NSW Total Allowable Fishing Committee

Report and Determination 2019

ABALONE FISHERY

19 November 2018

EXECUTIVE SUMMARY

Preamble

The NSW Total Allowable Fishing Committee (the Committee, formerly the Total Allowable Catch Setting and Review Committee) has responsibility under the NSW Fisheries Act (1994, No. 38) to determine the total allowable commercial catch of abalone by NSW commercial fishers. This determination is for the period 1 January to 30 June 2019, reflecting submissions by industry representatives and agreement by the NSW Department of Primary Industries (the Department) to change the Fishing Period for abalone from calendar to financial years. This determination therefore is for six months to effect that change in definition of Fishing Period. The determination is based on a scientific assessment of the abalone stocks, reports from fishery managers and compliance officers, comment from fishers, and input at a public forum convened in Sydney on October 10th 2018.

Determination

The Committee has determined that the total allowable catch of abalone by NSW commercial fishers during the 2019 fishing half-period (01 January to 30 June) should not exceed 50 tonnes (t), consistent with the annual allowable catch in the 2018 fishing period. The determination is set given likely catches of abalone by non-commercial fishers of up to 5 t and illegal and unreported commercial catches of up to 20 t.

Recommendations

The Committee provides the following recommendations to the NSW Department of Primary Industries (the Department) and the abalone industry (Industry) towards improving performance of the fishery. The Committee appreciates the Department's reporting against previous recommendations in its fishery management report this year.

Recommendation 1: The Department and industry develop a harvest strategy for the fishery with specific biological and economic objectives linked to target reference points.

Recommendation 2: The Department and Industry resolve robust and definite mechanisms for spatially-explicit management of the fishery, including spatially determined catch caps, efficient spatially-explicit quota management methods, and rigorous spatially-explicit monitoring and assessment.

Recommendation 3: The TACC be distributed amongst Spatial Management Units as recommended in Table 6.1, with regulatory or co-management measures to ensure that catch distribution.

Recommendation 4: The Department develop a robust, spatially explicit bio-economic assessment model to support TACC determinations, LML settings, and strategic management of the fishery.

Recommendation 5: The Department and Industry develop a strategy for regular economic survey and analysis of the fishery to inform economic optimisation of the fishery.

Recommendation 6: The Department obtains more robust estimates of recreational catch and makes no change to recreational bag limits until rigorous recreational catch monitoring is implemented and sound stock status is secured.

Stock Status

There was substantial improvement in the state of the stock from about 2006 through to about 2014. The reductions in TACC and increased Legal Minimum Length (LML) since the mid-2000s succeeded in rebuilding stock abundance and size composition until about 2014, demonstrated by substantial increases in catch rate, abalone density, abalone biomass, and mean weight of abalone across the fishery over that period. There was an about doubling of exploitable biomass during 2009–14.

This rebuilding has not persisted, however. All indicators in all the significantly fished Spatial Management Units (SMUs) have shown substantial decline since about 2015 that has continued through to the most recent year of analysis, 2017–18. The catch rate and biomass indicators show that by 2017–18 the abalone stock abundance had decreased to about the level last seen in 2011–12. This reduction has left less than half of the biomass rebuilt since 2009 available to the fishery. Harvest fractions have been particularly high in the southern part of the fishery (SMUs 3 and 4) in the last 1–2 years and further deterioration of the stock status there is expected if such levels of harvest persist.

It is concluded that the main cause of the recent deterioration in the abalone stock has been the widespread and substantial decrease in stock productivity from about 2015 in the context of static TACCs set in line with previously higher stock productivity. Other factors also might that contributed to this outcome, including:

- The impact of a major storm in southern NSW in 2016 potentially exacerbated declining productivity in some, but not all, Areas;
- Stock rebuilding between 2009 and 2014 was not as substantial as suggested by the catch rate and mean weight indicators;
- The lack of leading stock indicators, and the consequent delay in detecting the greatly decreased stock productivity from about 2015, resulted in application of static TACCs that were larger than the surplus production.
- Inadequately managed spatial distribution of catch has resulted in excessive harvest rate, first in SMU 4 in 2017 and then in both SMU 3 and SMU 4 in 2018.

Periods of low productivity have been observed previously in this fishery and they persisted for about 3–5 years. It is not known how long the current period of low productivity might persist. The only positive signal from any of the fishery indicators is a small and ambiguous increase in monthly standardised catch rates during the last 1–2 months of the 2017–18 financial year. This might be an early sign of increased stock productivity but that will be clarified only with future observations.

There are significant risks to the stock from the recommended TACC. The current TACC is 26% less than those that were associated with stock decline since 2015 and excessive harvest fractions in some SMUs, and it is greater than the estimated recent surplus production. This approach is accepted only because a change in fishing period means this Determination is for only 6 months (January–June 2019) and so an assessment of the information from the full 2018 calendar year under the reduced 100t TACC is planned for April 2019. That assessment is expected to be informative about the recent productivity of the stock and the effectiveness of the 2018 reduction in TACC and increase in LMLs. Further reduction of the TACC will be necessary if the stock does not show a return to higher productivity.

Economic Considerations

The fishery GVP in 2018 is expected to be around $3.9m, within the range of values observed over the last few years despite the reduction in the TACC. Beach prices increased by roughly 21% between 2017 and 2018, mostly offsetting the 23% reduction in TACC.

Productivity, in terms of CPUE, in most areas appears to have increased in the first half of 2018 relative to 2017. This will result in a decrease in the total number of days required to achieve the full quota if the higher catch rates persist, particularly given the lower quota. The reduced fishing time required to take the catch will have a positive impact on the economic performance of the industry in 2018 relative to 2017.

Share trading declined slightly between 2017 and 2018 (to September). Share trading prices however, increased, suggesting continued optimism for the medium to longer term economic outlook for the fishery despite the reduction in TACC in 2018. Estimates of the gross return per share have declined by around 7% between 2017 and 2018, a result of the higher share values and a slight decline in revenue per share. Lower costs associated with higher catch rates (if they are realised) may result in the net returns per share being similar or greater in 2018 than in 2017, contributing to higher share trading prices. Quota transfer prices, indicating short-run economic performance, are unavailable.

Industry reports that average beach prices currently are around $42/kg, compared with average processor prices of $38.7/kg this year, which may result in a further offset against the quota reduction in 2018. The overall higher prices are attributable to a weaker Australian dollar over 2018, lower supplies domestically resulting in increased competition between processors, lower supplies on international markets, and an increased preference for wild-caught product in international markets. These prices are expected to persist at this level for at least the next 12 months.

The Committee had little economic information to inform TACC setting other than that provided by Industry on a largely anecdotal basis and what can be assumed based on changes in processor prices, productivity, and available share trading prices. Reliable information is required on quota and share trading prices, abalone prices, and changes in fishing costs. The only economic performance study of the industry (i.e. costs and earnings) related to the 2011–12 financial year, and likely bares

little relevance to the current economic performance. Industry has again expressed a willingness to undertake a new economic survey to help support management decision making. This is especially important given the downward change in the TACC. The Committee recommends that the Industry undertake an economic survey of the current season (2018) and again in 2019 to identify the impacts of the change on industry profitability. The Committee again recommends that Industry and the Department resolve an ongoing strategy for economic monitoring of the operating costs and product prices for the fishery, including share and quota trading. Absence of such information continues to constrain setting economically optimised TACCs.

The Committee again notes that current economic indicators and triggers for the fishery lack specificity or clear management responses. Economic data for the fishery relating to long-term profitability are required to inform operational objectives, performance indicators, and target reference levels in a harvest strategy for the fishery.

Management Considerations

The NSW abalone fishery has been in the early stages of rebuilding since 2009, following historical lows in the fishery and a TACC reduction to 75t in 2009. The TACC increased through that recovery period to 130t. Last year, however, the Committee reduced the TACC to 100t in response to successive years of plateauing and then decreasing biological indicators. The available indicators are crude indicators in the absence of fishery-independent indicators and difficult to interpret for a single year but the pattern in indicator data over several years confirmed the Committee's emerging concerns about the stock in recent years with enough evidence to justify significant action. The Committee therefore is maintaining the TACC at 100t per year, prorata'd to 50t for the 6 month quota period. The Committee is comfortable with this approach given it will be able to review updated data in six months to assess the effectiveness of the reduction of the TACC last year.

The Committee to date has taken a precautionary approach to TACC-setting and simultaneously made strong recommendations to improve the management of the fishery and reduce uncertainty in understanding the performance of the fishery. The Committee's experience in setting this TACC again has reinforced the need for a harvest strategy that outlines the objectives the fishery is working toward, how performance will be measured, how data will be collected and analysed to inform decision-making, and how decisions will be made. The assessment process this year has underscored the need to resolve agreed performance indicators and reference levels rather than relying on the draft harvest strategy from 2015. The level of investment in monitoring and assessment programs needs to be revisited as a priority as the fishery has reached the point where under-investment is compromising efficient TACC decisions, as emphasised in previous reports.

Advice available to the Committee about non-commercial catch (Aboriginal, recreational, and illegal) suggests the range of estimates assumed in recent years remain appropriate. Compliance information presented to the Committee provides confidence that the quota system has integrity.

Conclusions

There is emerging evidence that the biological status and productivity of NSW abalone stocks have declined materially over approximately the last three years, following nearly a decade of rebuilding from very low levels. Reasons for this recent decline are not clear but it now is clear that the current stock cannot support the TACC set during 2015–17. It remains to be determined whether the reduction of TACC in 2018 and associated increase in Legal Minimum size Limits for harvest will arrest these recent declines.

The Committee has retained the TACC setting from 2018 for the first half of 2019 with the expectation that thorough review of indicators up to the end of March 2019 will indicate whether that level of harvest is sustainable in the short to medium term or further reduction in TACC will be necessary to rekindle stock rebuilding.

The appearance of this change in direction of stock behaviour, from rebuilding to decline, almost certainly could have been forecast had the Department and Industry had in place rigorous fishery-independent monitoring of key leading indicators and had retained, and further developed, robust stock assessment modelling such as that abandoned in 2008. The lagging retrospective recognition of adverse stock condition is compelling evidence that these management shortcomings need urgent rectification, as previous TACCs and this TAFC have been recommending for many years.

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1. INTRODUCTION

The Total Allowable Catch Setting and Review Committee was established by Division 4 (S26-34) of the *Fisheries Management Act 1994* and renamed the Total Allowable Fishing Committee (the Committee) and given broader responsibilities in a 2018 amendment to the Act (Part 2A S40) following structural reform of management arrangements for most NSW commercial fisheries. The committee in 2018 was:

- Dr Bruce Mapstone – Chair;
- Ms Kelly Crosthwaite – fisheries management;
- Dr Sean Pascoe – natural resources economics; and
- Dr Keith Sainsbury – fisheries science

The Committee is required to determine the Total Allowable Commercial Catch (TACC) for the commercial sector of the abalone fishery and, in doing so, give effect to the objectives of the *Fisheries Management Act 1994,* as amended where relevant by *Fisheries Management Amendment Acts (1997, 2004, 2006, 2010, 2015, 2018)*. The Committee is not subject to control or direction of the Minister but in reaching its decision is required to have regard to:

- All relevant scientific, industry, community, social, and economic factors;
- The need to ensure that the abalone resources are exploited in a manner that will conserve stocks in the long term;
- The impact of fishing on other species and the environment; and
- The precautionary principle as set out in Section 30(2)(c) of the Act.

The Committee also may be consulted out of session on a range of management issues.

The Committee produces a stand-alone report each year in support of the TACC determination. The report also sometimes includes recommendations for management of the fishery related to setting TACCs, based on the experience and background of the Committee members and reports received by the Committee. Constructive dialogue between the Committee and the Department and Industry on a range of issues related to the fishery, including recommendations from the Committee, is an important and valuable part of the Committee's deliberations in reaching a TACC determination. It is important to note, however, that the Committee makes a determination on the TACC and, potentially, matters it is required to regard that affect directly that TACC. The degree to which the Committee's suggestions or recommendations beyond that scope are accepted is a matter entirely for the Department. The Committee holds the position, however, that the abalone Determination is linked inextricably to selectivity (size limits for harvest) and spatial dynamics considerations and that its recommendations regarding these intrinsic components of the TACC should not be discretionary.

The Committee must consider the full extent of abalone exploitation to meet its statutory obligations. Total removals from the NSW abalone stock are made up of:

- The quota allocated to commercial fishers;
- The total legal catch by recreational and Aboriginal fishers; and
- Catches by commercial, recreational, or Aboriginal fishers not sanctioned by the Regulations controlling the fishery and not recorded in catch statistics (illegal catches).

The legal and illegal components of the non-commercial fishery currently are estimated as a single figure based on historical evidence, compliance information, and judgments from the Department and Industry.

The Act defines, in Section 30(2)(c), how the Committee should apply the precautionary principle, specifically:

> *'… if there are threats of serious irreversible damage to fish stocks, lack of scientific certainty should not be used as a reason for postponing measures to prevent that damage.'*

The Committee interprets 'threat' in this context to mean an 'indication of probable harm to come'. The Committee therefore must respond to evidence before it that indicates probable future harm to the fishery or the stocks and not postpone action to prevent that harm occurring even if there is uncertainty surrounding such evidence. Similarly, the Committee should not take pre-emptive decisions on issues such as increasing the TACC when there is insufficient verifiable information on which to base such decisions. The abalone fishery is an instance were the Committee currently takes a precautionary approach.

2. PROCEDURES

2.1 Public Consultation by Committee

The Committee, through the Department, called for public submission on the appropriate total allowable commercial catch under the requirements of Section 31 Division 4 of the *Fisheries Management Act* 1994. Abalone fishers, relevant industry and community bodies, and the community were invited to make submissions on the total allowable commercial catch. The consultative process is set out in Appendix 1. No written submissions were received from any non-government stakeholders in the abalone fishery.

The Committee obtained input from participants in the Total Allowable Fishing Committee Open Forum meeting in Sydney on October 10th 2018 and received written reports from:

- NSW Department Primary Industries (DPI) Fisheries Research and Abalone Council[1];
- NSW Department Primary Industries Commercial Fisheries Management;
- NSW Department Primary Industries Fisheries Compliance;

Public verbal submissions and presentations to the Committee were invited in the Open Forum meeting. The Committee also was able to call for *in-camera* discussions, where appropriate. No in-camera discussions were requested at the 2018 meeting.

2.2 Matters considered

The Committee considered the following matters before reaching its determination:

- Documentation available on the fishery and submissions received for this year;
- Management objectives set out in the management plan;
- The current state of the fishery;
- Advice on the status of management of the fishery provided by the Department;
- Advice on the economic status of the fishery by the Department and Industry representatives;
- Advice on compliance with regulations from the Department and Industry representatives;
- The data and assessment report for abalone stocks provided by the Abalone Council of NSW under contract to the Department;
- The spatial nature of the fishery; and
- Submissions, commentary, and presentations provided at or before the Open Forum.

The Committee commends the Department on the improved timeliness of reports this year, but emphasises the importance of delivering relevant reports also to expected attendees at the public forum with sufficient notice for those reports to be read before the forum.

2.3 Format of the Report

This report covers the three key areas affecting management of the fishery and setting the TACC:

- Status of the abalone stocks;
- Economic considerations; and
- Management considerations.

The key considerations for each of these areas are presented in the following sections 3, 4, and 5. Greater details, together with relevant historical context, for each topic are presented in Appendix 3 (Stock), Appendix 4 (Economics), and Appendix 5 (Management) for interested readers.

The Committee has made several recommendations with the Determination to clarify the position of the Committee on a number of issues related to the TACC. The primary recommendations are included in the Executive Summary and all recommendations appear as relevant in sections 3, 4, and 5 and Appendices A3, A4, and A5.

The Determination of the Committee is to be published by the Minister. The Minister is required to review the regulations and any other instruments under the Act In the light of the Determination. The Determination is to be implemented in accordance with the Management Plan.

[1] The research report titled Assessment of abalone stocks in NSW was prepared by the Abalone Council of NSW under contract to the NSW Department of Primary Industries and submitted to the Committee as a Department-endorsed report.

3. STATE OF THE STOCKS

3.1 Introduction

The state of the NSW abalone stock is determined from two primary sources of information: (1) logbook and related information from commercial fishing (including catch, dive time, catch rate, and mean weight of individuals in the catch) aggregated spatially at various scales; and (2) fine-scale GPS data-logger information on the location of divers during fishing events that can be linked to the logbook records of catch by dive-bins as they are filled and for the total dive.

Several performance indicators are calculated from this information and used to interpret trends in stock status. Key indicators used are:

- Total catch in tonnes (t);
- Total fishing effort in diver-hours (h);
- Catch rate in kilograms per diver-hour (Kg/h);
- Size of abalone in the catch, as weight (grams) in or length (g and mm);
- Area fished in hectares (Ha);
- Catch density (Kg/Ha searched);
- Biomass (t);
- Harvest fraction (catch/biomass); and
- Annual surplus production (t/year).

The last five of these indicators are calculated from the diver GPS-logger data. These are developmental and they require more formal testing but experience and confidence with their application is growing, but absolute values are considered less reliable than relative trends.

Indicator trends are examined at several spatial scales, including the four Spatial Management Units (SMUs) in the fishery. There is very little fishing in SMU 1 and the information available from it is not considered representative of the stock there. Examination of stock status consequently is focused on the more fished, southern SMUs 2, 3, and 4.

These indicators are all fishery dependent and so are influenced variously by changes in fishing operations, including targeting of different areas and abalone sizes. They also are all 'trailing indicators' that reflect past conditions; there are no 'leading indicators' of likely future conditions (such as abundance of undersized abalone that will soon recruit to the fishery or predictions from integrated assessment models). This inevitably causes delay in detecting changed stock conditions, and limits anticipation of changing conditions. These limitations place material constraints on inferences about the current and future states of the stock.

3.2 Stock status and trends

There was a substantial improvement in the state of the stock starting in about 2006 but particularly since about 2009 through to about 2015. The reduced Total Allowable Commercial Catch (TACC) and increased Legal Minimum size Limits for harvest (LMLs) since the mid-2000s, when those management interventions began, succeeded in that stock rebuilding. This is demonstrated by the substantial increases in catch rate, abalone density, abalone biomass, and mean weight of abalone for all SMUs over that period, which shows an about doubling of exploitable biomass between 2009 and about 2014.

Rebuilding has not persisted, however. All the significantly fished SMUs (SMUs 2, 3, 4) now show that stock abundance has declined since about 2015, with the decrease continuing through to 2017–18. Stock abundances in SMUs 3 and 4 have been reduced to the levels last seen in about 2011, while Stock abundance in SMU 2 has reduced to the level last seen in about 2012. Harvest fractions have been particularly high for SMU 3 in 2018 and for SMU 4 in both 2017 and 2018. Further deterioration of the stock status in those SMUs is expected if such levels persist.

The recent change in the catch rate, biomass, and mean weight indicators are summarised in Table 3.1.

The mean weight indicator is intrinsically ambiguous in the context of decreasing catch rates and changed LML and its estimation through different monitoring programs is inconsistent, but all interpretations of this indicator are negative to different degrees.

Table 3.1: Changes in primary indicators of stock status (catch rates, size of abalone caught) and an index of harvestable biomass (stock density) in each Spatial Management Unit (SMU). Annual changes averaged over the last three years are at the top of the table and total changes over the 3 year period are at the bottom of the table.

Average *annual* change in past 3 years	SMU 1	SMU 2	SMU 3	SMU 4
Catch rate	+4.3%	-8.3%	-6.7%	-7.6%
Index of biomass	+113.0%	-8.7%	-18.0%	-12.8%
Abalone weight (logbook and related data)	+0.9%	+0.5%	+0.6%	+1.2%
Abalone weight (measurement loggers)	N/A	-0.5%	-0.5%	-0.1%
***Total* change over past 3 years**	**SMU 1**	**SMU 2**	**SMU 3**	**SMU 4**
Catch rate	+13.8%	-26.5%	-21.3%	-24.0%
Index of biomass	+227.0%	-17.4%	-36.1%	-25.6%
Abalone weight (logbook and related data)	+2.8%	+1.5%	+1.9%	+3.8%
Abalone weight (measurement loggers)	N/A	-3.0%	-2.7%	-0.5%

The annual surplus production since 2000 was estimated from a combination of the biomass index and catch rate. Stock productivity has reduced in a long-term trend since 2000, and this reduction is overlaid with multi-year periods of higher or lower productivity. Stock productivity for all the SMUs where reliable estimation was possible (2, 3, 4) was relatively high during 2009–2014 when rebuilding was seen under the applied TACCs and resultant harvest fractions. Stock productivity in all these SMUs decreased abruptly and considerable in 2015, however, followed by stock decreases at harvest fractions similar to those that previously gave rebuilding. This low productivity has persisted through to 2017–18. The productivities of SMUs 2, 3 and 4 in 2017–18 are all at their lowest on record. The surplus production in SMU 3 has been particularly low in each of the last 3 years. The recently elevated harvest fractions in SMU 3 and SMU 4, and the apparent inability to keep catches within the recommended targets for these SMUs, are of particular concern.

The trends in surplus production estimates, like the biomass estimates on which they are based, are more reliable than the absolute values. The estimated annual production in each of the last 3 years, however, has been considerably less than the TACC in those years, and less than the 100t TACC applied in the 2018 calendar year. One of the Committee's explicit intentions in setting precautionary catch levels has been to prevent stock depletion during periods of low productivity, but the recent decreases in productivity have been greater than anticipated and have become clear only in retrospect.

