

# **Western Zone Abalone** *(Haliotis laevisgata & H. rubra)* **Fishery 2. Region B**

Fishery Assessment Report to PIRSA

October 2005

Mayfield, S., Chick, R.C. & T.M. Ward

This Fishery Assessment Report updates the 2004 report for Region B of the Western Zone Abalone Fishery and is part of SARDI Aquatic Sciences ongoing assessment program for this fishery. The aims of the report are to assess the current status of the resource, identify the uncertainty associated with the assessment and to identify future research needs for the fishery.

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**SARDI Aquatic Sciences**

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Sub-title Fishery Assessment Report to PIRSA  
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## EXECUTIVE SUMMARY

1. This fishery assessment report updates the 2004 report and assesses the current status of the abalone stocks in Region B of the Western Zone abalone fishery.
2. This assessment is based solely on fishery-dependent data that include catch, effort, catch-per-unit-effort (CPUE) and catch size-frequency data.
3. The total allowable commercial catch (TACC) in Region B has been 41.4 t.yr<sup>-1</sup> since 1994, which is not further subdivided between greenlip and blacklip abalone. This TACC is 42% greater than the mean catch from 1968 – 1990.
4. Mean CPUE declined substantially (>10%) between 2001 and 2004. In 2004, CPUE was 17% below maximum observed levels. Fishing effort in 2004 was at the highest level since 1999 and 10% greater than that in 2003.
5. The proportion of the TACC comprising greenlip abalone has increased since 1996, reaching >70% (30.5 t) in 2004.
6. Since 1994, at least half the total greenlip abalone catch has been obtained from one fishing area (fishing area 2).
7. The CPUE on greenlip abalone decreased significantly between 1978 and 1997. It has increased slowly since 1998, yet in 2004 it remained 30% below the highest level.
8. This trend, in association with increasing levels of catch, probably reflects an increase in the abundance of greenlip abalone in Region B over the last five years.
9. There was no evidence of ‘knife-edged’ fishing on greenlip abalone during 2004.
10. The blacklip abalone catch has declined significantly since 1996 and was ~11 t (<30% of the TACC) in 2003 and 2004.
11. Over the last 20 years, most of the blacklip abalone catch has been obtained from one fishing area (fishing area 2).
12. The CPUE on blacklip abalone has declined significantly since 1993. CPUE declined by >20% between 2002 and 2004, to the lowest level since 1987 (18 years).
13. There was no evidence of ‘knife-edged’ fishing on blacklip abalone during 2004.

## CONCLUSIONS

14. The available data suggest that the greenlip abalone stocks in Region B are stable and being fished within sustainable limits. This conclusion was supported by several lines of evidence, including recent increases in CPUE and catch, the large mean and modal size class of the catch and the lack of triggering of any PI.
15. In contrast, (1) significant declines in CPUE since 1993, (2) a 20% decrease in CPUE between 2002 and 2004, and (3) decreases in the proportion of the TACC comprising blacklip abalone suggest the abundance of this species has decreased substantially over recent years. Thus, the magnitude of the current catch may not be sustainable in future years. Hence, consideration of species-specific TACC in Region B may be warranted.
16. These conclusions would be substantiated by future commercial shell samples, fishery-independent surveys and data on the biology of both species.

## **ACKNOWLEDGEMENTS**

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# **1. GENERAL INTRODUCTION**

## **1.1 Overview**

This fishery assessment report for Region B of the Western Zone of the South Australian abalone fishery (hereafter referred to as Region B) updates the previous report for this Region (Mayfield & Ward 2004) and is part of SARDI Aquatic Sciences ongoing assessment program for the Western Zone abalone fishery. The aims of the report are (1) to assess the current status of the resource; (2) to identify the uncertainty associated with the assessment; and (3) to identify future research needs for the fishery.

This report covers the period 1 January 1968 to 31 December 2004. It is divided into four sections. The first section is the general introduction that (1) outlines the aims and structure of the report; (2) describes the Region B abalone fishery; and (3) documents the biological Performance Indicators identified for this fishery in the management plan.

Section two provides an assessment of the fishery-dependent data for greenlip and blacklip abalone in Region B from 1968 to 2004. Where appropriate, this includes spatial and temporal analyses of catch, effort, catch-per-unit effort (CPUE) and size-frequency distribution of the commercial catch.

In section three, the performance of the greenlip and blacklip abalone fisheries in Region B is assessed against the performance indicators identified in the management plan.

Section four is the general discussion. It synthesises the information presented in the previous sections, identifies areas of uncertainty in current knowledge, comments on the Performance Indicators for the fishery and outlines future research needs for the fishery.

## **1.2 Description of the fishery**

The Western Zone of the South Australian abalone fishery includes all coastal waters of South Australia between the Western Australia/South Australia border and Meridian 136°30'E. This Zone was further subdivided into Region A and Region B (Western Australia/South Australia border to Meridian 133°50.8'E) in 1985 (Figure 1.1). The fishing season extends from 1 January to 31 December each year.

The history of the fishery, management arrangements and major management milestones are comprehensively documented elsewhere (*e.g.* Mayfield *et al.* 2004a; Nobes *et al.* 2004).

