

Fishery Status Report to PIRSA Fisheries

Western Zone Abalone
***(H. laevigata & H. rubra)* Fishery**
(Region A)

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EXECUTIVE SUMMARY

1. This fishery status report provides an assessment of the current status of *Haliotis laevis* (hereafter referred to as greenlip) and *H. rubra* (hereafter referred to as blacklip) stocks in Region A of the Western Zone abalone fishery.
2. The total TACC in 2007 was 520.95 t. It was increased 20.7 t (in greenlip TACC) from 2006. Total effort in 2007 was 5 680 hr, the highest since 2003.

Greenlip

3. The TACC on greenlip in 2007 was 227.7 t. It was increased by 20.7 t from 2006.
4. Total catch of greenlip in 2007 was 223.6 t, 4.1 t below the TACC. Catches from fishing areas (FA) 9 and 18 have averaged 30% and 23%, respectively, of the TACC since 1997. Catch from FA 14 has increased by 28 t since 2003, to 37 t in 2007. Catches from FA 6, 8 and 19 decreased substantially between 2003 and 2007.
5. The catch-per-unit-effort (CPUE) in Region A declined from a historical high of 79.0 kg.hr⁻¹ in 2005, to 75.9 kg.hr⁻¹ in 2007, the lowest level since 2002. Similar patterns were evident in several key fishing areas. Notably, the CPUE in FA 9 decreased significantly between 2003 and 2007, to the lowest level since 2001. In contrast, the CPUE in FA 8 was at the highest level for any fishing area since 1979.
6. Since 2004, the mean length and modal length classes of greenlip measured from the commercial catch has exceeded the MLL (145 mm SL) by >15 mm and >5 mm, respectively.
7. Fishery-independent surveys indicate that greenlip abundance at Ward Island and Hotspot has generally increased since 2003. In contrast, abundance at Pearson Island, Point Avoid and 'The Gap' has generally decreased over the same period.
8. Sixteen performance indicators triggered. Ten of these are positive for the fishery.
9. Conclusion: Unambiguous assessment of the current status of greenlip stocks in Region A was impeded by inconsistent inferences from the datasets available. While some of the data suggest that the stocks remain in a strong position, other data, notably decreases in CPUE in key fishing areas, suggest the stock has weakened since 2005. These inferences are consistent with the time over which the TACC has been increased.

Blacklip

10. The TACC on blacklip in 2007 was 293.25 t. The total catch was >2.5 t below the TACC.
11. The spatial distribution of catch was more restricted in 2007 than in previous years.
12. An average of 20% of the catch has been harvested from FA 9 since 1997, though catch from this area has decreased since 2005. Catch in FA 4 and 14 increased by >15 t and >20 t since 2003, respectively. In 2007, catch in FA 14 was about double the historical maximum. Catch in FA 6 has decreased successively since 2003. In 2007 it was ~30 t less than in 2003, and the lowest since 1980. Catch in FA 5 has decreased by >9 t in the same time period.
13. The CPUE in Region A was stable between 2003 and 2006. It declined between 2006 and 2007 to the lowest level since 2002. Similar patterns were evident in several key fishing areas. Notably, CPUE decreased significantly in FA 5 and FA 9 from 2003 to 2007, and in FA 4 from 2006 to 2007. CPUE increased significantly in FA 4, 12 and 14 between 2003 and 2007.
14. Since 2003, the mean length of blacklip measured from the commercial catch has exceeded the MLL (130 mm SL) by >15 mm and the modal length class has varied <10 mm SL.
15. Twenty-two performance indicators triggered. Twelve of these are negative for the fishery.
16. Conclusion: Assessment of the current status of the blacklip stocks in Region A was complicated by the inconsistent inferences from the available datasets. Some data suggest the stocks remain in a relatively strong position. However, other data, principally decreases in catch and CPUE in key fishing areas, evident in the last 2-3 years, suggest the stock has weakened since 2005.

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1. INTRODUCTION

1.1 Report structure and content

This report assesses the current status of the abalone stocks in Region A of the Western Zone of the South Australian Abalone Fishery (hereafter referred to as Region A, see Figure 1.1). This report complements, and should be considered in association with, the 2006 assessment report (Chick *et al.* 2006). This is because this status report does not provide an exhaustive assessment of the fishery and does not present summaries of biological knowledge, outputs from a range of models, a detailed description of the methodology followed to assess the fishery or summaries of the current assessment of the recreational or illegal fisheries in this zone; rather, fishery-dependent and fishery-independent data are presented with a brief description of recent (~5 years) spatial and/or temporal patterns.

Following the Introduction this report consist of four sections. Summaries and descriptions of the commercial catch, effort, catch-per-unit-effort (CPUE, kg hr⁻¹) and length-frequency distributions of the catch for each of the greenlip and blacklip fisheries is provided in Sections 2 and 3, respectively. Fishery-independent survey data, describing changes in the abundance and population length structures for greenlip, are also presented in section 2. Section 4, provides an assessment of the greenlip and blacklip fisheries against the performance indicators identified in the South Australian (SA) Abalone Fishery Management Plan (Nobes et al. 2004). Section 5, summarises the current status of the Region A greenlip and blacklip fisheries.

1.2 Data sources and analysis

Commercial catch and effort data have been collected since 1968 in the form of daily entries into commercial logbooks submitted to the South Australian Research and Development Institute (SARDI). The logbook data were used to provide the spatial and temporal analyses of catch, effort and CPUE. CPUE was computed using the mean ratio estimator (after Rice 1995). Data on the length-frequency distribution of the commercial catch were obtained by measuring samples provided to SARDI by commercial fishers (1979 – 30 June 2005) and data provided by the Abalone Industry Association of South Australia (AIASA; 1 July 2005 – 31 December 2007). Estimates of greenlip abundance and population size structure were obtained from fishery-independent diver surveys undertaken by SARDI.

Fishery statistics in this report are provided at two spatial scales. These are (1) the whole Region A and (2) individual fishing areas within the region. Data were analysed as described in Chick *et al.* (2006).

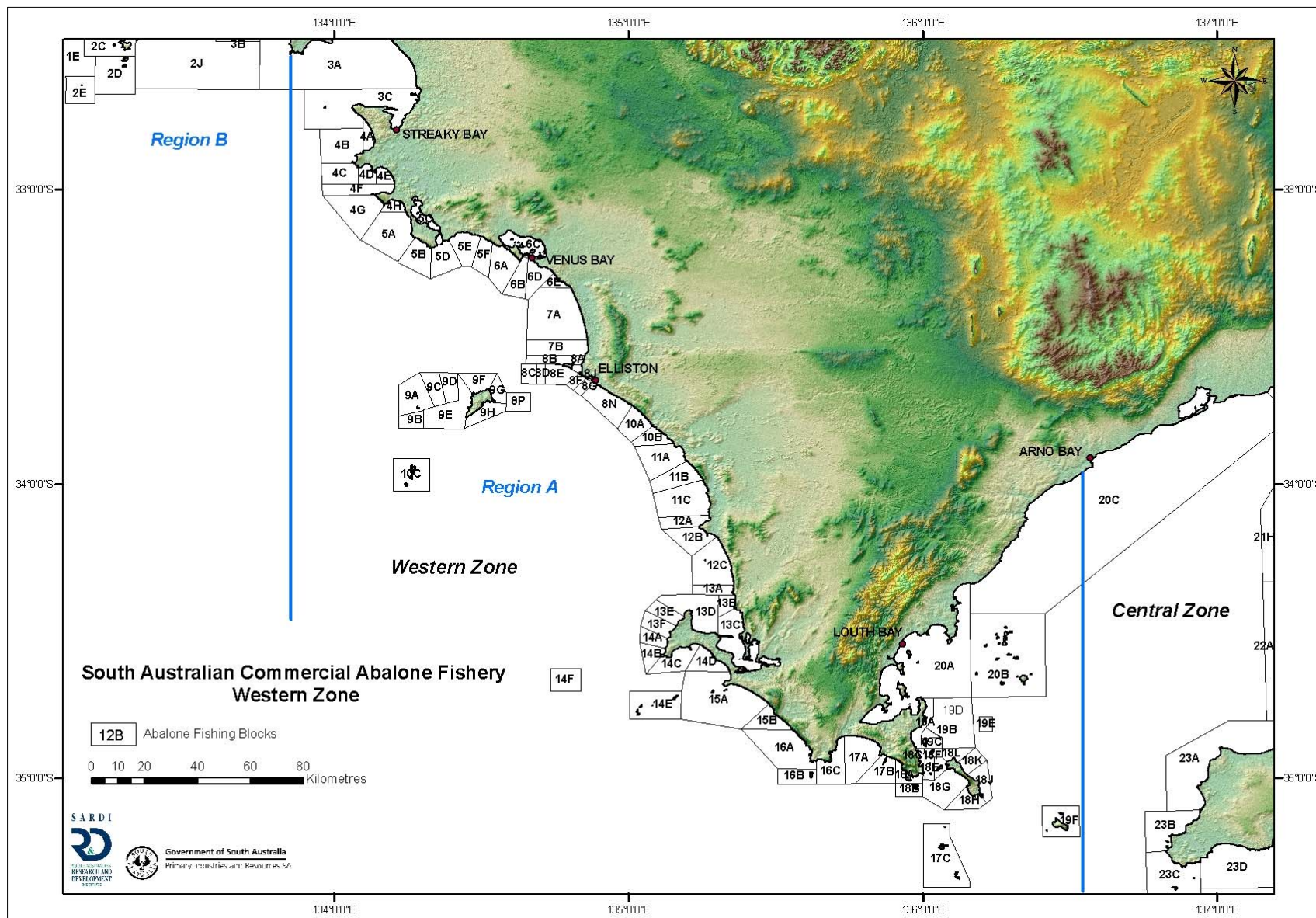


Figure 1.1 Fishing areas and map codes in Region A of the Western Zone South Australian abalone fishery.

2. GREENLIP

2.1 Catch

Prior to the implementation of a TACC in 1985, the catch of greenlip from Region A fluctuated between 991 t (1968) and 203 t (1974) (Figure 2.1). Following TACC implementation (1985) and amendment (1989 and 2006), catches have generally been stable. The TACC remained unchanged from 1989 to 2005 (207 t.yr⁻¹). It was increased by 20.7 t from 2006 and has remained at 227.7 t.yr⁻¹ since. In 2006 and 2007 the reported catch of greenlip was 228.1 t and 223.6 t, respectively. The catch in 2007 was ~4 t below the TACC.

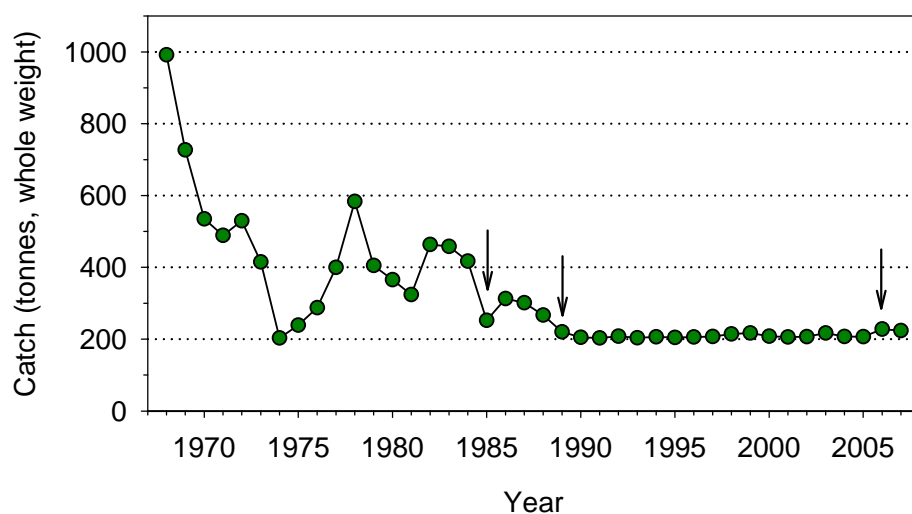


Figure 2.1 Catch (tonnes) of greenlip in Region A from 1968 to 2007. ↓ indicate the implementation (1985) and amendments (1989 and 2006) of TACCs.

Since 2003, more than 60% of the TACC has been obtained from three fishing areas (FA). For ten years prior to 2006 the top 3 fishing areas, in order of catch, were FA 9, 18 and 8. During 2006 and 2007 this order changed to FA 9, 18 and 14 (Figure 2.2). In 2007, catches in FA 9 (65.8 t) and 18 (48.9 t) represented 29.4% and 21.9% of the annual catch (Figure 2.3a and 2.3b). The catch in FA 9, in 2007, represents the highest proportion of annual catch from this fishing area since 2002. In 2006 and 2007 the catch in FA 14 was 33.9 t (14.9%) and 37.11 t (16.6%), respectively. These were the highest catches in this fishing area since 1986 and more than 3 times the average annual catch from 1998-2002 (Figure 2.3b). Catches in FA 6, 8 and 19 have generally declined over the last 5 years with catches in 2006 or 2007 representing the lowest catch since at least 2001 (Figure 2.3a and 2.3b).

2.2 Catch-per-unit-effort (CPUE)

The mean CPUE, in all fishing areas of Region A combined, has remained relatively stable since 2003, ranging less than 4 kg.hr⁻¹ from that in 2005 (79.0 kg.hr⁻¹), the highest CPUE since

at least 1979 (Figure 2.4). However, since 2005, mean CPUE in the region has decreased each year to 75.9 kg.hr⁻¹ in 2007, the lowest it has been since 2002.

Similarly to temporal patterns across the whole region within the last 5 years, CPUE in the fishing areas from which >5% of the TACC has been harvested (FA 4, 5, 8, 9, 14, 18 and 19) has been high, relative to historical levels (Figure 2.4). However, in six of these fishing areas (FA 4, 5, 9, 14, 18 and 19) mean annual CPUE has decreased over recent years. In 2007, mean annual CPUE in FA 5 (63.5 kg.hr⁻¹) and FA 9 (72.8 kg.hr⁻¹) was the lowest since 2002 and 2001, respectively, and in FA 9 CPUE has significantly decreased since 2003 (Figure 2.4 and Appendix 1). In contrast, in 2007, CPUE in FA 8 (103.0 kg.hr⁻¹) was significantly higher than in 2006 (87.7 kg.hr⁻¹) and the highest for any fishing area in the history of the fishery (Figure 2.4 and Appendix 1).

2.3 Length-frequency distribution of the catch

In each year since the establishment of the current MLL (1984), the length frequency distribution of greenlip measured from the commercial catch was generally normal, although right skewed as large (>180 mm SL) greenlip comprised a substantial proportion of the samples, ranging from 5.9% in 1999 to 19.9% in 2007. In 2007, the proportion of greenlip smaller than 155 mm SL was 10.2%, the lowest proportion of this size range since at least the introduction of the MLL. From 2004 to 2007 the modal length class has remain unchanged at 160 - 164 mm SL, and the mean length has increased each year from 168.2 mm SL, in 2004, to 169.0 mm SL, in 2007 (Figure 2.5).

During 2007, there were 8 fishing areas from which more than 100 shells were measured (Figure 2.6). The mean length of the commercial catch was greater than the 2007 regional average (169.0 mm SL) in four (FA 9, 15, 18 and 19) of the eight fishing areas. In each of the 8 fishing areas mean length exceeded the MLL (145 mm SL) by >15 mm SL. The modal length class in each area was at least 5 mm more than the MLL and ranged from 150 - 154 mm SL (FA 14) to 180 - 184 mm SL (FA 19). In FA 6 more than 5% of the measured catch was less than the MLL (145 mm SL) (Figure 2.6).

Cumulatively ~68% of the greenlip TACC was harvested from FA 9, 14 and 18 during 2007. In FA 9, the modal length class has remained unchanged since 2003 (160 - 164 mm SL) and the mean length has increased by 4 mm from 165.4 mm SL (2003) to 169.4 mm SL (2007) (Figure 2.7). There are few data for FA 14. However, data show the mean length in FA 14 has decreased by ~2 mm from 163.5 mm SL (2004) to 161.8 mm SL (2007), with >30% of greenlip being within 10 mm of the MLL. In FA 18 the modal length class and mean length decreased from 2003 (175 - 179 mm SL; 173.0 mm SL) to 2007 (170 - 174 mm SL; 171.7 mm SL), although the mean length increased from 2006 (170.5 mm SL) to 2007 (171.7 mm SL) (Figure 2.7).