A preliminary Length-Based Spawner Potential Ratio (LB-SPR) analysis was applied to reef systems in two southern Areas (17, 21) for the period 2000 to 2018 by Dr Jeremy Prince, in collaboration with Industry. That method uses length composition, basic population parameters and an assumption of equilibrium to estimate depletion in average lifetime spawning output caused by fishing and the ratio of fishing mortality to natural mortality, which is related to the harvest fraction. The full uncertainties in estimation and interpretation were not considered in the analysis and only a small part of the fishery was examined (2 Areas), but the results were reasonably coherent and consistent with other fishery-wide indicators. The estimated spawning depletion is to about 0.2–0.3 and trending towards the lower level in the last 3 years. Depletion to 0.2 is a common reference point to indicate a recruitment overfished stock. The trends in exploitation rate from LB-SPR are similar to those from other indicators but the absolute values from LB-SPR are more than double those estimated from the logger biomass data. This discrepancy requires further examination because even if approximately correct the LB-SPR values imply that serious overfishing has been occurring since about 2000 and this would have interacted very badly with the decreased productivity since 2015. Further development and application of LB-SPR analysis would be a useful contribution to assessment of the fishery.

The only positive signal from the available indicators is a small suggested increase in the monthly standardised catch rate during the last 1–2 months of the 2017–18 financial year. This increase is less apparent in the nominal CPUE, however, suggesting that interpretation is affected by operational details in those months that might not be well accounted for in standardisation. Nevertheless, this could be an early indication of a return to higher stock productivity or a reflection of the effect of the reduced 2018 TACC and increased LMLs, which will be clarified only with future observations.

3.3 Conclusions

It is concluded that the main cause of recent deterioration in the abalone stock has been the widespread decrease in stock productivity from about 2015 in the context of constant TACCs set on the basis of prior stock rebuilding. Other factors that might have contributed to this outcome, however, are noted below.

1. *The impact of a major storm in southern NSW in June 2016*. The decrease in productivity began in about 2014 or 2015 and was very widespread across at least SMUs 2, 3 and 4, so is not explained by this storm. The storm, however, might have exacerbated locally the effects of the combination of decreased productivity and continuation of a TACC that became greater than falling productivity.
2. *Stock rebuilding in the period 2010 to about 2014 was not as substantial as suggested by the indicators*. Catch rate, density, and mean weight indicators all showed substantial evidence of increases during 2010–2014. The recent decreases in catch rate and biomass show that the biomass increases achieved during that rebuilding period were relatively modest, notwithstanding the substantial increases in the catch rate and other indicators through that time.
3. *Lack of leading stock status indicators or predictions*. All the indicators available are trailing indicators that rely on retrospective detection of trends or changes in trend. There consequently is an inevitable delay in recognising changed circumstances. This is a weakness in the management system that has been highlighted many times previously, but it is a more serious weakness than previously appreciated. The abrupt decreases in productivity that have been seen recently mean that there are serious risks to the stock and economic performance from multi-year delays in detecting change. The delay in detecting the reduced productivity in about 2015 has resulted in the loss of much of the stock rebuilding achieved during 2009–14. The long-term decrease in estimated productivity also suggests that climate change or other external forcing is introducing a new and unpredictable dynamic into the abalone fishery under which timely detection of productivity change is increasingly important.
4. *Inadequately managed spatial distribution of catch leading to sequential depletion*. The attempts to distribute catch spatially to better match productivity have not been successful. There now are patterns in the fishery that are consistent with sequential depletion, though other interpretations of the patterns also are possible. Risk of sequential depletion is present, however, especially when the stock is relatively reduced and less productive, as has become the case since 2015.

The Committee has concluded that the TACC for the 6-month period January–June 2019 should be 50t. This is a 6-month pro-rata continuation of the 100t TACC applied for calendar year 2018. The Committee recommends that the catches be distributed among SMUs as shown in Table 3.2 and that there should be another assessment in April 2019, using data to the end of March, to determine the TACC for financial year 2019–20.

Maintaining the TACC for the period January–June 2019 at an annualised level of 100t contains significant risk to the stock. This approach is accepted only because early assessment of the information from the full 2018 calendar year under the reduced 100t TACC is possible as a result of the change in the quota year. That assessment is expected to be informative about the recent productivity of the stock and the early effects of quota reduction and increased LMLs from January 2018. The key risk to the stock is that the current quota allows continued catch at a level that is above the level of recent surplus production. Risk of continued decline is particularly high for SMUs 3 and 4 from which recent catches mostly have come and which appear to be recently depleted with elevated harvest fractions. These risks are exacerbated by the persistent inability to keep catches within recommended spatial limits, which may result in excessive catches to continue to be taken from SMU3 and SMU 4. The Committee strongly recommends implementation of robust mechanisms to regulate spatial catch-caps effectively.

Table 3.2: Recommended catch targets by SMU for January-June 2019.

SMU	Catch (t) January–June 2019
1	5.0
2	20.0
3	12.5
4	12.5
Total	**50.0**

4. ECONOMIC CONSIDERATIONS

4.1 Introduction

Economic information available to the TAFC included estimates of gross value of fishery production, beach prices, and reported share trading prices. Indirect productivity measures were available in the form of average catch rates for the fishery overall and by fishing Area and Spatial Management Unit (SMU).

The absence of contemporary data on fishing costs means it is not possible to make a complete analysis of economic performance of the NSW abalone industry. Using gross returns alone means that the economic implications of alternative TACC scenarios cannot be assessed fully. The constraints of limited economic information have been highlighted in previous reports and are discussed further below.

4.2 Gross value of the fishery and abalone prices

The gross value of production (GVP) of the fishery was relatively stable over the period 2011–12 to 2017, with the value in real terms[2] ranging between $3.72m and $4.25m and averaging $3.97m. Estimated fishery GVP in 2018 is $3.87m based on processor prices up to September 2018 and expectations that the 100 tonne TACC will be taken. This is slightly lower than several previous years due mainly to the lower TAC in 2018, although price increases have offset effects of the TACC reduction to a large extent.

Average prices to September 2018 were estimated to be $38.70/kg, the highest price in real terms since 2007–08, and roughly 21% and 19% higher than in 2017 in nominal and real terms respectively. Industry reports that beach prices have increased more than this to around $42/kg, due to lower levels of supply internationally and increased preference for wild-caught product in the main export markets, as well as greater competition between processors on the domestic market. ABARES forecast Australian abalone prices in general to be relatively constant over the next five years (Mobsby *et al.* 2018)[3] despite ongoing pressure from aquaculture production both within Australian and globally.,

Changes in the legal minimum length (LML) will potentially help NSW abalone compete in the international market over the next few years. The increase to 119mm in July 2018 and the further increase to 120mm in January 2019 (and higher LMLs for abalone caught south of Wonboyn) will help reduce competition with farmed abalone, which tends to be a smaller size. The reduction in import tariffs on abalone sold into the Chinese market has had a positive impact on prices in other states, and potentially has contributed (directly or indirectly) to improved prices received in NSW in 2018.

Industry representatives also suggested that the Australian domestic market has improved over recent years, through increased demand by local restaurants and increased competition among wholesalers. The Committee suggested previously that Industry undertake a marketing study of size preferences for abalone on the domestic and overseas markets and size–price relationships for abalone. This could be proposed as a national research priority given it is an issue affecting abalone marketing from all States.

4.3 Fishery Economic Performance and Share and Quota Trading Prices

Information on actual economic performance of the fishery is unavailable, but likely changes in performance can be inferred from fishing activity, productivity, and share or quota trading prices.

The number of active divers decreased from 33 in 2017 to 25 in 2018. This suggests that average revenue per diver increased from $124.8k in 2017 to $154.8k in 2018 (around 24%), assuming the full quota is taken by the active divers.

Productivity, in terms of CPUE (kg/hr), increased by roughly 25% between 2011–12 and 2016, although declined by around 12% in 2017, one of the key factors leading to the TACC reduction for 2018. Catch per day estimates from the Management Report for the year to September suggest that catch rates have improved in 2018. In contrast, standardised catch per hour estimates from the stock assessment report suggest that catch rates have declined for most SMUs over 2017–18, with some indication of improvement in the first half of 2018. The increase in LML is expected to have an adverse effect on catch rates in the short to medium term as the proportion of stock that is harvestable is reduced. Average

[2] Nominal values are the actual or 'raw' transaction values recorded at given times, without any adjustment for inflation from previous or later times. Real values are the transaction values at each time adjusted for inflation between the time of transactions and some standard reference period. Comparison of real values over time are more sensible because the effects of inflation have been removed. The Consumer Price Index (CPI) often is applied for this adjustment since it reflects changes in the costs of living, and so inflation, over time.

[3] Mobsby, D., Bath, A. and Curtotti, R. (2018). Annual fisheries outlook: Forecast to 2022-23, *Agricultural Commodities* 8, 128-137.

nominal weight of abalone across the fishery has continued to increase, also affected by the increase in the LML. The potentially higher catch rates in 2018 compared with 2017 and the lower TACC would mean that the total numbers of days fished to take full quota would decrease. Average catch per day from the Management Report indicates that around 500 days would be required to take the 100 t quota in 2018, compared with 664 days to take 130 t in 2017. This equates to roughly 20 days per diver in both 2017 and 2018 given the number of active divers in each year. Lower catch rates per hour from the stock assessment report suggest that fishers are working longer days to take their catch in 2018.

The above calculations suggest that costs (excluding quota lease costs) per active diver are likely to be about the same, or slightly higher, in 2018 as in 2017, while revenue has increased. This suggests that profitability per diver may have increased, although some of these profits would be reallocated to those leasing quota and fishers may have had to work more each day to realise these profits.

Share trading prices reflect expectations of longer term profitability of the fishery. Share trading prices increased from $8,344 per share in 2017 to $10,492 per share in 2018, suggesting expectations of higher future profits in the industry. The quantity of shares traded, however, was very small. The expected return per share decreased from $1,205 in 2017 to $1,120 in 2018, a result of a lower return per share (due to the lower TACC) and a higher share value. Quota trading price, a good indicator of short term economic performance, was unavailable.

4.4 Economic targets for the fishery

The Committee notes that there is no formal (or informal) economic objective for the fishery, nor an economically-based target level of biomass and catch. Industry representatives expressed a desire for an objective of maximum economic yield during the 2017 open forum and noted the substantial investment in shares by many fishers, the value of which can be maintained only by improving profitability in the fishery. Industry indicated a willingness to incur short term reduction in quota if it results in longer term, sustainable improvements in profitability. There is a trade-off between current (short term) and future profitability, but insufficient information is available to determine the optimal level of each.

Economic performance of the fishery may be enhanced longer-term through the higher Legal Minimum Length (LML) for harvest and improved biomass, particularly if a larger LML is sufficient to differentiate the wild caught from farmed product in the marketplace. There is a trade-off, however, between average size of the abalone (and its price) and the quantity that can be removed on a sustainable basis. There is also a trade-off in terms of how rapidly any increase in LML is implemented; a gradual increase may result in greater lost profitability during the adjustment phase than a larger increase over a shorter period.

The Committee suggests that Industry and managers consider developing a bio-economic model of the fishery to allow such trade-off analyses be done to help inform future TACC determinations. This will require additional investment in the science and monitoring for the fishery, and possibly the development of a funding bid for targeted research.

4.5 Future economic information needs

The Committee had little economic information to inform TACC setting. The only economic performance study of the industry, including costs and earnings, related to fishing in the 2011–12 financial year and likely bares little relevance to current economic performance. Quota trading prices also are unavailable. Absence of such information increasingly will constrain the setting of economically optimal TACCs.

The Committee again notes that current economic indicators and triggers for the fishery lack specificity or clear management responses. Economic data on long-term profitability are required to inform operational objectives, performance indicators, and target reference levels in a harvest strategy for the fishery.

Information on quota and share trading can provide an indication of the key drivers of change in economic performance of the fishery. Information on share trade prices was available this year, but information on quota trading prices was not. The Committee encourages individuals to report these prices (currently collected on a voluntary basis) to assist with future economic performance assessments of the fishery.

Industry indicated that they would be prepared to run a survey of fishers to help inform next year's assessment. This should be developed as a regular data collection process for the fishery.

*The Committee again **recommends** that Industry and the Department resolve a strategy for economic monitoring of the operating costs and product prices for the fishery, including for share and quota trading.*

5. MANAGEMENT CONSIDERATIONS

This fishery has sound fundamental management systems in place to manage abalone – individual transferable quotas, size limits, and an independent TACC-setting process. The existing system has been implemented in a way that has rebuilt the fishery from an over-fished condition and low TACC of 75 tonnes (t) to a recent maximum of 130 t. Primarily this has been through annual review of TACCs and to a lesser extent adjusting size limits, though not to the full extent recommended by the Committee.

There nevertheless are some changes to the decision-making framework that would enable better identification and strategic management of risks to the fishery, and drive optimisation.

One such improvement would be the formal incorporation of a mechanism for spatially spreading catch and managing stocks at a finer spatial scale. Another is the finalisation of a harvest strategy for the fishery so that the fishery has a strategic decision-making framework.

5.2 Spatial management

Some prerequisites of a finer-scale spatial management regime for the fishery have been implemented over the last seven years, with the collection of data from loggers and associated reporting and analysis at the finer "Area" scale. The recommended Area catch limits that had informed TACC-setting up until last year, however, had not been adhered to through the voluntary monitoring approach. The Committee therefore did not recommended catch limits for each Area in last year's Determination. The revised TACC for the whole fishery was based on recommended catch limits for the larger Spatial Management Units (SMUs) instead.

Concerns about declining stock status and uncertainty of assessment have increased the importance of active spatial distribution of the catch, at the least at SMU scale and potentially down to Area scale. Failure to regulate spatial distribution of catch is playing-out as expected, with data to 31 August 2018 indicating the recommended catches for SMU 3, and potentially SMU 4, likely to be exceeded in 2018, with a concurrent shift in catch from SMU4 to SMU 3 compared with previous years. Declines in some performance indicators are evident for 3 of 4 SMUs. These patterns point to potential serial depletion of the stocks at the relatively large SMU scale. The industry apparently now is monitoring catches throughout the season but the Committee maintains its view that a formalised system is necessary that effectively regulates the realised spatial distribution of catch.

The Department also advised that consideration is being given to making the use of electronic data loggers mandatory, to maximise the coverage, complexity, and volume of data collected. This is supported by the Committee as it would greatly increase the ability to manage the fishery at a finer spatial scale for optimum harvest.

*The Committee **recommends** that the Department implement a system to regulate the spatial distribution of catch to reduce risks of serial depletion of the NSW abalone stock.*

5.1 Decision-making framework

The Committee reiterates its comments from previous years about the importance of establishing a formal and robust harvest strategy for the fishery.

A harvest strategy is required to enable optimisation of the fishery. This has been highlighted in Determination reports as a priority for some years now, with some initial progress by the Department in 2015 which has since stalled. A harvest strategy would provide a decision-making framework to meet specifically articulated objectives of the fishery, identify the information necessary to inform management, guide TACC-setting through decision rules, and guide other management interventions. The absence of a robust harvest strategy, and in particular the setting of standards for the collection and analysis of appropriate data and how decisions will respond to those data, demonstrably and materially is affecting the management of the fishery.

The Committee is wary of the apparent reliance on the draft performance indicators and reference levels in the draft harvest strategy from 2015, which have neither been fully developed, reviewed, or formally agreed. They could be improved significantly and should not be relied on as the formal management framework for the fishery, though they provide a partially useful set of references in the absence of a robust harvest strategy.

5.3. Legal Minimum Length

Previous reports have discussed at length the close relationship between Legal Minimum Lengths for harvest (LMLs) and catch limits in managing abalone fisheries and have recommended increases in LMLs in the NSW fishery. The Committee last year recommended that the "*underlying LML for all of the fishery be set at 120 mm with specific variations for Areas 19, 20 and 21 south of Wonboyn (123 mm) and other Areas where recent biological information demonstrates a lower LML is appropriate to productivity in those areas".*

The LML increased to 119mm for abalone taken in waters north of Wonboyn and 125mm for those taken in waters south of Wonboyn from 10 July 2018. The LML for abalone in waters north of Wonboyn will be increased further to 120mm from 1 January 2019. The Department advise that they will, in consultation with industry and the Committee, develop criteria for identifying areas to which a lower LML might be applied in future.

These are very positive steps for management of the fishery. It will take some time to see the effect of the size changes in the performance in the fishery, however, and specifically targeted monitoring would be required to isolate the effects of changes in LML from other effects in the short term. These changes have been implemented during a declining phase of the fishery and they may have a more dramatic effect on catch rates in the medium term. The Committee nevertheless is encouraged that these changes have been made and has more confidence in the management arrangements compared to relying only on the TACC as the management tool for the fishery.

5.4 Compliance

The compliance performance of the fishery is important to TAC-setting as it provides the confidence that catch limits are being adhered to, and that the information on which decisions are based is accurate and reliable. The current management plan for the fishery establishes basic benchmarks about 'compliance rate' but this is not always relied-on at face-value because improvements in the targeting of offenders can lead to more offences being detected, as a proportion of contacts with fishers, than would be the case with ad-hoc compliance monitoring. Use of an intelligence-led and risk-based approach should lead to a higher rate of detections and therefore the appearance of lower rates of compliance, at least initially. Successes of targeted, intelligence-based enforcement will manifest as higher non-compliance rates when reported statistically together with other data. It is difficult to draw conclusions from crude 'compliance rate' information, therefore, without supporting explanations of the origins of the results. The Department continues to adjust its reporting but further (statistical) work would improve clarity about actual fishery-wide non-compliance.

There was again considerable discussion at the TACC meeting about illegal fishing by Aboriginal fishers and the potential availability of a native title defence to prosecutions. This discussion distinguished between legitimate Aboriginal cultural fishing, under the relevant bag and possession limits or cultural fishing permits, and illegal, unlicensed commercial fishing. The industry still perceives that native title is being misused in defence of illegal unlicensed commercial fishing and that the Government has been slow and non-committal in dealing with illegal take and sale of commercial quantities of abalone, to the detriment of the fishery and the community. Industry representatives expressed considerable frustration with the protracted times taken for alleged infringements to proceed to trial, especially, but not only, in cases were alleged offenders are Aboriginal. Long delays in bring cases to court potentially undermines industry confidence in enforcement strategies and management of the fishery.

The Committee sought to clarify whether it was considered by fisheries officers whether there had been material increases in the amount of illegal commercial abalone taken in the last year, notwithstanding the above concern. That discussion did clarify that for the purposes of setting the TACC:

- the estimate of illegal catch of 20–40t annually that has been used in recent years remains appropriate; and
- the Department is actively targeting organised illegal activity with good success, resulting in detection and prosecution, albeit with considerable procedural delays in some cases.

The Committee therefore continues to have confidence in the overall integrity of the quota system and other regulatory restrictions on catch. This is reinforced by the new requirement to pre-report fishing, and the prohibition on 'hanging' of abalone. These measures strengthen the ability of the Department to monitor the quota system effectively and efficiently and removes loopholes that undermine the integrity of the system.

The Committee notes that considerable compliance effort was invested this year in supporting the introductions of the Commercial Fishery Business Adjustment package, including the roll out of the

FisherMobile technology. This electronic reporting system, when operating as intended, should improve the integrity of the reporting system, and the ability of the Department to monitor the fishery efficiently. That improvement should in turn free-up resources to focus on other high-risk compliance issues that persist in high value fisheries such as abalone.

The Committee encourages the Department to review the reporting of its activities continuously to distinguish between improved targeted enforcement on the one hand and declining compliance on the other hand. A section in the compliance report providing the Department's critical assessment of the integrity of the quota system also would be helpful. This section could outline the offences detected for the year and an interpretation of what they mean for the integrity of the quota system, and whether material offences are stable, improving, or declining in frequency. For example, there are additional administrative offences in some years that relate to quota monitoring and reporting and those offences could either be benign, because they reflect a focus in that year by the Department on improving paperwork, or represent something more serious in relation to declining faith in and integrity of the quota system. It would be beneficial to the Committee to have the Department's assessment of such changes.

The Committee again recommends that a compliance strategy be developed for the abalone fishery. The strategy would not need to be complex, but should identify compliance objectives of the fishery, risks to achieving those aims, which compliance actions will be applied – including education activities – and how success will be measured. Such a strategy would inform future cost recovery discussions.

5.5 Fees

The Committee is of the view, consistent with previous years, that investment is required in several areas of the abalone fishery to secure sustainability of, and optimise benefits from, the fishery. The Department report that mandatory data loggers and scientific services for 2019 are amongst the issues being negotiated in relation to cost recovery for the coming year.

Other issues that the Committee recommend should be considered include:

- Fisheries management expertise and legal clarity to implement spatial management arrangements;
- Investment in analysis of optimum size limits to inform harvest settings in the longer term;
- Completion of a harvest strategy set within a clear policy framework to guide future TACC Determinations and any review of recreational harvest;
- Targeted investment in research to (a) collect and analyse commercial and recreational harvest data at relevant spatial scales, (b) collect and analyse economic data from the fishery, (c) implement an appropriate assessment model to inform strategic and tactical decision-making; and
- Sustained investment in compliance monitoring and enforcement to ensure illegal harvest declines, for which development of an abalone fishery compliance strategy would help.

