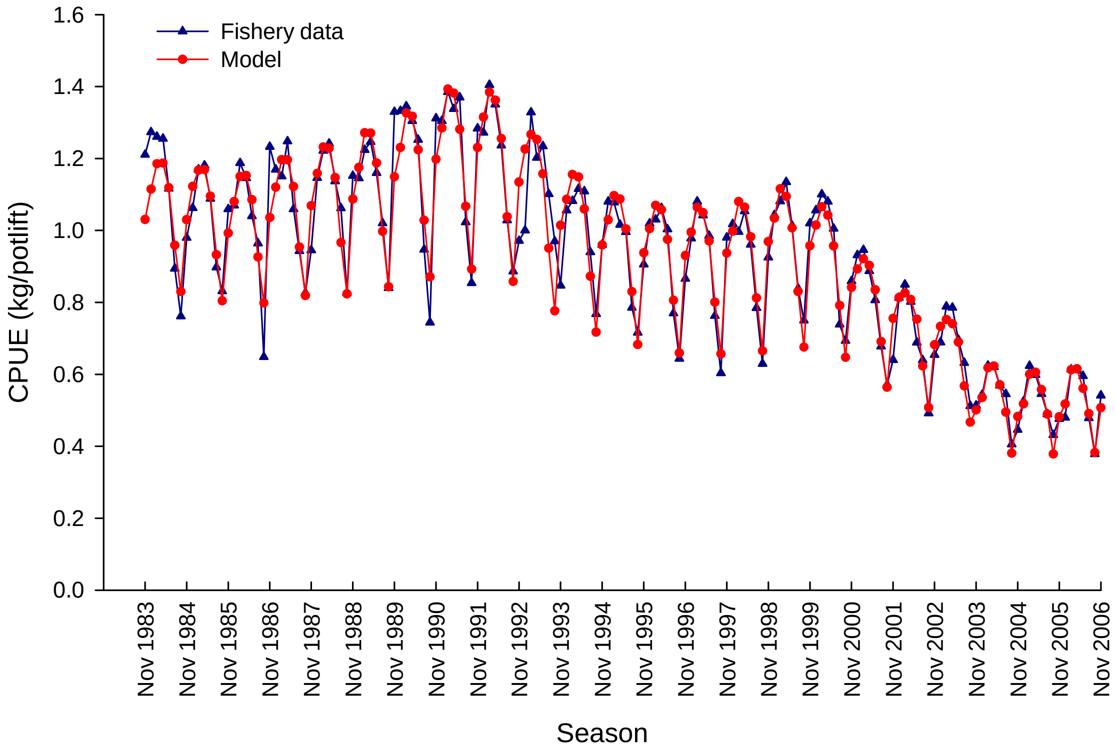

Figure 5-2 Fit of the LenMod model to monthly catch rate for the NZRLF, based on annual estimates from the fishery and those provided by the 2006 version of the model.