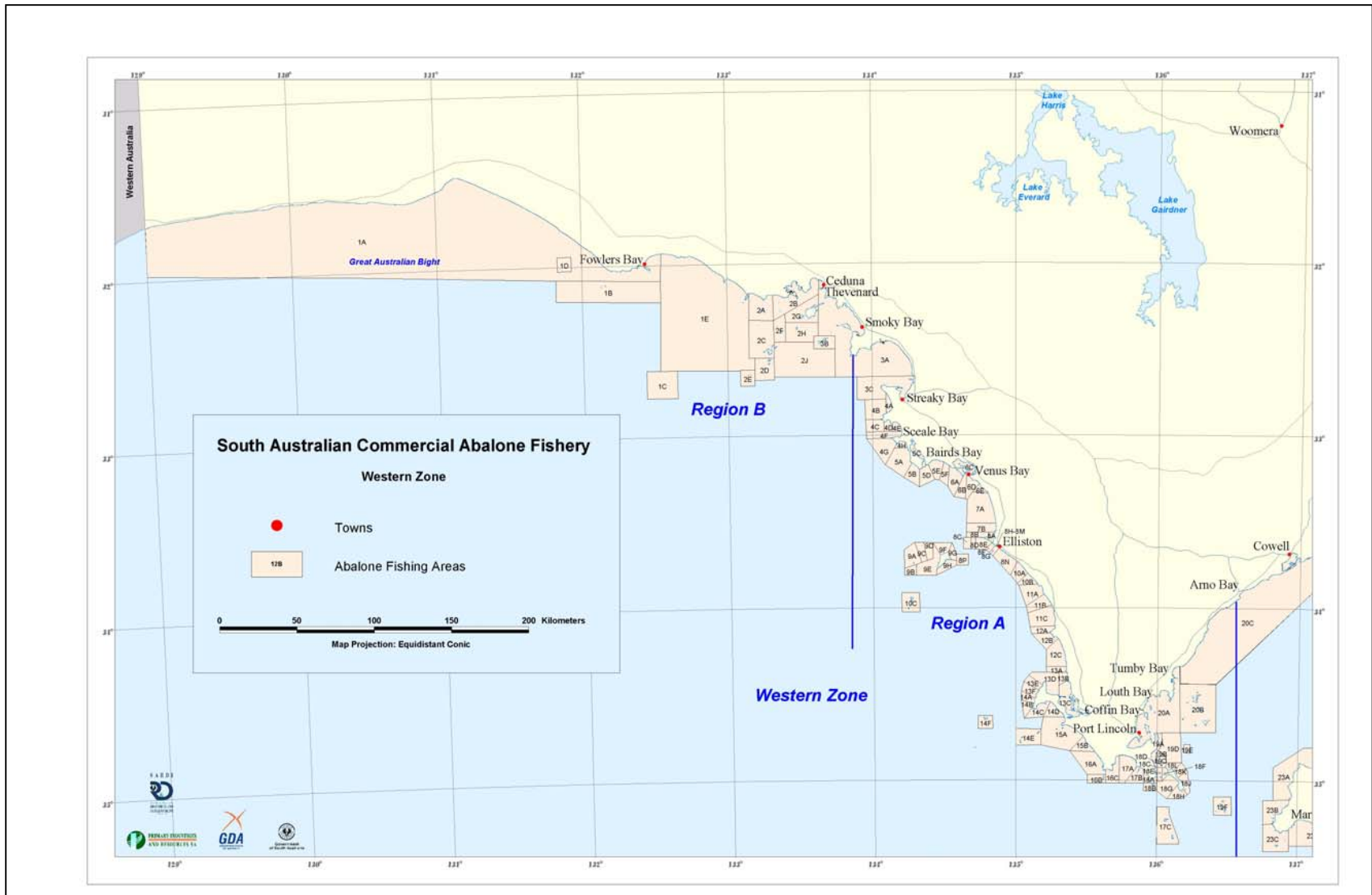


Figure 1.1: Fishing areas of the Western Zone of the South Australian abalone fishery.

Quotas were imposed on Region B in 1991 (27.6 t whole weight). The TACC was increased to 34.5 t in 1993, and to 41.4 t in 1994. The TACC has not changed since 1994. This TACC is not further differentiated between greenlip and blacklip abalone, thus permitting fishers a harvest choice.

As in the other Zones and Regions of the fishery, a research logbook must be completed for each fishing day and submitted to SARDI Aquatic Sciences at the end of each month. Commercial catch and effort data on this fishery have been collected since 1968. These data form the basis of the annual stock assessment reports submitted to PIRSA.

### **1.3 Objectives and strategies of the Management Plan**

During 2003, the first Management Plan for the South Australian Abalone Fishery (Zacharin 1997) was reviewed and updated (Nobes *et al.* 2004). This process included a re-evaluation of the performance indicators and associated reference and trigger points for the fishery.

The revised management plan identifies biological, economic, environmental and social management objectives and associated strategies. The three biological objectives are relevant to this report and are (1) to control, measure and regulate all catches/extractions from the resource; (2) to maintain sufficient egg and sperm production to provide for adequate levels of recruitment; and (3) to monitor and control disease.

Associated with these biological objectives are five strategies. These are:

1. To collect and collate fishery-dependent information (Strategy 1);
2. To set the TACC using the best available information (Strategy 2);
3. To harvest at an appropriate minimum legal length (Strategy 3);
4. To maintain abalone population densities (Strategy 4); and
5. To identify disease-infected areas (Strategy 5).

Performance indicators are linked with the five strategies, each of which has specified trigger points. The biological performance indicators and trigger points for each strategy for the blacklip and greenlip abalone fisheries in Region B are provided in Table 1.1. The performance indicators to be addressed in this report are shown in bold. An annual report on the diver's assessment of the status of the stock is provided by the Abalone Industry Association of South Australia.

**Table 1.1: Biological strategies and associated performance indicators, spatial scale of application and trigger points prescribed for performance assessment of the blacklip and greenlip abalone fisheries in Region B. All performance indicator are applied separately to each species.**

<b>Strategy</b>	<b>Performance Indicator</b>	<b>Scale of application</b>	<b>Trigger Point</b>
1	<b>Commercial logbooks</b>	-	<100% received
	<b>Catch and effort database</b>	-	<100% of logbooks received entered into the database
	Stock assessment report	Fishing Zone	Annual report not produced
	Diver assessment of stock status	All fishing areas of Region B combined	Change in stock status
	<b>Commercial catch</b>	Region B	<90% of TACC harvested
	<b>Mean daily catch</b>	All fishing areas of Region B combined	(1) Statistically significant inter-annual change (2) Statistically significant 5-year trend
	<b>Mean size</b>	All fishing areas of Region B combined	
	<b>Mean daily effort</b>	All fishing areas of Region B combined	
	<b>CPUE</b>	All fishing areas of Region B combined	
3	<b>% Egg production relative to pristine egg production</b>	All fishing areas of Region B combined	<50% of the pristine level

## **2. FISHERY STATISTICS**

Commercial catch and effort data on this fishery have been collected since 1968. Fishers complete a research logbook for each fishing day and submit those data to SARDI Aquatic Sciences at the end of each month. The logbook data supplied have been used to provide the spatial and temporal analyses of catch and catch-per-unit-effort (CPUE), from 1 January 1968 to 31 December 2004, presented in this section of the report. CPUE was computed using the mean ratio estimator (after Rice 1995). Data on the size-frequency distribution of the commercial catch were obtained from samples provided by commercial fishers. Fishery statistics in this section are provided at two spatial scales. These are (1) the whole fishery (*i.e.* all fishing areas of Region B combined) and (2) individual fishing areas. Data are presented as mean  $\pm$  1 standard error (SE) unless otherwise stated.

### **2.1 Catch**

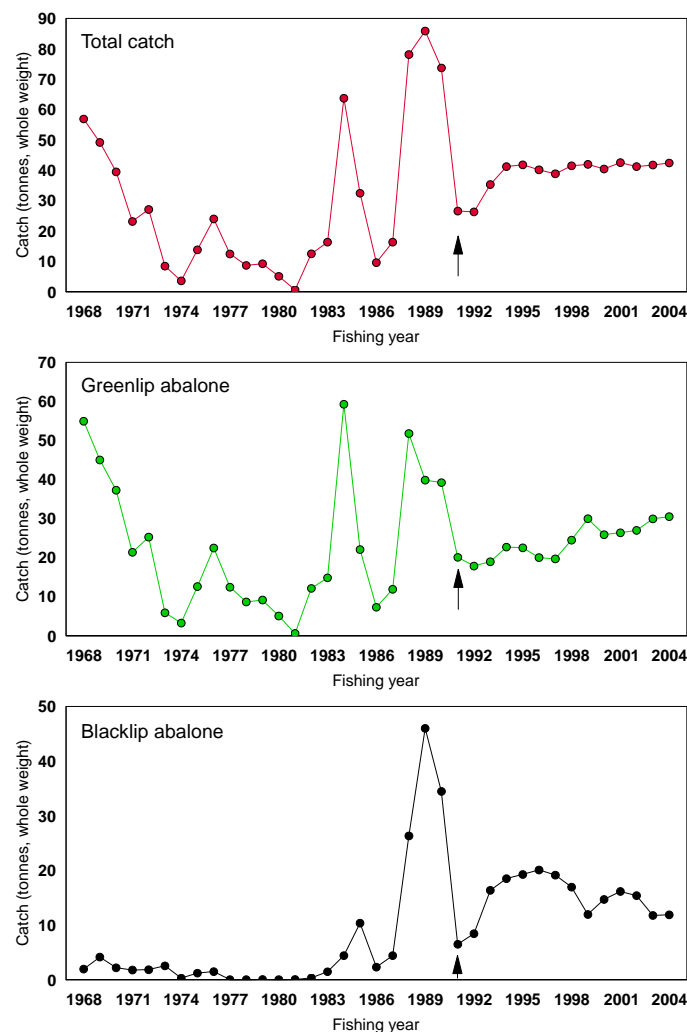
Total abalone catch in 1968 was 56.9 t (Figure 2.1). Over the next 14 years the catch declined significantly (Linear Regression (LR):  $r^2 = 0.71$ ,  $df = 12$ ,  $p < 0.01$ ) with just 600 kg harvested in 1981. Between 1982 and 1990, the catch fluctuated among years. Large catches were obtained in 1984 (63.7 t), 1988 (78.1 t), 1989 (85.8 t) and 1990 (73.7 t). Less than 10 t were harvested during 1986. Since 1991, catch in Region B has been restricted by a TACC that increased from 27.6 t (1991 and 1992) to 34.5 t (1993) to 41.4 t (1994 – 2004). The TACC is 42% greater than the mean catch from 1968 – 1990 (29 t.yr<sup>-1</sup>).