5.6 Total Allowable Commercial Catch

The Committee last year reduced the TACC from 130t to 100t. This was a significant cut intended to generate a measurable turn around in the recent declining status of the abalone stock. The impact of this cut is difficult to determine yet given the limited data and analysis available from the short time (8 months) since the reduction. The increase in key biological indicators has not yet been observed, and it is difficult to isolate the reasons for a suggested increase in CPUE from some areas.

The Committee Therefore will maintain the current TACC of 100t per year, pro-rata'd to 50t for the six month transitional quota period of January 01 to June30 2018.

The Committee considers this a prudent approach in the absence of robust monitoring and assessment procedures and given that it is expected to take some time to verify whether the changes in TACC and LMLs have had the intended effects. The transitional 6 month fishing period will enable review of post-change data again in six months to determine whether the initial reduction from 130t to 100t was sufficient to stop further declines in the fishery performance and to re-establish rebuilding of the stock.

6. CONCLUSION

6.1 Summary

The abalone stock and fishery metrics showed significant improvement over the decade 2006–16 but now are showing signs of stock decline in most areas. This is a worrying position given stock and fishery gains realised over recent years and not a condition on which to base further increases in harvest. Indeed, evidence of continues stock decline will necessitate further constraint of the abalone harvest.

The Committee again was impressed by the positive engagement of shareholders at the public forum and notes industry's advice that shareholders favour a cautious approach to TACC setting, with an emphasis on securing stock status and future rebuilding. Persistent uncertainties about the true status of stocks in the context of a legislative requirement for a precautionary approach also mean caution is required to regain improvements from recent years and redress emerging evidence of low stock productivity.

The Committee now is more concerned than ever about the low level of research and monitoring investment in the fishery, the absence of a sufficient assessment model to inform tactical or strategic decisions, and the lack of a well-developed harvest strategy with clear resource and economic objectives. There also are basic economic data needed to inform future TACC setting if quotas are to be set for economically as well as biologically optimal results. These deficiencies certainly have contributed to the delay in recognising recent stock declines and the need for dramatic corrective action and will continue to hamstring proactive management of the fishery, especially under continued instability in stock status

*The Committee **recommends** that investments in research, monitoring and assessment strategies for the fishery be reinstated as a matter of urgency.*

Recreational harvest continues to be very uncertain and the Committee recommends no increases to recreational bag limits until more robust information about recreational harvest and stock status are available and signals of stock decline have reversed.

*The Committee **recommends** that no changes to recreational bag limits be considered without robust monitoring to quantify recreational harvest.*

Abalone life history renders them extremely vulnerable to serial depletion despite seemingly stable fishery metrics and there now are signals that serial depletion of the stocks may be reoccurring. The scarcity of monitoring and biological assessment information makes it difficult to detect serial depletion with certainty, notwithstanding provision of detailed diver and catch logging data. Absence of effective management to implement spatially-explicit allowable catches and size limits also means the fishery remains vulnerable to serial localised stock depletion such as apparently depleted the stock historically and now again may be contributing to declining stock productivity.

A revised management plan with specific fishery objectives and a formal harvest strategy are needed urgently to facilitate further development of this fishery. Such a strategy should include formal limits and targets that incorporate economic as well as biological considerations to guide future setting of TACCs and review of LMLs, which should be determined together. The lack of such a harvest framework, and robust monitoring and assessment information to support it, potentially has contributed materially to the lag in recognising what now appears to be emerging stock decline and continue to constrain TACC Determinations given the requirement to act within a precautionary approach.

6.2 Total Allowable Commercial Catch for 2019

The Committee was presented with a detailed report provided jointly by the Abalone Council of NSW and the Department that summarised available fishery-dependant information. Management and compliance reports also were provided by the Department.

The key factors in arriving at the Total Allowable Commercial Catch for 2019 (January–June) were:

- Confirmation formally by the Department that the Fishing Period for abalone will be realigned with financial years from July 2019 rather than the current calendar year periods, requiring a once-only Determination for the six month interim period of January to June 2019;
- Standardised catch rates of abalone, whilst strong, appear to be declining in most Areas;
- Sizes of abalone landed also appear to have declined recently, though there is some ambiguity in this conclusion related to the metrics used;
- Indicators of abalone stock biomass suggest recent reductions in most areas to levels present in 2011–13, representing approximately half of the biomass built since 2009–10;
- Estimates of stock surplus production indicate material reductions in productivity since about 2015 to levels below recent TACCs;

- There are clear circumstantial signals of localised depletion in some Areas, changes in fisher behaviours, and concerning changes in catch to stock biomass ratios;
- There remains an absence of clear objectives or a coherent harvest strategy to which TACC settings can be referred;
- There continues to be insufficient biological or economic monitoring data or any robust bio-economic assessment to inform tactical or strategic TACC settings for the fishery or, in particular, to assess the true status of stocks or their prognosis;
- Current management arrangements are not sufficient to enforce effectively spatially distributed catches recommended by either the Industry or the Committee;
- Consistent advice is that compliance in the fishery is improving, notwithstanding the (potentially misleading) statistics from successful targeted enforcement activities and suspected recent increases in illegal harvest for sale; and
- Industry opinion favours a cautious approach to TACC setting to protect stock status whilst the status of abalone stock remains uncertain.

The Committee accordingly has decided that the TACC should be 50 t for the period January–June 2019.

The Committee acknowledges that there is some risk in retaining harvest at this level in the face of very worrying emerging signals of declining stock productivity. The Committee reduced the TACC in 2018, however, knowing that there would some lag in its effects and the data available thus far are insufficient to verify whether that reduction was sufficient or should be increased. We therefore accept the risk that further reduction might be required on the basis that a robust analysis of data to March 2019 will provide relatively early insights to the effectiveness of this TACC. We stress, however, that there should be no delay in that assessment and the full-period TACC for 2019–20 should be determined before June 2019 based on those analyses.

The Committee's determination is influenced heavily by persistent uncertainties in many aspects of the fishery that could be improved by strategic reinvestment in robust bio-economic assessment, fishery-independent monitoring, and development of a credible harvest strategy.

6.3 The Determination

The Total Allowable Fishing Committee, pursuant to Division 4 of Part 2 of the Fisheries Management Act 1994, determines that the Total Allowable Commercial Catch of abalone that may be taken in the NSW Abalone Fishery during the period 1 January 2019 to 30 June 2019 should be **50 tonnes.**

The Committee also ***recommends*** a spatial distribution of that catch by Spatial Management Unit per Table 6.1 and implementation of effective methods to ensure that distribution is realised, or at least that no SMU catch-cap is exceeded.

Table 6.1: Recommended catch targets by SMU for 2019, January 1–June 30.

SMU	Recommended 2018 SMU catch (t)
1	5.0
2	20.0
3	12.5
4	12.5
Total	**50.0**

Bruce Mapstone, Chair

Kelly Crosthwaite, Fisheries Management

Sean Pascoe, Natural Resource Economist

Keith Sainsbury, Fisheries Scientist

APPENDIX 1. DETAILS OF PUBLIC CONSULTATION

Public consultation steps taken by the Committee, with support from the Department, are summarised in the table below. These steps effected the consultation requirements stipulated, *inter alia*, in the *Fisheries Management Act 1994, Part 2a, Division 2, S40.*

Date	Fisheries Management Act Reference	Consultation Stages
04.09.2018	Section 40F(1)	Committee called for public submissions on the appropriate level of the annual TACC for Abalone for 2019 fishing period.
12.09.2018	Section 284 (1b)	Advertisement calling for public submissions placed in the Sydney Morning Herald and the Daily Telegraph.
04.09.2018	Section 284 (1b)	Individual calls for submissions sent to particular interest groups who the Committee considered might wish to provide collective submissions either due to their direct involvement in the abalone fishery or their interest in related issues. These groups included: ■ NSW Abalone Shareholders; ■ NSW Abalone Fishery Nominated Divers; ■ Abalone Association NSW; ■ NSW Recreational Fishing Advisory Committee; ■ NSW Aboriginal Fishing Advisory Committee; ■ Professional Fishermen's Association.
02.10.2018	Section 284 (1b)	Public consultation closing date, after at least 30 days.
04–08.10.2018	Section 40F (1)	The Committee received the following collated submissions: ■ NSW DPI – Commercial Fisheries Management Report; ■ NSW DPI & Abalone Council NSW Research Report; ■ NSW DPI Compliance Report. ■ The Abalone Association of NSW No other written submissions were received from NSW abalone fishery shareholders, or other stakeholders.
10.10.2018	Section 40F (2)	The Committee considered submissions and heard formal presentations and opinions at the Total Allowable Fishing Committee Open Forum meeting in Sydney on 10 October 2018. The following made presentations to the Committee: ■ Ms Fiona McKinnon, NSW DPI (Management); ■ Mr Nick Schroder, NSW DPI (Compliance); ■ Dr. D. Worthington (Abalone Council of NSW, contracted provider of stock status report to DPI); ■ Mr John Smythe (The Abalone Association of NSW). The following people also attended the public forum: ■ Mr Michael Arentz ■ Mr Stephen Bunney; ■ Mr Simon Chan ■ Mr Ray Critchlow ■ Mr Greg Finn; ■ Mr Ryan Morris; ■ Mr Gunther Pfrengle ■ Mr Greg Ryzy ■ Dr Rowan Chick, NSW DPI (Research); ■ Mr Martin Hill, NSW DPI (Compliance). *Ms Kelly Crosthwaite (TAF Committee) was an apology.*

APPENDIX 2. SUMMARY OF SUBMISSIONS

No submissions were received from either the Abalone Association of NSW (AANSW), abalone fishery shareholders, or other stakeholders in the NSW abalone fishery.

Submission from	Issue(s) Raised
The Abalone Association of NSW	The Association canvassed widely across the fishery for shareholder input to the TAFC process and provided the submission on behalf of most shareholders. The Association supports making use of data loggers compulsory by all abalone divers. The Association supported work by Dr Jeremy Prince to estimate key variables for the abalone stock. (*The report from Dr Prince was provided to the Committee after the public forum and is considered elsewhere in this Determination report*). Association members had done, with researchers, a series of urchin reductions intended to promote (kelp) habitat enhancement or recovery, with evidence of success after just 6 months. The Association supports steps to identify Areas where abalone have 'stunted' growth for which a reduced LML might be appropriate. A draft approach to 'trialling' such steps was provided, including with suggested Areas and lower LMLs. The Association considers " *... the decline in fishery indicators has been halted and has begun turning in the right direction*" as a result of the 30 t reduction in TACC and increases LMLs applied in 2018. An increase in abundance of sub-legal abalone has been reported by some divers. The Association supports steps taken to improve compliance with fishery regulations, including stopping hanging of abalone. The Association is very concerned at evidence of organised poaching of abalone in large quantities and the very long times taken to bring alleged offenders before the courts.

APPENDIX 3. STATE OF THE STOCKS — DETAILS

A3.1 Introduction

The stock assessment report was produced by the Abalone Council of NSW and was endorsed by both NSW DPI and the Abalone Association of NSW. The report was prepared by Dr Duncan Worthington, Executive Officer of the Abalone Council of NSW, under contract to the Department and was co-badged by the NSW DPI and the Abalone Association of NSW.

Timeliness of report delivery to the Committee this year was good and the consistency and clarity of the assessment report continues to improve. The report this year showed a marked improvement in clarify of description, consistency of reported information, and impartiality of interpretations.

Consistency between the assessment and management reports also has has greatly improved. The consistent definition and rationalisation of spatial units in the fishery has significantly improved in particular, though there is still some unnecessary duplication and complexity in use of the historic and current units across the various reports to the Committee. Avoiding duplication of the same indicators (e.g. catch rate, mean weight) in both the management and assessment report is a useful simplification.

Both the assessment and management reports refer to the 2015 draft harvest strategy. The assessment report makes extended use of it in interpretations of performance against indicators and benchmarks in the draft strategy, including references to criteria from the Status of Australian Fish Stocks (SAFS) reporting program. The Committee strongly supports development of a harvest strategy for this fishery but the 2015 draft harvest strategy has not been adopted and its content should not be emphasised as though it has been. Recent developments in the fishery highlight the need for additional technical analysis and testing of indicator and reference point options for NSW before they are adopted formally in a management strategy with TAFC decision rules or guidance. It is clear that some previously used indicators and reference points (e.g. the 1994 conditions used as a benchmark in the Share Management Plan) are inadequate to protect the stocks and provide good fishery performance. The observed multi-year fluctuations in stock productivity provide important and additional complexity to both reference point and decision rule selection that has not been considered in the harvest strategy processes to date. The Committee again emphasises the need to finalise a robust harvest strategy but also emphasises that the 2015 draft harvest strategy is immature and should not be treated as if it were final or agreed.

The Committee considers the current and likely future status of the stocks in making its determination. Two main inputs provide the background for this year's consideration: the historical context for the status of stocks and the analyses of relatively recent years (2008–2017), prior to the current assessment.

A3.2 Background and Context

A3.2.1 Historical Context for the Status of the Stocks

Previous inferences about the status of the stocks provide a key context for the current interpretations and recommendations. Several previous findings remain relevant to this year's assessment – especially the multi-year periods of high and low productivity demonstrated in earlier assessments, the causes of historical overfishing that need to be avoided now, and the status of stocks in northern NSW (i.e., historical Regions 1 and 2 that were aggregated into the current Spatial Management Unit SMU 1).

The NSW abalone stocks historically suffered from significant over-fishing and over-depletion. The actions of the Committee since the early 2000s were a response to that, with the aim of rebuilding the stocks and preventing repetition of the previous over-exploitation.

The stocks showed significant evidence of over-depletion in the 1990s and early 2000s (Fig. A3.1) including:

- Serial depletion starting in the north of NSW in Region 1, exacerbated in the north by mortality from a severe outbreak of the disease *Perkinsus* in the late 1990s, and progressing south;
- Recruitment overfishing in Region 2 from the early 1990s;
- Onset of recruitment overfishing in Regions 3 and 4 in about the mid-1990s;
- All the well monitored Regions (2-6) showed increasingly 'spiky' patterns in catch rates and estimated recruitment indicating multi-year periods of high and low productivity, with progressively lower lows between the spikes with briefer and progressively lower highs (Figure A3.1); and
- The fishery harvest became highly dependent on abalone that grew over the Legal Minimum Length (LML) each year.

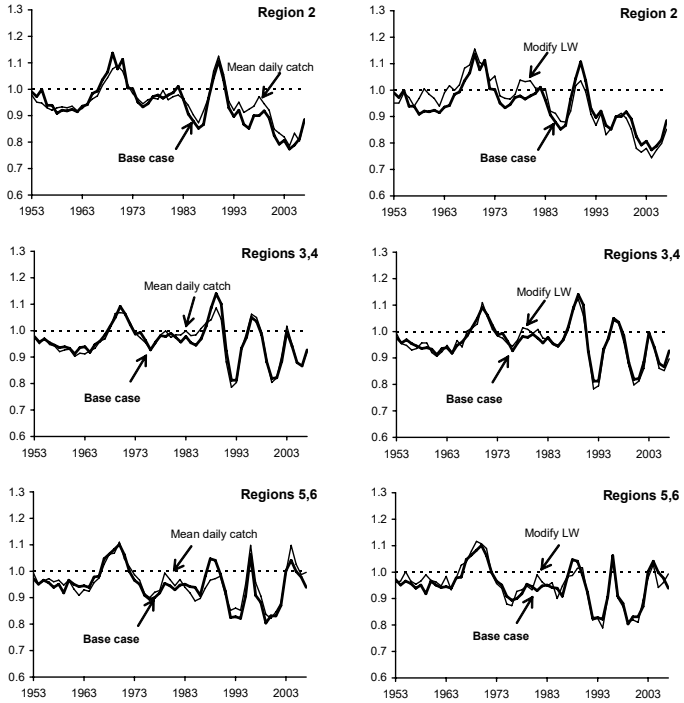

Figure A3.1. The pattern of recruitment estimated from the fitted population model in 2008, the last year of its application. Multi-year periods of high and low recruitment are evident, with high periods in about 1979, 1980, 1990, the mid-1990s, and the mid-2000s. Average recruitment since about 1990 in Regions 3, 4 and 5 and 6 has been lower than in the earlier period, with an increasingly 'spiky' pattern of recruitment in which different Regions showed different combinations of lower, and more persistent, lows and briefer highs. Decreased average recruitment in Region 2 started in about 1990.

The population modelling showed multi-year periods of high and low recruitment, but these are more appropriately interpreted as multi-year periods of high and low productivity. Changes in the rates of spat settlement, emergence from crypsis, growth, and natural mortality would all be interpreted through the model as changes in estimated recruitment. Overall this information indicated sequential depletion, a very high fishing mortality on abalone above the LML, a population that had lost most of its age structure and resilience, and a population with greatly reduced breeding potential because the high fishing mortality was applied with a LML that was relatively close to the size at reproductive maturity.

There also have been additional issues relating to the status of stocks in the northern part of NSW.

Region 1 North *(north of Port Stephens, Zones A-E, current Area 1 in SMU1)*

There was very little information available to assess the status of stocks in Region 1 north of Port Stephens. There was no Fishery Independent Survey in this area and there has been very little commercial fishing at any time since 1987, even when there were no regulatory restrictions on fishing there. It is not known whether, or to what extent, the stocks there were affected by *Perkinsus* that significantly reduced stocks in the southern portion of Region 1. Commercially targeted fishing was stopped in Region 1 North in 2002 but special catch allocations were made to allow structured collection of data to determine the extent of *Perkinsus* impacts, to support an initial assessment of the stocks, and to estimate a sustainable catch. Region 1 North was re-opened to targeted commercial fishing in 2010.

Region 1 South *(south of Port Stephens, Zones F-L, current Area 2 & northern part of Area 3 in SMU1)*

This area suffered a severe outbreak of *Perkinsus* in the late 1990s. There were relatively few Fishery Independent Survey sites in the southern portion of Region 1 but they all showed the death of 50-75% of abalone of all sizes. Some areas were closed to commercial fishing in 1996 and the whole of Region 1 South was closed in 2002. Fishery Independent Surveys following total closure showed continued low abundance and no recovery of the small or medium sized abalone. They showed an accumulation over time of increasingly large abalone, interpreted to be the survivors of the outbreak augmented by low recruitment. Fishery Independent Survey sites in Region 1 South were clustered in three southern areas – Port Stephens, Sydney, and Kiama (Zones F, J, K) – so there was concern about how representative these sites were of the whole region.

Trial fishing in Region 1 South during 2004 showed that it was possible to take large abalone at high catch rates from targeted sites, as was expected from the Fishery Independent Surveys. Information from that fishing, however, did not help assess the status of the stock or the extent of any recovery.

A more structured program of trial fishing was conducted in 2007 to test the change in status of the stock at pre-identified sites that had been productive historically. This program allowed comparison of the proportion of previously productive sites that remained productive, of the change in catch rate at those sites compared to catch rates in 1994, 1987, and 1982-85, and of the current catch rates at historically productive sites compared to sites chosen by divers in 2007 as being productive contemporarily. The general conclusions were:

i) About 36% of historically productive sites were still as productive as they were previously;

ii) 70-80% of historically productive sites had catch rates that were lower than those recorded at the same sites in 1994 or 1987;

iii) The northern Zones, between Pt Stephens and Sydney (Zones F, G, H; currently most of Area 2) had very low abalone abundance and a major loss of historically productive sites;

iv) The southern Zones, between Sydney and Wreck Bay (Zones J, K, L; currently southern Area 2 and northern Area 3) had considerably higher abalone abundance and had lost fewer historically productive sites than the northern Zones, with slightly more than half of all sites fished in these southern Zones having catch rates greater than was recorded at the same sites in 1994;

v) The median length of abalone taken was greater than 120mm for almost all sites; and

vi) The diver selected sites provided slightly higher catch rates than the pre-identified historically productive sites but did not materially change the overall results or conclusions.

These conclusions were consistent with the Fishery Independent Survey data in indicating that Region 1 South in the late 2000s supported some dense aggregations of large abalone, but that many historically productive sites still did not support dense abalone aggregations or significant numbers of small abalone despite several years of protection from fishing. The stock of legal sized abalone in the northern Zones (F, G, H) remained very depleted in 2007, while the stock of legal sized abalone in the more southern Zones (J, K, L) had recovered to 1994 levels at more than half of the sites fished.

The south Zones (Sydney to Wreck Bay) were re-opened to commercial fishing in 2010 and the northern Zones (Pt Stephens to Sydney) were reopened in 2012.

Region 2 (*Zones M-R or current southern Area 3 plus Areas 4, 5 and 6 in SMU 1*)

Region 2 was closed to commercial fishing in 2006 because of evidence of recruitment overfishing (Fig. A3.1). Average recruitment in Region 2 started decreasing in about 1995, including a decrease in the strength of recruitment in the 'pulse years'. The 1995–96 and 2001–02 pulses of increased recruitment and productivity were estimated to be very much weaker in Region 2 than in the more southern regions and were considerably weaker than was seen in Region 2 in the 1988–89 pulse. Special catch allocations were made each year following the closure of Region 2 to allow collection of data that would support an improved assessment of the stocks there, especially in relation to interpretation of recruitment overfishing. Region 2 was re-opened to commercial fishing in 2010.

3.2.2 Information and Analysis for 2008–2017 Assessments

The information available for stock changed considerably in 2008.