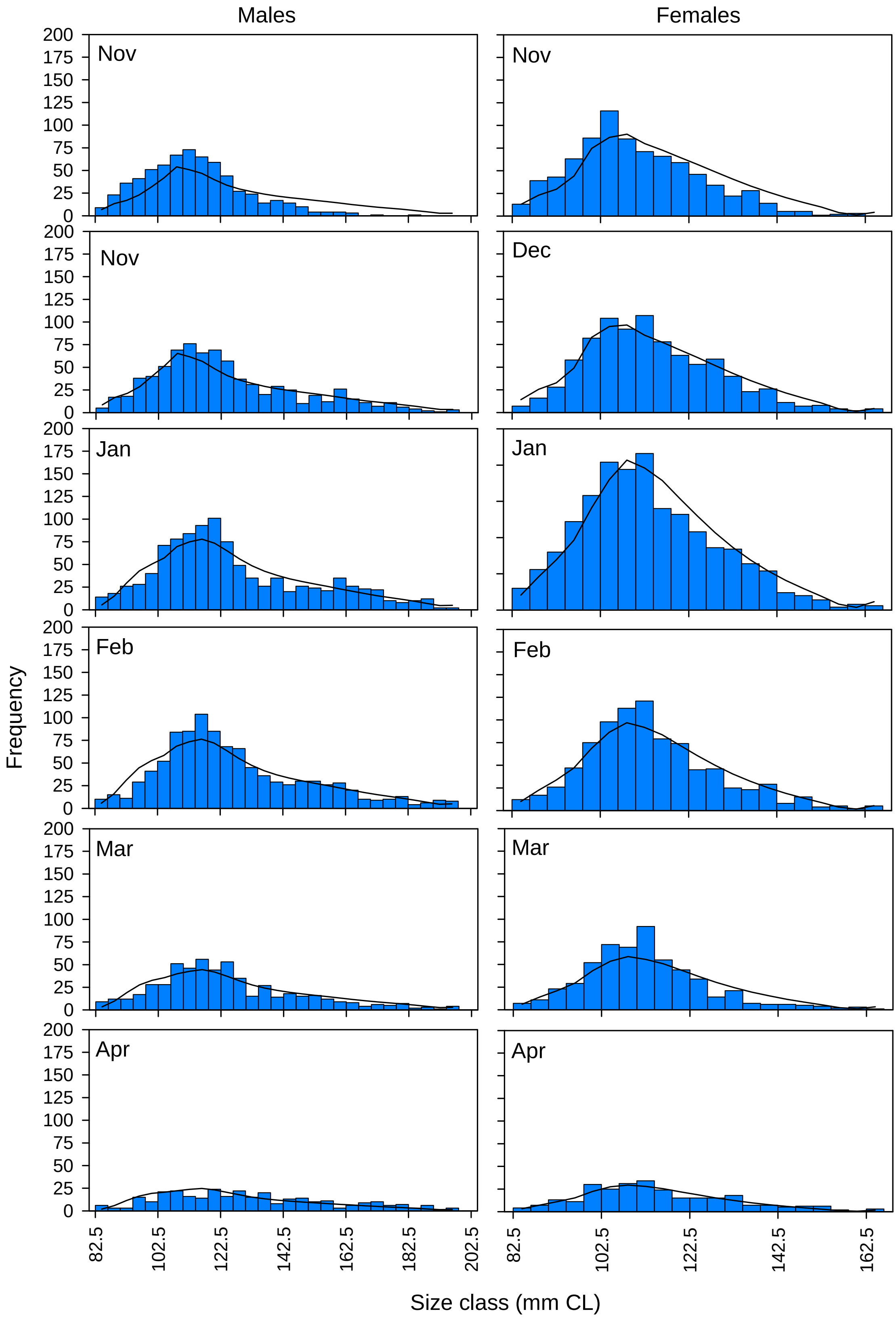

Figure 5-3 Sample of model fit (black line) to commercial length frequency data (blue bars) taken from the 2006 season in the NZRLF.

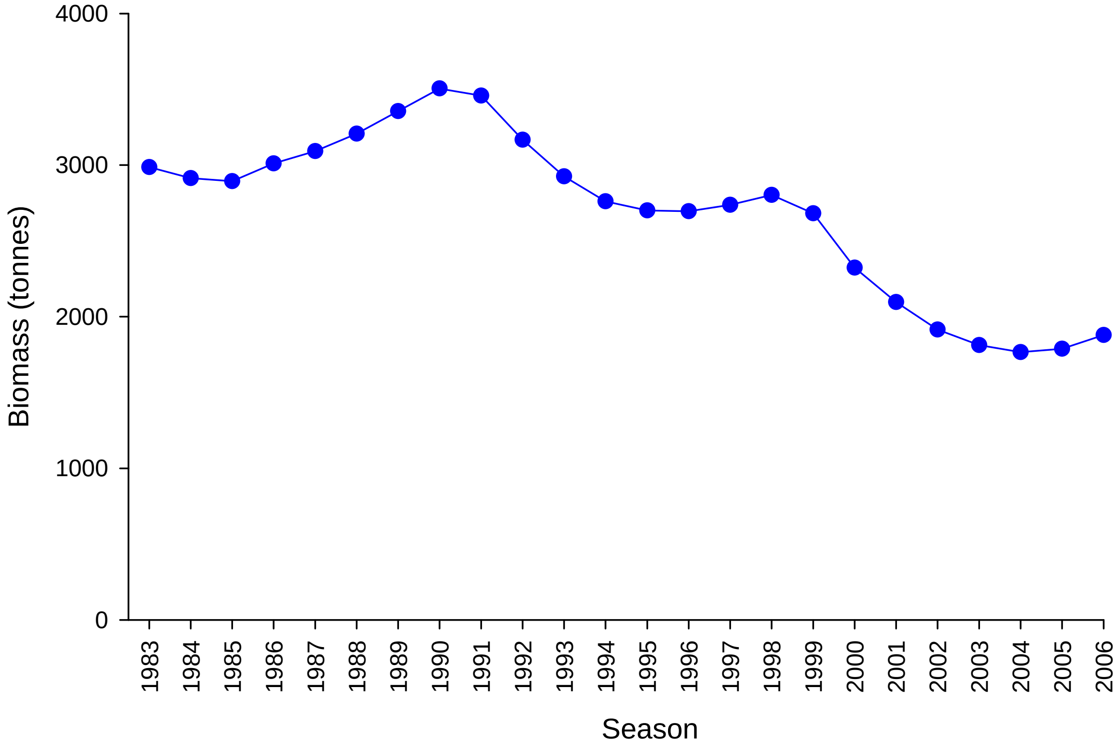

Figure 5-4 Estimates of biomass provided by the 2006 LenMod model.