The proportion of the total catch comprising greenlip abalone declined significantly between 1978 and 1997 (LR:  $r^2 = 0.82$ ,  $df = 18$ ,  $p < 0.01$ ; Figure 2.2). It was lowest in 1989 (46.4%) and also low between 1993 and 1996 (49.9%). Similar patterns are evident for fishing areas 1 and 2. Since 1996, the proportion of greenlip abalone in the catch has increased, attaining a level of 71.9% of the catch in 2004, the highest since 1991. Similar increases were evident in fishing areas 1 and 2, but not in fishing area 3 where the contribution of greenlip abalone to the total catch has remained between 68.4 and 80.2% from 1991 and 2004.

#### **2.1.1 Greenlip abalone**

The greenlip abalone catch in 1968 was 54.9 t (Figure 2.1). Catches declined significantly over the next 14 years (LR:  $r^2 = 0.68$ ,  $df = 12$ ,  $p < 0.01$ ) with <1 t harvested in 1981. Between 1982 and 1990, the catch fluctuated interannually. Large catches were obtained in 1984 (59.3 t) and 1988 (51.8 t), whilst catches of less than 12 t were harvested in 1986 and 1987.

Since 1991 the catch of greenlip abalone has increased significantly (LR:  $r^2 = 0.78$ ,  $df = 12$ ,  $p < 0.01$ ; Figure 2.1).



**Figure 2.1: Total catch (tonnes, top) and catch of greenlip (middle) and blacklip (bottom) abalone in Region B from 1968 to 2004. ↑ indicates implementation of TACC.**

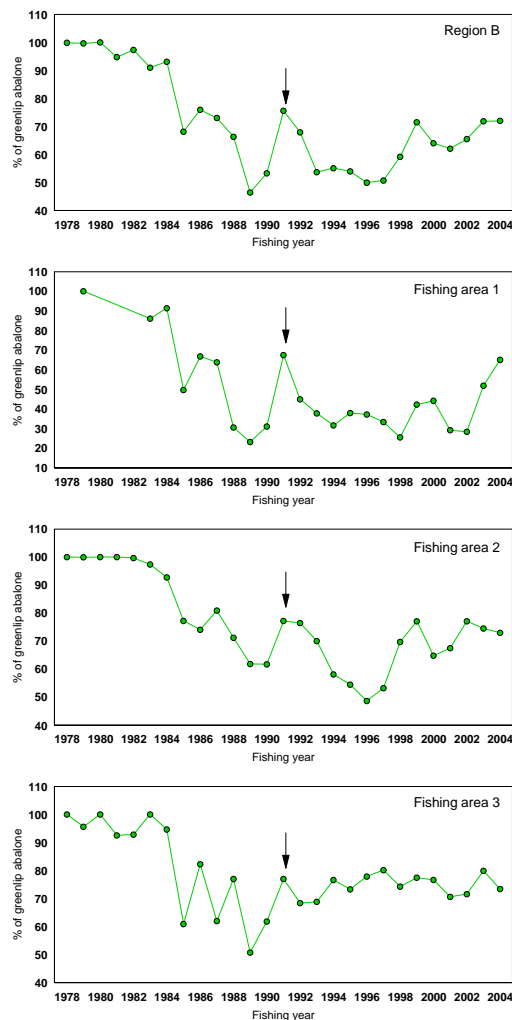
Since the mid 1980s, consistently more than 50% of the greenlip abalone catch has been harvested from fishing area 2. About 25 and 15% of the catches have been harvested from fishing areas 1 and 3, respectively (Tables 2.1a-c; Figure 2.3).

Levels of catch have fluctuated inter-annually within the fishing areas that comprise this Region (Figure 2.4). Large catches of greenlip were obtained from all three areas during 1983 and 1984, and again during the late 1980s and early 1990s. Since the TACC was imposed in 1991, the catch has generally increased in fishing area 2 (<10 to ~20 t.yr<sup>-1</sup>), but remained constant at ~3 and ~6 t.yr<sup>-1</sup> in fishing areas 1 and 3, respectively.

### 2.1.2 Blacklip abalone

Prior to 1983, less than 3 t of blacklip abalone were harvested each year (Figure 2.1). Over the next five years the catch generally increased, exceeding 45 t in 1989. Catches declined substantially between 1989 and 1990 (34.4 t), and again between 1990 and 1991 (6.5 t). Since 1996 the catch has declined significantly (LR:  $r^2 = 0.63$ ,  $df = 7$ ,  $p < 0.05$ ) from  $>20$  to  $<12$  t.yr<sup>-1</sup>. Catches in 2003 (11.7 t) and 2004 (11.8 t) were the lowest since 1992 (Figure 2.1). The mean catch since the TACC was implemented (1991; 14.8 t.yr<sup>-1</sup>) was more than double the mean catch from 1968 – 1990 (6.4 t.yr<sup>-1</sup>).

Since the mid 1980s, the majority of the blacklip abalone catch has been harvested from fishing area 2 (Tables 2.2a-c; Figure 2.5). The exceptions were 1990, 1998 and 2002, when the higher proportion of the catch came from fishing area 1. Smaller, and more variable proportions of the catch have been harvested from fishing area 3.



**Figure 2.2: Percentage of greenlip abalone in the total catch for the whole of Region B (top) and for fishing areas 1, 2 and 3 separately from 1978 to 2003. ↓ indicates implementation of TACC.**

**Table 2.1a: Average catch of greenlip abalone (tonnes), % of total catch and cumulative % for the fishing areas comprising Region B for the period 1980 – 1984.**

Fishing area	Catch (tonnes)	%	Cumulative %
2	11.7	63.7	63.7
3	4.0	21.9	85.6
1	2.6	14.4	100

**Table 2.1b: Average catch of greenlip abalone (tonnes), % of total catch and cumulative % for the fishing areas comprising Region B for the period 1991 – 1995.**

Fishing area	Catch (tonnes)	%	Cumulative %
2	11.3	55.2	55.2
3	5.3	26.0	81.2
1	3.8	18.8	100

**Table 2.1c: Average catch of greenlip abalone (tonnes), % of total catch and cumulative % for the fishing areas comprising Region B for the period 2000 – 2004.**

Fishing area	Catch (tonnes)	%	Cumulative %
2	18.5	66.0	66.0
3	6.5	23.3	89.3
1	2.9	10.7	100

**Table 2.2a: Average catch of blacklip abalone (tonnes), % of total catch and cumulative % for the fishing areas comprising Region B for the period 1980 – 1984.**