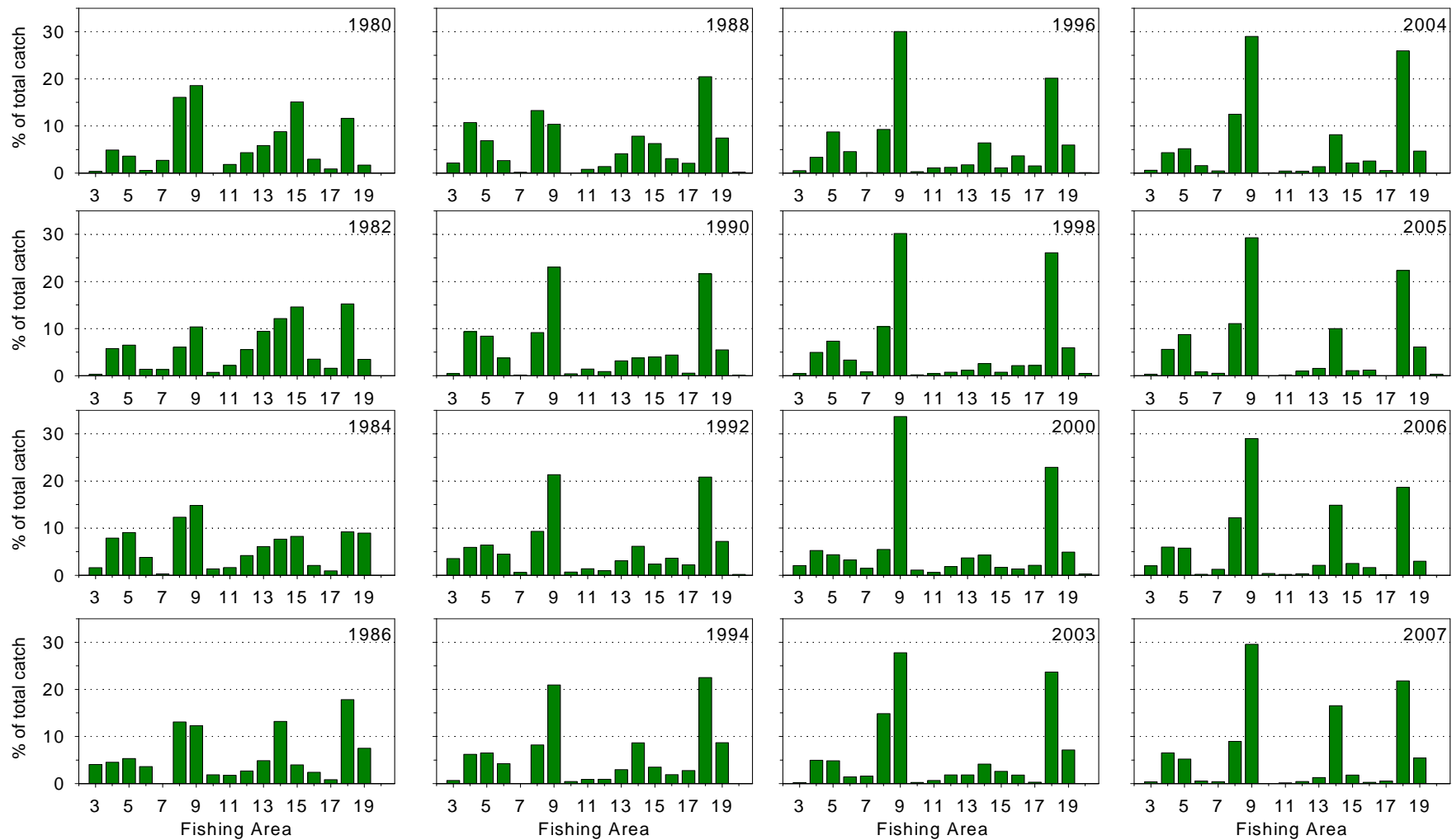


Figure 2.2. Spatial distribution of the greenlip catch (% of total catch) among each of the fishing areas in Region A of the Western Zone in alternate years from 1980 until 2000 and annually 2003 to 2007.

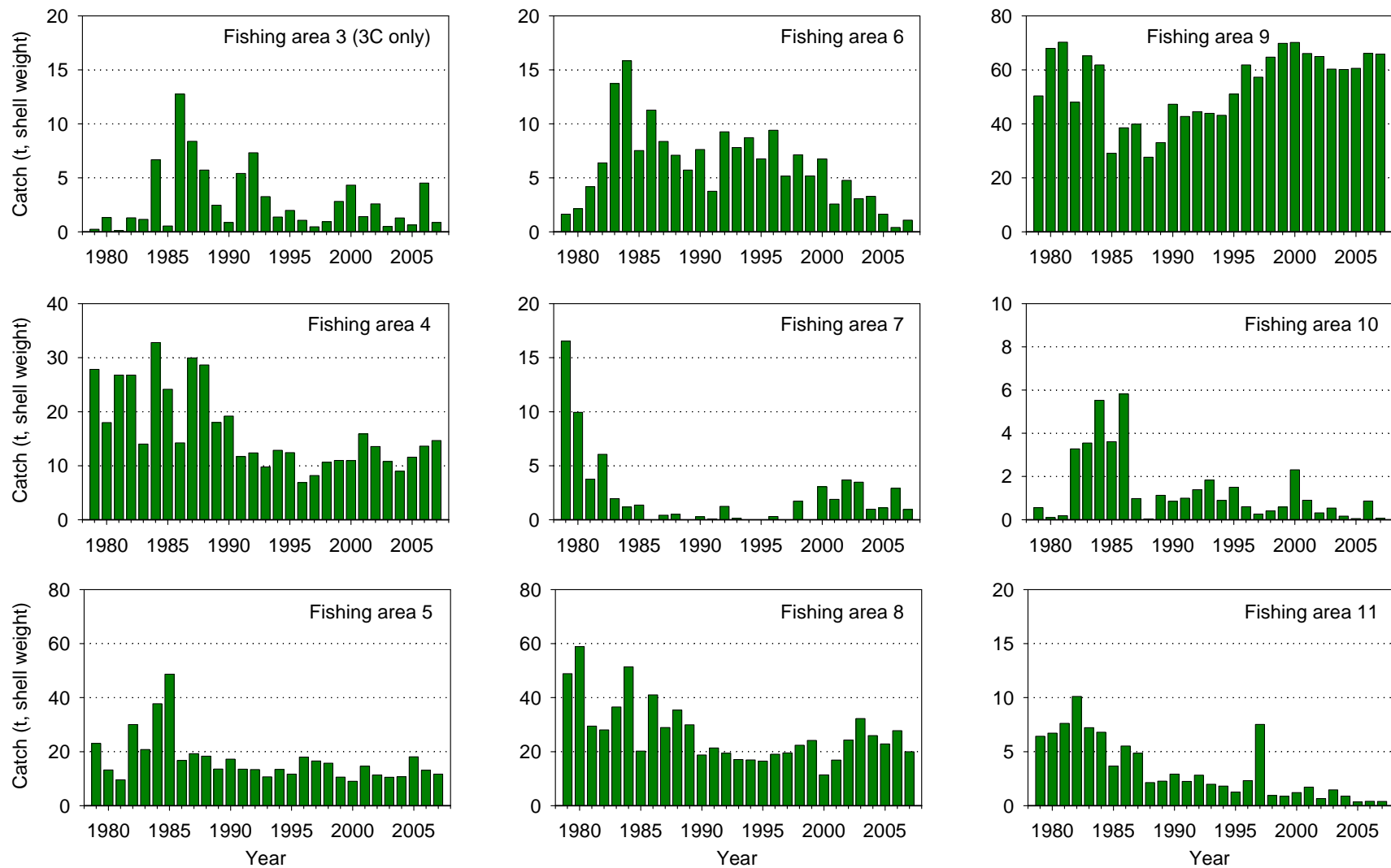


Figure 2.3a. Catch of greenlip (t, shell weight) in each of the fishing areas comprising Region A of the Western Zone from 1979 to 2007. Note: scales on Y-axis vary.

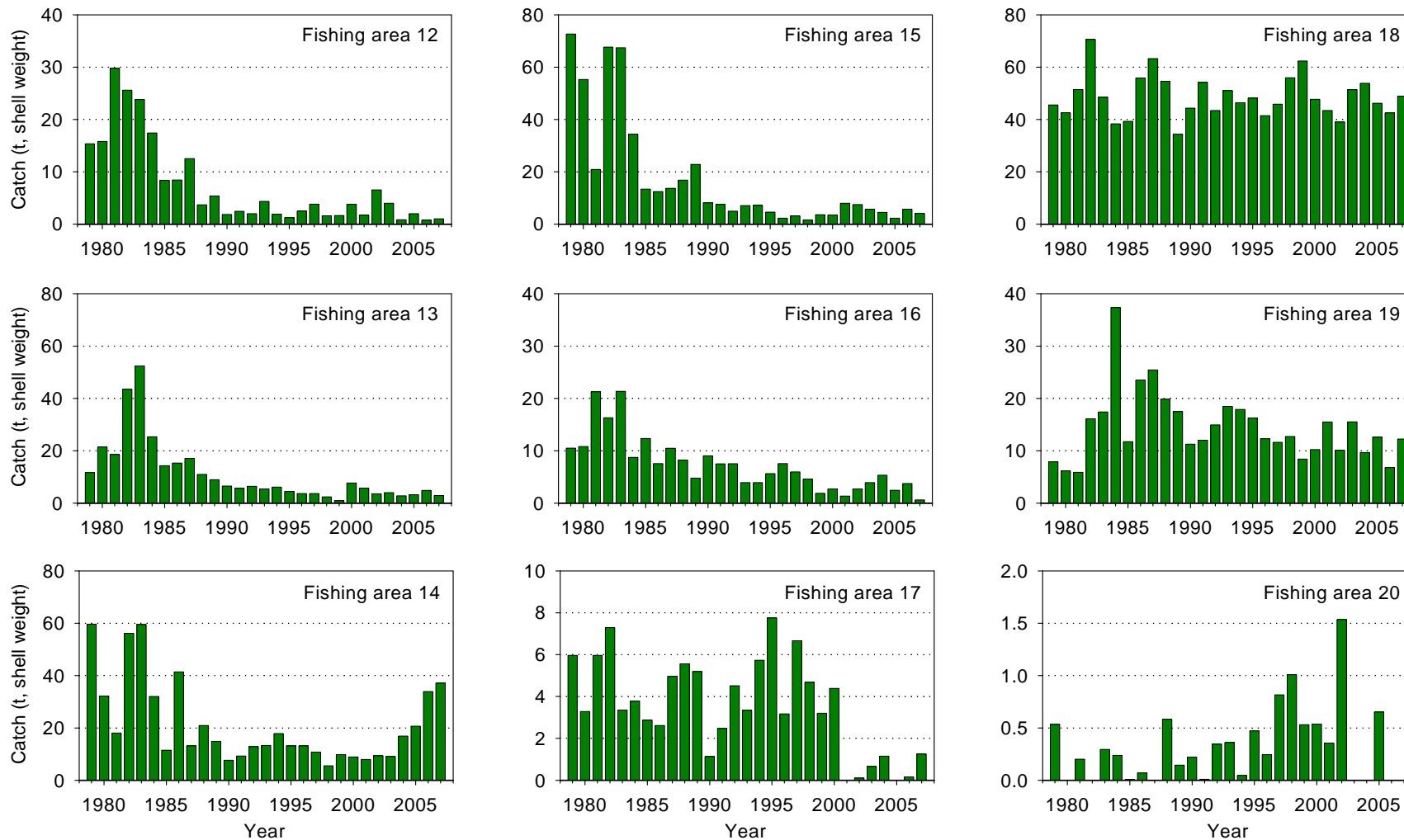


Figure 2.3b. Catch of greenlip (t, shell weight) in each of the fishing areas comprising Region A of the Western Zone from 1979 to 2007. Note: scales on Y-axis vary.

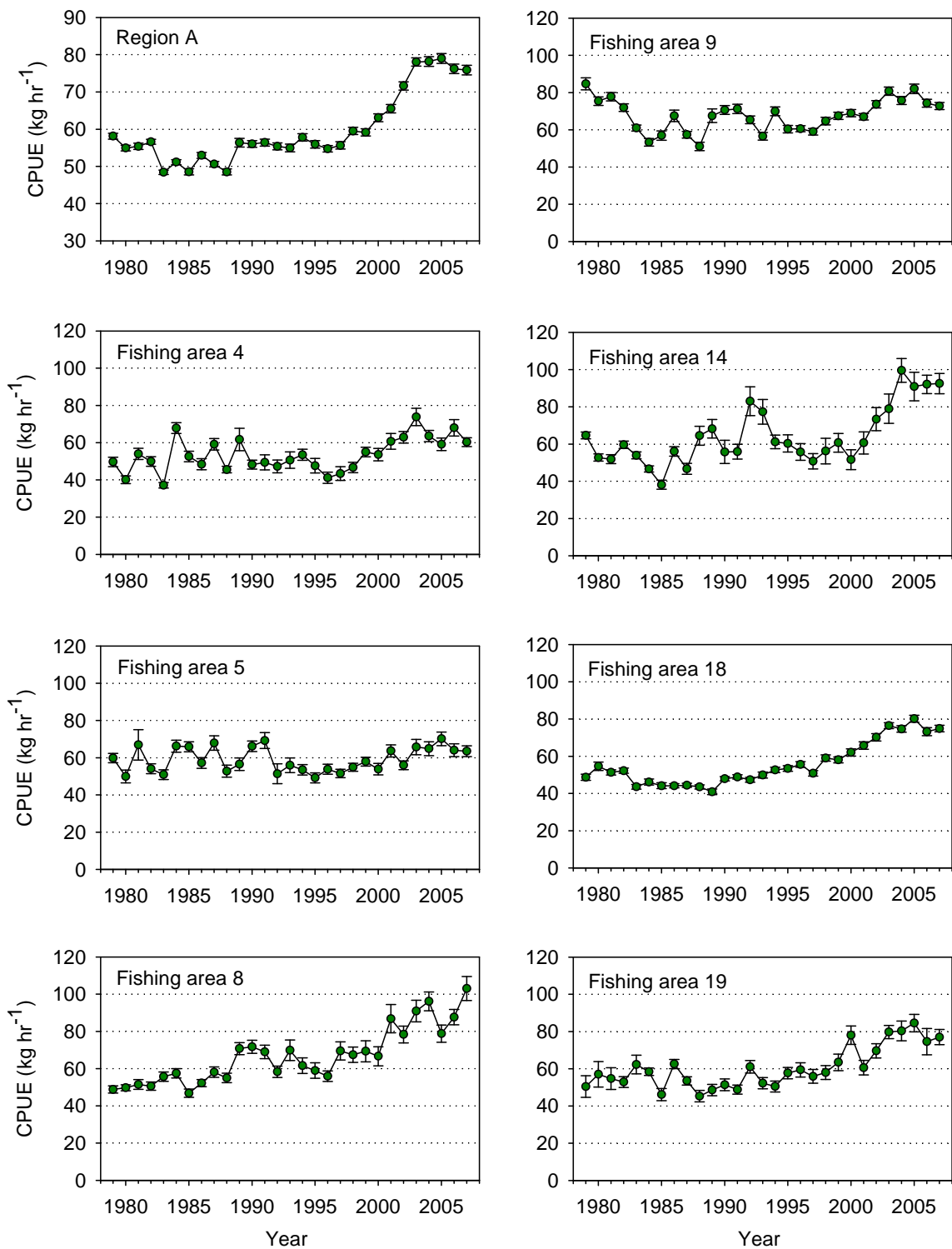


Figure 2.4 Mean catch-per-unit-effort (CPUE (kg.hr⁻¹) (\pm SE) on greenlip for all fishing areas of Region A combined, and for fishing areas 4, 5, 8, 9, 14, 18 and 19 from 1979 to 2007. Note: the scale on the Y-axis for Region A is different to those for fishing areas.