- The fishery assessments prior to 2008 were based on:
  - i) Fishery Independent Surveys of the relative abundance of different size categories of abalone, including abalone smaller than the LML for the fishery that provided a 'leading indicator' of recruitment to the fishery;
  - ii) Catch rate and weight composition from commercial fishing;
  - iii) Integrated analysis of this information through a length-based population model to estimate population size and recruitment; and
  - iv) Model prediction of the expected future trends in stock status under different levels of harvest.
- Fishery assessments between 2009 and 2018, inclusive, have included no formal scientific stock assessment or prediction of future stock condition. They primarily have relied upon interpreting trends in a small number of fishery-dependent indicators.
- Collection of fine scale data on fishing effort and catch, through the use of GPS-linked data loggers, started in 2008. The logger data allow estimates of catch per unit area searched, which is an indicator of relative population density that can be used to test the consistency of catch rates derived from logbooks. Logger data also allow estimation of the exploitable biomass and harvest fraction, which can be used as additional indicators for fishery assessment. The

performance and appropriate interpretation of these estimates has not been evaluated scientifically and reference points have not been developed or tested. Confidence in the logger-based indicators, however, has increased steadily through empirical experience. They have been used increasingly in the fishery assessment and management processes and have been a particularly important part of those processes in the last 4 years. The use of loggers has been a voluntary program, with logger use being 50–60% of the logbook fishing effort in 2014–15 and 2015–16 and 51% in 2016–17. Logger use in 2017–18 reduced to 30–40% of the effort recorded in logbooks. Logger use and reporting will be compulsory for all commercial abalone divers from 1 January 2019.

The information available to assess the status of stocks since about 2008 has been in a slow transition from the previous methods based on Fishery Independent Surveys, coarse scale data from commercial fishing, and population modelling to new methods that are cheaper and are potentially better. The new approach was based strongly on monitoring commercial catch rate from log-book returns and the mean weight of abalone in the catch, but also used fishery dependent fine scale data reporting through the GPS loggers. The previous methods were stopped, however, before the new methods were developed and shown to be adequate. Recent methods have been developed and variously applied through the annual assessment reports in an ad-hoc 'learn by doing' approach and the absence of any integrating population modelling increased the difficulty of interpretation of, prediction from, or validation of from these new methods. This has resulted in increased uncertainty about the state of the stock, increased uncertainty about the consequences of different catch levels, and the need for increased precaution in TACC setting. This approach has been both inefficient and risky, though confidence in the use of some logger indicators has slowly increased, albeit with material reservations in the absence of independent scientific review.

There now is heavy reliance on trends in commercial catch rate and average weight of abalone in the catch. Reliance on catch data has well-known problems, especially for abalone, which have highly aggregated populations that can be harvested selectively. The following are key issues in this fishery.

- The intent of the individually tradable quota management is for industry to innovate and change fishing practices to optimise economic returns in their dynamic biological and economic environment. These innovations and changed fishing practices can be expected to affect the indicators used for assessment, including the catch rate and mean weight of abalone caught.
- Commercial catch rate, particularly for aggregated areas and times, is notoriously 'hyper-stable' for abalone fisheries. High catch rates can be maintained for a time by targeting concentrations of abalone in known patches of preferred habitat or by searching faster even if the overall population is declining. Hyper-stable catch rates have been seen in the NSW abalone fishery at both Region and Sub-Region scales. Logger-based estimates of catch density (catch per unit area searched) can capture some, but not all, operational changes that result in hyper-stable catch rates (e.g., faster swims, short dives in unproductive areas).
- Catch rates and mean abalone weight in the catch are 'trailing indicators' that reflect what has happened, rather than 'leading indicators' of what will happen. They contain no information about numbers of sub-legal sized abalone that provide the future harvestable stocks. The available trailing indicators could be integrated through modelling to provide short term forecasts based on the current fishable stock and prospective TACCs, but this has not been done.
- The mean abalone weight in the catch is an ambiguous indicator. Increasing mean weight can be associated with balanced rebuilding of population size structure (a positive interpretation) or with reduced recruitment and fishing on the remaining large animals as they grow (a very negative interpretation). Conversely, decreasing mean weight can be associated with truncating size composition caused by high fishing mortality (a negative interpretation) or with recently increased recruitment giving many small animals in the population (a positive interpretation). The combination of mean weight with size-aggregated commercial catch rate, the main two indicators available in this fishery, are similarly ambiguous without additional information or judgements.

The current lack of size or age-based population analysis also precludes scientific examination of the LML that both optimises catch and provides adequate protection of the breeding stock. Consequently, this has been tested empirically in the fishery by applying small changes in allowable catch or LML and monitoring the results over subsequent years. This is inefficient because it does not make use of well-established scientific methods of prediction, slow because monitoring and measuring the consequences of each change before the next change can confidently be made takes time (years), and risky because mistakes are recognised only after their effects have occurred and become measurable.

Catch rate, mean weight, and biomass indicators all increased substantially as the stock rebuilt between 2006 and 2014. The indicators have plateaued in increasing numbers of Areas from about 2014,

however, and then decreased substantially in 2017. The abalone stock abundance by 2017 had decreased to about the level last seen in 2012–13. This stock decrease after 2014 mostly occurred at higher TACCs but generally similar harvest fractions to those that resulted in stock rebuilding during 2010–2014, though the harvest fraction in SMU 4 increased substantially in 2017 and there also was some increase in SMU 3. The biomass indicators and some preliminary surplus production calculations indicated that the main cause of the post-2014 stock reduction was reduction in population productivity, combined with only modest biomass increases during the rebuilding period 2010–2014 (despite large increases in indicators in that period), without compensating reductions in the recent TACCs. The Committee noted between 2014 and 2016 that "… *recent catches … have been taking most of the surplus production, leaving relatively little to contribute to further stock rebuilding*". That interpretation now appears to have been overly optimistic and instead catches through that time were beginning to exceed surplus production and lead to stock reduction.

A key issue in managing stock recovery, and preventing repeated overfishing is understanding and addressing what was wrong with the previous management settings. The Committee repeatedly has emphasised three issues important to that goal, in addition to setting an appropriate TACC for the fishery.

i) *Finer-scale management with finer scale monitoring and assessment*. Analysis and interpretation of logger data for stock assessment continues to improve and allow interpretations at finer spatial scales. Attempts to limit catch at finer spatial scales (e.g., at SMU and Area scales), however, have not been successful. Effectively regulating catch-caps at Area and SMU scales remains an important challenge to effect sustainable management of the fishery and avoid sequential stock depletion through unmanaged targeting of local populations.

ii) *Minimum Legal Lengths.* The fishery has a history of a relatively small LMLs compared to the those in other fisheries for the same species. The Committee has recommended for several years that a larger size limit be applied to the overall fishery in NSW, complemented by locally specific arrangements for areas where abalone growth is demonstrably higher or lower. There are several advantages of a higher 'default LML' which can be reduced selectively as appropriate, rather than low LMLs everywhere. In general, it protects population egg production by increasing breeding opportunities before abalone are subject to fishing. It also protects against localised overfishing of very productive abalone sub-populations that grow quickly, have a large size at first maturity, and reach large maximum size.

   The LML in NSW was 100mm in the 1970s, 108mm for most of the 1980s, 115mm for the 1990s and most of the 2000s, 117mm from 2008, 119mm from July 2018, and will be 120mm from 1 January 2019. The LML for SMU 4 was increased to 120mm in 2010, 123mm in 2012, and 125mm in July 2018. The recent LML settings are expected to be more appropriate for this stock.

iii) *Management Objectives.* The Committee has commented often that the benchmarks and reference levels used in the Share Management Plan and the Fishery Management Strategy were set at levels that did not adequately protect sustainability or achieve maximum productivity. Revision of these benchmarks and reference levels is necessary and should be grounded in scientific assessment of the biological productivity of the stocks, including multi-year periods of high or low productivity.

Previous reports have identified serious weakness in the current management situation. These include uncertainties about the robustness of the recent stock improvements, lack of leading indicators, lack of integrated assessment model interpretations and projections, and lack of benchmarks for overfishing and optimal fishing. It is neither appropriate nor possible in this situation for management measures to be based on detecting detailed nuances of population change. Rather, the indicators and information available are coarse and delayed so that management measures must be simple, speculative, and conservative. The recent stock declines demonstrate that the current management regime is not providing robust assessments and a stark illustration of the consequences of the above inadequacies.

A3.3 Information and Analysis for the Current 2018 Assessment

There were two primary sources of information available for the 2018 assessment:

1) logbook and related information from commercial fishing (including catch, catch rate, and mean weight of individuals in the catch) aggregated variously by Regions, Zones, Sub-Zones, Areas or Spatial Management Units (SMUs); and
2) fine-scale GPS data-logger information.

A3.3.1 Aggregate Catches, Catch Rates, Mean Weight and Mean Length from Logbooks

Catch and Catch Rates

The annual commercial catch and catch rate (CPUE in Kg/h) from logbook returns is shown for each SMU by year in Figure A3.2a and by month for the past 3 years in Fig3.2b. Catch rates are standardised for diver, area, and monthly effects and calibrated to the first year.

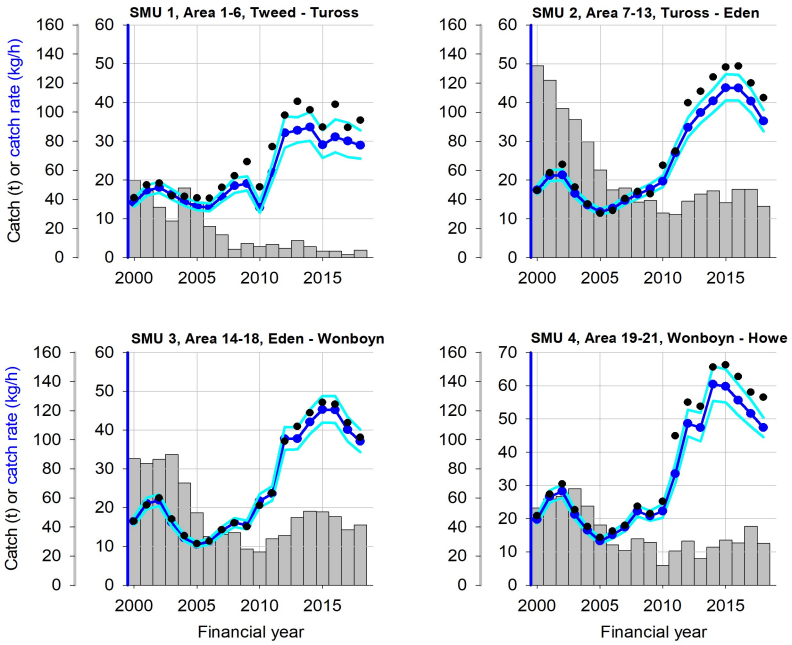

Figure A3.2a. Annual catch (histograms), nominal catch rate (black dots) and standardised catch rate (geometric mean in dark blue with 95% confidence interval in light blue) by year for each Spatial Management Unit (SMU). The standardization is for diver, area, and monthly effects and is calibrated to the first year (2000).

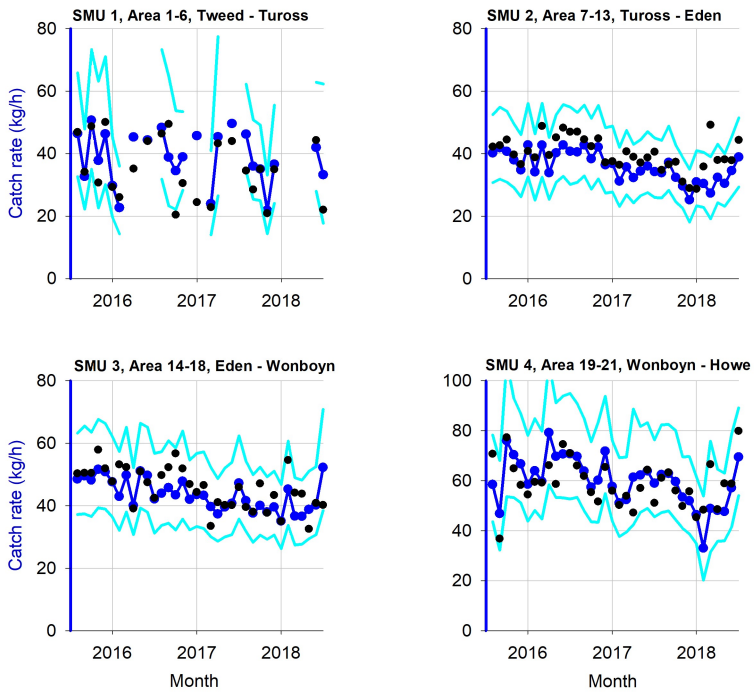

Figure A3.2b. Nominal (black dots) and standardised catch rate (blue dots and lines) by month for the last 3 years in each Spatial Management Unit (SMU).

There has been very little catch from SMU 1 during the last several years, including in the most recent year. Catch rate trends there likely reflect a few targeted areas rather than the SMU as a whole but, like

the other SMUs, the catch rate was low from 2000 to about 2010 then increased substantially before peaking in about 2013 decreasing slightly since then (Fig. A3.2a).

The trends in catch rate for the other SMUs are all very similar. Catch rates were low from 2000 to about 2010 and then increased substantially. All showed steady increases from 2010, followed by plateaus during about 2014–2016, and then marked decreases at about the same rate to 2018 (data to August).

Monthly catch rates (Fig 3.2b) during the last 3 years allow closer examination of recent trends and short-term fluctuations, including during 2018 since reduction in the TACC and increases in LMLs. All the significantly fished SMUs (i.e. 2, 3, 4) show steady deceases in standardised CPUE over almost all the time series followed by increases during the last 1-2 months (May, June) of 2018 data. This increase is less apparent in the nominal CPUE, however, indicating that operational details in the last months strongly affect interpretation and changes might or might not be well characterised in the standardisation. Nevertheless, the late up-swing might be an early indication of a return to higher stock productivity. That prospect will be clarified by future observations.

A complication to interpretation of recent trends in catch rate is that the area fished has contracted over the period for which area fished estimates are available and has decreased considerably since about 2014 (see Table A3.2). There has been a major long-term reduction in the catch, effort, and area fished in SMU1, but fishing area has also substantially decreased in the more consistently fished SMUs 2, 3 and 4. The estimated area fished in 2017–18 may be artificially low because of the relatively low logger coverage in SMUs 3 and 4. Logger use was higher and more consistent for the 3 years 2014–15 to 2016-–17, however, during which the area fished in those SMUs was 68% of the cumulative area fished for all years post-2009.

Contraction in the area fished can indicate sequential depletion but also operational constraints, and the causes are not clear from the information available. Such large contraction in the area fished, however, raises uncertainty about the degree to which the fishery catch rates represent the whole stock, including stock in areas not recently fished, or the true (relative) status of the stock. It effectively is not known , therefore, whether the areas unfished recently have lower abalone densities for whatever reason, and so were avoided, meaning that the trends in catch rates over-estimate relative abundance of the whole stock. This is not resolvable with the information available and remains a key uncertainty in interpreting recent catch rates. The same issues apply to estimating abalone density and biomass from logger data.

Mean Weight

Figure A3.3 shows recent trends in mean weight of landed abalone from logbooks and related reporting for each SMU. These mean weights are standardised to account for diver, area, and month effects.

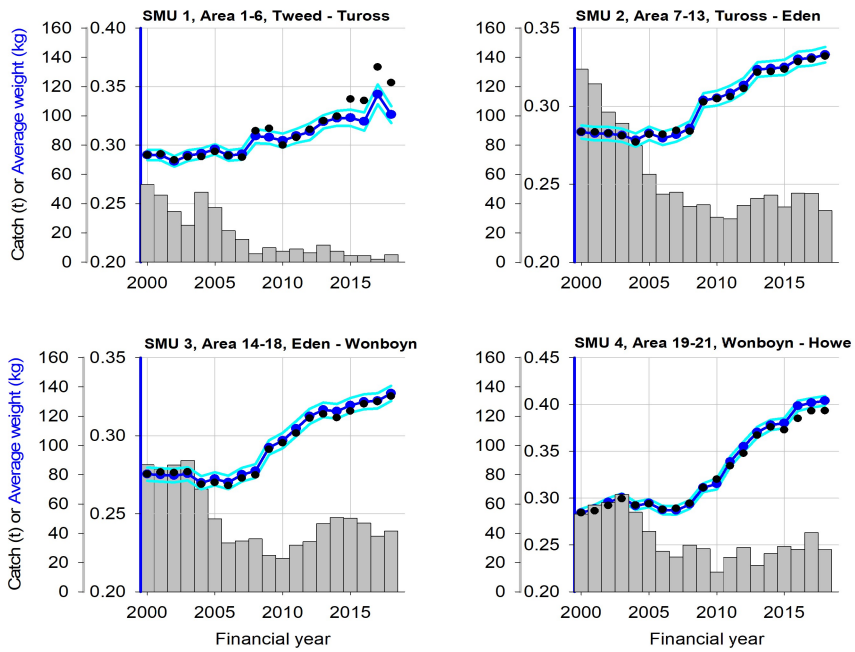

Figure A3.3. Recent trends in nominal (black dots) and standardised (geometric mean in dark blue with 95% confidence interval in light blue) mean weight by SMU calculated from logbook and related reporting. The overall LML was increased from 115mm to 117mm in late 2008 and in SMU 4 then increased to 120mm in late 2010 and to 123mm in late 2012.

There has been very little catch from SMU 1 during the last several years and mean weight trends from the log-book monitoring likely reflect a few targeted areas rather than the SMU as a whole (Figure A3.3). Mean weight in SMU 1 was low from 2000 to about 2008, similar to that in other SMUs, and has increased reasonably steadily since 2008.

The trends in mean weight from log-book records for SMUs 2, 3 and 4 are all very similar (Figure A3.3). Mean weights were low from 2000 to about 2008 then increased substantially. All these SMUs showed reasonably steady increases in mean weights that continued through to 2018, though SMU 4 may have experienced a plateau in mean weight over the last 2 years (Fig. A3.3).

Inconsistencies between the standardised and nominal mean weight calculations In last year's assessment resulted in discussion and uncertainty about the effects of standardisation and of changing practices in the monitoring programs, including changes in various conversion factors used to account for transport bin weights and the amount of water retained in the mantle cavity of abalone after harvest. This was more thoroughly examined for this year's assessment. The conclusion was that there have been multiple changes in the weight monitoring programs that could affect materially the mean weight estimate, but that these have been poorly documented and not calibrated. There should be continued effort to harmonise estimates from different sources but there are few data to do so. The effect of changed monitoring programs remains an uncertainty in interpreting mean weights from logbook and related data.

A different method of estimating the mean weight of abalone in the catch is from logger measurement of shell length of individual abalone and application of a length-weight relationship. Length measuring loggers are used to measure individual abalone (i) in processor facilities to a design intended to sample in proportion to the catch from each fishing Area, with records linkable to diver logbook reports, and (ii) at sea by divers on an *ad hoc* basis or as part of various structured fishing plans. These logger data are combined to estimate the mean length and weight of abalone in the catch, which includes a standardisation for year, SMU, Area, and diver effects. The average annual change in the weight of abalone in the catch, and the total change over the past 3 years, calculated from both the log-book monitoring and the measurement loggers are given in Table A3.1.

The mean weight estimates from logbook monitoring and measurement loggers give different trends over the last 3 years (at least). Estimates from logbook monitoring give increasing mean weight for all SMUs (particularly strongly for SMU 4) while estimates from the measurement loggers give decreasing mean weight for all SMUs (particularly strongly for SMU 2). The size of the difference between the estimates over (3-4%) is significant because mean weight is generally expected to be a relatively insensitive indicator. The difference in the estimates direction of change is important because increasing and decreasing mean weight have very different implications in the context of decreasing catch rate. In general, and for reasonably constant fishery selectivity:

- Decreasing catch rate combined with increasing mean weight (the pattern from the logbook weights, especially for SMU 4) is a symptom of significant recruitment decline; and
- Decreasing catch rate combined with decreasing mean weight (the pattern from logger weights) is a symptom of a general stock decline and also a negative signal, though arguably not as urgent or severe as recruitment decline.

There is no compelling reason from the information available to accept one mean weight estimate over the other because both are subject to unknown biases.

Mean weight is one of only a few primary indicators available in this fishery and it is of serious concern that its measurement and interpretation is in such doubt. It may not be possible to rectify or robustly interpret the historical information, but a robust and well documented monitoring program for the future should be established. Standardised widespread use of measurement loggers with properly ground-truthed length-weight relationships may be the easiest approach.

Overall Interpretation of Catch, Catch Rate and Mean Weight

The changes in catch rate and mean weight, as estimated from both log-book reporting and measurement loggers, are summarised in Table A3.1.

SMU 1 has received very little fishing and the fishery dependent data are not considered to be representative of the whole stock there. SMU 1 in effect is not reliably assessable with the information available. The information available, however, suggests some incremental improvement in stock status following many years of low fishing effort and catch and that, unlike for other SMUs, this improvement has been maintained post-2015.

There are consistent patterns in catch rate across the significantly fished SMUs 2, 3, and 4.

- Annual catch rates increased rapidly from about 2009 through to a plateau in about 2014–2016, after which they decreased substantially at about the same rate through to 2018.
- The cumulative reductions in catch rate over the past 3 years are substantial; about 20% in SMU 3 and 25% in SMUs 2 and 4. The 2018 catch rates for all these SMUs are about the same as they were in 2012. These general patterns are repeated at the Area spatial scale within SMUs.