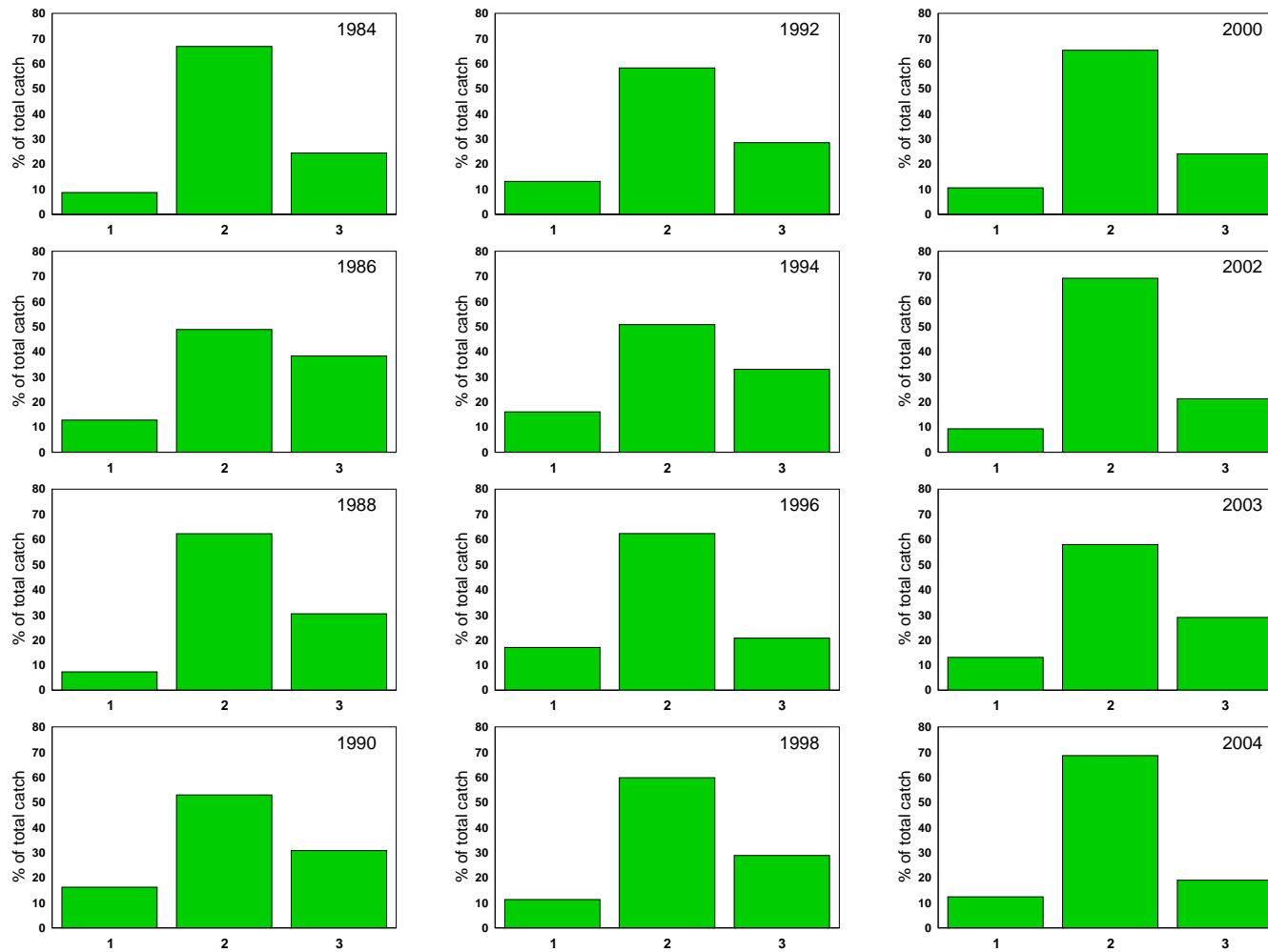
Fishing area	Catch (tonnes)	%	Cumulative %
2	0.7	52.7	52.7
1	0.4	28.7	81.4
3	0.2	18.6	100

**Table 2.2b: Average catch of blacklip abalone (tonnes), % of total catch and cumulative % for the fishing areas comprising Region B for the period 1991 – 1995.**

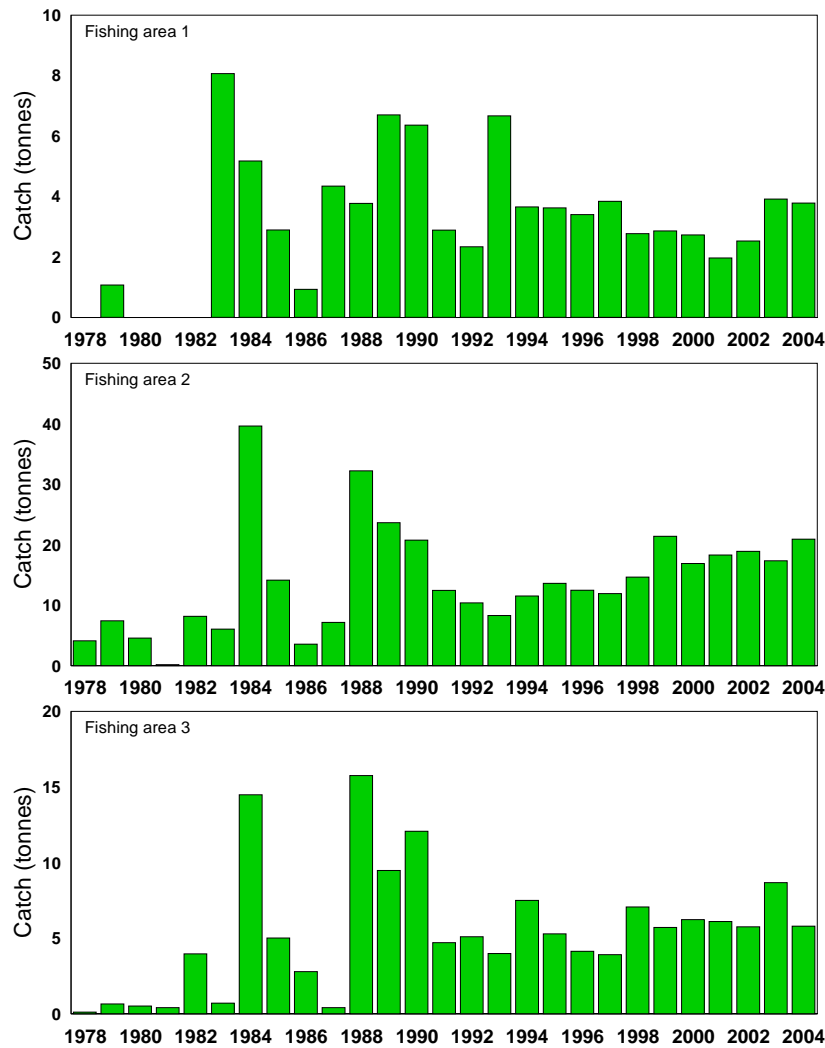
Fishing area	Catch (tonnes)	%	Cumulative %
2	6.0	43.7	43.7
1	5.8	42.1	85.8
3	1.9	14.2	100

**Table 2.2c: Average catch of blacklip abalone (tonnes), % of total catch and cumulative % for the fishing areas comprising Region B for the period 2000 – 2004.**

Fishing area	Catch (tonnes)	%	Cumulative %
2	7.7	55.2	55.2
1	4.1	29.0	84.2
3	2.2	15.8	100



**Figure 2.3: Catch of greenlip abalone (% of total harvest) harvested from each of the three fishing areas comprising Region B in 1984, 1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000, 2002, 2003 and 2004.**