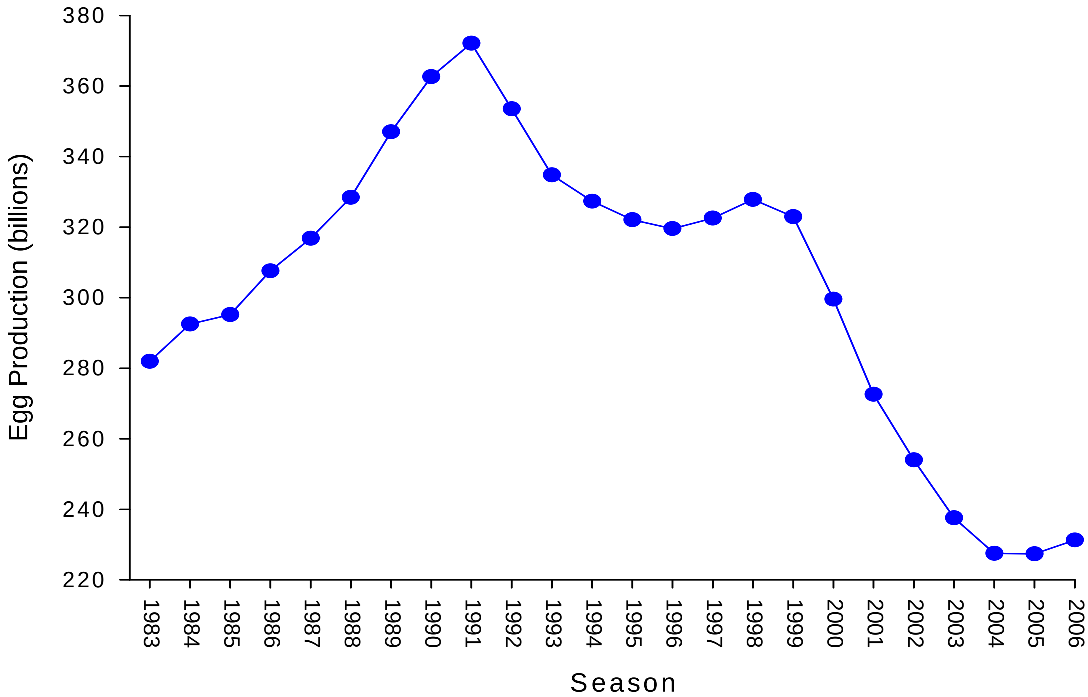

Figure 5-5 Estimates of egg production provided by the 2006 LenMod model.

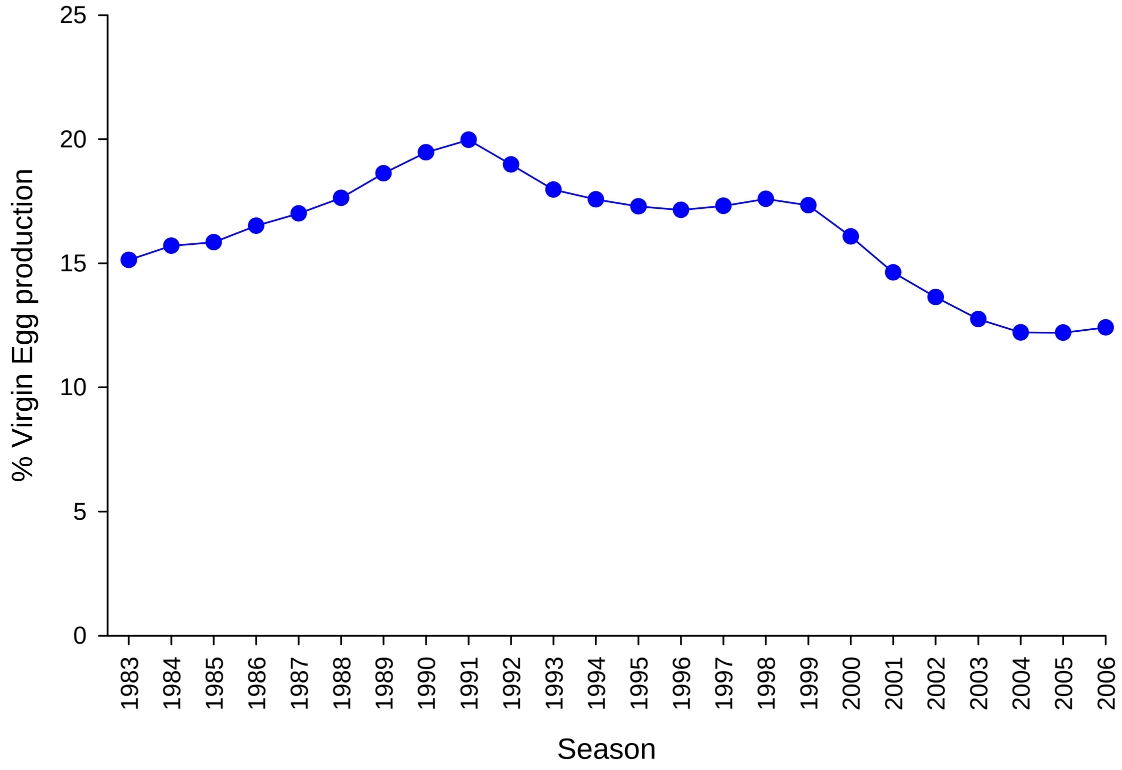

Figure 5-6 Estimates of percent of virgin egg production provided by the 2006 LenMod model.