Table A3.1: Changes in primary indicators of stock status, the log book catch rate and the average weight of abalone in the catch, for each Spatial Management Unit (SMU). The average annual change over the past 3 years and cumulative change over the past 3 years are given for each indicator. The average weight of abalone in the catch is calculated from the standardised logbook reported weight and numbers in landed bins as the primary indicator, but can also be calculated from logger measurement of individual abalone and application of a length-weight relationship.

	SMU 1	SMU 2	SMU 3	SMU 4
Average annual change in past 3 years				
Catch rate	+4.3%	-8.3%	-6.7%	-7.6%
Abalone weight (from logbook and related data)	+0.9%	+0.5%	+0.6%	+1.2%
Abalone weight (from measurement loggers)	N/A	-0.5%	-0.5%	-0.1%
Total change over past 3 years				
Catch rate	+13.8%	-26.5%	-21.3%	-24.0%
Abalone weight (from logbook and related data)	+2.8%	+1.5%	+1.9%	+3.8%
Abalone weight (from measurement loggers)	N/A	-3.0%	-2.7%	-0.5%

The patterns in mean weights of abalone in SMUs 2, 3, and 4 over the past 3 years are different for the different methods of monitoring them. Mean weights estimated from log-book data have increased while mean weights estimated from the measurement loggers have decreased. Stock status interpretation from this indicator consequently is very uncertain, though in combination with a decreasing catch rate all interpretations are negative.

Interpretation of catch rate and mean weight indicators is complicated further by the increases in LML in recent years. The expected initial effect of increasing the LML is to increase mean weight of landed individuals and to decrease catch rate, but there is no analysis or modelling to estimate the size of this effect or help separate underlying trends in stock status from transient changes. The catch rate and mean weight indicators overall, however, suggest a substantial and continuing deterioration in stock status since about 2014 and that current stock conditions are approximately as they were in 2011 or 2012. The only positive sign is some indication that catch rate increased in the last 1-2 months of 2017–18 year, the most recent data included in this assessment. Confirmation and persistence of this up-swing through coming months would suggest the beginning of a period of increased productivity but further declines would suggest the recent measures taken to arrest stock deterioration were insufficient.

Arrangements to implement Area-based and SMU-based catch targets and limits are important to manage to avoid repetition of localised and sequential depletion. Spatial catch targets and limits have been identified previously, both by Area (by industry and previously by the Committee) and by SMU (by the Committee last year) but it is apparent that voluntary limitation of catches within the intended spatial ranges has not been successful. Considerably more catch than intended has been taken from some Areas over several years while persistently less has been taken from others. Reported catches to 3 October in calendar year 2018 were almost ¾ of the annual TAC but catches were substantially below the target for SMU 1 and 2, already over the target in SMU 3 (with industry comment that further catches would be made) and about as expected to meet the target in SMU 4 (but with catches in some Areas within SMU 4 already over their targets). The Committee intentionally set a low catch for SMU 3 because of the apparent very low stock productivity there in recent years, and for SMU 4 because catches there have exceeded recommended levels for several years despite industry and Department support for spatial catch caps.

A3.3.2. Fine Scale Data and Interpretations

All divers in the fishery have access to GPS data-loggers though not all divers operate them on all fishing days and there are occasional equipment failures. The 2017–18 logger data for the current assessment

covered 36% of logbook diver hours. The 2017–18 logger use in SMUs 1 and 2 was high and similar to historical levels, but use in the southern SMUs was about half the historical levels, at 23% in SMU 3 and 29% in SMU 4. Logger use each year from 2009–10 to 2016–17 covered 60–77% of logbook diver hours and was similar across SMUs. The reduction in use for the southern SMUs in 2017–18 considerably increases uncertainty of interpretations based on logger data there and was apparently a result of diver choice. The data-logger information increasingly is critical to assessment of the fishery, especially in the absence of any robust stock assessment modelling or fishery-independent monitoring.

Logger data were used to calculate abalone density (Kg/Ha), the area of productive reef fished (Ha), biomass (t) and harvest fraction (catch/biomass). Preliminary analysis used in last year's assessment were extended this year to use biomass estimates to estimate surplus production each year from 2000. Logger data also were used to calculate several indicators related to diving operations, including searching rate (Ha/h), the area covered per dive, the frequency of short dives, dives per day, and spatial overlap of dives. The use of logger data for to estimate these variables is relatively new and evolving. Relative trends from logger analysis are likely to be more reliable than the estimated absolute values, particularly for biomass, harvest fraction, and surplus production estimates. Experience with the logger-based indicators has been very promising and the estimates have been intuitively reasonable but it must be stressed that the reliability of logger-based estimates has not been tested or demonstrated rigorously.

Abalone density (Kg/Ha) was calculated from logger data for each SMU and for most Areas for the period 2010 to 2018. These density estimates should proportional to biomass under the assumptions of representative observations and constant habitat area. Two methods of standardising the density estimates were used; one standardised to the average (or 50%) diver and the other to an above average diver in the 70th percentile of performance (70% diver). Standardising to the 70% diver is considered the most appropriate because this gave results very similar to the density measured by fishery independent surveys in some southern reefs in 2013. Both time series of standardised density estimates were then calibrated to the fishery independent surveys. The 'base case' abalone density estimates used the 70% diver standardisation and are shown by SMU in Figure A3.4.

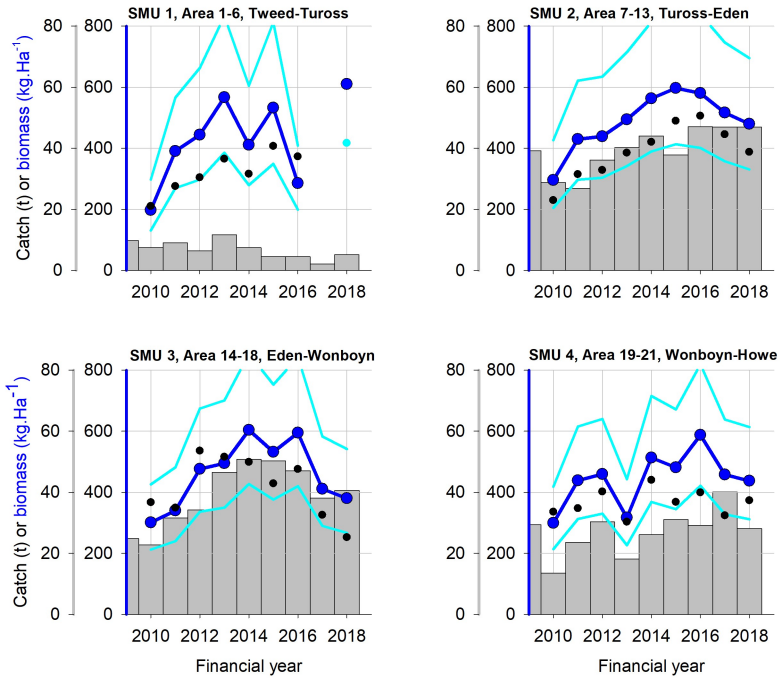

Figure A3.4. Density (Kg/Ha, blue dots and lines) of legal sized abalone for each SMU calculated from the GPS logger data using the 70% diver standardisation and calibrated to the scientific surveys of some southern reefs in 2013 . The pale blue line gives the 50% confidence interval for the standardised density and the black dots give the unstandardised density. Data were standardised for diver and site effects.

The density indicators for all SMUs show a recent and very substantial decrease in stock abundance. The decreases in density between the year of each SMU peak and 2018 were 25% (from 2015) in SMU 2, 35% (from 2014–16) in SMU 3, and 30% (from 2016) in SMU 4. Densities in SMUs 3 and 4 have reduced levels last seen in about 2011, while density in SMU 2 has reduced to that last seen in about 2013.

Comparison of the time series of commercial catch rate (Kg/h, Figure A3.2) and logger-based density estimates (Kg/Ha, Figure A3.5) by SMU indicates these two indicators of abalone density show substantially the same patterns, including that recent abalone abundance has been reduced to the level last seen in about 2011–13. This agreement increases confidence in both indicators. Both indicators show increasing stock abundance in all SMUs from 2010 to 2014–16 followed by substantial decreases to the present. The patterns for both indicators in 2017–18 are similar for SMUs 3 and 4, implying that the logger observations are reasonably representative of density there despite reduced logger use. The main discrepancy is that the logger data indicate a smaller reduction in density in SMU 4 during 2017–18 than logbook data. Reduced logger use may have resulted in positive bias in logger-based density for SMU4.

Comparing logbook catch rate with logger density estimates allows detection of hyperstability in commercial catch rate caused by some operational changes (e.g. in search speed). It cannot detect other causes of hyperstability, however, such as spatial effort selection or abalone size selection, which are not detectable through fishery-dependent observations. The similar patterns in catch rates and logger-based density estimates throughout the time series for SMUs 2 and 3 indicates no detectable hyperstability at the SMU level. Logger-derived estimates of density, productive area, and biomass are in Table A3.2.

The biomass in this analysis is estimated by multiplying a constant productive area by the density for each SMU, and so does not include the possibility of changes in productive area through time. Differences in the productive area assumption change the absolute values of estimated biomass (also the estimated harvest fraction and surplus production) but not the temporal pattern of relative change for each SMU. Consequently, the temporal pattern of estimated biomass is the same as for estimated density (Figure A3.4) and so is not further interpreted.

The productive area estimate is intended to reflect the area over which it is reasonable to extrapolate the current density to give an estimate of total biomass. Two extreme assumptions are that the current density applies only to the area currently fished or that the current density applies to all areas ever fished. The same two assumptions also arise in interpreting commercial catch rate data as an index of abundance if the fished area changes. Two productive area estimates have been used previously for biomass estimation: (1) the cumulative area fished in the most recent 3 years, which is interpreted as reflecting recent production patterns in the fishery; and (2) the cumulative area fished since 2009, when the logger program was introduced, and which is interpreted as an upper bound.

The low logger use in SMUs 3 and 4 in the 2017–18 reduces the reliability of the estimated area fished there in the most recent year. Logger use in SMU2 has been consistent over several years and shows reduction in the area fished in 2017–18 to about 2/3 of the area fished in the previous two years. The logger data for SMU 3 shows a similar reduction in the area fished in 2017–18, so the logger data from SMU 3 in 2017–18 may be representative of the areas fished despite the reduced logger use if fishing behaviours were similar in SMU 2 and SMU 3. Fishing area in SMU 4 in 2017–18, however, is about 1/3 of that in previous years, which seems an unreasonably large reduction given the level of catch from SMU 4. It seems likely that the estimated area fished in SMU 4 in 2017–18 is too low because the reduced logger use there was not representative of general fishing behaviours. Including estimates of area fished in SMU 4 in 2017–18 to calculate the productive area therefore is expected to produce overly pessimistic results. Nonetheless, the information available, including from the more consistently covered SMU 2, suggest that areas fished in SMUs 2, 3, and 4 in 2017–18 were lower than those fished in the previous few years. Three methods were used to capture the likely range of recent productive areas in the fishery.

- The cumulative area fished in the 'most recent 3 years' that was used in the 2017 stock assessment (i.e. 2014–15, 2015–16 and 2016–17). This is the 'base case' and will produce optimistic results for 2017–18 if there has been a reduction in productive area in 2017–18.
- The cumulative area fished in the current most recent 3 years (i.e. 2015–16, 2016–17 and 2017–18). This method is likely to produce pessimistic results if the reduced logger use in 2017–18 is unrepresentative and underestimates the area fished in 2017–18, particularly for SMU 4.
- The cumulative area fished since 2009. The area fished in the most recent years is much smaller than the cumulative area fished since 2009 for all SMUs. This method is likely to be optimistic to the extent that some areas previously fished are no longer productive.

The estimated biomass and harvest fractions for the assessment base case interpretation (i.e. density standardised to the 70% diver combined with cumulative area fished in the last 3 years as used in the 2017 assessment) are shown in Figure A3.5.

Table A3.2. Estimated density (A), total area fished (B), and total biomass (C) for legal sized abalone in each SMU estimated from logger data each year since 2009–10. Density (A) and biomass (C) were not calculated for SMU1 in 2017 because of the very low fishing effort there.

(A) Density (Kg/Ha) estimates for two data standardisations: standardised to the catch and area fished by the 'average (50%) diver' (left number) and standardised to the '70% diver' (right).

	Density (kg/Ha)			
Year	**SMU 1**	**SMU 2**	**SMU 3**	**SMU 4**
2009–10	197–215	296–322	301–328	299–326
2010–11	390–425	430–468	340–371	438–478
2011–12	444–483	439–478	476–519	459–501
2012–13	566–617	494–538	495–539	317–345
2013–14	411–448	563–613	604–658	513–559
2014–15	532–580	597–650	532–580	481–524
2015–16	285–311	580–632	595–648	587–640
2016–17	NA	517–563	411–448	458–499
2017–18	610–664	480–523	380–414	437–476

(B) Five estimates of productive area based on: cumulative area fished in all years since 2009; cumulative area fished in all years for which there are logger data, including some pre-2009; cumulative area fished in the 'last 3 years' used in the 2017 assessment (2014–17); cumulative area fished in the 'last 3 years' used for the 2018 assessment (2015–18); and area fished in each of the last 3 years.

Note: Areas given here for "Last 3 years 2017" for SMU 3 & 4 differ from those given in the 2018 assessment report. The values here are those from the 2017 report and are the correct values, used to calculate all other derived indicators (D. Worthington, pers. comm.).

	Estimated Productive Area (Ha)			
Basis of Estimate	**SMU 1**	**SMU 2**	**SMU 3**	**SMU 4**
All years	801	1323	757	444
All years + pre '09	1139	1362	766	446
Last 3 years, 2017	225	837	552	325
Last 3 years, 2018	145	816	527	286
2015–16	102	525	325	163
2016–17	13	575	360	216
2017–18	43	386	245	70

(C) Estimates of biomass for a range of combinations of density standardisation (A) and productive area estimates (B). The 'base case' biomass estimate is outside the brackets and is for density standardised to the 70% diver combined with the cumulative area fished in the last 3 years used in the 2017 assessment. Inside the brackets are the 70% standardised density combined with (on the left) area from the last 3 years of the 2018 assessment and (right) the area from all years since 2009 combined.

	Calculated Biomass (t) (Density x Area)			
Year	**SMU 1**	**SMU 2**	**SMU 3**	**SMU 4**
2009–10	48 (31–172)	270 (263–426)	181 (173–248)	106 (93–145)
2010–11	96 (62–341)	392 (382–620)	205 (195–281)	155 (137–212)
2011–12	109 (70–387)	400 (390–633)	286 (274–393)	163 (143–222)
2012–13	139 (89–494)	451 (439–712)	298 (284–408)	112 (99–153)
2013–14	101 (65–358)	513 (501–812)	363 (347–498)	182 (160–248)
2014–15	130 (84–465)	544 (531–861)	320 (306–439)	170 (150–233)
2015–16	70 (45–249)	529 (516–837)	358 (341–490)	208 (183–284)
2016–17	NA	471 (459–745)	247 (236–339)	162 (143–221)
2017–18	149 (96–532)	437 (426–691)	229 (218–314)	155 (136–212)

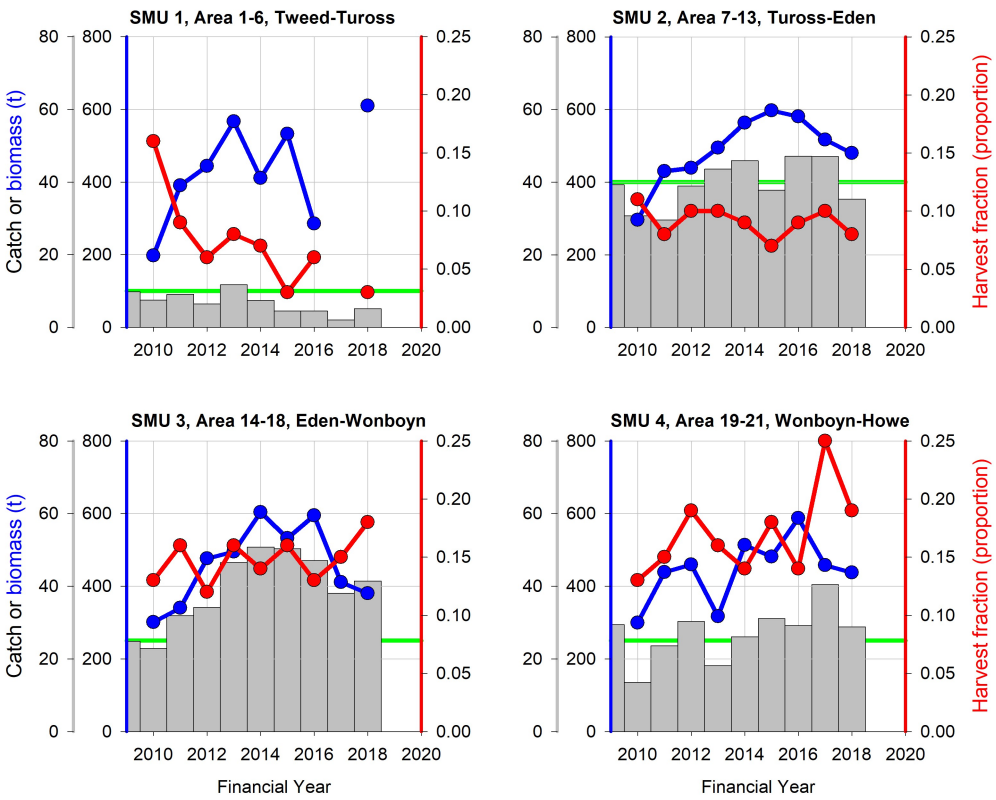

Figure A3.5. The biomass and harvest fraction (catch divided by biomass) estimated from logger data year since 2009–10. These are calculated for the 'base case' scenario: density standardised to the 70% diver and cumulative area fished over the 'last 3 years' in the 2017 assessment (2014–17).

There is a consistent gradient of low to high harvest fractions from northern to southern SMUs, though their temporal patterns differ among SMUs.

- The estimates in SMU 1 are considered to be unreliable because they are based on very small catches of questionable representativeness. They nonetheless show a consistently low harvest fraction that is feasible. Future analysis in SMU 1 should relate the spatial densities from the data loggers with the earlier scientific monitoring locations and the experimental fishing sites in Region 1 (south) in 2007 to examine any recovery and determine harvest potential there.
- Harvest fraction in SMU 2 has been about 7–10% since 2010, and the estimate for 2017–18 remains within this range. The stock was rebuilding between 2010 and about 2015 but since then the biomass has reduced significantly, all within the same range of harvest fraction.
- Harvest fraction in SMU 3 varied between 12–16% during 2010 to 2017 then increased to 18% in 2018. The stock was rebuilding until about 2014, was about stable from 2014 to 2016, and then substantially decreased during 2017 and 2018.
- Harvest fraction in SMU 4 varied between 14–18% during 2011 to 2016, substantially increased in 2017, and declined slightly further in 2018. Stock rebuilding occurred until about 2016.

There was a pattern of stock rebuilding from 2010 until 2015 or 2016 for all the substantially fished SMUs (2, 3, 4) followed by plateauing and subsequent decline during the last about 3 years. The cessation of stock recovery and the onset of decline during about 2014–2016 occurred under estimated harvest fractions very similar to those previously associated with recovery. The biomass in SMUs 2, 3, and 4 have continued to decline during the past 2–3 years. Harvest fractions were particularly high for SMU 3 in 2018 and for SMU 4 in 2017 and 2018.

Changes in productivity have been examined more directly through calculation of the annual surplus production by SMU from 2000 (Figure A3.5). Annual surplus production is calculated from the estimated biomass at the end of each year minus the biomass at the beginning of that year plus the catch taken during that year. Biomass estimates from 2009 are from the base case interpretation of the logger information. Estimates for 2000–2008 are from the standardised logbook catch rate calibrated to the post–2009 logger biomass estimates.

The surplus production estimates show several significant patterns.

- All SMUs had relatively high productivity in the first years of estimation, 2000 and 2001. There are no earlier estimates available for comparison but this is consistent with a common comment by those with a long history with the fishery that the fishery was more productive historically.
- The recent estimates for SMU 1 are likely to be unreliable because of the reduced fishery activity there but there is an overall decrease in productivity suggested over the time series.
- SMU 2 and SMU 3 show similar patterns, with relatively low productivity 2002–2008, higher productivity from 2009 to about 2013 or 2014, then an abrupt decrease in productivity in 2015 to very low levels that persist to 2017–18. The recent decrease is particularly severe in SMU 3, which shows close to zero surplus production each year since 2015.
- SMU 4 also had relatively low productivity between 2002 and 2008 but had some years of high productivity during 2009–14 (2009, 2010, 2014) and other years of relatively low productivity. There was an abrupt decrease in productivity in 2015 which has persisted to 2017–18

There has been an overall reduction in stock productivity since 2000, overlaid with multi-year periods of higher or lower productivity. Stock productivity for all the SMUs where estimates seem reliable (SMUs 2, 3, 4) was relatively high during 2009–14 when rebuilding was evident. Stock productivity then decreased abruptly and considerably in 2015, associated with stock decreases at harvest fractions similar to those previously associated with rebuilding. This low productivity has persisted through to 2017–18, with the productivity of SMUs 2, 3 and 4 in 2017–18 all at their lowest on record.

The relative trends in estimated surplus production are expected to be more reliable than the absolute values. Variation through time in the estimated absolute values is large, however, and in each of the last 3 years the estimated absolute surplus production is much less than the set TACCs:

Mean annual surplus production 2003–08 = 153t, TACCs 105–281t;
Mean annual surplus production 2009–2014 = 221t, TACCs 75–125t;
Mean annual surplus production 2015–2017 = 55t, TACCs 130t.