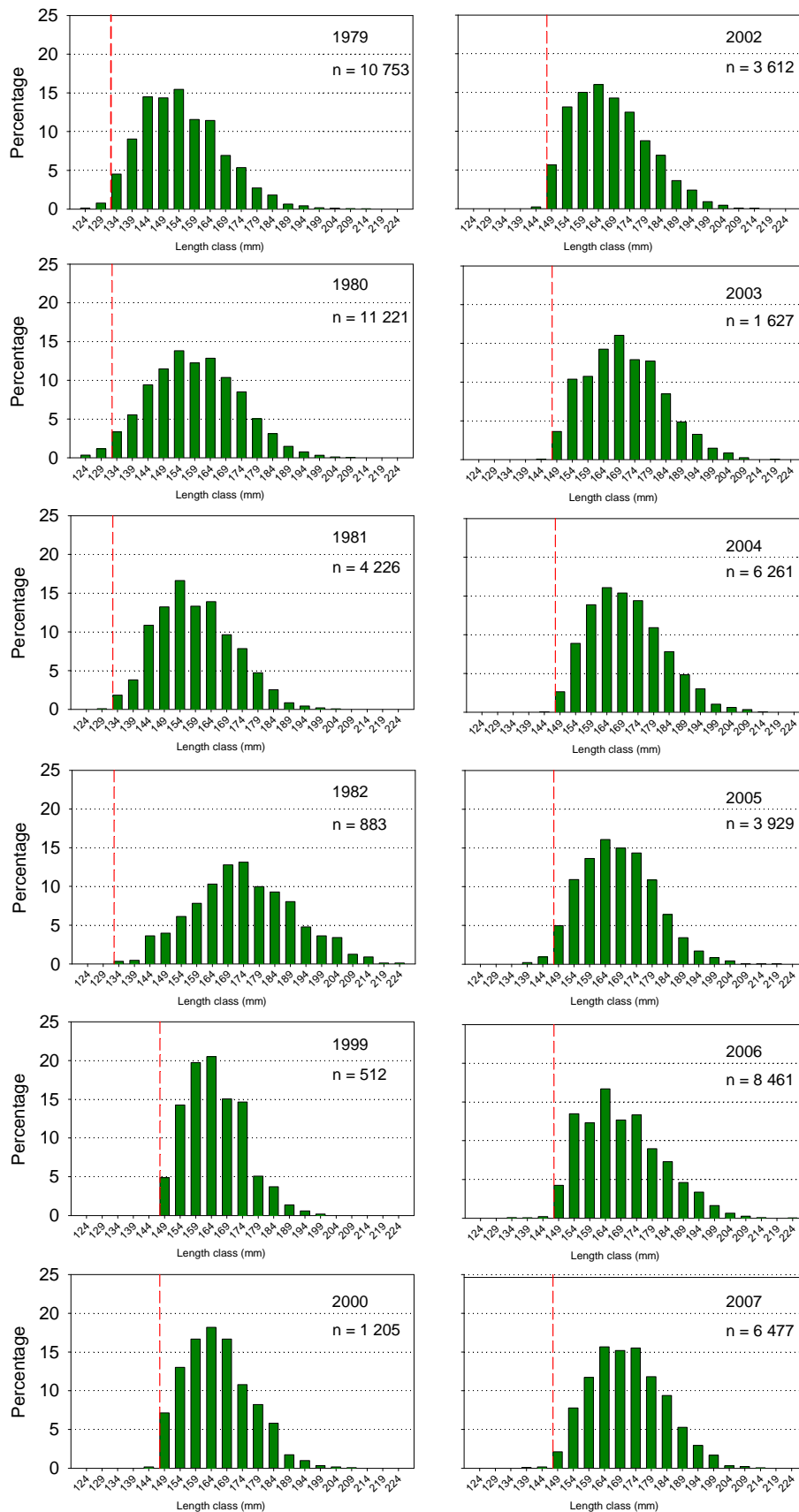


Figure 2.5 Length-frequency distribution obtained from measuring greenlip shells from the commercial fishery from Region A during the years 1979-1982, 1999, 2000 and 2002-2007. Vertical red line indicates MLL (130 mm SL (< 1984) and 145 mm SL (\geq 1984)).

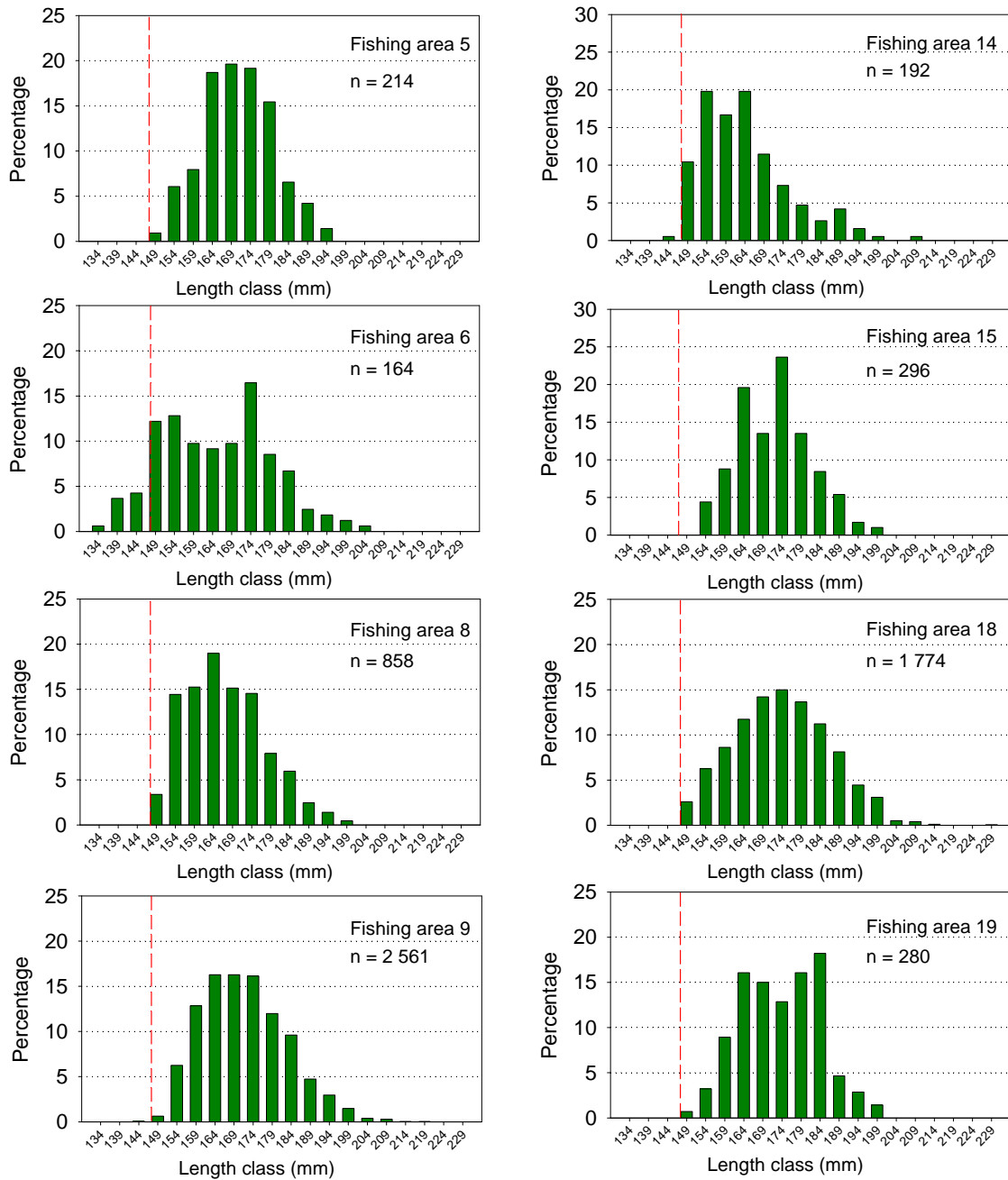


Figure 2.6 Length-frequency distribution obtained from measuring greenlip shells from the commercial fishery in fishing areas 5, 6, 8, 9, 14, 15, 18 and 19 during 2007 (where $n > 100$). Vertical red line indicates MLL (145 mm SL).

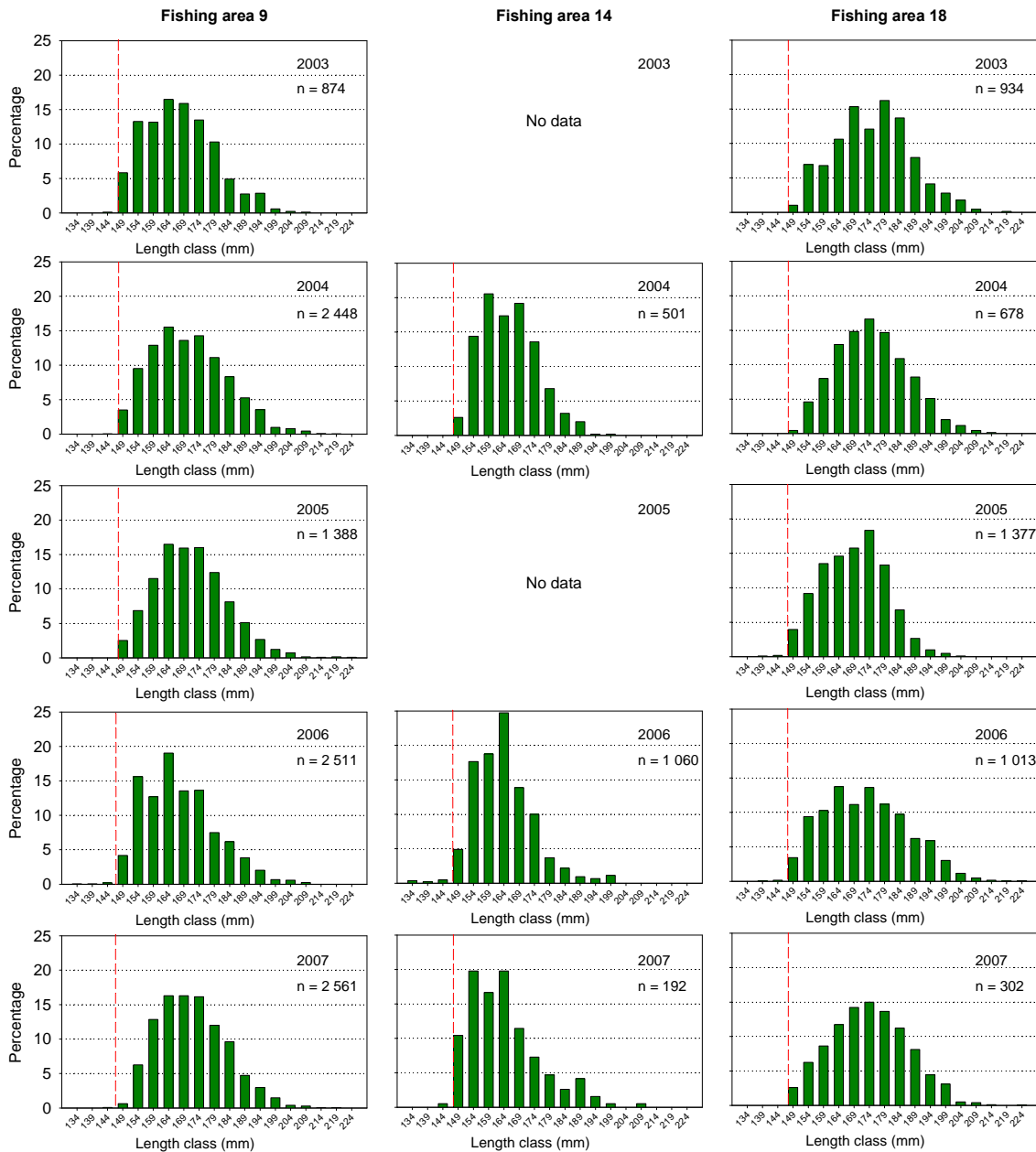


Figure 2.7 Length-frequency distribution obtained from measuring greenlip shells from the commercial fishery in fishing area 9, 14 and 18 from 2003 to 2007. Vertical red line indicates MLL (145 mm SL).

2.4 Fishery-independent abalone surveys

Changes in abundance of greenlip within each of the 3 length categories (all, legal and sub-legal) are not consistent within and between survey sites, through time. However, there is greater consistency through time within sites (Figures 2.8 and 2.9). Similar patterns are also reflected in the length-frequency distributions of the number of greenlip encountered per-minute-swum at these sites (Figure 2.10 and 2.11).

Since 2002 the abundance of all, legal and sub-legal greenlip at Ward Island has increased each year (Figure 2.8 and 2.10). In 2006, the abundance of each category was at the highest level since at least 1998. The abundance of all and legal greenlip at Flinders Island has generally been stable since 2003 (Figure 2.8 and 2.10). However, the abundance of sub-legal greenlip has generally declined from 2003. The abundance of greenlip in each category at Hotspot has generally increased through time (Figure 2.8 and 2.10). The greatest increase was observed in the sub-legal category over recent years, to the highest level, in 2007, since surveys began (Figure 2.8 and 2.10)

At Pearson Island legal-size greenlip are dominant (Figure 2.11). While their abundance has generally increased since 1990, the abundance of all, legal and sub-legal greenlip has decreased successively since 2004 (Figure 2.9 and 2.11). The abundance of greenlip at Point Avoid has generally decreased through time, whilst their size has increased (Figure 2.9 and 2.11). In 2006 the abundance of all greenlip at Point Avoid was at the lowest level since 1993 (Figure 2.9). The abundance of all, legal and sub-legal greenlip at 'The Gap' have generally declined over the last 5 years (Figure 2.9 and 2.11).

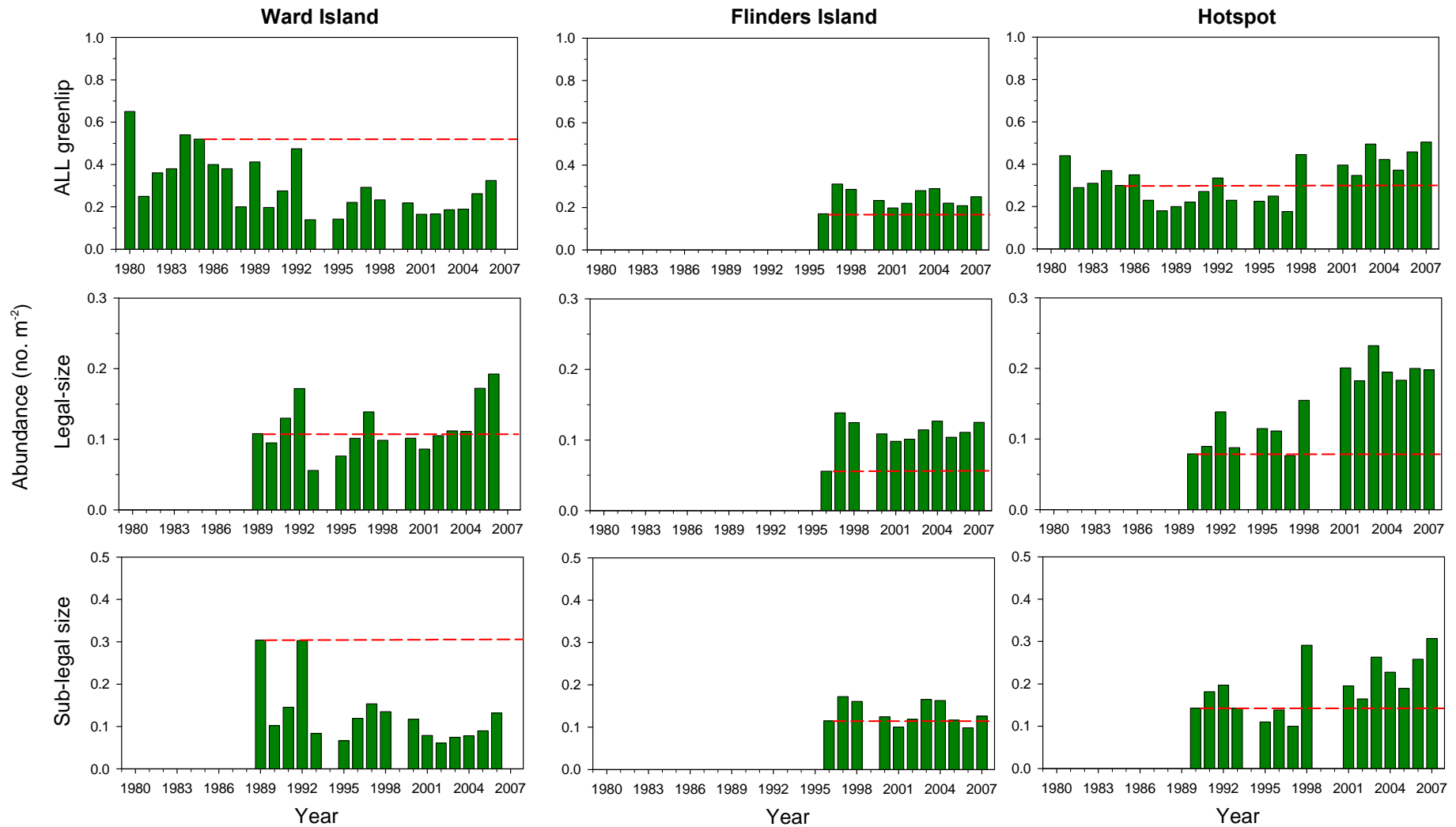


Figure 2.8 Estimated abundance (no.m⁻²) of all (top), legal-sized (middle) and sub-legal sized (bottom) greenlip at Ward Island, Flinders Island and Hotspot, since surveys commenced. The dashed red line indicates estimated density in 1985 (the first year of a TACC) or the first year for which there are data. Gaps in the annual estimates indicate there are no comparable data available.