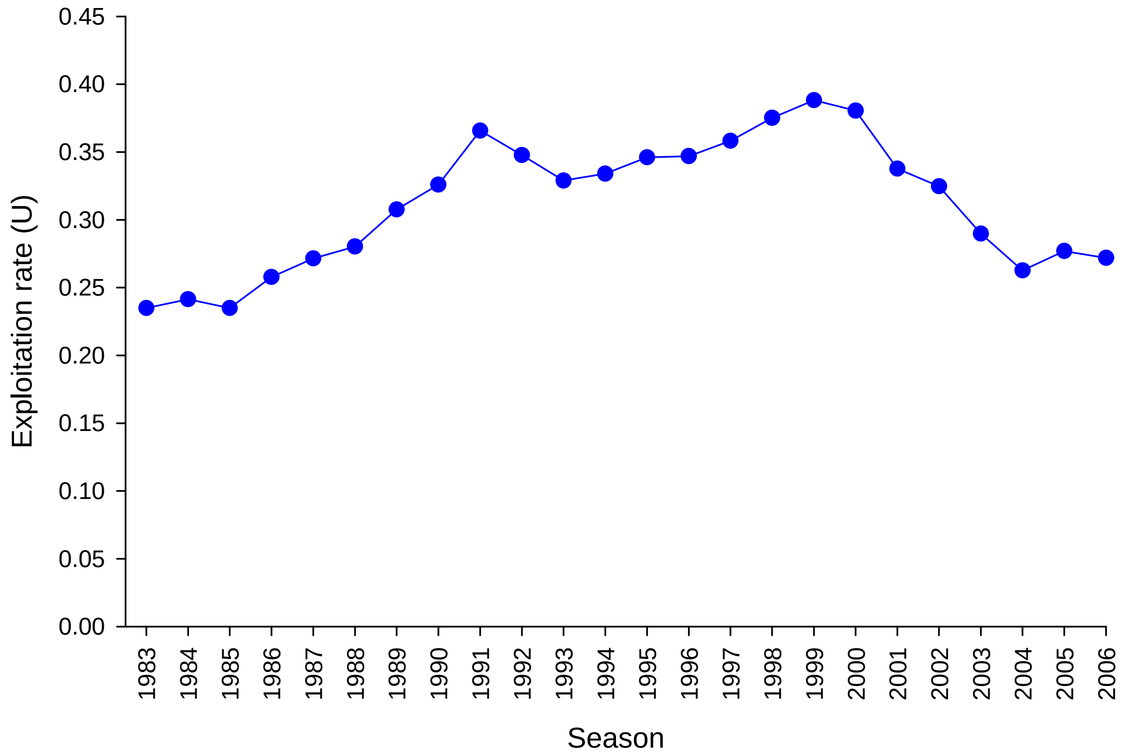

Figure 5-7 Estimates of exploitation rates provided by the 2006 LenMod model.

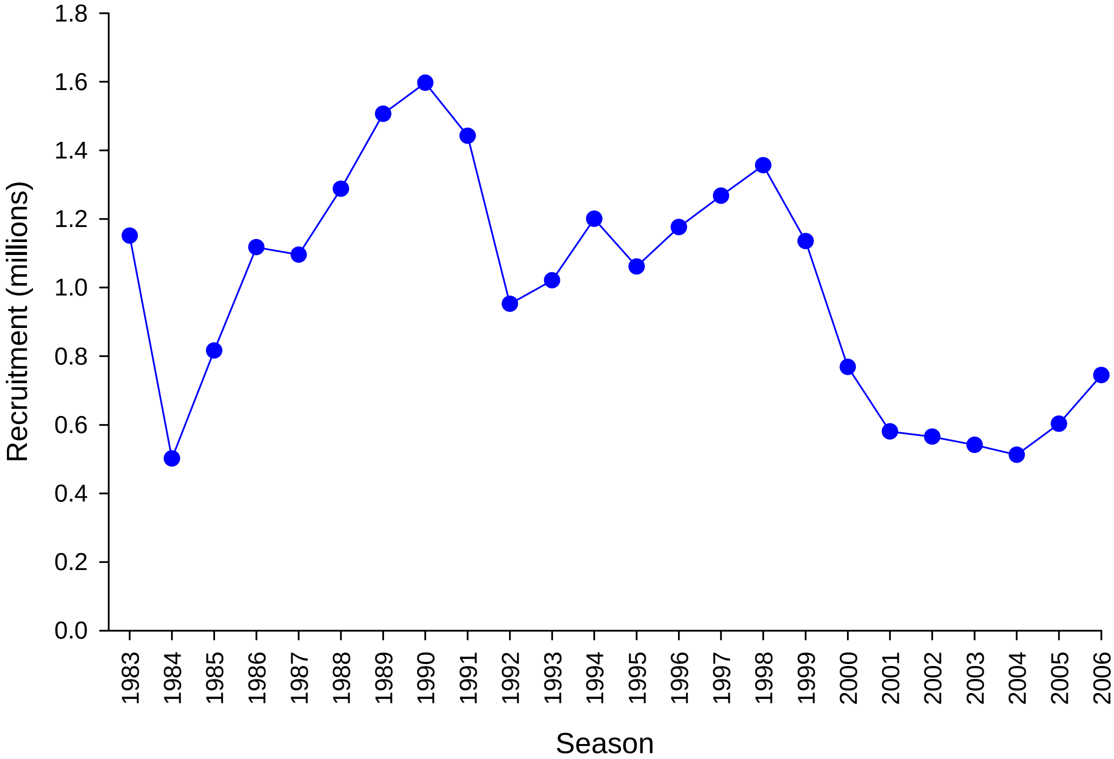

Figure 5-8 Estimates of recruitment provided by the 2006 LenMod model.