It was known From earlier assessments that multi-year variation in productivity has occurred in this stock (Figure A3.1). One of the Committee's explicit intentions in setting precautionary catch levels has been to prevent stock depletion during periods of low productivity, but the recent decreases in productivity have been greater than anticipated and only clear in retrospect, meaning that recent TACCs have been set at levels above the (unknown) stock productivity. This situation highlights one of the consequences of a lack of robust monitoring and stock assessment modelling for the fishery that mean the appropriateness of each TACC can be assessed only in hindsight.

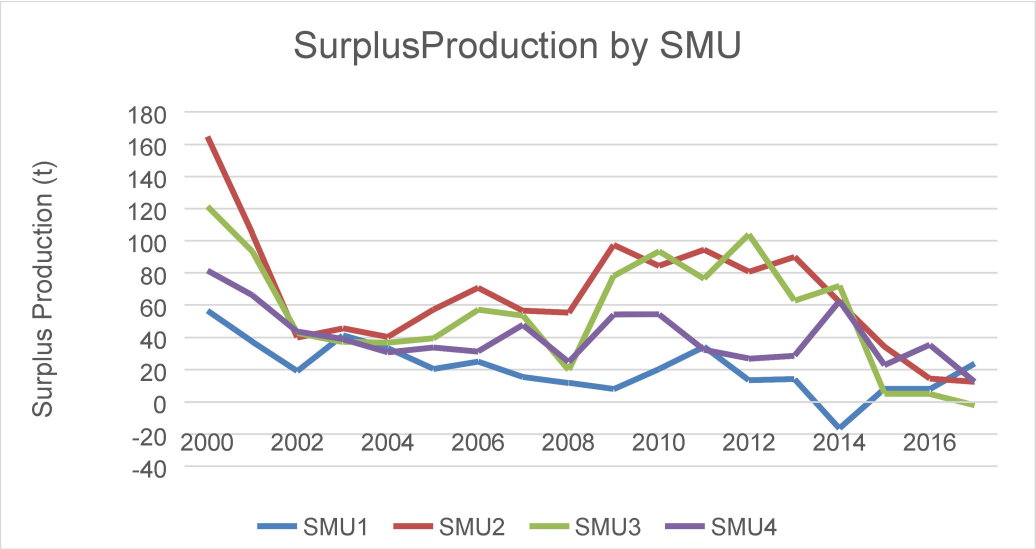

Figure A3.5. Annual surplus production by SMU from 2000 to 2017.

Harvest fractions for common fishery management objectives (e.g., maximum sustainable yield, MSY) have not been calculated for NSW abalone. Victorian experience with this species suggests harvest fractions of about 10–15% are likely to allow rebuilding after stock depletion. Harvest fraction in SMU 2 have been within this range since 200, whilst those for SMU 3 have been at the high end of or slightly above the range for most years and significantly above it in 2018. Harvest fractions in SMU 4 mostly have been above the suggested range, significantly so 2017 and 2018.

The NSW fishery is more complex than that in Victoria because: (i) there is a strong north–south gradient in productivity, and hence the appropriate harvest fraction, in the NSW fishery; and (ii) there are strong multi-year changes in productivity within each SMU. Both have important implications for interpretation of current stock status, spatial management including appropriate spatial catch limits, fishery reference points, and the appropriate (yet to be delivered) harvest strategy.

This analysis illustrates the potential value of the fine scale data and their analysis, notwithstanding that the methods are not yet well developed or verified. Analytical methods are becoming more standardised from year to year, however, allowing cross-comparison with more standard indicators (e.g., logbook catch rate and mean weight) and allowing exploration of some of the key questions of stock recovery and sustainability. The Committee strongly supports use of finer-scale information for assessment and management of the fishery, and development of verified, robust indicators for routine application.

A3.3.3. Length-Based Spawner Potential Ratio analysis

A preliminary application of length-based Spawner Potential Ratio (LB-SPR) analysis was completed this year for two Areas [17 (Green Cape–Disaster Bay) and 21 (Cape Howe)] of the fishery by Dr Jeremy Prince in collaboration with some industry operators. One figure of the report was presented by the Fishery Manager to the Committee during the October public forum, but discussion was limited without access to the methods. A report was circulated later to the Committee for consideration.

SPR is the ratio of the expected reproductive output of a fished population to that of an unfished population (or that ratio for an average individual in such populations). The SPR ratio measures the reduction in spawning potential caused by fishing. An SPR of 0.2 is a common reference point considered to indicate recruitment overfishing. The method also allows estimation of the ratio of fishing mortality to natural mortality, which is a common indicator of fishing pressure or harvest fraction.

SPR is commonly calculated from the age structure of the catch, but LB-SPR is a length-based method. The method requires measuring the size composition of the catch and specifying several population parameters (length at maturity and variability in growth) and key ratios (natural mortality rate, growth rate, length at maturity, and asymptotic length). The estimation assumes a population at equilibrium and so does not reflect transient effects such as the recent change in LML (though it can be used to predict the long-term effects of changed LML). The results will be biased if the population is increasing or decreasing at the time of application (e.g. if pulses of particularly high or low recruitment are passing through the population).

Prince used in-situ length sampling of all emerged abalone (including those below the LML) in September 2018 to estimate the length at maturity. The length compositions of commercial catches from two divers were used for LB-SPR calculation in most years from 2010 to 2018.

The results of Dr Prince's work indicate that stocks in both Areas analysed have very high exploitation rates and are significantly depleted. The ratio of fishing mortality to natural mortality was estimated to be in the range 4–6 in most years, and to have increased markedly in Area 21 in the past 2 years. This implies a very high harvest fraction that is about double the highest value estimated from the logger-derived biomass. The SPR is estimated to be in the range 0.2–0.3, with the estimates decreasing towards 0.2 in both Areas over the past 3 years. The SPR analysis indicates that the recently higher LML is important in maintaining the SPR, despite the very high exploitation rates, through protection of some mature size classes.

This LB-SPR analysis provides useful information but is clearly preliminary. It does not fully consider the estimation or interpretation uncertainties, and it is applied to just two Areas in the fishery. It nonetheless clearly demonstrates the ease of application of the method to readily accessible data and provides the first recent estimates of absolute stock depletion in relation to commonly used reference points. The trends in exploitation rate and depletion estimated from LB-SPR are similar to those from other indicators but the absolute values of the harvest fraction from LB-SPR indicate much higher fishery impact. This discrepancy requires further examination because even if approximately correct the LB-SPR values imply that serious overfishing has been occurring since about 2000. Further development and application of LB-SPR analysis would be a useful contribution to assessment of the fishery.

A3.3.4. Illegal, Unreported, and Non-commercial Catches

The level of illegal, unreported, and non-commercial (recreational and Aboriginal) catch, and trends during the history of the fishery, remain very uncertain. The Committee was informed that recent recreational catch was likely to be unchanged and less than 10t. An aggregate catch for Aboriginal fishing was not provided specifically but the Committee was advised that legal harvest by Aboriginal fishers was

estimated to be very low and consistent with permitted catch. The recent implementation of Aboriginal cultural fishing permits is not considered to have caused a significant increase in Aboriginal legal catch.

The illegal and unreported catch in previous years has been assumed to be 40% (40t) of the legal and reported catch in 1987 (102t from Regions 2-6). General impressions from compliance officers and Industry are that the illegal catch probably was about 100t per year last century, that it was likely to have been below 100t but above 50t by 2008, and to have been about 20–40t per year from about 2010. It is considered to have been trending down and in the lower part of that range between 2010 and 2013, and to have been trending up and in the upper part of the range since then, particularly since about 2016.

There are no reliable data available to test these impressions, but illegal catch is considered to have been about 20-40t since about 2010. It is recognised that there is likely to have been some increase in illegal catch in recent years but it is unlikely to have exceeded 40t or impacted materially stock sustainability.

Some changing illegal fishing practices have been raised with the committee in the past 2 years. These include serious localised depletion caused by very high illegal fishing mortality across all sized abalone in targeted areas. Abalone have very low dispersal and are very slow to recolonise and recover from near total removal from an area, as illustrated by the disease impacts in northern NSW and in parts of Victoria. Small-scale occurrence of such fishing practice, while locally very damaging, would not be expected to quickly compromise the overall stock and fishery at the level of illegal catch currently considered likely in NSW. The practice is reported to be increasing, however, and could give rise to cumulative sequential depletion if persistent or expanded. Addressing this is a need recognised by NSW compliance officers.

A3.4 Conclusions

There was a substantial improvement in the state of the stock starting in about 2006, and particularly since about 2009, through to about 2015. The reduced TACC and increased LML since the mid-2000s, when those management interventions began succeeded in that stock rebuilding. This is demonstrated by the substantial increases in catch rate, abalone density, abalone biomass, and mean weight of abalone for all SMUs over that period, with an about doubling of exploitable biomass during 2009–14.

Rebuilding has not persisted, however. Recent changes in catch rate, biomass, and mean weight indicators are summarised in Table A3.4. All significantly fished SMUs (2, 3, 4) show decreases in stock abundance since about 2015, with the decrease continuing through to 2017–18. Stock abundances in SMUs 3 and 4 have been reduced to the levels last seen in about 2011, while stock abundance in SMU 2 has reduced to that last seen in about 2012. Harvest fractions have been particularly high for SMU 3 in 2018 and SMU 4 in 2017 and 2018. Further deterioration of stock status is expected if such levels persist.

The mean weight indicator is intrinsically ambiguous in the context of decreasing catch rates and its estimation through different monitoring programs is inconsistent, but all interpretations of this indicator nevertheless are negative to different degrees.

Table A3.4: Recent changes in primary indicators of stock status (catch rate, size of abalone caught) and an index of harvestable biomass (stock density) in each (SMU). Average *annual* changes over the last 3 years (top) and *total* changes over those 3 years (bottom) are presented.

Average *annual* change in past 3 years	SMU 1	SMU 2	SMU 3	SMU 4
Catch rate	+4.3%	-8.3%	-6.7%	-7.6%
Index of biomass	+113.0%	-8.7%	-18.0%	-12.8%
Abalone weight (logbook and related data)	+0.9%	+0.5%	+0.6%	+1.2%
Abalone weight (measurement loggers)		-0.5%	-0.5%	-0.1%
***Total* change over past 3 years**	**SMU 1**	**SMU 2**	**SMU 3**	**SMU 4**
Catch rate	+13.8%	-26.5%	-21.3%	-24.0%
Index of biomass	+227.0%	-17.4%	-36.1%	-25.6%
Abalone weight (logbook and related data)	+2.8%	+1.5%	+1.9%	+3.8%
Abalone weight (measurement loggers)		-3.0%	-2.7%	-0.5%

The surplus production estimates suggest that stock productivity has declined overall in a long-term trend since about 2000, and that this decline is overlaid with multi-year periods of higher or lower productivity. Stock productivity for SMUs 2, 3 and 4 in particular has decreased abruptly and considerable since about 2014, to levels in 2017–18 that are the lowest on record.

One of the Committee's explicit intentions in setting precautionary catch levels has been to prevent stock depletion during periods of low productivity, but the recent decreases in productivity have been greater than anticipated and only clear in retrospect. The absolute values of surplus production are uncertain but estimated annual production in each of the last 3 years has been considerably less than the TACC in those years, and less than the 100t TACC applied in the 2018 calendar year. Estimated surplus production in SMU 3 has been particularly low in each of the last 3 years. The recently elevated harvest fractions in SMU 3 and SMU 4, and the apparent inability to keep the catches within the recommended targets for these SMUs, therefore are of particular concern.

The only positive signal from the available indicators is a small increase in the monthly standardised catch rate during last 1-2 months of the 2017–18 financial year. This increase is less apparent in the nominal CPUE, however, suggesting that interpretation is affected by operational details in these last months that may not be well accounted for in standardisation. Nevertheless, these recent data could be indicating a return to higher stock productivity or a reflection of the effect of the reduced 2018 TACC, which will be clarified only with future observations.

A widespread decrease in stock productivity in about 2015 is concluded to be the main cause of the recent deterioration in the abalone stock status. The following other factors, however, also might have contributed to this outcome.

1. *The impact of a major storm in southern NSW in June 2016*. The decrease in productivity began in from about 2014 or 2015 and was very widespread across at least SMUs 2, 3 and 4, so is not explained by this storm. The storm, however, may have exacerbated locally the effects of the combination of decreased productivity and a TACC that was greater than productivity at the time.
2. *Stock rebuilding in the period 2010 to about 2014 was not as substantial as suggested by the indicators*. Catch rate, density, and mean weight indicators all showed substantial evidence of increases during 2010–2014, but it was not possible from the analysis available to determine what increase in stock biomass was occurring. The recently observed decreases in catch rate and estimated biomass under relatively modest total catches show that the biomass increases during that period were relatively modest - notwithstanding the substantial increases in the catch rate and other indicators through that time. The past few years have demonstrated that this rebuilt stock can be depleted quickly by TACCs that are relatively modest compared to historical levels.
3. *Lack of leading stock status indicators or predictions*. All the indicators available are to some extent trailing indicators, and most rely on detection of trends or changes in trend. There consequently and inevitably is delay in recognising changed circumstances. This is a weakness in the management system that has been highlighted by the Committee many times previously, but it is a more serious weakness than previously appreciated. The relatively abrupt changes in the productivity that have been seen, and the scale of these changes (especially of decrease), mean that there are serious risks to the stock and to economic performance if there is multi-year delay in detecting such change. Delay in detecting the reduced productivity has resulted in the loss of much of the stock rebuilding achieved between 2009 and 2015. Further, the long-term decrease in productivity seen may indicate climate or other external forcing that may change unpredictably.
4. *Inadequately managed spatial distribution of catch leading to sequential depletion*. The attempts to distribute catch spatially to better match productivity have not been successful. There have been mismatches between recommended and actual catches at both SMU and Area levels in the past several years, with some locations providing more catch than intended and others less. Patterns are appearing now in the fishery that are consistent with sequential depletion, though other explanations for them also are possible. The risk of sequential depletion nevertheless exists, especially when the stock is relatively reduced and less productive.

The recent and current stock status, including loss of most of the stock that was rebuilt during the past decade, and recent low productivity should trigger revision of the monitoring and assessment program and key aspects of the management arrangements for the fishery. Recommended actions for this revision include the following, most of which have been recommended previously by the Committee.

- Ensure the proposed implementation of compulsory data loggers from 1 January 2019.
- Develop a robust, spatially explicit assessment model to integrate the data available and support both TACC determinations and strategic management of the fishery.
- Identify leading indicators of stock status through additional monitoring and short term predictive modelling. It is notable that the sampling the lengths of emerged abalone of the sort done for the LB-SPR analysis could be used to provide a leading indicator of sub-legal abalone.

- Further develop and test indicators from the GPS data loggers, particularly for estimating of relative and absolute density, biomass, harvest fraction, and surplus production.
- Develop and implement arrangements between industry and government to improve management of the spatial distribution of the TACC, including effective local catch targets and caps that provide reasonable operational flexibility whilst protecting local and overall stocks.
- Develop a harvest strategy that identifies the high level and operational management objectives, monitoring, assessment, indicators, and reference points for the fishery.

This recommended revision of the monitoring, assessment, and management approaches implies significant investment, but the emerging situation carries a high risk of significant damage to the resource base of the fishery that cannot be forecast, and managed, without such investment. The current and likely future situation is likely to be very challenging for science, management, and industry. The overall trend of decreasing productivity of the stock since at least 2000 indicates that current and future patterns of productivity are different from the past, and that expectations and management settings based on the past are likely not to be entirely appropriate. The abrupt decrease in productivity in about 2015 is to unprecedented low levels. Potential future patterns obviously are unknown, but even if there was a quick return to higher productivity it will take many years to rebuild the lost stock. Ongoing management must include the possibility that such decreases may repeat, or that productivity might remain low for a long time. Management and assessment of the fishery has been limited severely for many years by under-investment in monitoring and scientific assessment. It is well past time that the decisions of the late-2000s to restrict funding of the monitoring, research, and management programs are reconsidered.

The Committee has concluded that the TACC for the 6-month period January–June 2019 should be 50t. This is a 6-month pro-rata continuation of the 100t TACC applied for calendar year 2018. The Committee recommends that the catches be distributed among SMUs as shown in Table A3.5 and there be a further assessment in April 2019 (using data to end March) to determine the TACC for financial year 2019–20.

Maintaining the TACC for the period January–June 2019 at an annualised level of 100t contains significant risk to the stock. This approach is accepted only because early assessment of the information from the full 2018 calendar year under the reduced 100t TACC is possible as a result of the change in the quota year. That assessment is expected to be informative about the recent productivity of the stock and the effectiveness of the reduced TACC and increased LMLs in arresting the decline in stock condition. The risks to the stock are from continued catch at a level that is above the estimated level of recent surplus production, with catches mostly coming from recently depleted SMUs (3 and 4 in particular) that already have elevated harvest fractions. This risk is exacerbated by the persistent inability to keep catches within recommended spatial caps. It is essential that effective mechanisms are implemented to prevent excessive catches from, especially, SMU 3 and SMU 4.

Table A3.5: Recommended catch targets by SMU for January–June 2019.

SMU	Catch (t) January–June 2019
1	5.0
2	20.0
3	12.5
4	12.5
Total	**50.0**

APPENDIX 4. ECONOMIC CONSIDERATIONS — DETAILS

A4.1 Introduction

The economic status of the NSW abalone industry is described in this section, consistent with the requirement that the Committee have regard to economic and social issues in making its determination.

Discussion is provided of the data affecting the economic performance of the abalone fishery, including gross revenue, export prices, and catch per unit effort. Much of the information provided in this section is derived from the Management Report provided by NSW Department of Primary Industries (McKinnon and Foster 2018)[4] and is reproduced in this report for completeness. This section also follows a similar format to economic background information sections in previous determination reports, for consistency.

A4.2 Volume and Value of Production

The volume of reported catch of abalone in 2017 was 128.8 tonne (t) and catch is expected to come close to the 100 t TACC for 2018. Data to September 2018 has the reported catch at 69% of the TACC, the same proportion of the TACC at the same time in 2017. The proportion of TACC caught by the end of the season has remained above 97% since 2005–06 and over 99% of the TACC since 2008–09 (Fig. A4.1).

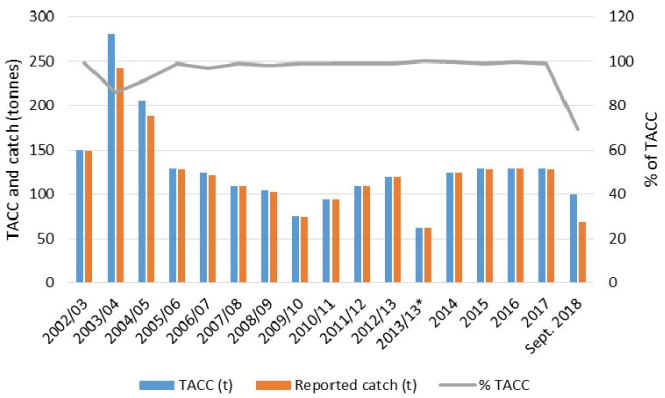

Figure A4.1. TACC (t), total reported commercial catch (t), and percentage of TACC caught (%) for each fishing period from 2002–03 to September 2018 (* 6 month fishing period 2013).

The gross value of reported catch of abalone has remained fairly constant since 2011–12 in real terms[5] despite the changes in TACCs.[6] The 2018 gross value of production (GVP) is expected to be $3.87 million, assuming the 100t TACC is reached (Fig. A4.2), relatively consistent with recent years' values.

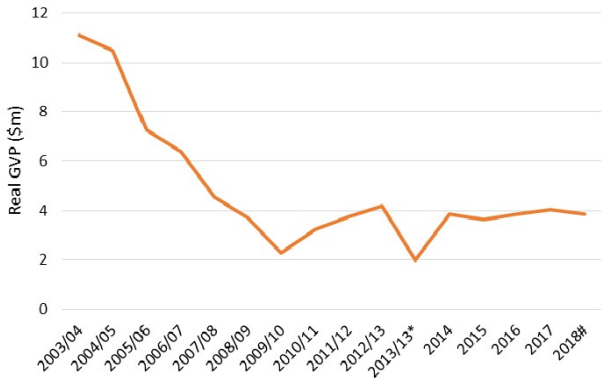

Figure A4.2. Estimated real gross value of production in the fishery ($m) for each fishing period from 2002–03 to the end of 2018. [* 2013–13 catch figures applied to a six-month adjusted reporting period. # 2018 value assumes the 100 t TACC is reached.]

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[4] McKinnon, F., Foster, J. (2018). Management Report 2018 – NSW Abalone Fishery, Report to the TAF Committee for the 2018 Fishing Period, *OUT18/13464*. NSW Department of Primary Industries, Sydney.

[5] Real values are CPI adjusted values using RBA "all groups" CPI data up to 2018.

[6] The apparent decline in GVP in "2013/13" is due to this representing only half a season. Scaled to a full season the GVP would be around $4m.

A4.3 Abalone Markets and Prices

The NSW abalone industry is predominantly export-oriented. Prices received for NSW abalone therefore are subject to economic conditions and exchange rate fluctuations in the main export markets, and competition from exports from other abalone exporters. Another significant factor affecting prices is increasing competition from cultured product.