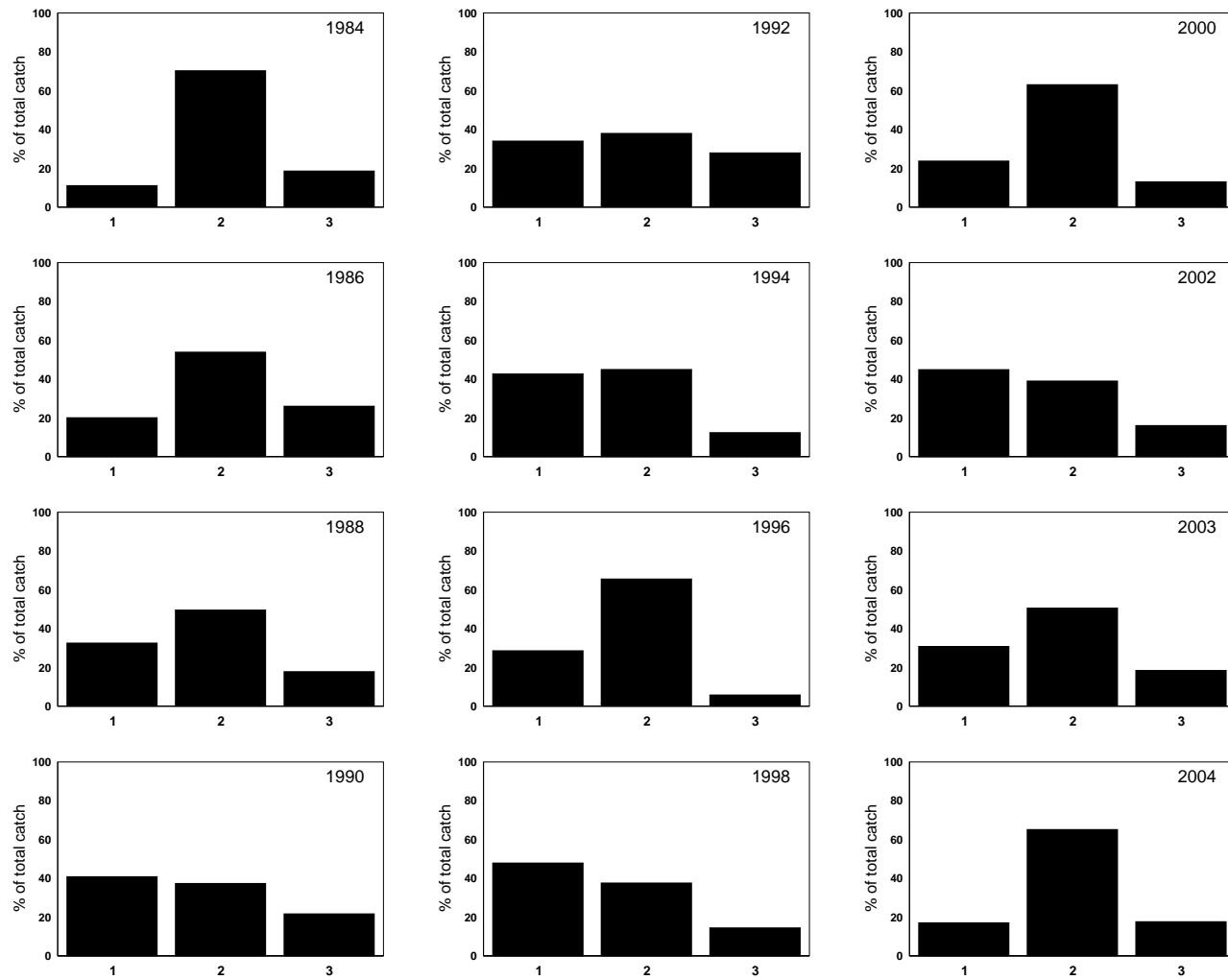


**Figure 2.4: Catch of greenlip abalone (tonnes) in each of the fishing areas comprising Region B from 1978 to 2004.**

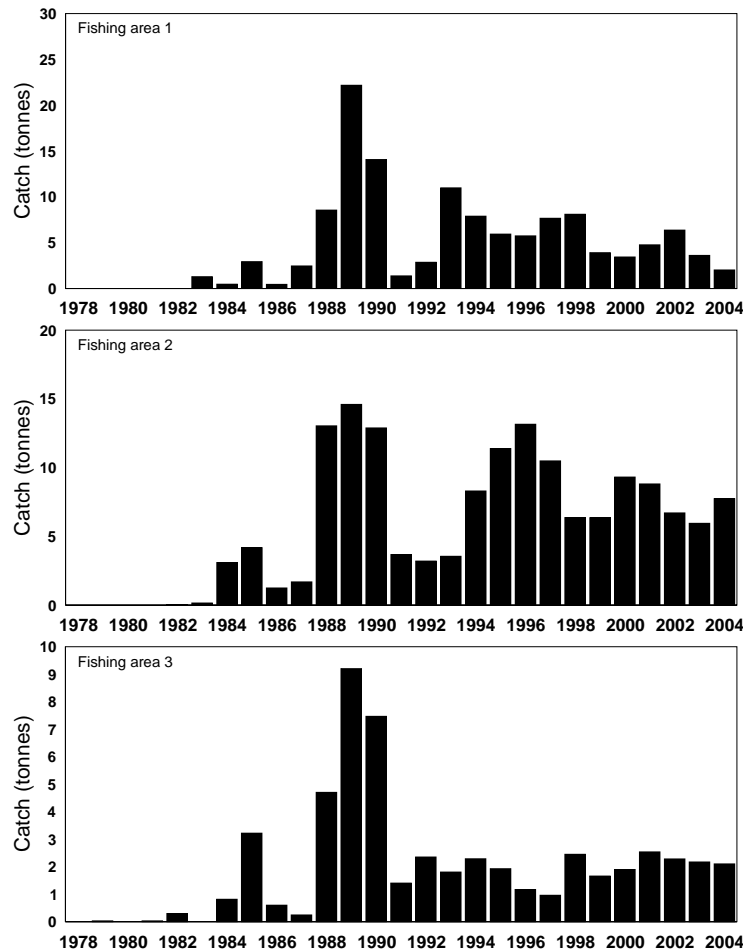
Levels of catch have fluctuated inter-annually within the different fishing areas (Figure 2.6). Large catches of blacklip were obtained from all three areas during 1988, 1989 and 1990. Catches have declined substantially in fishing areas 1 and 2 since 1993 and 1996, respectively. There was no long-term trend in catch in fishing area 3 after 1991.

## 2.2 Catch-per-unit effort (CPUE)

All estimates of CPUE in Region B (catch (kg) / total daily effort (hours)) were computed using the mean ratio estimator (after Rice 1995) to avoid the bias in determining mean CPUE as the mean of daily CPUE. Mean CPUE across both species in the Region has fluctuated inter-annually since 1978, ranging between  $48.5 \pm 1.8 \text{ kg}\cdot\text{hr}^{-1}$  (1985) and  $75.1 \pm 5.5 \text{ kg}\cdot\text{hr}^{-1}$  (1982; Figure 2.7), with no evidence of a long-term trend (LR:  $r^2 = 0.06$ ,  $df = 24$ ,  $p > 0.05$ ). However, the CPUE in 2004 was the lowest since 1999.



**Figure 2.5: Catch of blacklip abalone (% of total harvest) harvested from each of the three fishing areas comprising Region B in 1984, 1986, 1988, 1990, 1992, 1994, 1996, 1998, 2000, 2002, 2003 and 2004.**