6 PERFORMANCE INDICATORS

Current biological performance indicators for the NZRLF are catch rate and pre-recruit index (PRI). Limit and target reference points (LRPs and TRPs) have been set for each indicator as defined in the new Management Plan for the resource (Sloan and Crosthwaite 2007). LRP recovery trajectories have been developed for the whole fishery and for each region (see Figure 1-4 and Table 1-5).

Only a LRP is set for PRI. Therefore PRI at any time is either above or below the reference point. For the purposes of setting LRPs for PRI, a reference period between 1995 and 2004 (inclusive) has been chosen. This ten-year period is representative of recent fishery performance. In order to set reference points for pre-recruit abundance, the average over this period has been taken (Table 1-4).

6.1 Zonal Catch rate

In 2006, the zonal estimate of 0.88 kg/potlift (November-April inclusive) was above the limit reference trajectory of 1 kg/potlift over 12 years as per the new Management Plan for the resource (Figure 6-1).

6.2 Regional Catch rate

In 2006, regional CPUE estimates were above the target limit trajectories in Regions A and B (Figure 6-2). However, it should be noted that Region A is not used in the current TACC decision making process as <10% of the total is currently taken in this area. Regional CPUE estimates were below the limit reference trajectories in Regions C and D.

6.3 Zonal Pre-recruit Index

In 2006, the 3-year average PRI (2004-2006) was 0.38, which is above the long-term LRP for the NZRLF (Figure 6-3).

6.4 Regional Pre-recruit Index

In 2006, the 3-year average PRI (2004-2006) was above the long-term LRP in Region B and below it in Regions C and D (Figure 6-4).

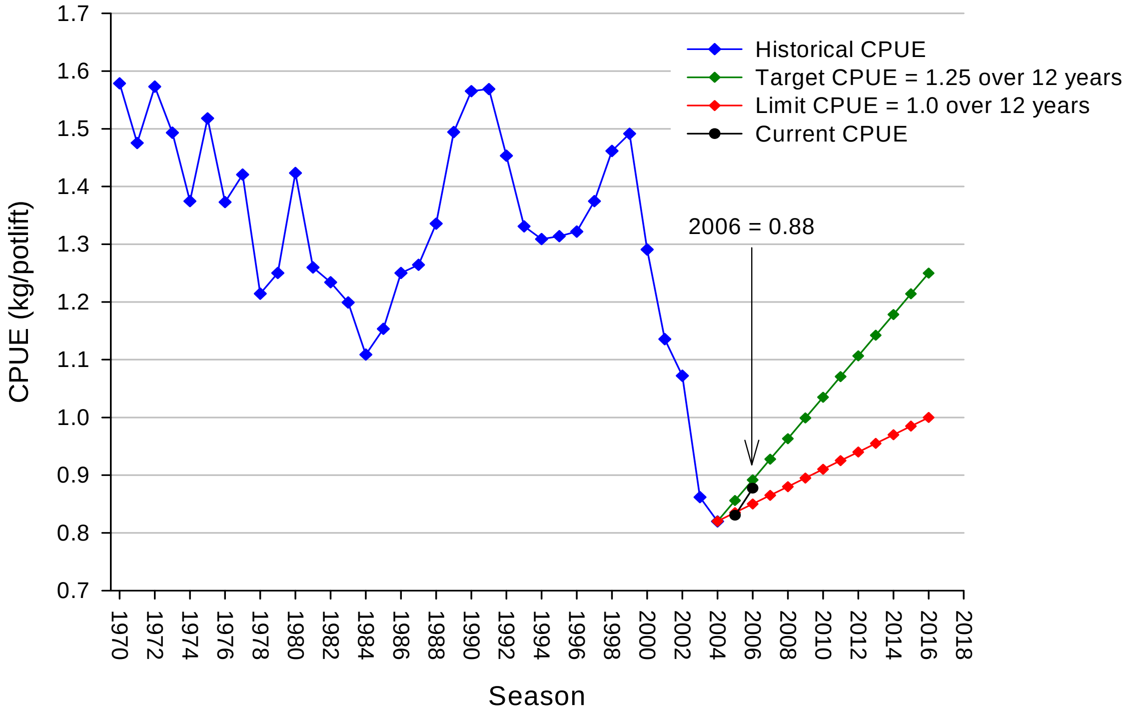

Figure 6-1 Zonal limit and target reference points for CPUE in the NZRLF including current estimates from the 2006 season.