The main export markets for Australian abalone are China, Hong Kong, and Japan. The main market for NSW abalone in 2018 was Japan, for which the main product was live abalone. China is seen as a potential new market for NSW abalone, with industry in other States reporting high prices on that market.

Beach prices for abalone are estimated from data provided to the Department by abalone processors. Real prices declined between 2002–03 and 2008–09, remained relatively stable between 2008–09 and 2015, and have trended upwards in more recent years (Fig. A4.3).

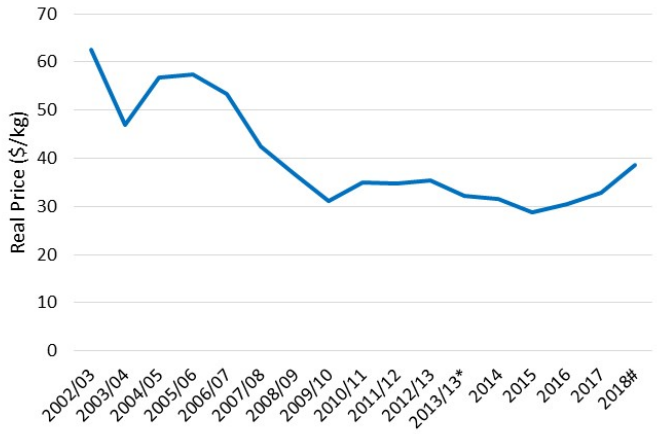


Figure A4.3. Estimated real beach prices ($/kg) for each fishing period from 2002–3 to September 2018.

Part of the price increase since 2014 is likely due to exchange rate movements. The Australian dollar depreciated roughly 20% against the Yen and 35% against the Hong Kong Dollar between 2013 and 2015 (Fig. A4.4), and has since tended to fluctuate around these lower levels against both currencies.

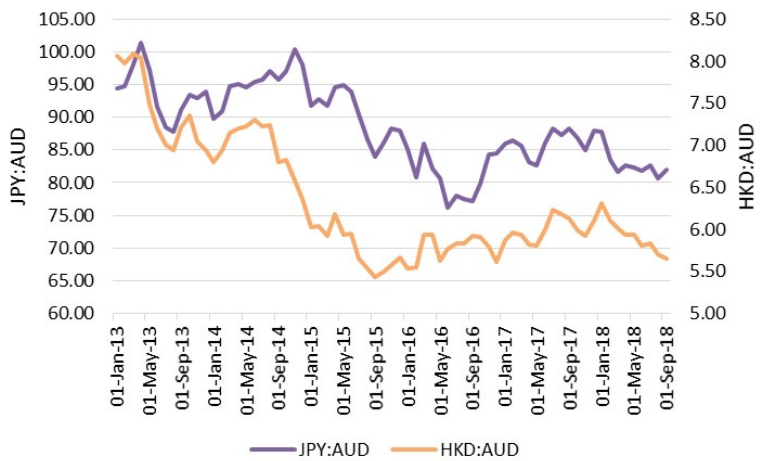


Figure A4.4. Exchange rates JP¥:AUD and HK$:AUD 2013 to 1 September 2018 (source: RBA).

The decrease in prices from earlier years also largely corresponds with the expansion of farmed abalone both within Australia and globally. Australian farmed abalone has more than doubled between 2010 and 2015 from 456 t to 965 t (Cook 2014[7]). Farmed abalone has increased globally from 8,700 t in 2002 to 130,000 t in 2015, while wild caught product has declined from 10,000 t to 6,500 t over the same period (Cook 2016[8]). China and Korea are the two largest producers of farmed abalone with production levels in

[7] Cook, P.A. (2014). The worldwide abalone industry, *Modern Economy* 5, 1181.
[8] Cook, P.A. (2016). Recent Trends in Worldwide Abalone Production, *Journal of Shellfish Research* 35, 581-583.

2015 of 115,397 and 9,400 t respectively (Cook 2016). Costs associated with producing cultured abalone are continuing to fall both in Australia and, more significantly, China and Korea. This is resulting in lower prices for cultured abalone, undercutting those for wild caught, particularly smaller, abalone.

The challenges from decreasing prices facing NSW abalone producers also are being felt by other Australian abalone producers. Beach prices for NSW and Victorian abalone have been close to prices of farmed product over recent years, while prices for Tasmanian, Western Australian, and South Australian product have been higher (Fig. A4.5). The latter States have variable LMLs with many areas subject to LMLs >130mm. Anecdotal evidence from Industry suggests Tasmanian prices have increased in recent years particularly for larger abalone with a premium on the international markets (particularly China). A decline in Chinese domestic aquaculture production due to a typhoon in late 2016 resulted in a shortage on the Chinese market and a substantial price increase for Australian product exported to China in 2017. Tasmanian prices are reported to have reached $60/kg during 2017–18 as a result of this shortage.

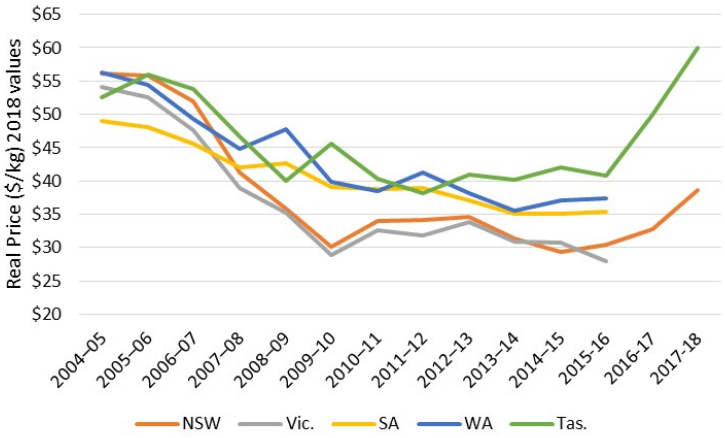


Figure A4.5. Estimated beach prices ($/kg) by State, 2010–11 to 2017–18 (real values). Data for 2015–16 and 2017–18 for NSW prices were taken from the Management Report (McKinnon and Foster 2018). Prices for 2017–18 are based on current reported prices. Prices for other years and States were derived from ABARES (2017[9]).

NSW abalone is sold through registered fish receivers, two main processing plants along the NSW coast, and a processing plant in Mallacoota, Victoria. The capacity of the two main NSW processing plants to take abalone was identified as a key constraint by many divers interviewed through a previous survey of the fishery. This also was raised by an industry representative at the TACC Committee public forum in 2016, who noted that trip limits often were imposed on fishers supplying to the processors. Preferences expressed by processing plants affected significantly decisions on days to fish, where to fish, and the size of abalone to target, aside from effects of weather or availability of quota.

The relatively small size of the NSW industry and irregularity in demand from overseas were identified in 2016 as key reasons for the processors' caps on abalone intake. The reduction in TACC for 2018 and the subsequent reduced supply available to processors has resulted in increased competition for the catch, which has contributed to the increase in beach price in 2018. Shareholders and divers continue to sell increasing amounts of abalone through 'AFCOL' in Mallacoota. The absence of daily catch limits to abalone landed at Mallacoota and willingness from that processor to travel as far north as Tathra to collect product means there is likely to be increasing interest in landing NSW catch through Mallacoota, possibly accompanied by movement of effort toward the southern boundary of the NSW fishery. The location of processors to a large extent dictates where divers fish, as processors are not willing to travel long distances to pick up from a single diver. This may be relevant particularly to the northern areas of the fishery that have been fished below their recommended level in recent years and also contribute to the increasing harvest from southern areas.

One Victorian processor indicated at a previous meeting that size preference for abalone sold through AFCOL in Mallacoota differs from NSW processors. AFCOL cans or freezes abalone and is happy to buy a range of sizes of abalone. The strongest demand, and highest prices, elsewhere in Victoria, however, is for smaller sized (250g in the shell) live abalone, which the NSW industry can supply. A NSW shareholder, in contrast, maintained that the main processor in NSW, Pacific Shoji, preferred larger

[9] ABARES (2017). Australian fisheries and aquaculture statistics 2016. ABARES, Canberra.

abalone to supply live to Japan. The strongest demand, and highest price, was for abalone over 130mm. The other main supplier of live abalone, Southern Ocean Seafood, sells a range of sizes, with a preference for larger animals.

Evidence provided to the Committee previously indicated that tastes and preferences in overseas markets were changing away from product that can be supplied easily by NSW abalone fishers. It was stated that the niche market that NSW abalone previously held in Japan in particular was shrinking due to competition from cultured product and that a separate Japanese market was emerging for larger size abalone due to a recent change in consumer preferences. Hoshino et al. (2015[10]) found that Japanese consumers did not differentiate between wild and farmed abalone on the market, and that any "wild premium" instead would result through size based differentiation in which a preference for larger abalone would be met by wild-caught product but not by farmed product, given the costs associated with the additional time it would take to grow farmed abalone to larger sizes. NSW fisher comments in both 2017 and 2018, however, suggest that wild-harvest abalone of all sizes may be preferred in the contemporary Japanese market. Continuing growth in demand in Chinese markets also may have affected other Asian markets through increased competition for the product, with higher prices in turn being paid for NSW abalone in 2018.

A4.4 Catch per Unit Effort and Average Size

The fishery has been in a rebuilding stage over the last decade with TACCs set to help rebuild stock abundance. There are well known risks in relying on overall catch per unit effort (CPUE) as an indicator of stock abundance of abalone but it does provide an indication of changes in the availability of abalone to the fishery. It also reflects changes in the cost of catching the quota.

CPUE has doubled since 2008–09 from 19.6 kg/hr to an average of 48.6 kg/hr in 2016, although decreased in 2016 and 2017. Unstandardised CPUE during the first half of 2018 appears to have increased over 2016 and 2017 levels, but still remains lower than the earlier peak catch rates. These earlier (2009–15) increases most likely resulted from stock growth under lower TACCs and higher size limits. Industry reports that a substantial storm in mid-2016 adversely affected parts of the fishery, with fishing effort transferring out of the storm-affected areas into the southern area of the fishery. Higher size limits and significantly reduced TACC in 2018 were intended to arrest declining stock condition seen emerging from recent data and put the fishery in a position to continue rebuilding. More recent analysis suggests, however, that the fishery may be in a more general period of reduced productivity. The estimated biomass across the fishing regions has decreased since 2014–15 by between 9% (SMU4) and 28% (SMU3) (Fig. A4.6).

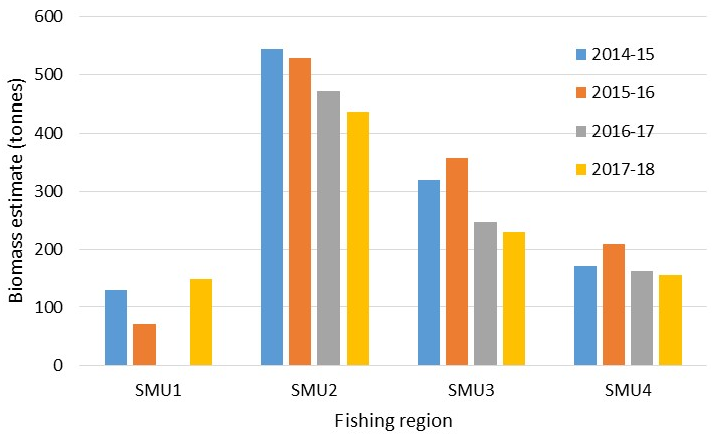


Figure A4.6. Estimated abalone biomass in each fishing region, 2014–15 to 2017–18. Source: 2018 report to the TACC on assessment of abalone stocks in NSW.

The average size of abalone in the fishery catch has risen continuously from 280g in 2005–06 to 352.6g in the first nine months of 2018. Part of this increase in average weight is attributable to the increase in the legal minimum length. The average weight in the different areas in the first eight months of 2018

[10] Hoshino, E., Gardner, C., Jennings, S. and Hartmann, K. (2015). Examining the Long-Run Relationship between the Prices of Imported Abalone in Japan, *Marine Resource Economics* 30, 179-192

ranged from 320g–409g (Fig. A4.7). The current premium market grades[11], in contrast, appear to be in the range 340g–450g, suggesting that the fishery is operating at least in the lower half of the premium grade range. The increased quantity of larger abalone would also have contributed to the increase in the average price received in 2018.

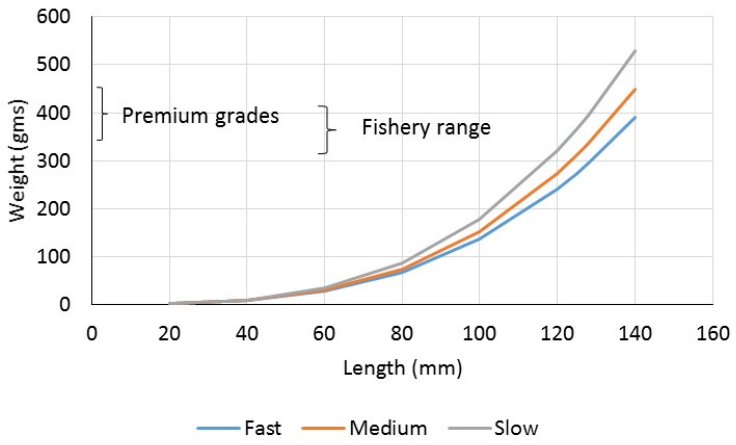


Figure A4.7. Relationship between length and weight of NSW abalone, premium market grades and performance of the fishery in 2018. Length-Weight derived from Worthington and Andrew (1998)[12]. 'Fast' refers to animals showing rapid growth in length; 'Slow' refers to animals with relatively slow growth in length.

The LML is to increase again in 2019, which should lead to further increases in average weight. There is a trade-off, however, between LML and allowable catch, and the benefits of increasing LML any further to achieve higher prices need to be assessed against the potential overall reduction in catch. Building the stock further to increase the proportion of larger animals also will take time and there are trade-offs between the speed at which it rebuilds and the longer term benefits against the short term costs to the industry. Previous increases in LML, however, indicate that reductions in catch have been relatively short-lived (less than 1 year) compared to the long-term improvement in CPUE and, likely, economic efficiency.

*The Committee **recommends** that bio-economic modelling analysis be done to assess short-term vs long-term harvest and economic trade-offs associated with further increases in LML to inform future TACC determinations.*

A4.5 Economic Performance Indicators

Economic data for the fishery are not collected routinely so assessments of economic performance rely on imperfect indicators such as changes in CPUE and quota trading amounts or prices.

The Committee notes that the only available direct information on the economic performance of the NSW Abalone Fishery relates to the 2011–12 fishing period. Price, productivity, and cost conditions have changed considerably since then so these data are likely to have materially diminished relevance as indicators of current performance. The Committee would like to see analogous surveys run more regularly (every 1–2 years) to capture structural economic dynamics of the fishery.

Industry indicated at the public forum that they would still be willing to undertake an economic survey of fishers to provide better input into the 2019–20 quota considerations. It would be beneficial if a regular survey could be undertaken to monitor economic performance of the industry and better assess the effects of potential changes in TACCs, given recent and proposed changes in the fishery.

*The Committee **recommends** that Industry and the Department regularly update economic data for the fishery.*

Some estimates of changes in economic performance can be derived from available information, despite the lack of objective economic data. The number of active divers decreased from 33 in 2017 to 25 in

[11] Based on information on the Southern Oceans Seafood webpage.

[12] Worthington, D. and Andrew, N. (1998). Small-scale variation in demography and its implications for an alternative size limit in the fishery for blacklip abalone (Haliotis rubra) in New South Wales, Australia, *Canadian Special Publication of Fisheries and Aquatic Sciences*341-348.

2018, suggesting that average revenue per diver increased from $124.8k in 2017 to $154.8k in 2018 (around 24%) despite the lower TACC, asssuming the full quota is taken by the active divers.

The total costs of fishing largely relate to changes in the amount of effort required to take the catch. The higher catch rates of larger animals in recent years has resulted in relatively small changes in the average number of days fished since 2015 (Fig. A4.8), although this level is lower than in most years prior to 2015. This suggests that the cost per unit of catch generally would have declined over time, at least until 2016, with improved in economic performance of individual fishers, all else being equal, over the data period.

The number of days fished per diver was similar in 2018 and 2017 but average revenue per diver increased, so it is likely that the average profitability per diver increased between the two periods despite the decrease in quota. Fewer divers were active in 2018 than in 2017, however, so total industry profits may not have increased. Some of these "higher" profits would have been redistributed to the inactive divers through the lease cost if the active divers also leased-in additional quota. Finally, given the disparity in trends between catch per day and catch per hour, the active divers may have had to spend longer diving in 2018 than in 2017 to receive their returns.

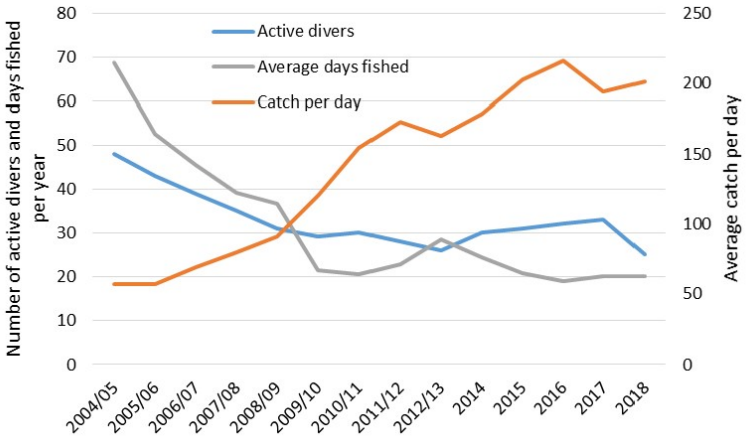


Figure A4.7. Days fished (average per diver) and catch rates since 2000. Data for 2018 assumes full 100t TACC is caught.

Share trading prices increased slightly between 2017 and 2018, suggesting continued optimism for the medium to longer term economic outlook for the fishery despite the reduction in the TACC. Share prices in theory reflect longer term expectations of profitability of the fishery. The incidence of share trading in 2017 and 2018 was lower than previous years (200 shares traded in 2017 and 190 in 2018 compared with 344 in 2016 and 254 in 2015). The reduced share trading in 2017 was reported to be linked to individuals increasing shareholding to enable them to become endorsed to participate in the fishery (i.e. hold more than 70 shares) rather an existing active fishers expanding their share in the fishery.

Quota trading price information, a good indicator of short term economic performance, is unavailable for this fishery. Quota trading price information is supplied on a voluntary basis only and industry generally has not reported sufficient data on which to estimate trading prices reliably. Anecdotal information provided by Industry in 2017 suggests that quota transfer prices increased in 2017, despite other indicators of a short term decline in fishery performance. Information was not provided for 2018. It would be helpful to the Committee if the Department required the collection of quota trading price data and undertook such calculations in the same manner that data on share trading prices are collected. Reporting by shareholders of all information on the price of share and quota transfers would provide invaluable information for assessing the economic status of the fishery and implementing management settings, including TACCs, which favoured optimum economic performance.

The Committee suggests that Industry make available information on the price of share and quota transfers in the abalone fishery and that the Department and Industry work together to develop more detailed information on the structure and operation of the quota market.

A4.6 Share and Quota Markets

A key feature of fisheries operating with individual transferable quotas is the opportunity for fishers to adjust quota holdings to improve their individual economic performance. The potential for the economic

performance in the fishery to improve is dependent on the ability for fishers to adjust their operations in response to changing stock, price, or cost conditions. This may be either long term adjustment through trade of shares in the fishery or shorter term adjustment through leasing quota on an annual basis.

There has been a 3,454 shares in the fishery since 2003–04. Quota attached to each share is determined by the TACC divided by the number of shares. Quota per share in 2018 was 28.95kg (Table A4.1).

Table A4.1. Quota per share and quota transfers 2003–04 to 2018 (to September)

Fishing period	TACC (t)	Quota (kg/share)	Total quota transferred (kg)	% TACC	Nº shareholders supplying quota
2003–04	281	76.90	34,937	12	25
2004–05	206	56.38	29,474	14	23
2005–06	130	35.58	23,428	18	21
2006–07	125	34.21	29,743	24	21
2007–08	110	31.85	24,590	22	20
2008–09	105	30.40	32,826	31	NA
2009–10	75	21.71	24,512	33	21
2010–11	94	27.21	29,911	32	22
2011–12	110	31.85	31,993	29	25
2012–13	120	34.74	36,703	31	21
2013–13*	125	36.19	17,472	28	21
2014	125	36.19	42,263	34	27
2015	130	37.64	37,413	29	21
2016	130	37.64	44,640	34	28
2017	130	37.64	36,230	36	25
2018**	100	28.95	29,669	28	23

** Incomplete fishing period to September 2018.

There were 48 shareholders in 2018 (no change from 2017), with shareholdings ranging between 10 and 170 shares. Thirty six of these shareholdings were eligible for an endorsement to fish in 2018 (up to September), which requires a holding of ≥ 70 shares. The remaining 15 shareholders were able to lease their quota to active fishers.

The Fisheries Management (Abalone Share Management Plan) Regulation 2000 stipulates that shares can be traded only in packages of 10. Restrictions also exist on quota trading, including that quota may be transferred only in lots of 100 kilograms (or as otherwise approved by the Director) and that a shareholder may not acquire by any quota transfer more than twice the amount of quota owned by the shareholder at the beginning of the fishing period. Previous Committees have expressed a concern that these restrictions may impede potential improvements in efficiency compared with what might arise if transfers were less restricted. Share trading occurs despite these restrictions, although only around 5% of all shares were transferred in 2018, substantially fewer than in previous years (e.g. 21% in 2013–14).