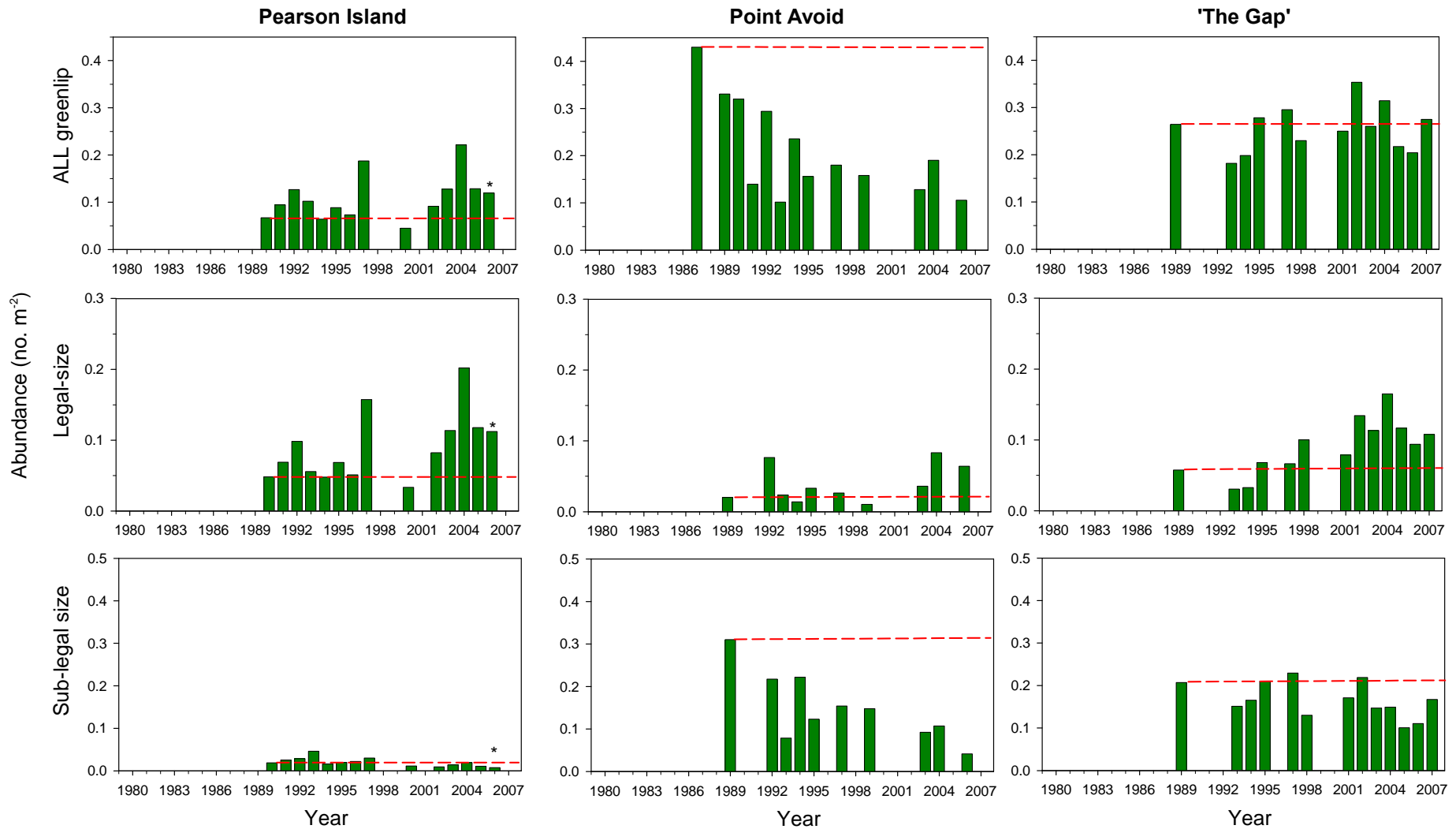


Figure 2.9 Estimated abundance (no.m⁻²) of all (top), legal-sized (middle) and sub-legal sized (bottom) greenlip at Pearson Island, Point AVOID and 'The Gap', since surveys commenced. The dashed red line indicates estimated density in 1985 (the first year of a TACC) or the first year for which there are data. Gaps in the annual estimates indicate there are no comparable data available (* only 1 of 4 locations surveyed).

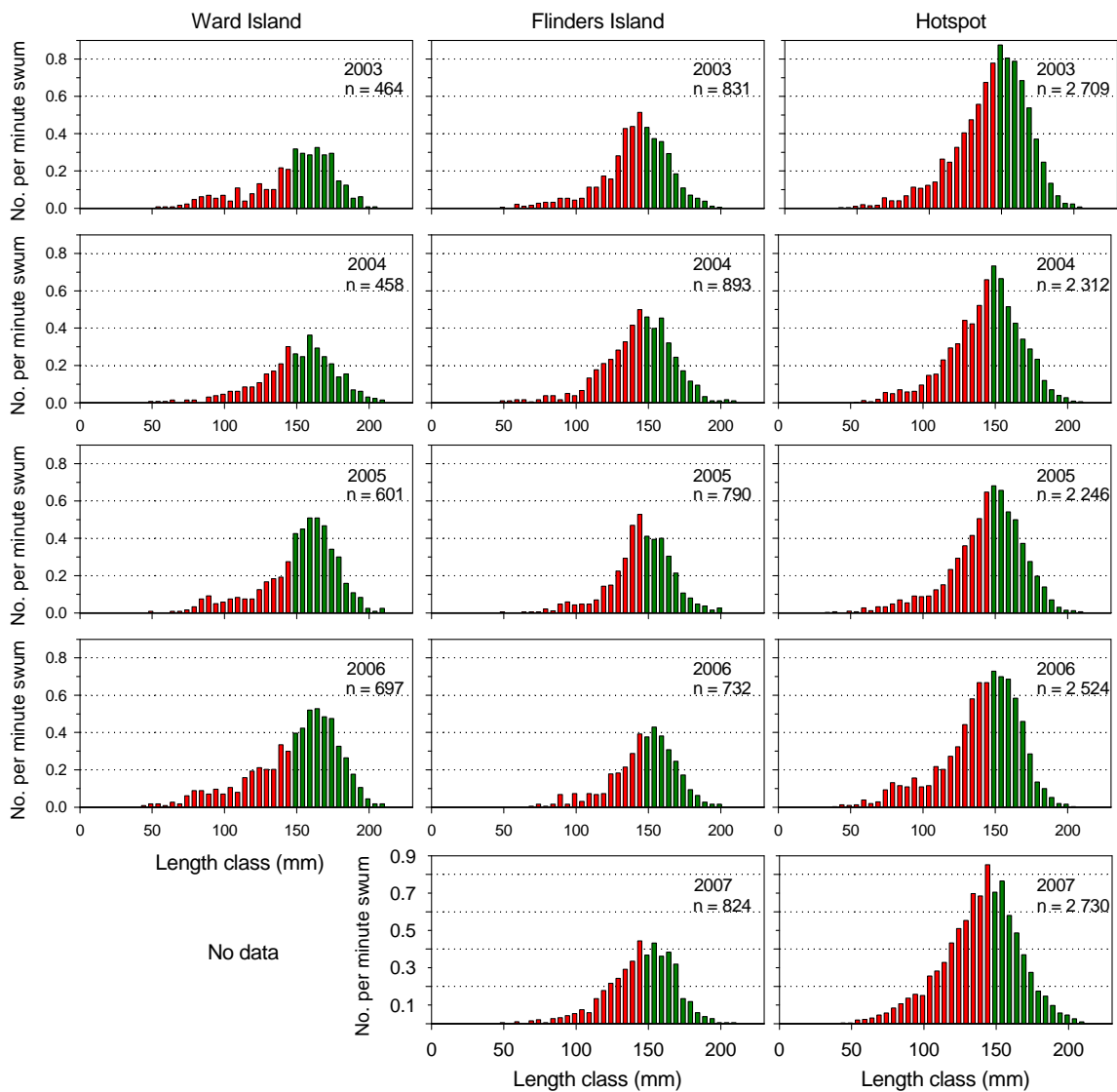


Figure 2.10 Length-frequency distribution of legal-sized (≥ 145 mm SL, green bars) and sub-legal-sized (< 145 mm SL, red bars) greenlip surveyed per-minute-swum at Ward Island, Flinders Island and Hotspot on fishery-independent surveys between 2003 and 2007. Length classes are 5 mm SL.

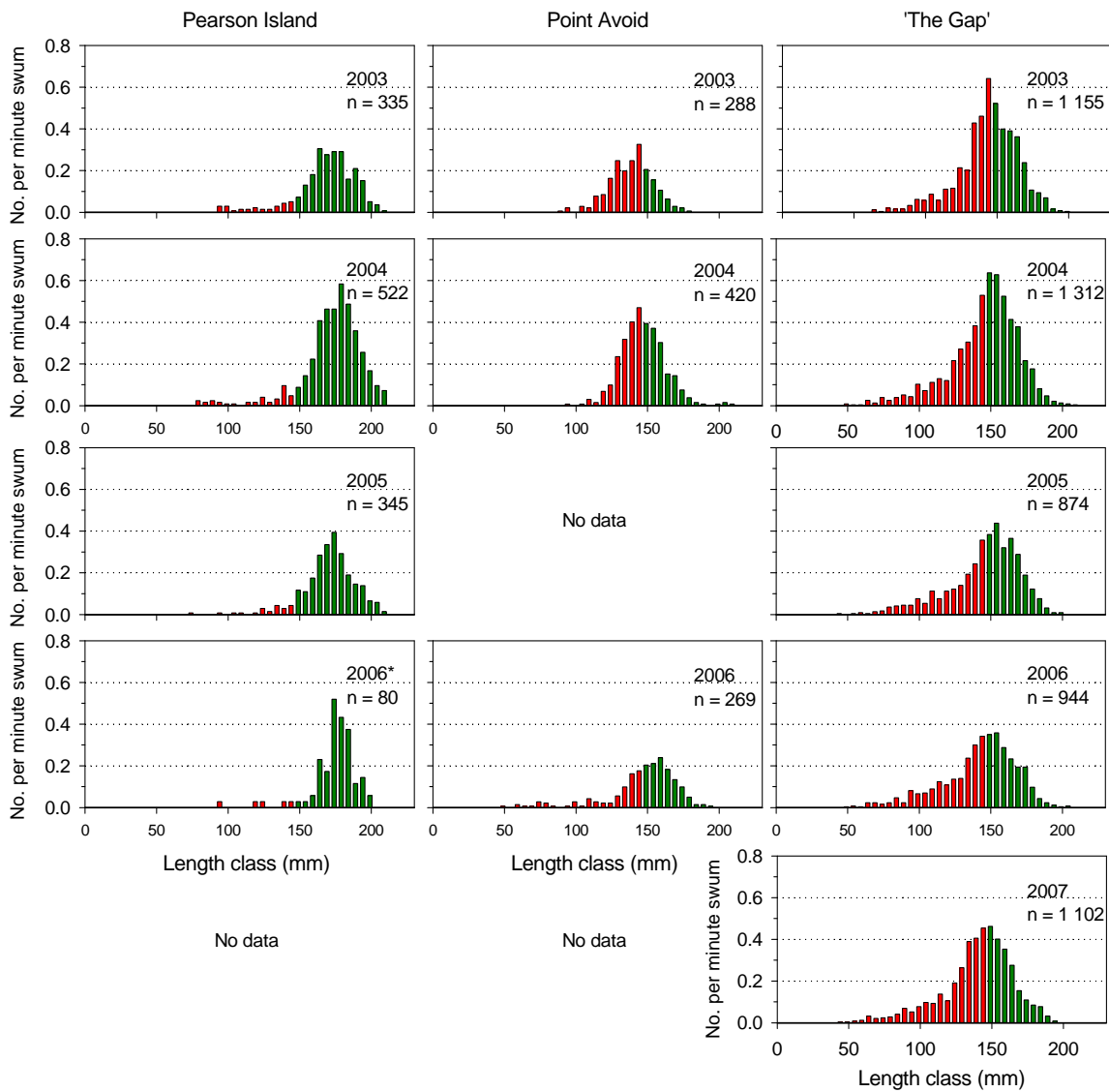


Figure 2.11 Length-frequency distribution of legal-sized (≥ 145 mm SL, green bars) and sub-legal-sized (< 145 mm SL, red bars) greenlip surveyed per-minute-swum at Pearson Island, Point AVOID and 'The Gap' on fishery-independent surveys between 2003 and 2007 (* only 1 of 4 locations surveyed). Length classes are 5 mm SL.

3. BLACKLIP

3.1 Catch

Prior to the implementation of a TACC in 1985, the catch of blacklip from Region A varied between 380.3 t (1969) and 99.8 t (1975). Since the TACC was amended in 1989 (293.25 t), catches have been generally stable, with the exception of 1996 where there was a reduction of 35.25 t to a TACC of 258 t for one year (Figure 3.1). In 2006 and 2007 the catch of blacklip was 293.4 t and 290.6 t¹, respectively. In 2007, the catch was >2.5 t below the TACC.

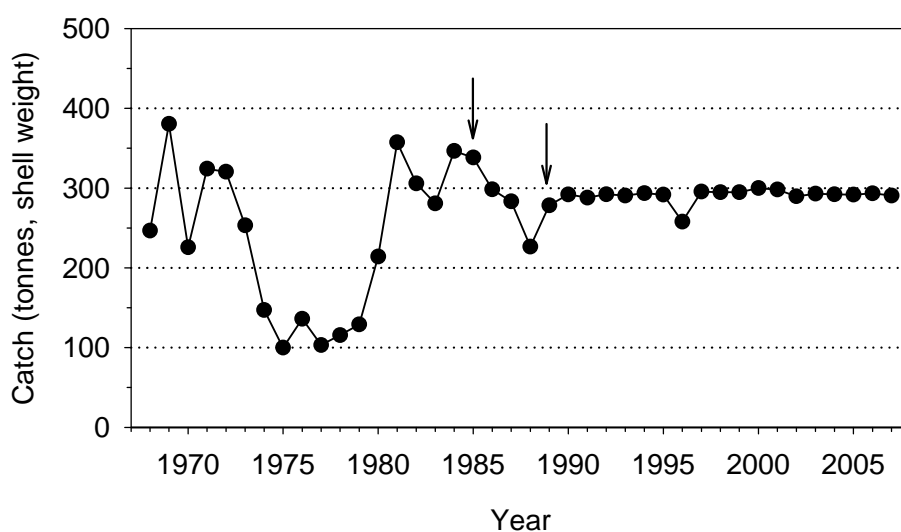


Figure 3.1 Catch (tonnes) of blacklip in Region A from 1968 to 2007. ↓ indicate the implementation (1985) and amendment (1989) of TACCs.

From 2003 to 2006, >5% of the annual blacklip catch has been taken from at least 8 of the 18 fishing areas in Region A (Figure 3.2). In 2007, this number of fishing areas reduced to 7 (FA 4, 5, 8, 9, 11, 12 and 14), with 19% of the TACC harvested from FA 9. Moreover, prior to 2003, >5 fishing areas were utilised to obtain >60% of the annual blacklip catch. From 2003 to 2007, the number of fishing areas utilised to obtain this proportion of the annual catch was 5. The specific fishing areas from which >60% of annual catch has been taken has changed annually, with only FA 9 and FA 5 represented in these top 5 fishing areas each year (Figure 3.2).

Levels of catch have fluctuated inter-annually within the fishing areas comprising Region A (Figure 3.3a and 3.3b). From 2003 to 2007 annual catch of blacklip increased by more than 15 t in FA 4 (from 19 to 34 t) and FA 14 (from 14 to 38 t) and increased by 4 t in FA 18 (from 9 to

¹ During 2007, Primary Industries and Resources South Australia (PIRSA), AIASA and SARDI undertook a research project in Waterloo Bay (within FA 8). During this exercise 17.7 t of blacklip (at an effort of 226.4 hrs) was harvested from within the TACC. These data have been excluded from analyses of changes in patterns of fishery-dependent data from within or among fishing areas, including the calculation of performance indicators described in the Management Plan. However, these data have been included in results of total catch and effort from within Region A.

13 t). Notably, in FA 14 annual catches have increased ~ 10 t.yr⁻¹ since 2005. In 2007 the catch in FA 14 (38 t) represented the highest level in the history of this fishing area and exceeded previously historic levels by >18 t. From 2003 to 2007 catch decreased by at least 8 t (and up to 29 t) in FA 5 (from 35 to 26 t), 6 (from 36 to 7 t), 8 (from 25 to 15 t) and 13 (from 20 to 12 t). Notably, in FA 6 catches have declined in successive years since 2003. In 2007 the catch in FA 6 (7 t) represented the lowest level since 1980 and a 29 t decrease from the contemporary historic high catch of 36 t in 2003. Catch in FA 9 has decreased in successive years from 64 t in 2005 to 56 t in 2007. Since 2003, in other fishing areas where catches have averaged >1 t.yr⁻¹ (FA 3, 10, 11, 12 and 15), catch has remained relatively stable among years, although has fluctuated with peaks up to 1.6 times the 5 year average (FA 10) (Figures 3.3a and 3.3b).