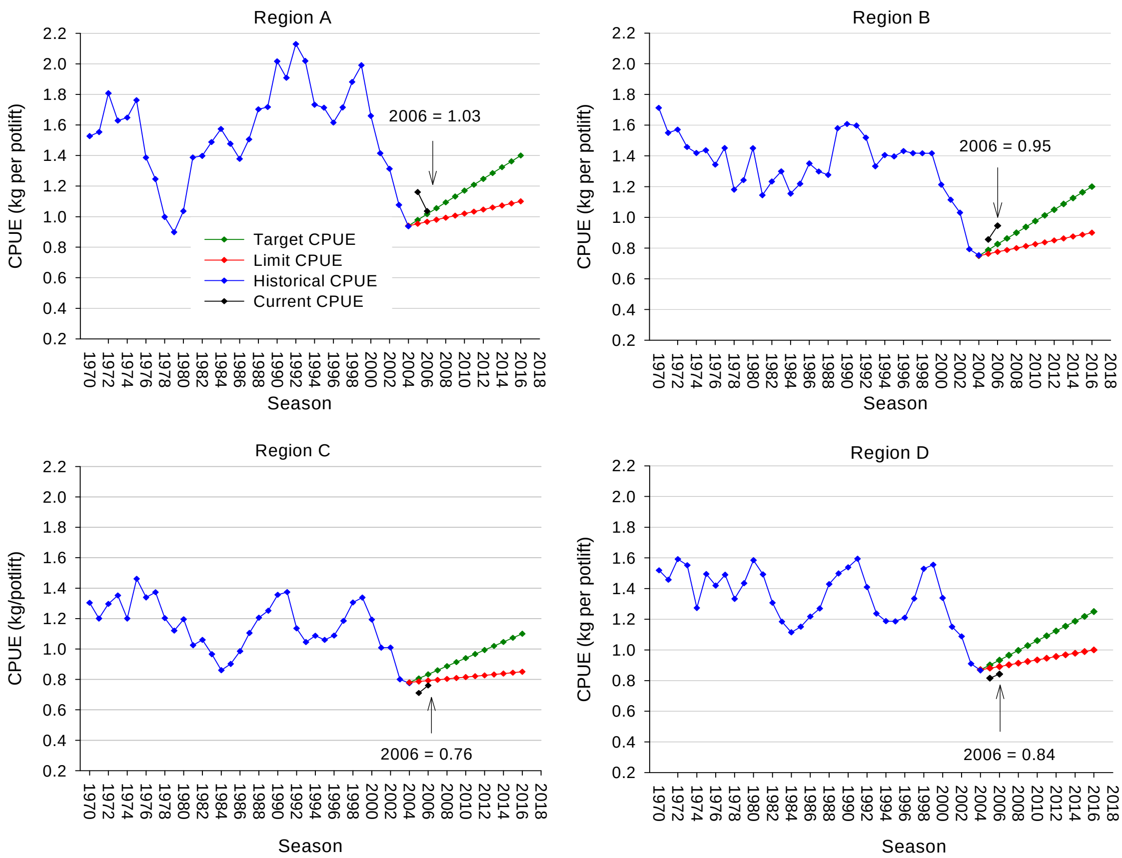

Figure 6-2 Regional limit and target reference points for CPUE in the NZRLF including current estimates from the 2006 season.