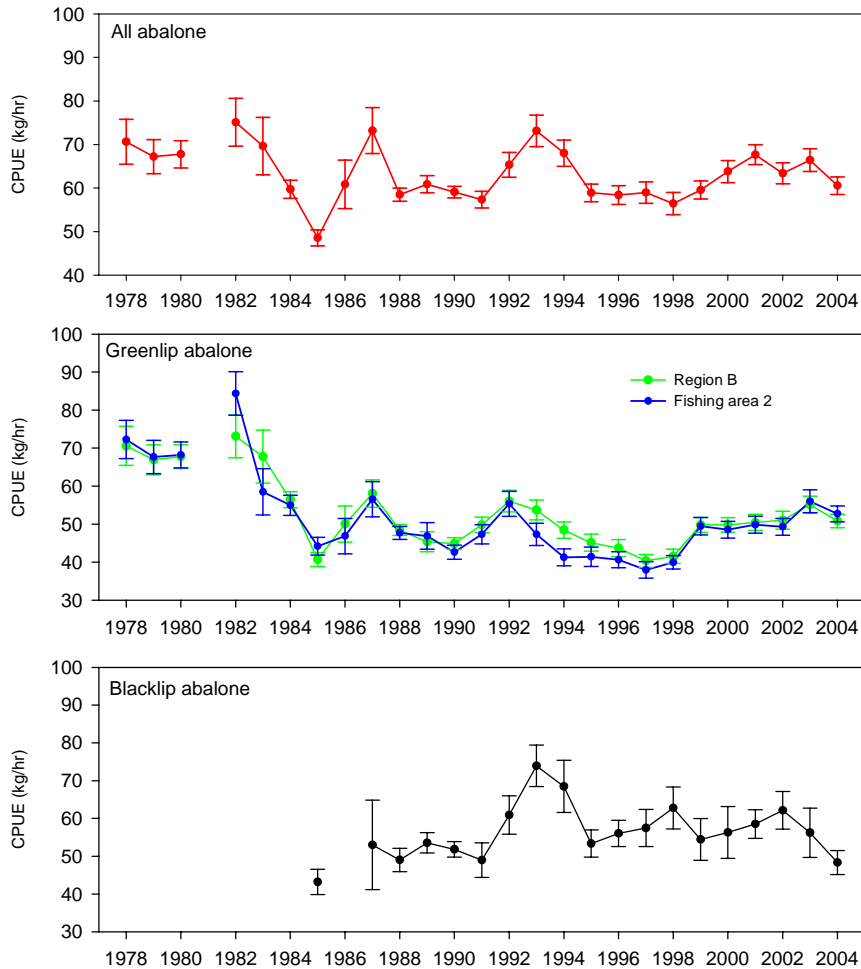
**Figure 2.6: Catch of blacklip abalone (tonnes) in each of the fishing areas comprising Region B from 1978 to 2004.**

### 2.2.1 Greenlip abalone

The CPUE on greenlip abalone, computed from those daily records where the greenlip abalone catch comprised  $\geq 50\%$  of the total catch, declined significantly (LR:  $r^2 = 0.61$ ,  $df = 17$ ,  $p < 0.01$ ) from  $70.6 \pm 5.1 \text{ kg.hr}^{-1}$  in 1978 to  $40.3 \pm 1.7 \text{ kg.hr}^{-1}$  in 1997 (Figure 2.7). Since 1998, the CPUE has increased, exceeding  $50 \text{ kg.hr}^{-1}$  from 2001 to 2004. However, this CPUE is 30% below the maximum observed value, of  $73.1 \pm 5.7 \text{ kg.hr}^{-1}$ , in 1982. Similar patterns were observed in fishing area 2.

### 2.2.2 Blacklip abalone

The CPUE on blacklip abalone, computed from those daily records where the blacklip abalone catch  $\geq 50\%$  of the total catch, increased rapidly from  $43.2 \pm 3.4 \text{ kg.hr}^{-1}$  in 1985 to  $73.9 \pm 5.5 \text{ kg.hr}^{-1}$  in 1993 (Figure 2.7). Since 1993, the CPUE on blacklip abalone has declined significantly (LR:  $r^2 = 0.60$ ,  $df = 10$ ,  $p < 0.05$ ), falling to  $48.3 \pm 3.2 \text{ kg.hr}^{-1}$  in 2004, the lowest value since 1985.



**Figure 2.7: Catch-per-unit effort (CPUE,  $\text{kg}\cdot\text{hr}^{-1}$ ) on all abalone (top), and on greenlip (middle) and blacklip (bottom) abalone separately for all fishing areas of Region B combined, and on greenlip abalone in fishing area 2 (middle).**

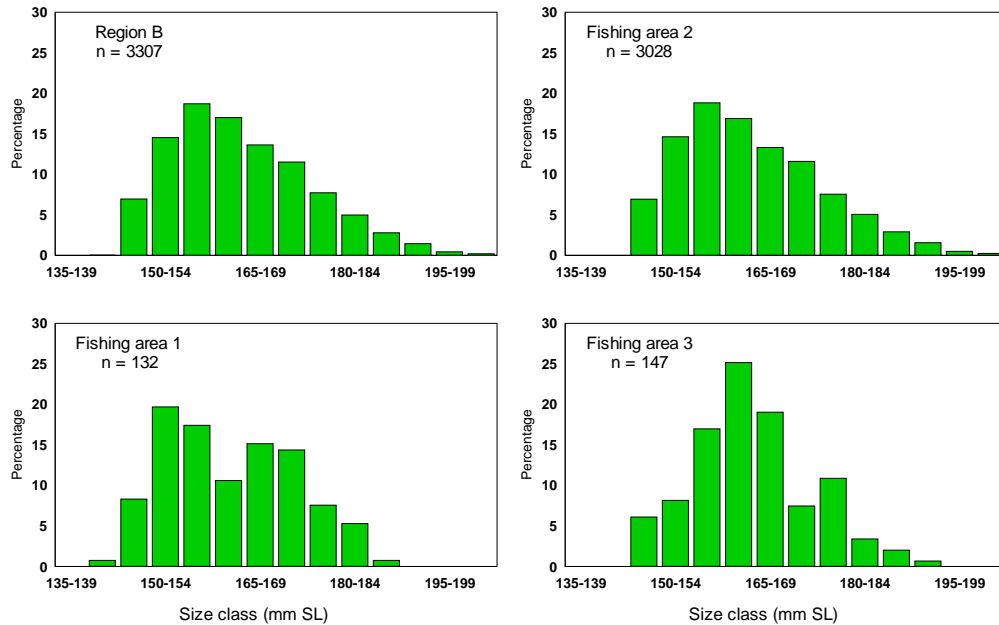
### 2.3 Size-frequency distribution of the catch

Data on the size-frequency distribution of the commercial catch are only available for 2004, during which 3 307 greenlip and 853 blacklip abalone shells were measured. Samples of greenlip abalone were obtained from all three fishing areas, but for blacklip abalone they were only obtained from fishing area 2.

#### 2.3.1 Greenlip abalone

In 2004, the mean size of sampled greenlip abalone was  $163.74 \pm 0.19$  mm SL and the modal size class was 155 – 159 mm SL (Figure 2.8). The mean size did not vary substantially among fishing areas, ranging from  $162.26 \pm 0.89$  to  $164.07 \pm 0.76$  mm SL in fishing areas 1 and 3, respectively. However, the modal size class increased sequentially from west (150 – 154 mm SL in fishing area 1) to east (160 – 164 mm SL in fishing area 3). These size

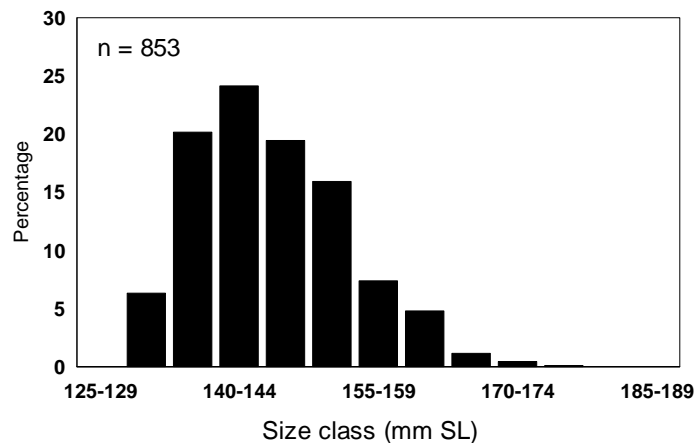
structures showed no evidence of knife-edged fishing on greenlip abalone in Region B during 2004.



**Figure 2.8: Size-frequency distribution obtained from measuring greenlip abalone commercial shell samples in Region B, and in fishing areas 1, 2 and 3 during 2004.**

### 2.3.2 Blacklip abalone

In 2004, the mean size of blacklip abalone sampled from the commercial catch was  $145.06 \pm 0.28$  mm SL and the modal size class was 140 – 144 mm SL. The size distribution showed no evidence of knife-edged fishing on this species in this Region during 2004 (Figure 2.9).