3.2 Catch-per-unit-effort (CPUE)

The mean CPUE on blacklip, in all fishing areas of Region A combined remained stable between 2003 and 2006 (range: 79.1 - 81.0 kg.hr⁻¹, Figure 3.4). However, mean annual CPUE in the Region in 2007 (76.7 kg.hr⁻¹) was substantially lower than in 2006 (81.0 kg.hr⁻¹), and at the lowest level since 2002 (Figure 3.4). Patterns of mean annual CPUE in the 7 fishing areas from which $>5\%$ of the TACC was harvested in 2007 are inconsistent (Figure 3.4). However, in four of these fishing areas (FA 4, 8, 9 and 11) mean annual CPUE has decreased from levels observed in 2005. Further, CPUE has decreased significantly in FA 5 and FA 9 between 2003 and 2007, and in FA 4 between 2006 (92.2 kg.hr⁻¹) and 2007 (78.1 kg.hr⁻¹) (Figure 3.4; Appendix 2). In contrast, CPUE has increased significantly between 2003 and 2007 in FA 4, 12 and 14 (Figure 3.4; Appendix 2). In the remaining 2 fishing areas (FA 8 and 11) there have been no significant changes since 2003 or between 2006 and 2007. However, CPUE in FA 8 in 2006, and FA 11 in 2007 were at the lowest level since 2002 and 2000, respectively.

3.3 Length-frequency distribution of the catch

Estimates of individual lengths of abalone in the commercial catch of blacklip have been obtained from shell samples since 1999 (Figure 3.5). In all years for which data were available, the frequency distribution was generally normal, although slightly right skewed as large (≥ 165 mm SL) blacklip comprised a small proportion of the samples (range: 6.3 - 14.8%). Over the same period the proportion of blacklip smaller than 140 mm SL ranged from 6.9% (1999) to 26.0% (2000).

The modal length class has varied by no more than 10 mm SL among years from 2003 to 2007, ranging between 140 - 144 mm SL and 150 - 154 mm SL. The mean length of the commercial catch has varied by <3 mm SL since 2003, ranging between 149.4 mm SL (2005) and 152.1 mm SL (2007). In all years for which there are data, the mean length has exceeded the MLL (130 mm) by >15 mm SL.

During 2007, there were 13 fishing areas from which more than 100 shells were measured (Figure 3.6). The modal length classes in these fishing areas were commonly >10 mm larger than the MLL (130 mm), with the modal length class in FA 10 (155 - 159 mm SL) exceeding the MLL by more than 20 mm SL. The modal length class in FA 3 and FA 4 was <10 mm above the MLL and was 135 - 139 mm SL in both cases (Figure 3.6). The mean length of the commercial catch exceeded 150 mm SL in 10 (FA 4, 5, 6, 8, 9, 10, 11, 12, 15 and 18) of the 13 fishing areas for which more than 100 shells were measured. Further, in FA 10, the mean size exceeded 155 mm SL (156.9 mm SL). The mean length did not vary substantially among FA 13 and 14 (147.1 mm SL and 147.2 mm SL respectively) and in FA 3 was 142.2 mm SL. The only evidence of 'knife-edge' fishing (individuals having a high probability of capture as they attain the MLL) on blacklip in Region A during 2007 was in FA 3 (Figure 3.6).

Cumulatively, 56% of the blacklip TACC was harvested from FA 4, 9, 11 and 14 during 2007. The mean length of the commercial catch decreased significantly in FA 4 from 2006 to 2007 and decreased 3 mm in FA 14 from 2003 to 2007 (Appendix 2, Figures 3.7 and 3.8). In contrast, the mean length of the commercial catch has increased significantly in FA 9 since 2003 and in FA 11 between 2006 and 2007 (Appendix 2, Figures 3.7 and 3.8). Similarly, in FA 4 the modal length class has decreased 5 mm in each year since 2004, to 134 - 139 mm SL in 2007 (Figure 3.7). In FA 9 the modal length class has increased 10 mm from 2004 (140 - 144 mm SL) to 2007 (150 - 154 mm SL) (Figure 3.7). In FA 11 and 14 the modal length class has fluctuated among years, and in 2007 was 150 - 154 mm SL and 140 - 144 mm SL, respectively (Figure 3.8).

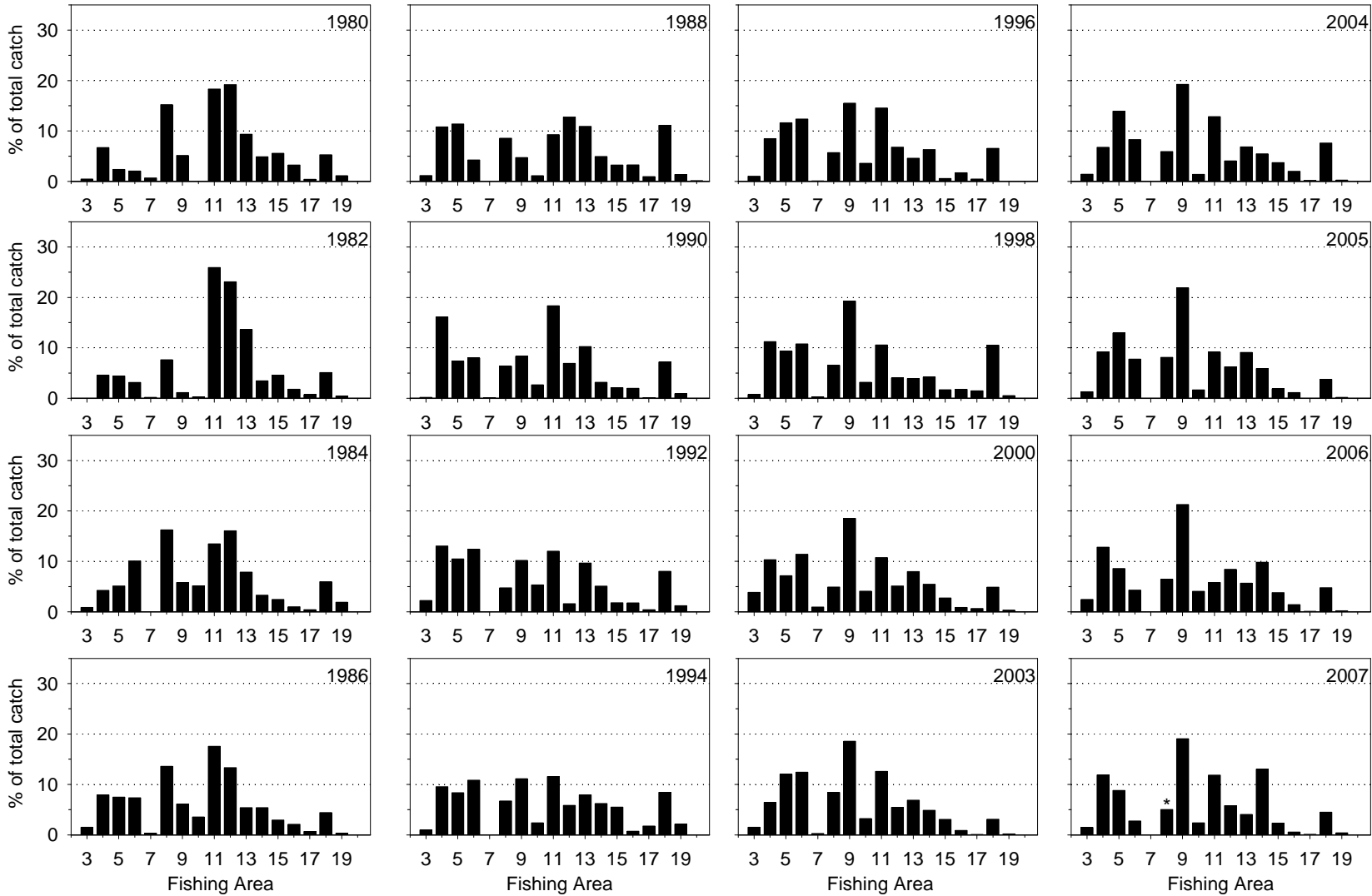


Figure 3.2. Spatial distribution of the blacklip catch (% of total catch) among each of the fishing areas in Region A of the Western Zone in alternate years from 1980 until 2000 and annually 2003 to 2007. *Excludes catch from directed fishing in Waterloo Bay during 2007.

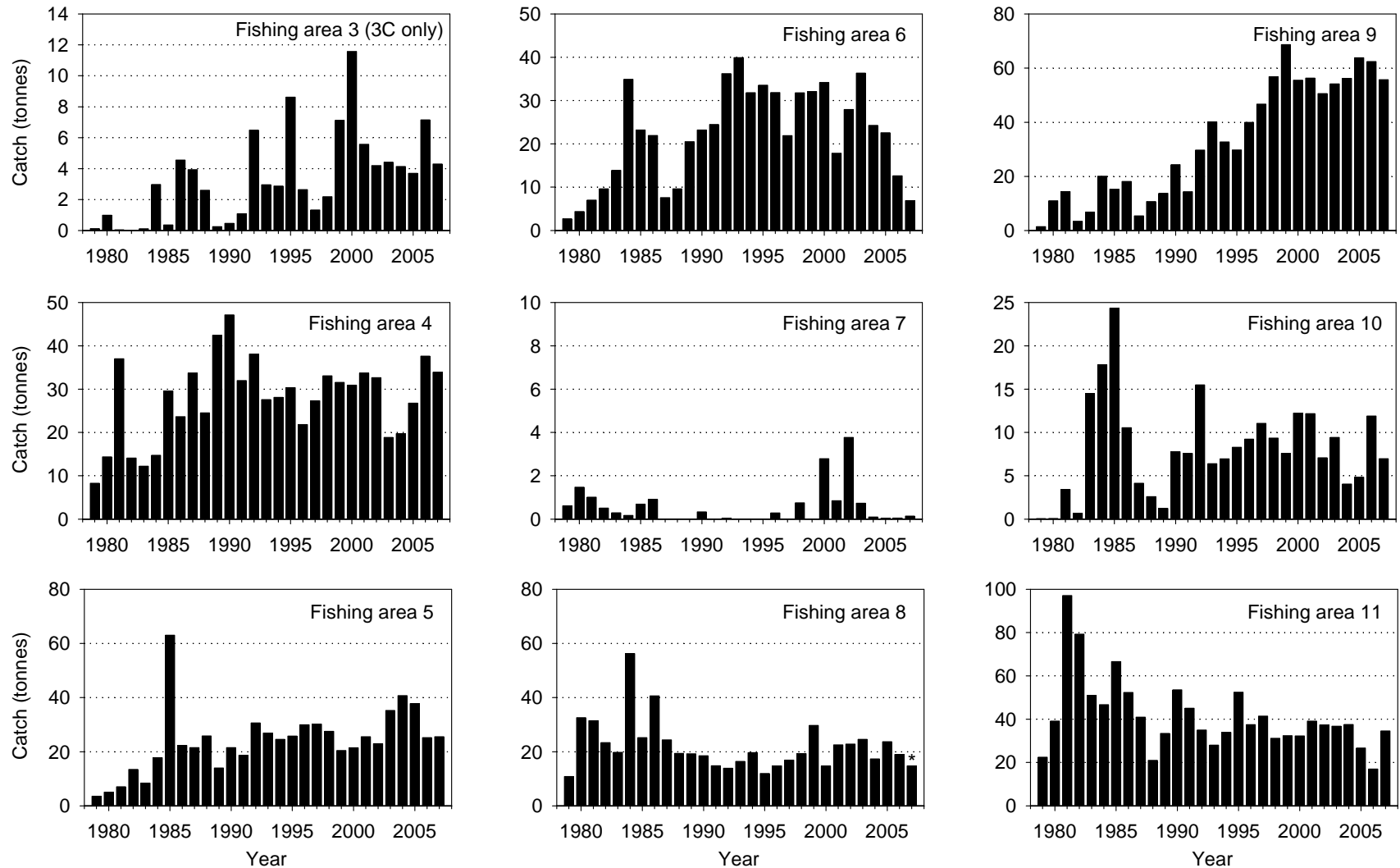


Figure 3.3a. Catch of blacklip (tonnes, shell weight) in each of the fishing areas comprising Region A of the Western Zone from 1979 to 2007. Note: scales on Y-axis vary. *Excludes catch from directed fishing in Waterloo Bay during 2007.

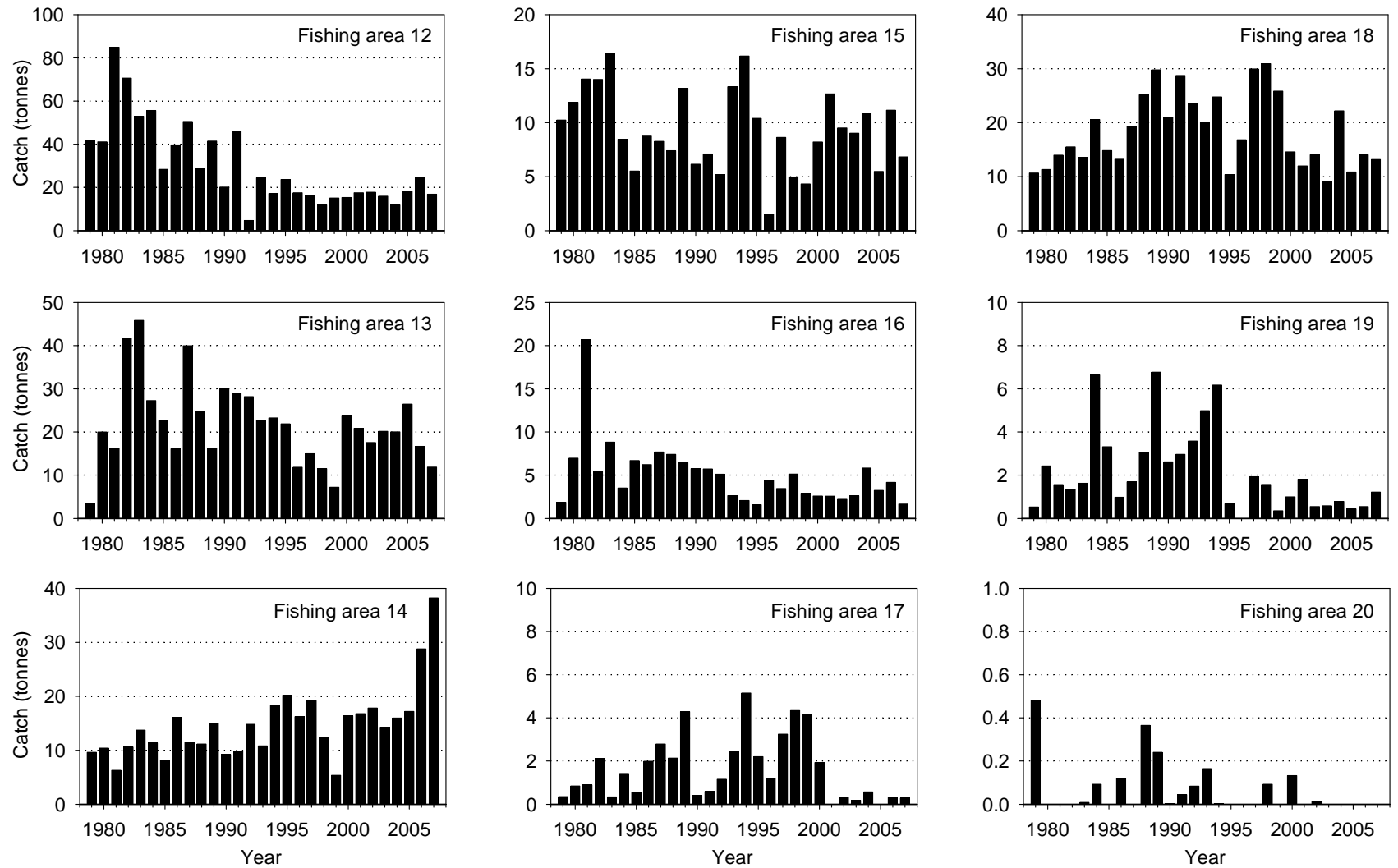


Figure 3.3b. Catch of blacklip (tonnes, shell weight) in each of the fishing areas comprising Region A of the Western Zone from 1979 to 2007. Note: scales on Y-axis vary.