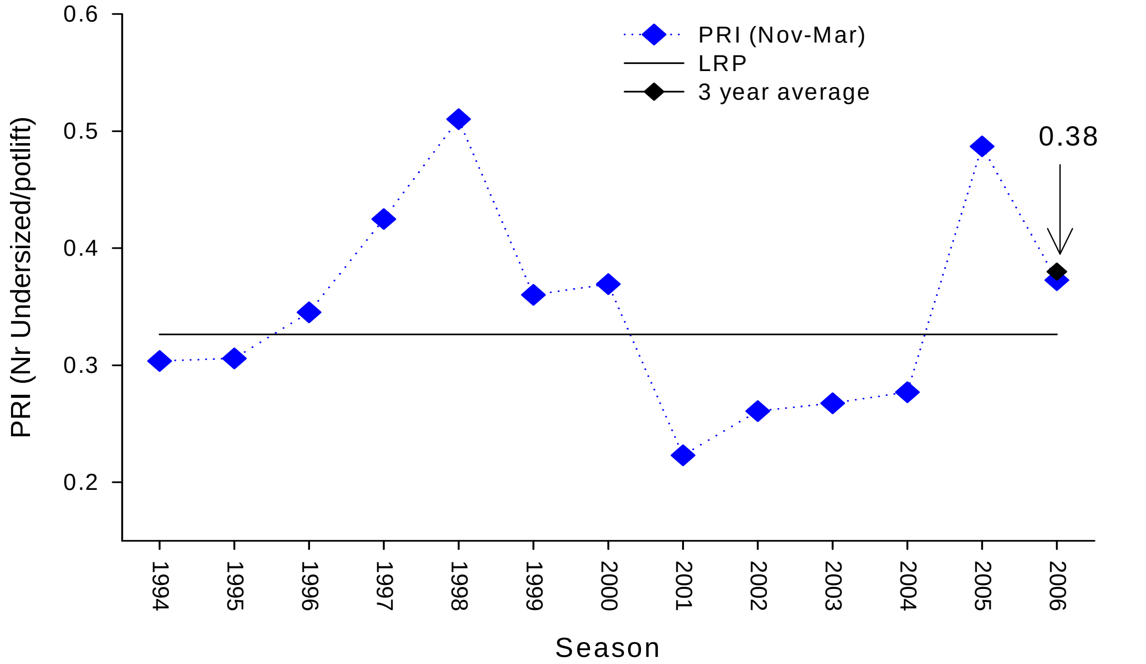

Figure 6-3. Zonal pre-recruit indices (PRI) (1994-2006) with Limit Reference Point (LRP) and current 3-year average.

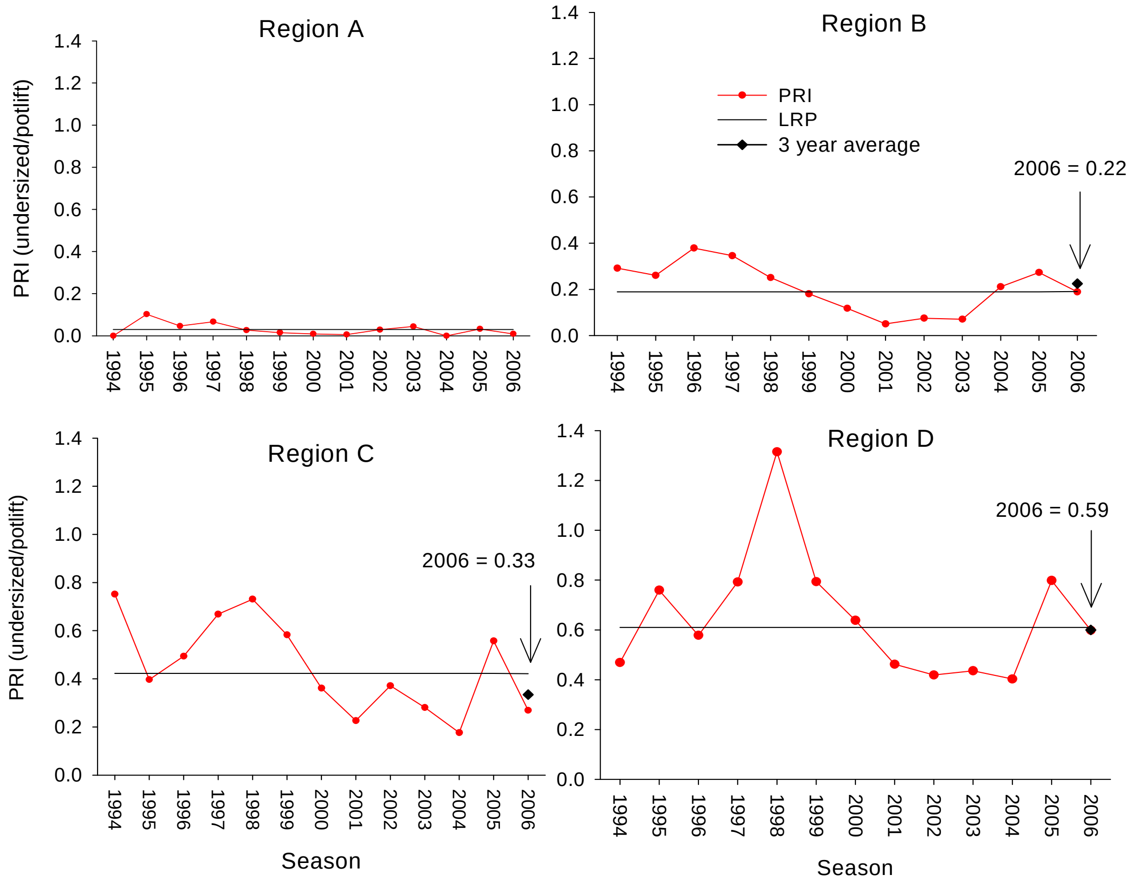

Figure 6-4 Regional pre-recruit indices (PRI) (1994-2006) with Limit Reference Points (LRPs) and current 3-year average.

7 GENERAL DISCUSSION

7.1 Information available for the fishery

Stock assessment of the NZRLF is aided by documentation on the history of the management of the fishery in the Management Plan and recent stock assessments and status reports (e.g. Sloan and Crosthwaite 2007; Linnane et al. 2007). The Management Plan also describes the management arrangements in place at the time of this assessment and the biological reference points used for assessing the fishery.

Comprehensive catch and effort data have been collected since 1970. Data collected since 1983, however, provide more reliable information on effort. Voluntary catch sampling data have been collected since 1991 and provide critical information on length frequency, pre-recruit indices and reproductive condition of females. Data from 1994 onwards are more robust due to low levels of participation in the early years of the program. Fishery stock assessments are also aided by puerulus settlement data and stock assessment model outputs. In addition to the qR model outputs, this report provides outputs from the newly developed LenMod model (refer to Chapters 4 and 5 for details of each model).