**Figure 2.9: Size-frequency distribution obtained from measuring blacklip abalone commercial shell samples in Region B during 2004.**

### **3. PERFORMANCE INDICATORS**

This section provides a report on the performance of the fishery against the performance indicators (PI) for Region B as defined in the management plan and documented in Table 1.1 (Section 1.3).

Commercial logbooks from all licence holders for the period ending 31 December 2004 were received and the data entered into the database. The reported catch for 2004 was 13.8 t (meat weight). This exceeds 90% of the TACC (13.8 t) and therefore did not trigger the PI.

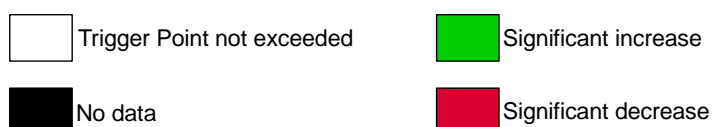
#### **3.1 Greenlip abalone**

There are 10 biological PI specified for greenlip abalone in Region B. Of these, nine are addressed in this report. The remaining PI, diver assessment of stock status, is addressed in another report submitted to PIRSA Fisheries.

Data are available to assess fishery performance against six of the nine (67%) PI to be addressed in this report. None of these six PI have triggered (Table 3.1; Appendix 1).

**Table 3.1: Assessment of the performance of the greenlip and blacklip abalone fisheries in Region B against the performance indicators prescribed in the management plan (inter-annual: 2003 – 2004; 5-year trend: 2000 – 2004).**

Performance indicator	Temporal scale	Greenlip	Blacklip
Mean daily catch	Inter-annual		
	5-year trend		
Mean daily effort	Inter-annual		
	5-year trend		
CPUE	Inter-annual		
	5-year trend		
Mean size	Inter-annual		
	5-year trend		
Egg production/pristine	Annual		



### **3.2 Blacklip abalone**

There are 10 biological PI specified for blacklip abalone in Region B. Of these, nine are addressed in this report. The remaining PI, diver assessment of stock status, is addressed in another report submitted to PIRSA Fisheries.

Data are available to assess fishery performance against six of the nine (67%) PI to be addressed in this report. None of these six PI have triggered (Table 3.1; Appendix 2).

## **4. GENERAL DISCUSSION**

### **4.1 Status of the abalone fishery in Region B**

Information and data available for assessment of the abalone stocks in Region B are limited to (1) a clear documentation of the history and management of the fishery, (2) fine-scale catch and effort data from 1968, and (3) the size-frequency distribution of the catch in 2004. There are (1) no data from fishery-independent surveys, (2) no data on the biology, and (3) no model outputs for either greenlip or blacklip abalone in this Region. Hence, the assessment for this Region is limited to the interpretation and analysis of commercial catch and effort data.

The quality of the catch and effort data for this Region is poorly understood. There are few data on the magnitude of the illegal and recreational catches from this Region. This impedes estimation of the total catch and limits the assessment of stock status.

Analyses on the catch data provide useful information on the spatial and temporal distribution of catch within individual fishing areas within fishing zones (*e.g.* Mayfield *et al.* 2004a-c), and hence their catch histories. Here, we have also used catch rate (catch-per-unit-effort = CPUE), to assess stock status. The use of CPUE as an index of abundance is reliant on the assumption that changes in CPUE reflect a change in the size of the fishable stock (Tarbath *et al.* 2002, 2003, 2005). CPUE can be strongly influenced by numerous factors, and is often viewed as a biased index of change in abalone abundance (Harrison 1983; Breen 1992; Prince & Shepherd 1992; Gorfine *et al.* 2002). For example, catch rates may remain high as a result of re-aggregation of abalone, masking fluctuations in population size arising from local depletion (Officer *et al.* 2001a,b).

Interpretation of CPUE data is further complicated by the decision rule necessarily applied in calculating the CPUE on each species. An estimate of CPUE on each species was computed from those daily catch and effort records where the greenlip and blacklip abalone catch was equal to or exceeded 50% of the total catch, respectively. This was done to ensure that CPUE estimates for each species were derived from daily records in which that species was probably being targeted. While this approach has been used in both Regions of the Western Zone for several years, the appropriateness of this decision rule requires interrogation. For example, this approach fails to consider the effect of harvesting greenlip abalone on the blacklip abalone CPUE, and vice versa. Thus, a basic assumption of this approach is that equal fishing effort is required to catch both species.

This is the first Region B stock assessment report for which data on the size-frequency distribution of the commercial catch have been available. Less than 4% of the catch was measured in 2004. The level to which these data are representative of either the catch from the major fishing areas or the abalone populations in this Region is unknown.

Region B is unique within Australian abalone fisheries in that the TACC (41.4 t since 1994) is not further differentiated between species, thus permitting fishers a harvest choice. Given this, it is notable that in 2004 the greenlip abalone catch was at its highest (30.5 t) whilst that of blacklip abalone was at its equal lowest (11.9 t) level since 1994. Whilst it is noted that this may be the result of non-biological factors, such as the higher beach price (~20%) for greenlip abalone (*i.e.* market forces), it may also be a consequence of relative differences in abundance between the two species.

The mean CPUE has declined substantially (>10%) since 2001 and, in 2004, was ~17% below maximum observed levels. Fishing effort in 2004 was the highest since 1999 and 10% greater than that in 2003. These patterns in catch, effort and CPUE suggest that either the magnitude or composition of current catches in Region B may not be sustainable in future years. This evidence is strongest for blacklip abalone (section 4.1.2) for which catch and CPUE have both declined significantly since 1996 and 1993, respectively.

#### 4.1.1 Greenlip abalone

Data available for the greenlip abalone stocks suggest that these populations are stable and being fished within sustainable limits. This conclusion is supported by eight lines of evidence: (1) CPUE has increased substantially since 1997; (2) catch and CPUE have both increased in fishing area 2 (from which ~70% of the greenlip abalone catch was harvested during the last decade) since 1996; (3) catches from fishing areas 1 and 3 have been stable since 1994; (4) the proportion of the TACC comprising greenlip abalone has increased since 1996; (5) the mean size of the commercial catch in 2004 was at least 15 mm greater than the MLL (145 mm SL); (6) the modal size class was 155 – 159 mm SL; (7) there was no evidence of knife-edged fishing in any of the three fishing areas comprising Region B; and (8) no PI triggered.

Greenlip abalone catch has increased steadily from ~20 t.yr<sup>-1</sup> in the early 1990s to ~30 t.yr<sup>-1</sup> in 2003 and 2004. This trend resulted in greenlip abalone comprising >70% of the total catch from Region B during 2004. Over the last 20 years, most of the catch has been obtained from fishing area 2. Since the early 1990s, greenlip abalone catches have generally increased in fishing area 2 and remained stable in fishing areas 1 and 3. These patterns may reflect

changes in greenlip abalone abundance within these fishing areas, a shift in diver behaviour unrelated to abalone abundance, or, more likely, a combination of these factors.

The CPUE on greenlip abalone in Region B declined significantly between 1978 and 1997, suggesting their abundance declined substantially during this period. The CPUE has increased slowly since 1998, yet remained 30% below maximum observed levels. This trend, in association with increasing levels of catch, probably reflects an increase in abundance of greenlip abalone in Region B – although it likely remains substantially lower than that in the early 1980s. Similar temporal patterns were observed in fishing area 2.

The mean size of the samples from the commercial catch exceeded the MLL by >15 mm SL, the modal size class was 155 – 159 mm SL, and there were substantial numbers of large individuals (>165 mm SL) in the catch. The patterns were similar in each fishing area and provided no evidence of knife-edged fishing on greenlip abalone during 2004.