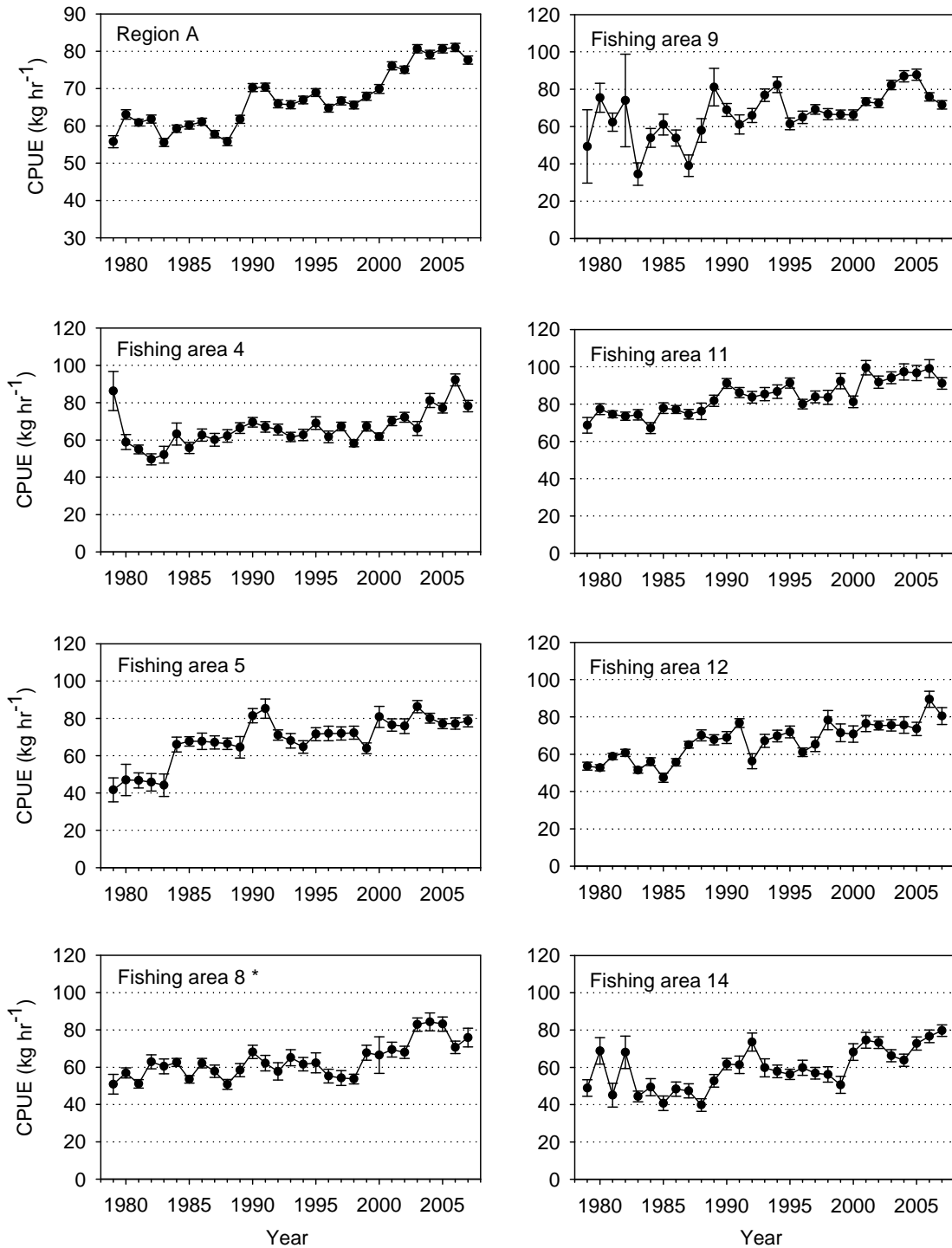


Figure 3.4 Mean catch-per-unit-effort (CPUE (kg.hr⁻¹) (\pm SE) on blacklip for all fishing areas of Region A combined, and for fishing areas 4, 5, 8, 9, 11, 12 and 14 from 1979 to 2007. *Excludes data from directed fishing in Waterloo Bay during 2007. Note: the scale on the Y-axis for Region A is different to those for fishing areas.

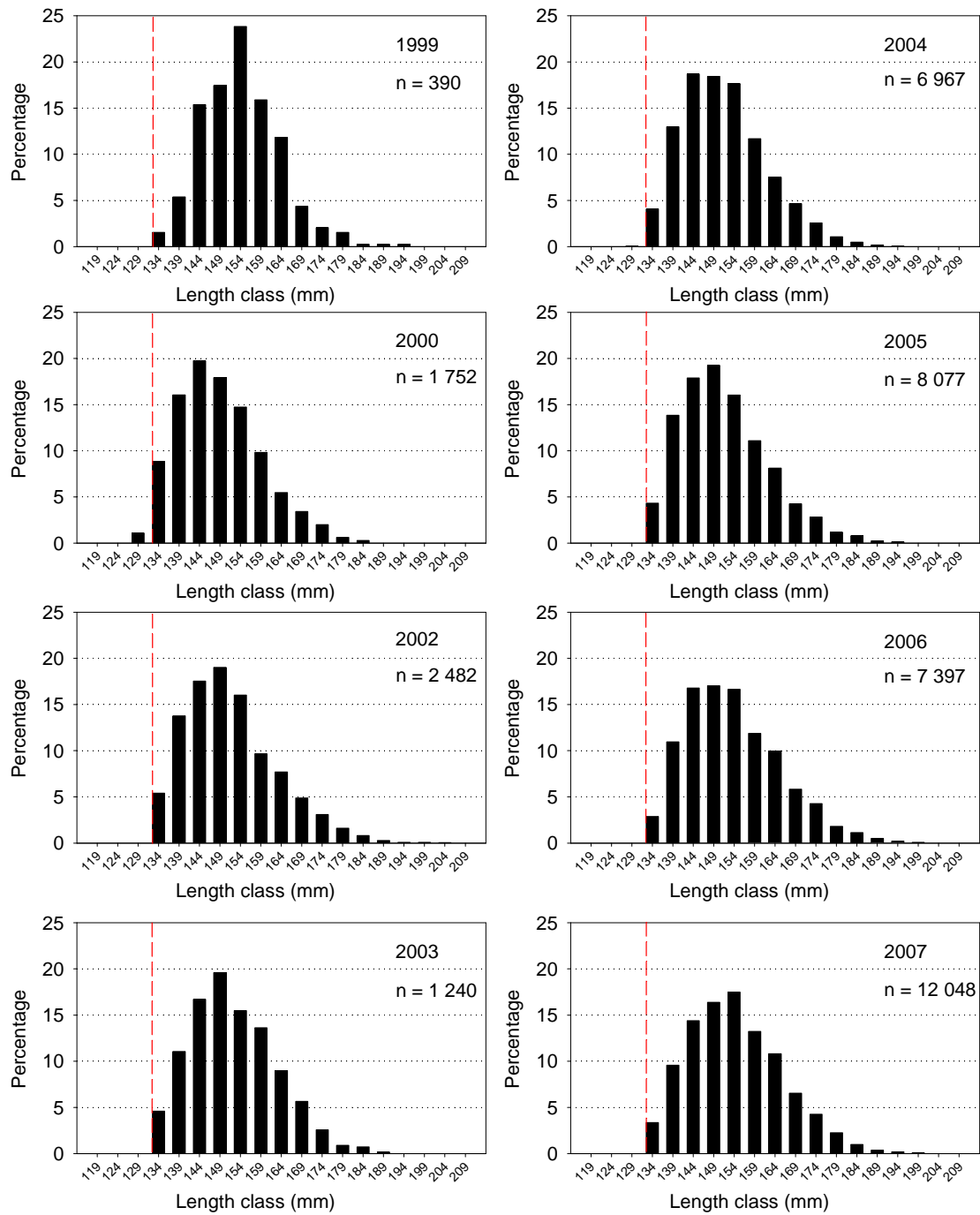


Figure 3.5 Length-frequency distribution obtained from measuring blacklip shells from the commercial fishery from Region A during the years 1999, 2000 and 2002-2007. Vertical red line indicates MLL (130 mm SL).

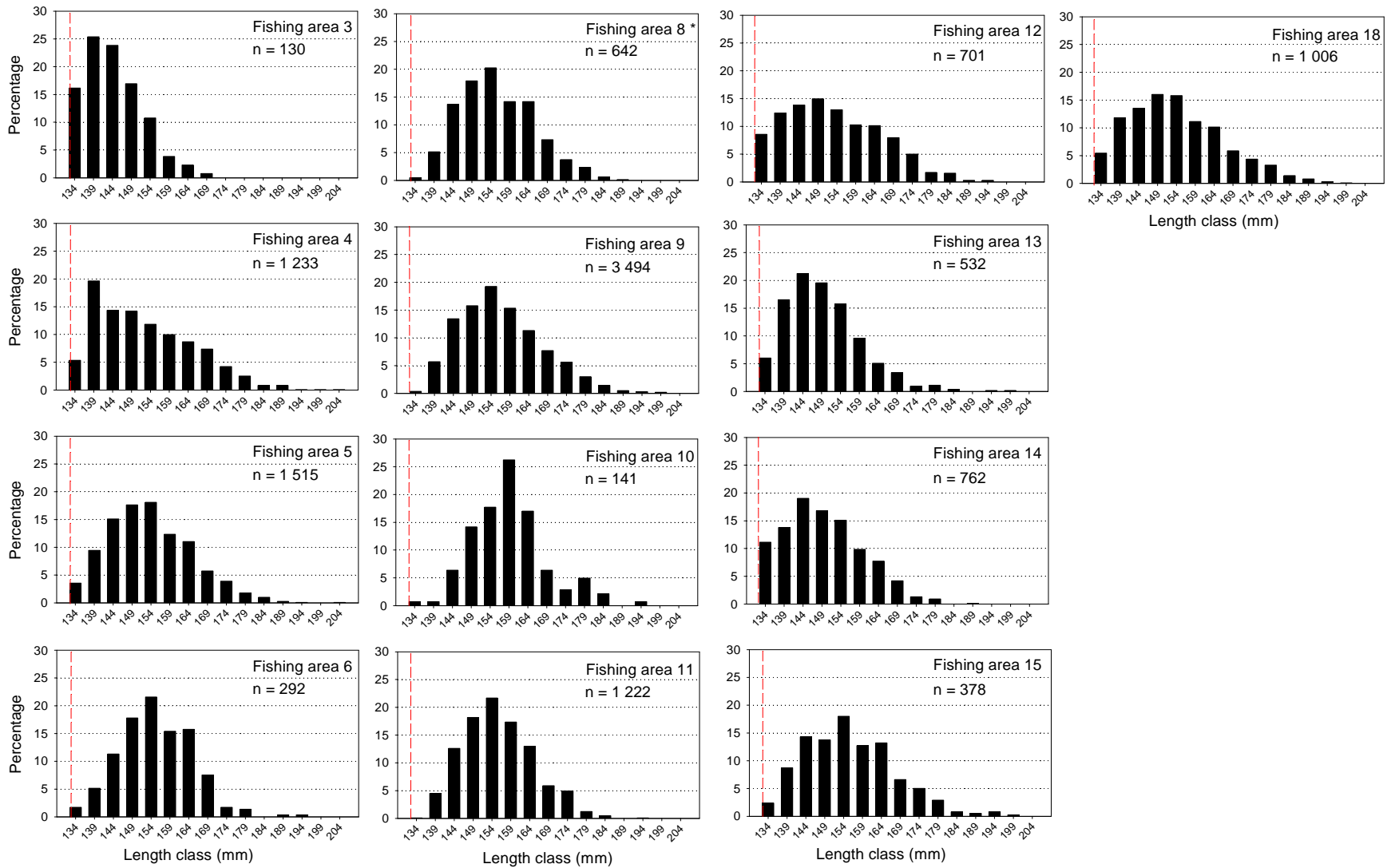


Figure 3.6 Length-frequency distribution obtained from measuring blacklip shells from the commercial fishery in fishing areas 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15 and 18 during 2007 (where $n > 100$). Vertical red line indicates MLL (130 mm SL). *Excludes data from directed fishing in Waterloo Bay during 2007.

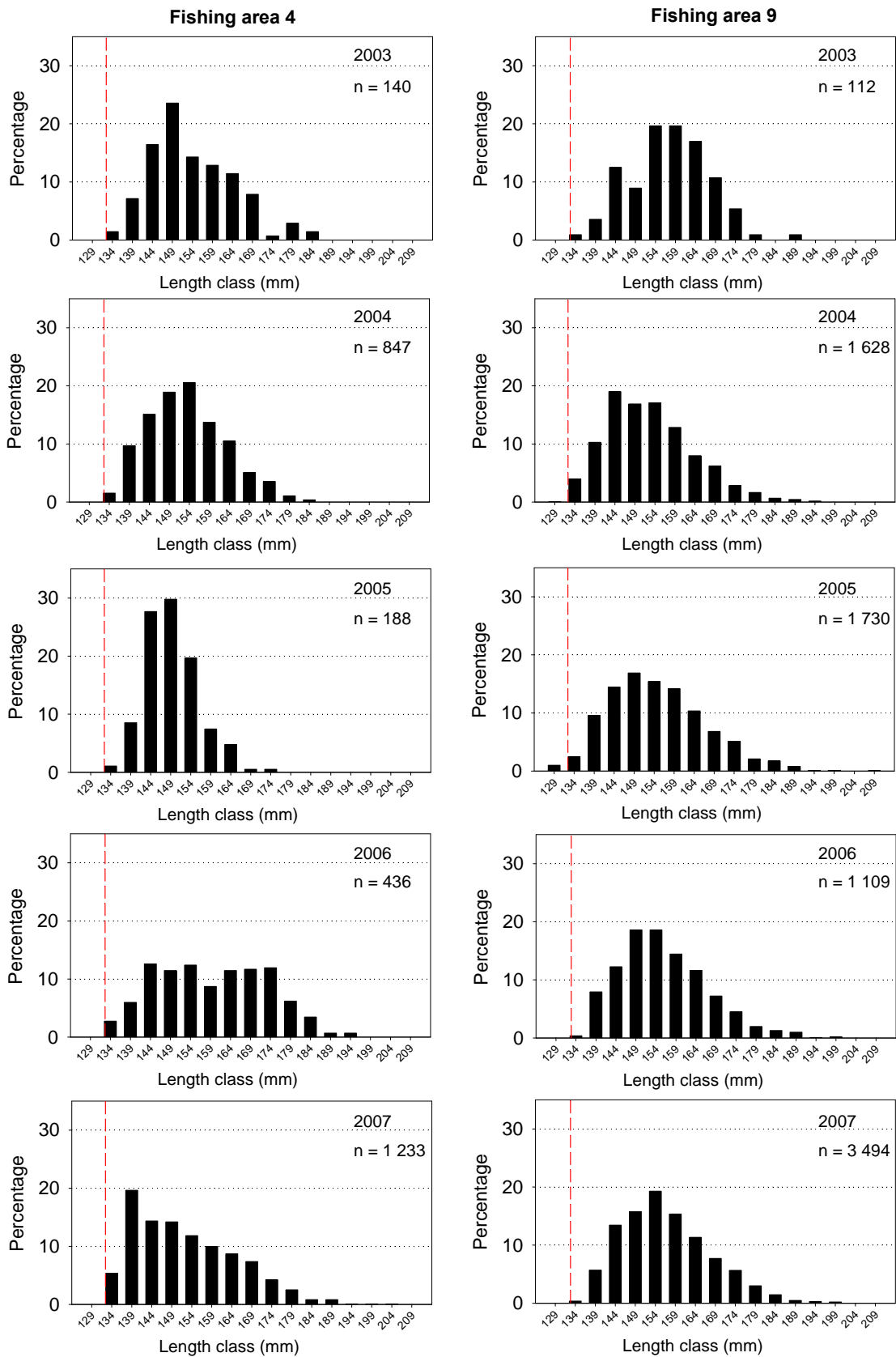


Figure 3.7 Length-frequency distribution obtained from measuring blacklip shells from the commercial fishery in fishing areas 4 and 9 from 2003 to 2007. Vertical red line indicates MLL (130 mm SL).