Assessment of the NZRLF currently depends mainly upon commercial catch and effort data. Future stock assessment would be enhanced by the collection of additional fishery-independent information. A fishery-independent monitoring survey (FIMS) is currently being developed in the SZRLF. Application of the sampling protocol and data analysis procedures to the NZRLF in future years will help to substantially reduce the level of uncertainty in the assessment.

7.2 Current Status of Northern Zone Rock Lobster Fishery

The fishery-dependent data provided in this report continues to support the conclusion from recent stock assessments (e.g. Linnane et al. 2007) that the resource on which the NZRLF is based is currently in one of its weakest positions since the inception of the fishery. Several lines of evidence support this conclusion. For example, while the catch in 2006 was 491.5 tonnes, representing an increase of 15.1 tonnes from 2005, it remains the third lowest in the history of the fishery. In addition, the 2006 catch was 28.5 tonnes below the TACC and therefore represents the fourth consecutive season in which the TACC was not caught. The decline in catch from 1998 to 2004 is partially explained by recent decreases in effort and changes in market demand. However, the main reason for the recent reductions in catch is the substantial decline in fishable biomass. Catch rate in the NZRLF has decreased annually over the period 1999 to 2004. While CPUE has increased marginally over the last two seasons, the 2006 estimate of 0.86 kg/potlift is the fourth lowest in the history of the fishery.

Pre-recruit indices, based on voluntary catch sampling data, have increased over the period 2001 – 2005, with the 2005 estimate being the second highest since sampling began in the early 1990’s. The increase in PRI over this period is believed to represent the spike in puerulus settlement observed across both the NZRLF and SZRLF in 2002. Given that the time between settlement and recruitment in the NZRLF is estimated to be ~4 years (McGarvey et al., 1999a), this cohort entered the fishable biomass in 2006 which presumably reflects the increase in both catch and catch rate observed during this season. Importantly, the decrease in PRI in 2006 is likely to reflect the low settlement indices observed in both 2003 and 2004 within the fishery.

There is close agreement from both qR and LenMod in relation to the current status of the NZRLF. Both models estimate that biomass in the zone has decreased considerably since the late 1980’s reaching a historical low of between 1700–2000 tonnes in 2004. Current levels of biomass are estimated to be in the range of 1800 - 2000 tonnes. Trends in % of virgin egg production from both models are also in agreement. Current estimates put egg production at between 12-17%. Current estimates from both models suggest that the rapid decrease in both biomass and egg production has been arrested, with outputs from both qR and LenMod showing a marginal increase in both these measures in 2006. This is supported by the observed increase in recruitment in 2006.

Despite the recent negative trends in some performance indicators, this report also highlights some positive signs for the NZRLF. The decreasing trends in catch and catch rate since 1998/1999 have been arrested with marginal increases in both indicators in 2006. In addition, biomass and egg production estimates marginally increased for the first time since 1999 within the fishery. The high levels of puerulus settlement recorded in the NZRLF in 2005 and 2006 are also positive signs for the future of the fishery. However, it should be noted that the PSI estimate for 2007 was the lowest on record. In addition, that PSI estimates recorded since 1996 are low compared to the SZRLF suggesting that settlement peaks in the NZRLF may be sporadic due to the different oceanographic and environmental conditions influencing settlement in each zone. This is highlighted by the low PSI estimates observed in 2003, 2004 and 2007.

7.3 Implications for Management

The current Management Plan for the NZRLF requires that both legal-sized catch rate and pre-recruit index performance indicator must trigger before a management response is taken. In 2006, zonal catch rate and PRI were above the limit reference points and as a result, the TACC remained at 520 tonnes. As stated, the increase in catch rate in 2006 is likely to reflect the spike in puerulus settlement observed in 2002. However, given the level of variation in recruitment to the NZRLF and the degree of uncertainty associated with puerulus settlement data, careful consideration should be given as to how pulses of recruitment are conserved. For example, data from 2007 will indicate if the current increase in both catch and catch rate can be sustained from the 2002 settlement cohort through the expected periods of low recruitment in 2007 and 2008 due to poor settlement in 2003 and 2004. If this fails to materialize, then it may be necessary for management arrangements to be developed that afford greater levels of protection for recruitment pulses during the stock rebuilding phase, as these pulses clearly need to sustain catches for extended periods within the NZRLF.

7.4 Future Research Priorities

Given the inherent problems associated with fishery-dependent data, a fishery independent monitoring survey of the NZRLF would greatly improve future assessments of the resource.

Given the observed regional trends in fishery performance highlighted in this assessment, there is a strong need for assessment at a finer spatial scale. Future research should therefore aim to investigate the implementation of user-friendly onboard technology that provides real time spatial information on fishing effort.

Further research into the oceanographic and environment influences that underpin both settlement and catch rate within the resource is also required. Specifically, research into the environmental effects on the relationship between puerulus settlement, pre-recruit indices and legal sized catch rate should be prioritised. The strategic research plan for the NZRLF is currently under review.

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