In summary, most of the data indicates that the greenlip abalone stocks in this Region are stable and being fished within sustainable limits. This conclusion would be usefully substantiated from future commercial shell samples, fishery-independent surveys and data on the fisheries biology (*e.g.* growth rate, fecundity) of this species.

#### 4.1.2 Blacklip abalone

Most of the data available for the blacklip abalone stock suggest that the magnitude of the current catch may not be sustainable in future years: (1) the blacklip abalone catch has declined significantly since 1996; (2) the proportion of the TACC comprising blacklip abalone has declined since 1996; (3) CPUE has decreased significantly since 1993; and (4) CPUE declined by 22% between 2002 and 2004 to the lowest level since 1987 (*i.e.* 18 years). These four lines of evidence suggest that the blacklip abalone stocks in Region B are declining. Data on the size-frequency distribution of the commercial catch, that provide no evidence of knife-edged fishing, do not necessarily support this statement.

Relatively few (<10 t.yr<sup>-1</sup>) blacklip abalone were harvested prior to 1987. Large catches (average 36 t.yr<sup>-1</sup>) were obtained in 1988, 1989 and 1990. Catch decreased significantly from ~20 t.yr<sup>-1</sup> (1995 – 1997) to <12 t in 2003 and 2004. This trend resulted in blacklip abalone comprising <30% of the total catch from this Region during 2004. The reasons for these changes are unknown, but may have been driven by a decreased abundance of blacklip abalone consequent from the large catches obtained in 1988, 1989 and 1990, market forces,

diver behaviour or a combination of these factors. Despite these declines, the catch of blacklip abalone in 2004 was twice the mean catch from 1968 to 1990.

Over the last 20 years, most of the catch has been obtained from fishing area 2. Catches have declined in fishing areas 1 and 2 over about the last decade, but remained stable in fishing area 3. These patterns may reflect changes in blacklip abalone abundance within these three fishing areas, a shift in diver behaviour unrelated to abalone abundance, or, more likely, a combination of these factors.

The CPUE on blacklip abalone increased substantially from 1987 to 1993, but declined significantly between 1993 and 2004, and decreased by 22% between 2002 and 2004. The CPUE during 2004 was at the lowest level for 18 years. These patterns suggest that the abundance of blacklip abalone in Region B has declined substantially over the last decade, with the rate of decrease likely greatest since 2002.

The mean size of the samples from the commercial catch in 2004 exceeded the MLL (130 mm SL) by 15 mm SL, the modal size class was 140 – 144 mm SL, and about 10% of the measured catch comprised individuals larger than 155 mm SL. There was no evidence of knife-edged fishing on blacklip abalone in Region B during 2004.

In summary, almost all of the data available to assess the blacklip abalone stock in Region B suggest that the magnitude of the current catch may not be sustainable in future years. Several lines of evidence, including simultaneous reductions in both catch and CPUE since 1996 and large reduction in CPUE between 2002 and 2004 supported this conclusion. It is notable that current catches of blacklip abalone from this Region are at least double historical levels. This, in conjunction with current patterns in catch and CPUE, suggests that consideration of species-specific TACC in Region B may be warranted in future years.

#### **4.2 Future research needs**

Future assessment of the Region B abalone fishery would be strengthened by (1) additional interrogation of the catch and effort data, (2) more representative sampling of shell lengths from the commercial catch, (3) conducting regular fishery-independent surveys to monitor changes in the abundance of legal and sub-legal sized abalone in key fishing areas, and (4) obtaining representative biological data on both species from throughout Region B and particularly from fishing area 2.

Data on the size-frequency distribution of the commercial catch is limited to 2004, and further constrained by small sample sizes. Shell samples are required regularly from all fishers in this Zone to ensure adequate and representative sampling of the commercial catch during 2006, and subsequent years (after Andrew & Chen 1997).

There are no biological data available for either greenlip or blacklip abalone in Region B. As a priority, data on (1) growth and mortality rates, and (2) fecundity, are required for both species at Flinders Reef and Evans Island (fishing area 2) and Franklin Island (fishing area 3). to help determine life history trends of both species in this Region.

Fishery-independent surveys to monitor changes in the abundance of greenlip and blacklip abalone should be implemented and then undertaken regularly (*e.g.* every two years), at Flinders Reef and Evans Island (fishing area 2) and Franklin Island (fishing area 3). This will provide data to determine changes in the abundance and population structure of abalone in the main fishing areas comprising Region B.

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**Appendix 1: Assessment of the greenlip abalone fishery in Region B against the biological Performance Indicators prescribed in the Management Plan. Values are mean  $\pm$  SE. Red indicates statistical significance.**

Performance Indicator	Units	Spatial Scale	2000	2001	2002	2003	2004	Inter-annual change	5-year trend
Mean daily catch	kg.day <sup>-1</sup>	Region B	247.0 $\pm$ 11.6	256.3 $\pm$ 11.9	240.2 $\pm$ 13.2	248.0 $\pm$ 12.9	243.4 $\pm$ 11.3	$t = 0.27$ , df = 221 $p > 0.05$	$F_{1,504} = 0.14$ $p > 0.05$
Mean daily effort	hr.day <sup>-1</sup>	Region B	5.0 $\pm$ 0.2	5.1 $\pm$ 0.2	4.7 $\pm$ 0.2	4.5 $\pm$ 0.2	4.8 $\pm$ 0.2	$t = 1.25$ , df = 221 $p > 0.05$	$F_{1,504} = 2.98$ $p > 0.05$
CPUE	kg.hr <sup>-1</sup>	Region B	49.8 $\pm$ 1.9	50.4 $\pm$ 2.1	51.0 $\pm$ 2.4	55.1 $\pm$ 2.2	50.8 $\pm$ 1.7	$t^1 = 1.52$ , df = 208.7 $p > 0.05$	$F^2_{1,504} = 0.72$ $p > 0.05$
Mean size	mm SL	Region B	No data	No data	No data	No data	163.7 $\pm$ 0.2	-	-

**1. Based on the ratio estimator (after Rice 1995)**

**2. Based on daily CPUE**

**Appendix 2: Assessment of the blacklip abalone fishery in Region B against the biological Performance Indicators prescribed in the Management Plan. Values are mean  $\pm$  SE. Red indicates statistical significance.**

Performance Indicator	Units	Spatial Scale	2000	2001	2002	2003	2004	Inter-annual change	5-year trend
Mean daily catch	kg.day <sup>-1</sup>	Region B	289.7 $\pm$ 41.1	319.4 $\pm$ 28.6	331.1 $\pm$ 30.8	277.5 $\pm$ 39.2	226.1 $\pm$ 19.7	$t = 1.23$ , df = 60 $p > 0.05$	$F_{1,163} = 2.77$ $p > 0.05$
Mean daily effort	hr.day <sup>-1</sup>	Region B	5.1 $\pm$ 0.3	5.4 $\pm$ 0.3	5.3 $\pm$ 0.3	4.9 $\pm$ 0.3	4.7 $\pm$ 0.3	$t = 0.55$ , df = 60 $p > 0.05$	$F_{1,163} = 2.34$ $p > 0.05$
CPUE	kg.hr <sup>-1</sup>	Region B	56.3 $\pm$ 6.9	58.5 $\pm$ 3.8	62.2 $\pm$ 5.0	56.2 $\pm$ 6.5	48.3 $\pm$ 3.2	$t^1 = 1.09$ , df = 39.7 $p > 0.05$	$F^2_{1,163} = 0.67$ $p > 0.05$
Mean size	mm SL	Region B	No data	No data	No data	No data	145.1 $\pm$ 0.3	-	-

**1. Based on the ratio estimator (after Rice 1995)**

**2. Based on daily CPUE**