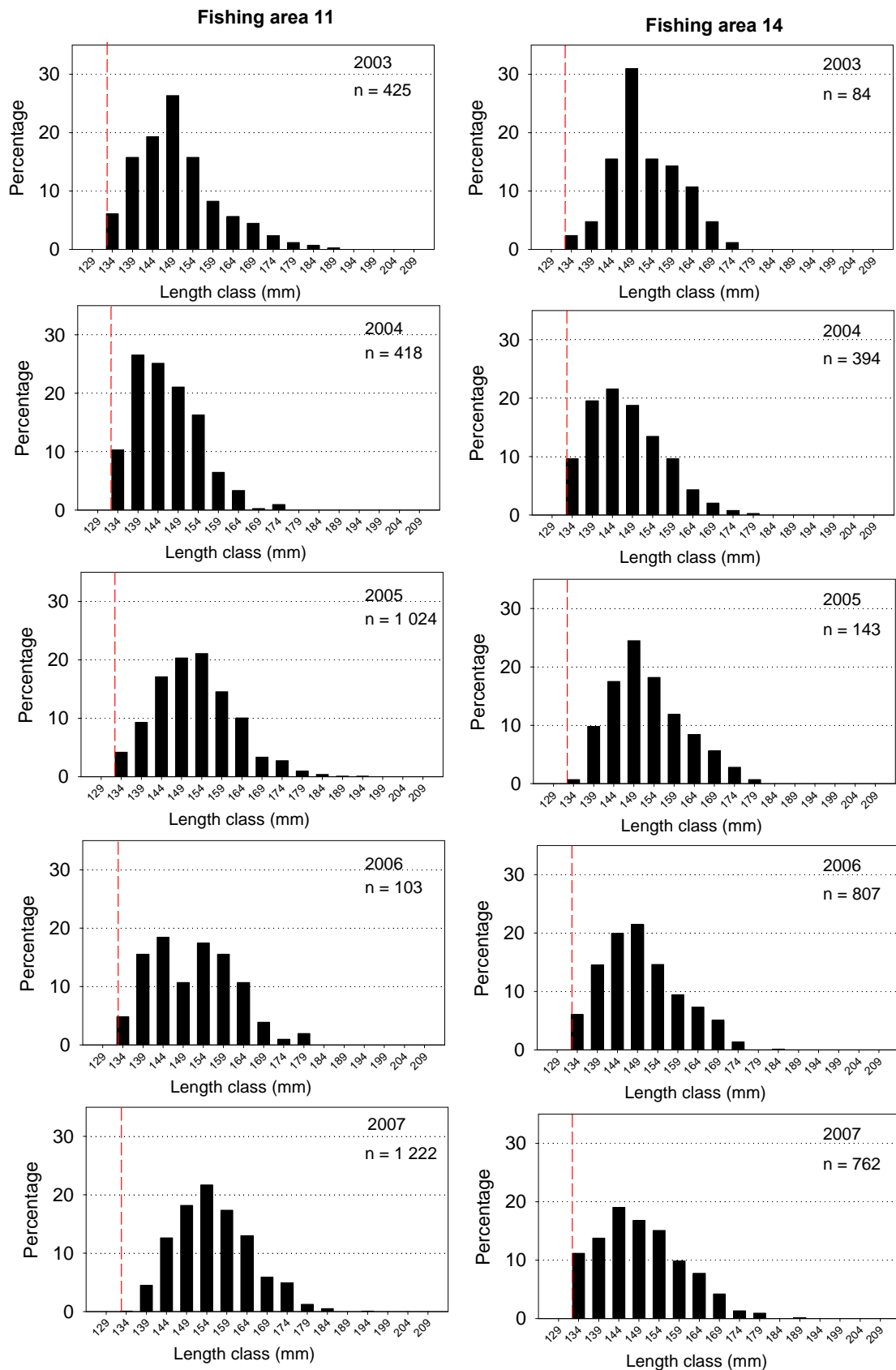


Figure 3.8 Length-frequency distribution obtained from measuring blacklip shells from the commercial fishery in fishing areas 11 and 14 from 2003 to 2007. Vertical red line indicates MLL (130 mm SL).

4. PERFORMANCE INDICATORS

This section provides a report on the performance of the fishery against the performance indicators (PI) for Region A as described in the Management Plan (Nobes *et al.* 2004).

Commercial logbooks from all licence holders for the period ending 31 December 2007 were received and the data entered into the database.

4.1 Greenlip

There are 112 biological PI specified for greenlip in Region A. Of these, 102 are addressed in this report. The remaining ten PI (diver assessment of stock status (in FA 4, 5, 8, 9, 14, 18 and 19); harvest discard; illegal catch; and recreational catch) are addressed in other reports submitted to PIRSA Fisheries.

Data are available to assess fishery performance against 75 of the 102 (74%) PI to be addressed in this report. Sixteen of these 75 PI (21%) have triggered (Table 4.1; Appendix 1). Of these, 10 (63%) may be considered positive for the fishery.

The reported catch in 2007 was 74.2 t (meat weight). This exceeds 90% of the TACC (75.9 t) and therefore did not trigger the PI (Table 4.1). There was no change to the order or composition of the five most important greenlip fishing areas (by catch) between 2006 and 2007.

Fishing effort on greenlip abalone did not change significantly between 2003 (2 371 hr) and 2007 (2 413 hr).

Mean daily catch decreased significantly in FA 9 between 2006 and 2007. Contrastingly, mean daily catch increased significantly in FA 5 and 9 over the last five years (2003 – 2007). In FA 9 and 18 mean daily effort decreased significantly between 2006 and 2007. Mean daily effort increased significantly in FA 4, 5 and 9 over the last five years (2003 – 2007).

CPUE increased significantly in FA 8 between 2006 and 2007. CPUE decreased significantly in FA 9 between 2003 and 2007.

The mean size of greenlip in the commercial catch increased significantly in FA 5, 8, 9 and 18 between 2006 and 2007. In FA 9 mean size of greenlip increased significantly over the last five years (2003 – 2007).

Estimates of egg production in FA 9 and 18 were 27.2% and 78.1% of ‘unfished’ levels respectively. The trigger point was exceeded for FA 9 as the level was less than 50%.

4.2 Blacklip

There are 106 biological PI specified for blacklip in Region A. Of these, 96 are addressed in this report. The remaining ten PI (diver assessment of stock status (in FA 4, 5, 8, 9, 11, 12, and 14); harvest discard; illegal catch; and recreational catch) are addressed in other reports submitted to PIRSA Fisheries.

Data are available to assess fishery performance against 58 of the 96 (60%) PI to be addressed in this report. Twenty two of these 58 PI (38%) have triggered (Table 4.2; Appendix 2). Of these, ten (45%) may be considered positive for the fishery. The reported catch in 2007 was 96.6 t (meat weight). This exceeds 90% of the TACC (97.75 t) and therefore did not trigger the PI (Table 4.2).

The proportion of the TACC harvested from FA 12 declined from 8.4% (2006) to 5.8% (2007) while FA 11 increased from 5.8% to 11.8%. FA 14 increased (9.8% to 13.0%) whilst FA 4 declined (12.8% to 11.9%) between 2006 and 2007. These changes resulted in a change in order of the five most important blacklip fishing areas, determined by their contribution to total catch.

Fishing effort on blacklip has not changed significantly from 3 229 hr (2003) to 3 266 hr (2007) over the last five years. Mean daily catch increased significantly in FA 4 and 12 over the last five years (2003 – 2007) and decreased significantly in FA 4 between 2006 and 2007. In FA 4, 5, 8, 9 and 12 mean daily effort increased significantly between 2003 and 2007.

CPUE decreased significantly in FA 4 between 2006 and 2007. CPUE decreased significantly in FA 5 and 9 between 2003 and 2007, yet increased in FA 4, 12 and 14 over the same time.

The mean size of blacklip in the commercial catch increased significantly in FA 8, 11 and 12 between 2006 and 2007 and in FA 5 and 9 between 2003 and 2007. However, it declined significantly in FA 4 and 5 between 2006 and 2007.

Estimates of egg production in FA 9 and 11 were 62.9% and 82.8% of 'unfished' levels respectively. The trigger point was not exceeded as the levels are more than 50% of the pristine level.

Table 4.1 Assessment of the performance of the greenlip abalone fishery in Region A and fishing areas 4, 5, 8, 9, 14, 18 and 19 against the performance indicators prescribed in the management plan (inter-annual: 2006 – 2007; 5-year trend: 2003 – 2007). WI, FI, HS, PI, PA, TG refer to Ward Island, Flinders Island, Hotspot, Pearson Island, Point Avoid and 'The Gap', respectively.

Performance indicator	Temporal scale	Region A	4	5	8	9	14	18	19
Commercial catch	Annual		Blue	Blue	Blue	Blue	Blue	Blue	Blue
Spatial distribution of catch	Inter-annual		Blue	Blue	Blue	Blue	Blue	Blue	Blue
Commercial effort	5-year trend		Blue	Blue	Blue	Blue	Blue	Blue	Blue
Mean daily catch	Inter-annual	Blue				Red			
	5-year trend	Blue		Green		Green			
Mean daily effort	Inter-annual	Blue				Red		Red	
	5-year trend	Blue	Green	Green		Green			
CPUE	Inter-annual	Blue			Green				
	5-year trend	Blue				Red			
Mean size	Inter-annual	Blue		Green	Green	Green		Green	
	5-year trend	Blue	Black		Black	Green	Black		Black
Egg production/pristine	Annual	Blue	Black	Black	Black	Purple	Black		Black

Performance indicator	Temporal scale	WI	FI	HS	PI	PA	TG
Abundance of abalone larger than L ₅₀	Inter-annual	Black			Black	Black	
	5-year trend	Black			Black	Black	
Legal-sized abalone abundance	Inter-annual	Black			Black	Black	
	5-year trend	Black			Black	Black	
Sub-legal-sized abalone abundance	Inter-annual	Black			Black	Black	
	5-year trend	Black			Black	Black	



Table 4.2 Assessment of the performance of the blacklip abalone fishery in Region A of the Western Zone and fishing areas 4, 5, 8, 9, 11, 12 and 14 against the performance indicators prescribed in the Management Plan (inter-annual: 2006 – 2007; 5-year trend: 2003 – 2007). RH, TA, SH, WI and PL refer to Reef Head, Talia, Sheringa, Ward Island and Point Labatt, respectively.

Performance indicator	Temporal scale	Region A	4	5	8	9	11	12	14
Commercial catch	Annual		PI not applicable	PI not applicable	PI not applicable	PI not applicable	PI not applicable	PI not applicable	PI not applicable
Spatial distribution of catch	Inter-annual	Trigger Point exceeded	PI not applicable	PI not applicable	PI not applicable	PI not applicable	PI not applicable	PI not applicable	PI not applicable
Commercial effort	5-year trend		PI not applicable	PI not applicable	PI not applicable	PI not applicable	PI not applicable	PI not applicable	PI not applicable
Mean daily catch	Inter-annual	PI not applicable	Significant decrease						
	5-year trend	PI not applicable	Significant increase					Significant increase	
Mean daily effort	Inter-annual	PI not applicable							
	5-year trend	PI not applicable	Significant increase	Significant increase	Significant increase	Significant increase		Significant increase	
CPUE	Inter-annual	PI not applicable	Significant decrease						
	5-year trend	PI not applicable	Significant increase	Significant decrease		Significant decrease		Significant increase	Significant increase
Mean size	Inter-annual	PI not applicable	Significant decrease	Significant decrease	Significant increase		Significant increase	Significant increase	
	5-year trend	PI not applicable		Significant increase	No data	Significant increase	No data	No data	
Egg production/pristine	Annual	PI not applicable	No data	No data	No data			No data	No data

Performance indicator	Temporal scale	RH	TA	SH	WI	PL
Abundance of abalone larger than L ₅₀	Inter-annual	No data	No data	No data	No data	No data
	5-year trend	No data	No data	No data	No data	No data
Legal-sized abalone abundance	Inter-annual	No data	No data	No data	No data	No data
	5-year trend	No data	No data	No data	No data	No data
Sub-legal-sized abalone abundance	Inter-annual	No data	No data	No data	No data	No data
	5-year trend	No data	No data	No data	No data	No data



5. DISCUSSION

Unambiguous assessment of the current status of greenlip stocks was impeded by inconsistent inferences in the datasets available. Some data, consistent with other recent assessments (Chick *et al.* 2006), continue to support the conclusion that the stocks are being fished within sustainable limits. These data include: 1) annual catches that generally reflect the TACC (noting the ~4 t deficit in 2007); 2) relatively stable catches in FA 9 and 18 since 1997; 3) increasing catch in FA 14 since 2003; 4) consistently large modal length classes and mean lengths of greenlip in the commercial catch from key fishing areas; 5) a general increase in greenlip abundance at Ward Island and Hotspot since 2003 and; 6) the triggering of 10 PI in a direction that was positive for the fishery.

However, other data provide an indication that stock status has generally weakened since the TACC was increased (i.e. since 1 January 2006). These data include: 1) changes in the spatial distribution of catch; 2) declining catches from FA 6, 8 and 19 since at least 2003; 3) declining CPUE in the region and in FA 4, 5, 9, 14, 18 and 19 in recent years; 4) a decrease in the modal length class and mean length of greenlip harvested from FA 18 since 2003; 5) a decrease in greenlip abundance at Pearson Island, Point Avoid and 'The Gap' since 2003 and; 6) the triggering of 6 PI in a direction that was negative for the fishery. Consequently, catch, effort, CPUE, length structures from the commercial catch and fishery-independent abundance should be closely monitored, and a greater level of spatial management considered (Mayfield and Saunders 2008), in forthcoming years.

Assessment of the current status of blacklip stocks was complicated by (1) a paucity of available data and (2) inconsistent inferences from those data. Similarly to other recent assessments (Chick *et al.* 2006), some data continue to support the conclusion that the stocks are being fished within sustainable limits. These data include: 1) stable annual catches reflecting TACCs; 2) increasing catch in FA 4, 14 and 18 since 2003; 3) stable and historically high levels of CPUE in the Region between 2003 and 2006; 4) significant increases in CPUE in FA 4, 12 and 14 since 2003; 5) consistently large modal length classes and mean lengths of blacklip in the commercial catch from key fishing areas and; 6) the triggering of 10 PI in a direction that was positive for the fishery.

However, other data suggest that stock status stocks has generally weakened over the last two to three years. These data include: 1) a contraction in the spatial distribution of catch; 2) catches in FA 5, 6, 8 and 13 decreasing by at least 8 t (and up to 29 t) since 2003, and catch in FA 9 decreasing by 8 t since 2005; 3) a decrease in CPUE in the whole region and FA 4, 9, 11 and 12 between 2006 and 2007; 4) a significant decrease in CPUE in FA 5 and FA 9 between 2003 and 2007; 5) a reduction in the mean length of the commercial catch from FA 14 between 2003 and 2007 and; 6) the triggering of 12 PI in a direction that was negative for the fishery. Consequently, fishery-dependent data along with estimates of fishery-independent abundance from recently-established survey sites should be closely monitored in forthcoming years. As with greenlip, approaches for greater spatial management of the fishery may warrant consideration (Mayfield and Saunders 2008).

6. REFERENCES

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Appendix 1: Assessment of the greenlip fishery in Region A of the Western Zone of the South Australian Abalone Fishery against the biological performance indicators in the management plan. Values are mean \pm SE. Red indicates statistical significance.

Performance Indicator	Units	Spatial Scale	2003	2004	2005	2006	2007	Inter-annual change	5-year trend
Commercial effort	hr	Region A	2371	2254	2138	2445	2413	-	$r^2 = 0.40$, $df = 3$ $p > 0.05$
Mean daily catch	kg.day ⁻¹	Area 4	231.8 \pm 23.7	235.0 \pm 18.4	198.1 \pm 15.1	294.0 \pm 23.4	266.0 \pm 17.1	$t = 0.97$, $df = 73$ $p > 0.05$	$F_{1,188} = 3.88$ $p > 0.05$
		Area 5	215.4 \pm 26.9	204.9 \pm 14.2	284.8 \pm 23.0	280.7 \pm 22.5	270.0 \pm 15.8	$t = 0.39$, $df = 67$ $p > 0.05$	$F_{1,183} = 7.16$ $p < 0.05$
		Area 8	404.3 \pm 35.1	475.8 \pm 33.7	387.2 \pm 28.5	454.3 \pm 31.7	509.6 \pm 49.4	$t = 0.99$, $df = 89$ $p > 0.05$	$F_{1,244} = 2.17$ $p > 0.05$
		Area 9	334.2 \pm 12.8	382.3 \pm 14.3	466.7 \pm 15.2	430.5 \pm 14.6	385.0 \pm 11.6	$t = 2.47$, $df = 259$ $p < 0.05$	$F_{1,648} = 12.92$ $p < 0.01$
		Area 14	430.1 \pm 53.7	556.2 \pm 44.1	483.1 \pm 45.2	489.7 \pm 31.0	503.7 \pm 29.5	$t = 0.32$, $df = 106$ $p > 0.05$	$F_{1,177} = 0.03$ $p > 0.05$
		Area 18	362.0 \pm 14.1	414.4 \pm 12.7	432.7 \pm 13.3	403.3 \pm 14.9	376.7 \pm 13.3	$t = 1.33$, $df = 221$ $p > 0.05$	$F_{1,580} = 0.31$ $p > 0.05$
		Area 19	345.0 \pm 28.4	401.4 \pm 28.2	450.0 \pm 41.0	333.6 \pm 44.0	373.3 \pm 27.8	$t = 0.80$, $df = 50$ $p > 0.05$	$F_{1,147} = 0.13$ $p > 0.05$
Mean daily effort	hr.day ⁻¹	Area 4	3.1 \pm 0.3	3.7 \pm 0.2	3.4 \pm 0.2	4.3 \pm 0.3	4.4 \pm 0.2	$t = 0.23$, $df = 73$ $p > 0.05$	$F_{1,188} = 18.50$ $p < 0.01$
		Area 5	3.3 \pm 0.3	3.2 \pm 0.2	4.1 \pm 0.3	4.4 \pm 0.2	4.3 \pm 0.2	$t = 0.44$, $df = 67$ $p > 0.05$	$F_{1,183} = 16.21$ $p < 0.01$
		Area 8	4.4 \pm 0.2	5.0 \pm 0.3	4.9 \pm 0.2	5.2 \pm 0.2	4.9 \pm 0.3	$t = 0.66$, $df = 89$ $p > 0.05$	$F_{1,244} = 2.98$ $p > 0.05$
		Area 9	4.2 \pm 0.1	5.1 \pm 0.1	5.7 \pm 0.1	5.8 \pm 0.1	5.3 \pm 0.1	$t = 2.92$, $df = 259$ $p < 0.01$	$F_{1,648} = 58.81$ $p < 0.01$
		Area 14	5.4 \pm 0.3	5.6 \pm 0.3	5.3 \pm 0.2	5.3 \pm 0.2	5.5 \pm 0.2	$t = 0.48$, $df = 106$ $p > 0.05$	$F_{1,177} = 0.04$ $p > 0.05$
		Area 18	4.7 \pm 0.2	5.6 \pm 0.1	5.4 \pm 0.1	5.5 \pm 0.2	5.0 \pm 0.2	$t = 2.27$, $df = 221$ $p < 0.05$	$F_{1,580} = 1.70$ $p > 0.05$
		Area 19	4.3 \pm 0.3	5.0 \pm 0.3	5.3 \pm 0.4	4.5 \pm 0.4	4.9 \pm 0.3	$t = 0.83$, $df = 50$ $p > 0.05$	$F_{1,147} = 0.92$ $p > 0.05$

Appendix 1. (continued)

Performance Indicator	Units	Spatial Scale	2003	2004	2005	2006	2007	Inter-annual change	5-year trend
CPUE	kg.hr ⁻¹	Area 4	74.0±4.7	63.6±3.0	59.1±3.4	67.9±4.4	60.3±2.4	$t^1 = 1.54, df = 55.6$ $p > 0.05$	$F^2_{1,188} = 2.39$ $p > 0.05$
		Area 5	65.7±4.1	64.9±3.7	70.1±3.7	64.0±3.4	63.5±2.9	$t^1 = 0.12, df = 65.0$ $p > 0.05$	$F^2_{1,183} = 0.11$ $p > 0.05$
		Area 8	90.9±5.8	96.1±5.0	79.0±4.6	87.7±4.1	103.0±6.5	$t^1 = 2.01, df = 62.5$ $p < 0.05$	$F^2_{1,244} = 0.65$ $p > 0.05$
		Area 9	80.7±2.2	75.8±2.2	82.0±2.6	74.3±2.1	72.8±1.9	$t^1 = 0.54, df = 252.0$ $p > 0.05$	$F^2_{1,648} = 7.65$ $p < 0.05$
		Area 14	79.0±7.9	99.6± 6.4	91.0±7.7	92.1±5.0	92.5±5.5	$t^1 = 0.06, df = 104.0$ $p > 0.05$	$F^2_{1,177} = 0.76$ $p > 0.01$
		Area 18	76.4±1.6	74.7±1.8	80.2±1.9	73.2±2.2	74.9±1.8	$t^1 = 0.60, df = 200.0$ $p > 0.05$	$F^2_{1,580} = 0.30$ $p > 0.05$
		Area 19	80.0±3.5	80.3±5.4	84.5±4.7	74.6±7.0	77.0±4.1	$t^1 = 0.30, df = 31.9$ $p > 0.05$	$F^2_{1,147} = 0.01$ $p > 0.05$
Mean size	mm, SL	Area 4	No data	165.2±0.6	164.5±1.5	161.8±1.6	166.7±1.3	$t = 2.25, df = 135$ $p > 0.01$	-
		Area 5	164.1±0.6	167.7±0.6	163.5±0.9	163.8±0.6	168.7±0.6	$t = 5.44, df = 405$ $p < 0.01$	$F_{1,938} = 0.07$ $p > 0.01$
		Area 8	No data	170.7±1.0	160.0±0.6	158.8±0.4	164.7±0.4	$t = 11.32, df = 1518$ $p < 0.01$	-
		Area 9	165.4±0.4	168.6±0.3	169.1±0.3	165.3±0.2	169.4±0.2	$t = 12.80, df = 5070$ $p < 0.01$	$F_{1,9780} = 8.28$ $p < 0.01$
		Area 14	No data	163.4±0.4	167.4±1.6	160.8±0.3	161.8±0.9	$t = 1.17, df = 1250$ $p > 0.01$	-
		Area 18	173.0±0.5	172.6±0.3	167.2±0.3	170.5±0.3	171.7±0.3	$t = 2.90, df = 4883$ $p < 0.01$	$F_{1,7952} = 6.58$ $p > 0.01$
		Area 19	No data	167.0±0.5	167.4±0.5	170.2±0.6	171.4±0.6	$t = 1.30, df = 483$ $p > 0.01$	-

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

2. Based on daily CPUE.

Appendix 1. (continued)

Performance Indicator	Units	Spatial Scale	2003	2004	2005	2006	2007	Inter-annual change	5-year trend
Egg production retained	%	Area 4	No data	No data	No data	No data	No data	NA	NA
		Area 5	No data	No data	No data	No data	No data	NA	NA
		Area 8	No data	No data	No data	No data	No data	NA	NA
		Area 9	40.2	42.0	27.6	24.5	27.2	NA	NA
		Area 14	No data	No data	No data	No data	No data	NA	NA
		Area 18	69.5	70.6	46.5	51.2	78.1	NA	NA
		Area 19	No data	No data	No data	No data	No data	NA	NA

Performance Indicator	Units	Survey site	2003	2004	2005	2006	2007	Inter-annual change	5-year trend
Abundance of abalone >L ₅₀	no.m ⁻²	Ward Island	0.170±0.018	0.176±0.026	0.241±0.026	0.297±0.035	No data	-	-
		Flinders Island	0.265±0.065	0.272±0.046	0.210±0.020	0.202±0.027	0.242±0.035	$t = 0.90, df = 46$ $p > 0.05$	$F_{1,118} = 0.89$ $p > 0.05$
		Hotspot	0.458±0.021	0.391±0.047	0.342±0.031	0.414±0.037	0.466±0.035	$t = 1.03, df = 94$ $p > 0.01$	$F_{1,238} = 0.01$ $p > 0.05$
		Pearson Island	0.122±0.018	0.205±0.026	0.124±0.013	0.118±0.037	No data	-	-
		Point Avoid	0.126±0.043	0.188±0.049	No data	0.101±0.027	No data	-	-
		The Gap	0.244±0.025	0.290±0.035	0.200±0.025	0.190±0.025	0.256±0.044	$t = 1.31, df = 62$ $p > 0.05$	$F_{1,154} = 0.95$ $p > 0.05$

NA indicates not applicable.

Appendix 1. (continued)

Performance Indicator	Units	Survey site	2003	2004	2005	2006	2007	Inter-annual change	5-year trend
Legal-sized abalone abundance	no.m ⁻²	Ward Island	0.115±0.014	0.110±0.018	0.171±0.017	0.193±0.017	No data	-	-
		Flinders Island	0.114±0.023	0.127±0.019	0.106±0.014	0.111±0.014	0.125±0.021	$t = 0.52, df = 46$ $p > 0.05$	$F_{1,118} = 0.02$ $p > 0.05$
		Hotspot	0.236±0.014	0.197±0.023	0.186±0.018	0.200±0.019	0.198±0.020	$t = 0.13, df = 94$ $p > 0.05$	$F_{1,238} = 1.23$ $p > 0.05$
		Pearson Island	0.111±0.019	0.190±0.026	0.114±0.012	0.112±0.035	No data	-	-
		Point Avoid	0.038±0.018	0.084±0.020	No data	0.064±0.020	No data	-	-
		The Gap	0.115±0.010	0.168±0.018	0.119±0.014	0.094±0.010	0.108±0.016	$t = 0.85, df = 62$ $p > 0.05$	$F_{1,154} = 3.07$ $p > 0.05$
Sub-legal-sized abalone abundance	no.m ⁻²	Ward Island	0.074±0.013	0.077±0.014	0.089±0.014	0.132±0.023	No data	-	-
		Flinders Island	0.166±0.045	0.160±0.035	0.114±0.012	0.099±0.019	0.126±0.020	$t = 1.07, df = 46$ $p > 0.05$	$F_{1,118} = 2.69$ $p > 0.05$
		Hotspot	0.259±0.013	0.224±0.034	0.185±0.017	0.258±0.031	0.307±0.029	$t = 1.21, df = 94$ $p > 0.05$	$F_{1,238} = 1.84$ $p > 0.05$
		Pearson Island	0.014±0.005	0.019±0.004	0.011±0.003	0.007±0.002	No data	-	-
		Point Avoid	0.090±0.030	0.106±0.034	No data	0.042±0.009	No data	-	-
		The Gap	0.145±0.021	0.146±0.023	0.099±0.015	0.111±0.021	0.167±0.036	$t = 1.37, df = 62$ $p > 0.05$	$F_{1,154} = 0.00$ $p > 0.05$

Appendix 2: Assessment of the blacklip fishery in Region A of the Western Zone of the South Australian Abalone Fishery against the biological performance indicators in the management plan. Values are mean \pm SE. Red indicates statistical significance.

Performance Indicator	Units	Spatial Scale	2003	2004	2005	2006	2007	Inter-annual change	5-year trend
Commercial effort	hr	Region A	3229	3215	3189	3050	3266	-	$r^2 = 0.03$, $df = 3$ $p > 0.05$
Mean daily catch	kg.day ⁻¹	Area 4	241.2 \pm 16.6	331.9 \pm 22.2	346.7 \pm 22.1	477.9 \pm 23.0	409.0 \pm 19.1	$t = 2.30$, $df = 145$ $p < 0.05$	$F_{1,341} = 53.47$ $p < 0.01$
		Area 5	334.3 \pm 20.3	338.4 \pm 17.8	372.9 \pm 17.5	356.2 \pm 20.6	376.8 \pm 22.1	$t = 0.69$, $df = 115$ $p > 0.05$	$F_{1,415} = 2.18$ $p > 0.05$
		Area 8*	364.3 \pm 24.0	391.4 \pm 32.4	430.6 \pm 31.0	391.0 \pm 24.9	390.1 \pm 29.6	$t = 0.02$, $df = 69$ $p > 0.05$	$F_{1,212} = 0.66$ $p > 0.05$
		Area 9	367.0 \pm 18.3	489.8 \pm 21.9	577.1 \pm 25.5	469.1 \pm 18.3	428.7 \pm 17.8	$t = 1.61$, $df = 200$ $p > 0.05$	$F_{1,487} = 4.00$ $p > 0.05$
		Area 11	489.2 \pm 20.7	522.2 \pm 26.0	544.4 \pm 31.1	549.5 \pm 33.2	500.9 \pm 21.9	$t = 1.23$, $df = 98$ $p > 0.05$	$F_{1,293} = 0.24$ $p > 0.05$
		Area 12	351.5 \pm 22.4	370.2 \pm 29.9	437.6 \pm 23.9	503.7 \pm 28.4	432.4 \pm 23.0	$t = 1.88$, $df = 86$ $p > 0.05$	$F_{1,203} = 13.79$ $p < 0.01$
		Area 14	365.0 \pm 27.3	378.8 \pm 21.2	413.0 \pm 25.6	433.0 \pm 19.7	417.9 \pm 16.4	$t = 0.58$, $df = 124$ $p > 0.05$	$F_{1,228} = 4.91$ $p > 0.05$
Mean daily effort	hr.day ⁻¹	Area 4	3.7 \pm 0.2	4.1 \pm 0.2	4.5 \pm 0.2	5.2 \pm 0.2	5.4 \pm 0.1	$t = 1.03$, $df = 145$ $p > 0.05$	$F_{1,341} = 69.83$ $p < 0.01$
		Area 5	3.9 \pm 0.2	4.2 \pm 0.2	4.8 \pm 0.2	4.6 \pm 0.2	4.9 \pm 0.2	$t = 0.96$, $df = 115$ $p > 0.05$	$F_{1,415} = 20.86$ $p < 0.01$
		Area 8*	4.4 \pm 0.2	4.6 \pm 0.2	5.2 \pm 0.3	5.5 \pm 0.3	5.1 \pm 0.3	$t = 1.02$, $df = 69$ $p > 0.05$	$F_{1,212} = 11.9$ $p < 0.01$
		Area 9	4.5 \pm 0.2	5.6 \pm 0.2	6.6 \pm 0.2	6.2 \pm 0.1	6.0 \pm 0.1	$t = 1.02$, $df = 200$ $p > 0.05$	$F_{1,487} = 66.38$ $p < 0.01$
		Area 11	5.2 \pm 0.2	5.4 \pm 0.2	5.6 \pm 0.2	5.6 \pm 0.3	5.5 \pm 0.2	$t = 0.1$, $df = 98$ $p > 0.05$	$F_{1,293} = 3.12$ $p > 0.05$
		Area 12	4.7 \pm 0.3	4.9 \pm 0.3	6.0 \pm 0.2	5.6 \pm 0.2	5.4 \pm 0.2	$t = 0.6$, $df = 86$ $p > 0.05$	$F_{1,203} = 9.33$ $p < 0.01$
		Area 14	5.5 \pm 0.3	6.0 \pm 0.3	5.7 \pm 0.2	5.7 \pm 0.2	5.3 \pm 0.1	$t = 1.73$, $df = 124$ $p > 0.05$	$F_{1,228} = 2.34$ $p > 0.05$

* excludes data from directed fishing in Waterloo Bay during 2007.

Appendix 2. (continued)

Performance Indicator	Units	Spatial Scale	2003	2004	2005	2006	2007	Inter-annual change	5-year trend
CPUE	kg.hr ⁻¹	Area 4	66.1±3.8	81.1±3.7	77.1±2.7	92.2±3.2	75.8±2.7	$t^1 = 3.91, df = 141.7$ $p < 0.01$	$F^2_{1,341} = 4.27$ $p < 0.05$
		Area 5	86.3±3.3	80.1±2.7	77.1±2.6	77.2±3.0	77.4±3.1	$t^1 = 0.05, df = 114.9$ $p > 0.05$	$F^2_{1,415} = 4.60$ $p < 0.05$
		Area 8*	82.9±3.6	84.3±4.8	83.1±3.8	70.6±3.3	75.9±5.0	$t^1 = 0.88, df = 57.1$ $p > 0.05$	$F^2_{1,212} = 2.91$ $p > 0.05$
		Area 9	82.3±2.5	87.0±3.0	87.8±3.0	75.9±2.2	71.3±2.3	$t^1 = 1.42, df = 199.9$ $p > 0.05$	$F^2_{1,487} = 12.84$ $p < 0.01$
		Area 11	94.1±3.1	97.2±4.4	96.7±4.1	99.0±4.8	90.6±3.1	$t^1 = 1.47, df = 56.3$ $p > 0.05$	$F^2_{1,294} = 0.83$ $p > 0.05$
		Area 12	76.5±3.1	75.6±4.4	73.6±3.6	89.4±4.3	79.7±4.6	$t^1 = 1.56, df = 83.4$ $p > 0.05$	$F^2_{1,203} = 6.89$ $p < 0.05$
		Area 14	66.2±3.3	63.8±3.3	72.7±3.5	76.7±3.4	79.7±3.0	$t^1 = 0.67, df = 111.3$ $p > 0.05$	$F^2_{1,228} = 20.72$ $p < 0.01$
Mean size	mm, SL	Area 4	151.8±0.9	151.2±0.3	147.5±0.5	157.4±0.6	150.3±0.4	$t = 9.88, df = 1667$ $p < 0.01$	$F_{1,2842} = 0.12$ $p > 0.01$
		Area 5	152.8±0.8	147.8±0.3	151.3±0.5	154.3±0.4	151.5±0.3	$t = 5.52, df = 2297$ $p < 0.01$	$F_{1,3854} = 43.45$ $p < 0.01$
		Area 8*	No data	151.3±0.7	149.1±0.4	151.3±0.4	153.3±0.4	$t = 3.82, df = 1280$ $p < 0.01$	-
		Area 9	154.9±0.9	150.5±0.3	152.7±0.3	153.6±0.3	154.3±0.2	$t = 1.90, df = 4601$ $p > 0.01$	$F_{1,8074} = 101.46$ $p < 0.01$
		Area 11	No data	143.7±0.4	150.0±0.3	149.0±1.0	153.5±0.3	$t = 4.70, df = 1323$ $p < 0.01$	-
		Area 12	No data	146.6±0.4	143.3±0.2	144.5±0.6	150.9±0.5	$t = 6.81, df = 899$ $p < 0.01$	-
		Area 14	150.4±0.9	145.3±0.4	150.1±0.8	147.3±0.3	147.2±0.4	$t = 0.2, df = 1567$ $p > 0.01$	$F_{1,2188} = 0.30$ $p > 0.01$

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

2. Based on daily CPUE.

* excludes data from directed fishing in Waterloo Bay during 2007.

Appendix 2. (continued)

Performance Indicator	Units	Spatial Scale	2003	2004	2005	2006	2007	Inter-annual change	5-year trend
Egg production retained	%	Area 4	No data	No data	No data	No data	No data	NA	NA
		Area 5	No data	No data	No data	No data	No data	NA	NA
		Area 8	No data	No data	No data	No data	No data	NA	NA
		Area 9	35.5	38.3	65.2	59.4	62.9	NA	NA
		Area 11	No data	67.4	60.6	35.2*	82.8	NA	NA
		Area 12	No data	No data	No data	No data	No data	NA	NA
		Area 14	No data	No data	No data	No data	No data	NA	NA

NA indicates not applicable.

* commercial shell sample size, $n < 120$.