Around one third of the total available quota has been transferred each year since 2008–09, with the number of shareholders actively involved in trading also being fairly constant. These short term and long term transfers suggest that the quota and share markets are fairly healthy despite the current share transfer restrictions[13] and are not likely to be impediments to economic performance in the fishery. The proportion of total available quota traded in 2018 has been similar as in previous years.

[13] Newell *et al.* (2005), for example, concluded that the New Zealand quota market was operating efficiently with 5-10% of the total shares being transferred annually. Higher levels of quota leasing were observed, although this was largely from non-fishing quota owners to fishers.

Newell, R.G., Sanchirico, J.N. and Kerr, S. (2005). Fishing quota markets, *Journal of Environmental Economics and Management* 49, 437-462.

The number of shareholders owning 70 or more shares remained constant between 2017 and 2018 (Table A4.2). The number of non-fishing shareholders (i.e. those with less than 70 shares), also remained constant. The 210 share cap could be considered unnecessarily restrictive as it is far smaller than would be necessary to prevent any near-monopoly situation. The Committee notes the Department's intention to amend the maximum shareholding to 40% of the total number of shares initially issued in the fishery, which should facilitate improved opportunity of rationalisation of the fishery.

Table A4.2. Distribution of shares among 48 shareholders in 2017 and 2018 (to September)

	Number of shares held											
Year	10	20	30	50	70	80	84	90	100	120	150	170
2017	4	4	3	1	13	3	1	3	13	2	1	0
2018	4	4	3	1	14	3	1	3	13	2	1	1

A4.7 Recreational and Aboriginal Catch

Recreational and cultural catch of abalone generates non-market values to the groups that participate in these activities. Studies to estimate those values for abalone harvesting in NSW have not been done, so it is not possible to quantify associated economic values.

Recent advice suggests that abalone are not often targets of recreational fishing *per se* but are harvested by recreational divers whilst targeting rock lobster (West *et al.* 2015)[14]. Recreational take of abalone is restricted to 2 animals in possession per-person. Estimates of total recreational catch in 2013–14 were 18,423 individuals (West et al. 2015), equivalent to around 5.4 tonnes assuming an average of 300g per individual. This catch was taken across three regions – Hunter, Sydney, and mid-south coast, all north of Tuross Heads and hence in the "Northern" zone of the fishery. Commercial catch for 2016 in these areas was estimated to be 1.4 tonnes, substantially lower than the estimated recreational catch. The distribution of recreational fishing and the relatively low catch overall suggest that recreational fishing is unlikely to have material impact on the main areas of the commercial fishery. A better understanding of the economic value of recreational abalone fishing may help appropriate allocations to be made in those areas of higher recreational and lower commercial harvest.

Aboriginal peoples' connection to the fisheries resource was recognised formally distinctly from recreational and commercial fishing and implemented in fisheries legislation through the introduction of a new object to the Act, . The current policy makes special provisions for Aboriginal people to take up to 10 abalone to provide for cultural needs where elders, the incapacitated, or other community members are unable to fish for themselves. Allowances also are made for cultural events in which greater numbers may be taken if an appropriate permit is obtained. There have been no attempts to equate an economic value to these cultural activities.

A4.8 Illegal and unreported removals

Previous reports by the Committee have discussed the loss of economic value from the fishery due to perceived high levels of illegal catch. Illegal take has been estimated previously to be as high as 40 per cent of legal take but the more recent compliance reports suggest that there was a downward trend in serious illegal abalone activity after about 2010 and illegal harvest in recent years has been estimated to be 20-40t. Discussion of illegal take at both the 2017 and 2018 open forum suggested that there likely had been an increase in illegal activity in the last few years, such that the most recent illegal catches were likely to be nearer the upper end of that 20–40t range.

A4.9 Community Contribution

The Community Contribution charge in the NSW Abalone Fishery was based on a decision by the NSW Government to return to society economic rent earned by abalone fishers. The Community Contribution for a fishing period is calculated annually and considers CPI, abalone beach price, and TACC. It is payable by each shareholder following each fishing period. The Community Contribution has been calculated at zero ($0) since 2005–06 following declines in TACCs and average estimated beach prices.

The aim of the community contribution is to return some of the resource rent generated through fishing back to the community. Resource rent represents the economic profits being generated in the fishery

[14] West, L., Stark, K., Murphy, J., Lyle, J. and Ochwada-Doyle, F. (2015). Survey of Recreational Fishing in New South Wales and the ACT, 2013/14, *Fisheries Final Report Series*. NSW Trade & Investment, Sydney, pp 150.

once all costs, including unpaid labour and a normal return to capital, have been taken into account. The results of the earlier economic survey suggest that economic rent was being generated in the NSW Abalone Fishery in 2011–12, although that calculation excluded the costs of fisheries management. True economic rent is likely to be lower than was estimated through that survey, though it is unclear whether the actual value in 2016 would be zero. Some of this rent also is not true 'resource rent' that is a result of the natural resource being used (i.e. the abalone stock). The other types of rent — entrepreneurial rent that is attributable to the skill of the fisher and quasi-rent that is surplus that can occur for external reasons such as exchange rate fluctuations — should not be removed from the fishery.

Estimating how much of each of the different types of rent is present and, therefore, how much should be extracted from the fishery each year for Community Contribution, is a complex task that has not yet been undertaken and would not be feasible without detailed economic information on the fishery.

A4.10 Economic targets and performance indicators for the fishery

The Committee notes that the economic indicators and triggers in the Fishery Management Strategy for abalone lack specificity and relevance and fail to stipulate clear management responses to trigger point violations. These indicators and triggers need to be revised as a matter of urgency to make them more relevant to measuring the economic status of the industry.

The Committee notes that such indicators should be refined and expanded as a formal harvest strategy is developed and in any revised management plan for the fishery. Economic performance indicators for the fishery should relate to long-term profitability.

*The Committee **recommends** that a more meaningful set of performance indicators and economic reference points be developed as part of the proposed harvest strategy for the Abalone fishery.*

A4.11 Conclusion

The long-term economic outlook for the NSW Abalone Fishery remains uncertain in the light of increasing aquaculture production and the effect of cultured product on global prices. NSW abalone product is competing with strong market-place competition from aquaculture product nationally and internationally. Industry's assertions of a preference for wild-product over aquaculture produce abalone, however, appear to be supported by the recent price increases. Higher prices paid for quota shares also suggests that industry has an optimistic view about the future profitability of the fishery.

The reduction in the TACC in 2018 appears to have had little impact on individual fisher profitability, at least for the active divers. The reduction in catch largely has been offset by an increase in price, while fleet rationalisation has resulted in an increase in revenue per active diver. Fishing operating costs are likely to have remained around the same level as in recent years.

The inference that economic performance in 2018 may not have been adversely affected by the reduction on the TACC needs validation. The Committee has noted previously that economic information for the fishery is lacking and recommends again here that steps be taken to implement more routine economic data collection. Analyses of such data would inform the setting of TACCs and size limits for harvest, increase or optimise returns from the fishery, and inform the risk–catch–cost trade-offs for investing in research and monitoring for the fishery. Industry appear willing to participate in such a data collection.

Quota markets appear to be functioning well, and autonomous adjustment seems to be occurring in the fishery. Information on quota trading and leasing prices would provide useful data for assessing the short term economic performance of the fishery and help inform future TACC determinations.

The Committee notes that the economic indicators and triggers in the proposed Fishery Management Strategy for abalone are lacking in specificity and relevance. These indicators and triggers should be revised during development of a formal harvest strategy to make them more relevant to measuring the economic status of the industry.

APPENDIX 5. MANAGEMENT CONSIDERATIONS — DETAILS

A5.1. Data collection and stock assessment

A5.1.1 Recreational Fishing

The Committee has used an estimate of 10t for non-commercial harvest for some time now and continues to rely on this estimate. The Department support this estimate, although they report that recreational fishers consider it a high estimate on the basis that the reduction in bag limit from 10 to two has reduced significantly the desirability of recreational fishing for abalone.

Targeted surveys to estimate recreational abalone catch and effort would be required to provide robust estimates of total harvest, particularly if bag limits are increased (see below). Identifying an adequate sample size in small recreational dive fisheries is notoriously difficult and therefore expensive unless divers are identified through some type of registration such as a licence endorsement, as is the case in Tasmania. The Committee has made repeated recommendations in previous years about such surveys.

The Department advised this year that they recently commenced the Integrated Angler Monitoring Program, which involves repeat statewide surveys of recreational fishing (similar to the 2013–14 survey) every two years. A (voluntary) 'tick box' also was introduced to the recreational fishing licence application form from April 2018 to identify intending recreational underwater harvesters of lobster or abalone. This can provide a sampling frame for future surveys of these niche fisheries, though that sampling frame will be compromised by the voluntary status of indicating one's intention to take abalone or lobster. The Department so far have received an indication of an intention to fish for those species from approximately 5000 fisheries for each species. The system has been implemented for online applications but is still being rolled out for paper-based applications and so presumably these numbers will increase.

The Committee considers that it would be prudent to delay any decisions about recreational bag limits for abalone or lobster until the data from the planned more targeted surveys are collected and analysed and . recreational harvests are known with more certainty than currently available. It also is essential that regular monitoring of recreational catch is established and the extent of the recovery of the resource is better understood before considering any increase in bag limit, given recent evidence of reduced stock status and productivity. The Committee again emphasises the need for an updated management plan and robust harvest strategy for the fishery to guide management of the fishery, including TACC Determinations and decisions about relative share between the commercial and recreational sectors.

A5.1.2 Aboriginal Fishing

The current Aboriginal fishing interim access policy allows an Aboriginal person to take up to 10 abalone to provide for cultural needs where elders, the incapacitated, or other community members are unable to fish for themselves. The arrangements apply by increasing an individual fisher's limit – it is not an accumulating limit related to the number of people for who the abalone are being provided.

Applications for Aboriginal cultural fishing permits can be made if Aboriginal people have a need to access the fisheries resource for larger cultural events. A written request to the Department outlining species and numbers proposed to be taken is required before aboriginal cultural fishing permits can be issued. Permits that have been issued over recent years are set out in the Department's Fisheries Management Report for the fishery and those data are reproduced in Table A5.1.

Table A5.1. Aboriginal cultural event fishing permits that included abalone harvest issued since 2014–15 (from 2018 Management Report to the TAFC Committee).

Year	District	Target Species	Max # Abalone	Nº. People
2014–15	Far South Coast	Abalone, lobster, mussels	150	100+
	Shoalhaven	Abalone, lobster	150	40
	Far South Coast	Abalone, lobster, mussels, oysters	1000	500+
	Far South Coast	Abalone, lobster, oysters	150	30–40
2015–16	Shoalhaven	Abalone, lobster, mussels, oysters	150	60
	Far South Coast	Abalone	200	500
	Shoalhaven	Abalone, lobster	300	300–400
2016–17	Batemans Bay	Abalone, lobster, finfish	550	100+
2017–18	Batemans Bay	Abalone, lobster, mussels, oysters	100	50

It should be noted that permits are issued for a basket of species, not just abalone, and so it is unlikely that the full number taken will be all abalone. Advice from the fishery compliance officers is that actual take continues to be significantly less than the amounts formally permitted, suggesting that catch under cultural fishing permits is unlikely to have a detectable impact on the resource.

A5.1.3 Commercial Fishing

Formal catch and effort information is collected through regulated logbooks and managed in a Departmental database (the quota management system). The data logger program is implemented by the Abalone Council of NSW as a service provider to the Department. The Abalone Council of NSW (and specifically one of its Directors, Duncan Worthington) provide scientific services under contract to the Department, using the Department's catch and effort data and the logger data. Data loggers are not mandatory but have been used by a majority of divers in recent years. It is the position of the Abalone Association of NSW as stated at the TAFC public forum this year that loggers be made mandatory.

The Department has advised that approval for making logger use compulsory has been granted and that use of loggers will be compulsory for all abalone divers from January 1 2019. The Committee acknowledges the industry's work in establishing a system of collecting and analysing data at a fine spatial scale through the data logger system and welcomes the introduction of compulsory use of such loggers. The stock status sections of this report discuss in detail the commercial fishery data and their implications, and the shortcomings in the available data and analysis.

The Council's presentation to the Committee and subsequent provision of data on request again built on the feedback from previous years, with some useful simplifications in presentation but also some inconsistencies that undermine the Committee's confidence in the information presented and underscore the need to continually interrogate the analysis provided. It is still the case therefore that work is needed to identify the key indicators that should be used in decision-making, to standardise and document how the data will be treated, and decide what analyses would best inform the management of the fishery. This should be done through the development and implementation of a harvest strategy and peer-reviewed stock assessment model.

A5.2 Current management arrangements for the commercial fishery

A5.2.1 Quota management system, size limits and finer spatial scale management

The core management arrangements in the commercial abalone fishery are the system of individual transferable quotas and Minimum Legal Length (LML) regulations. The history of these management tools is outlined in previous reports. These measures are relatively blunt instruments for managing an abalone fishery in the absence of explicit spatial management arrangements. Species like abalone with relatively low movement among local populations often have different recruitment, growth, and productivity characteristics in different areas and also are vulnerable to 'hyper-stability' of catch rates where catch rates can continue to appear healthy or stable as successive local populations are harvested, even though the stock overall is declining. The existing management tools need to be applied differentially, at a finer spatial scale, to be more effective and appropriate to the abalone fishery.

The Committee is encouraged that there have been changes recently to the LMLs across the fishery. The LML for abalone increased to 119mm in waters north on Wonboyn and 125mm in waters south of Wonboyn from 10 July 2018. The LML for abalone in waters north of Wonboyn will be increased further to 120mm from 1 January 2019. The Department advise that they will, in consultation with industry and the Committee, develop criteria for identifying areas to which a lower LML may be applied in future.

The fishery has attempted to effect some fine scale management of commercial harvest via voluntary Area-specific catch-caps and different LMLs south of Wanboyn. The last four years have demonstrated, however, that voluntary catch-caps have not been effective in keeping fishing levels at those recommended by either the Committee or Industry for many Areas, nor for last year at the SMU scale. The Committee has consistently recommended, therefore, that a formalised system be introduced to spread catch and ensure adherence to catch-caps for Spatial Management Units, and preferably by Area.

A5.2.3 Management plan and decision-making framework

The current management plan is obsolete. It does not reflect the status of the stock, changes in monitoring and assessment, or (informal) implementation of fine scale approaches and knowledge of the resource, and it contains inappropriate targets and indicators.

The fishery has no long-term objectives, meaningful indicators, or reference points, which materially impacts TAFC decisions and the strategy that should be applied in reaching them (e.g. what rate of rebuilding is desired, what trade-offs should be made between total yield, catch rates, or range of size

classes available). Defined objectives for the fishery and, in particular, the operational objectives contained in a harvest strategy would guide these decisions and inform the balance of the various risks.

The lack of a meaningful harvest strategy and management plan leaves the fishery in a very uncertain management environment. There is no structure to maximise the benefit from the fishery in the medium to long term and no basis on which to make decisions about the appropriate level of investment in either the fishery's management or fishing businesses. Lack of guidance to the decisions that can be made mean that there is no explicit choice between growing the fishery to its potential or, alternatively, to stabilise it more conservatively at some lower harvest levels. There was constructive discussion last year at the TAFC public forum by members of the Abalone Association of NSW about the central importance of stock security and a preference for conservative decision-making and secure stock rebuilding. This discussion would be a positive starting point for developing a harvest strategy for the fishery and articulating specific objectives for the fishery.

The Department's initial work to prepare a draft interim harvest strategy was seen as a significant step forward in meeting the deficiencies in the current management arrangements. That work has not progressed since 2015. Resolution of an ongoing harvest strategy ideally will sit within a revised management plan for the fishery, which the Committee continues to recommend as an urgent priority. The revised management plan should, among other things, formalise the co-management arrangements in place for the abalone fishery and establish appropriate governance mechanisms to ensure agreed regulatory mechanisms function as intended.

The Committee is firmly of the view that the development of a harvest strategy is a role of fisheries management. Science is fundamental to a good harvest strategy but it is not the only factor. Harvest strategy development should be led by fisheries managers skilled in bringing relevant stakeholders together and creating an objective-driven framework that provides structure for trade-offs and risk-weighted decisions, informed by appropriate research and monitoring.

A5.2.3 Co-management

The history of industry involvement in the management of the fishery has been documented in previous reports. The relationships between government and industry has been acrimonious at times but appers more constructive recently. The industry appears to have been moving to a greater level of consensus as the stock has improved over the last decade and has supported cautious TACC setting but the advisory and co-management processes remain relatively unstructured. Standard governance arrangements such as the use of independent chairs, Departmental oversight of industry driven research, communication protocols, peer review processes, etc., have been identified in the past for consideration.

The Committee's observation is that the input of the Abalone Association of NSW into the management of the fishery in general, and TAFC decision-making specifically, in the last three years has been very constructive with markedly improved relations with the Department. The Committee has confidence that it is being provided with balanced and strategic advice from the Association.

A5.2.4 Fees

The abalone fishery is subject to the Government's policy on cost recovery whereby shareholders must meet all identified management costs attributable to the commercial fishery, less any savings passed on to shareholders. Management charges are payable by each shareholder in proportion to shareholdings. The management charge is re-determined annually. The management charge for 2017–18 remained at $64.21 per share, the same as the previous year. The fees for 2018–19 have not been determined yet.

The Department outlined the following in relation to how the charge was calculated:

"*The management charge is based on:*

- *Salary costs for staff directly providing administration services to the commercial fishery as well as those conducting the policy development and research (external service) needed for effective management of the fishery.*
- *Operating costs associated with the above fishery management services along with compliance operations.*
- *Contribution towards corporate overheads (estimated as 48% of base salary costs).*

Less

- *An "efficiency" discount of 20% on the total salary costs.*
- *An "efficiency" discount of 20% on total salary costs.*
- *A proportional recreational discount for the indirect benefit to recreational fishers.*
- *A discount of 6.65% to offset the increase in shareholder costs due to the cancellation of shares in marine park buyouts.*"

Abalone shareholders may be required to make an annual Community Contribution for the right of access to the fisheries resource, similarly to other share management fisheries, but the community contribution for the abalone fishery has been set at $0 since 2005–06.

The Committee has noted before that the decision to drastically reduce funding for research and monitoring in 2008 had over-whelming support from shareholders but also notes that that decision has left the fishery in a very difficult position with respect to management decision making. The consequences of the reduction and the flow-on effects to the task of setting a TACC have been discussed extensively in previous reports and we note again here that absence of robust assessments will continue to constrain TACC setting whilst ever this low investment persists.

An immediate priority for the fishery is the development of a harvest strategy, led by an experienced person with fisheries management expertise. It is in the industry's and the fishery's interests that this work is resourced properly – whether through licence fees or some other mechanism.

A5.2.5 Compliance

Reporting on compliance and infringement detection rates is notoriously difficult as improvements in the targeting of compliance effort can lead to more offences being detected, which then can appear as higher levels of non-compliance when reported statistically. Use of an intelligence-led approach should lead to a higher rate of detections and therefore seemingly lower rates of compliance, at least initially. It is difficult to draw conclusions from crude 'compliance rate' information, therefore, without supporting qualitative explanations or separation of metrics about intelligence-driven targeted enforcement from more routine 'on patrol' compliance data. The Committee accordingly finds the discussions with Fisheries Officers at the annual TAFC public forum very useful.

The licensed commercial compliance rate of 77% in 2018 (Table A5.2) has increased from recent years (last year 57%), suggesting a welcome reversal from the previous ten-year decline in compliance rate.

Table A5.2. Compliance rates by sector.

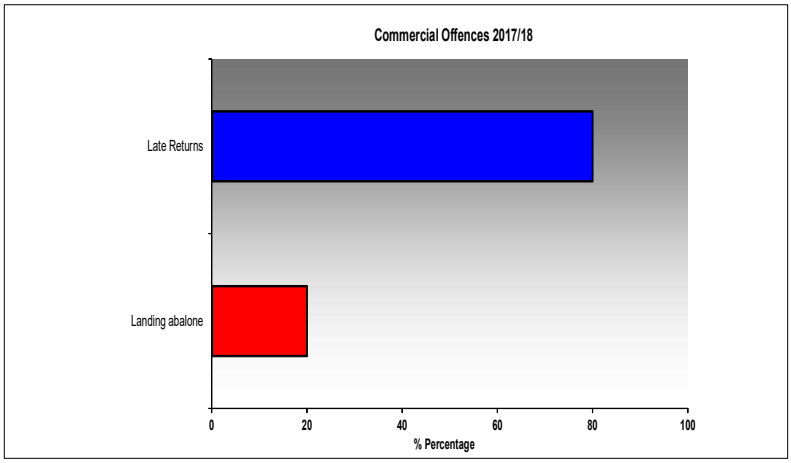
	Compliance Rate					
Compliance activity type	**2012–13**	**2013–14**	**2014–15**	**2015–16**	**2016–17**	**2017–18**
Unlicensed and recreational	56%	69%	73%	63%	73%	76%
Licensed commercial	71%	51%	64%	52%	57%	77%

Table A5.3. The amount of compliance effort put into the abalone fishery in recent years.

	Compliance Effort (hours)						
Compliance type	**2011–12**	**2012–13**	**2013–14**	**2014–15**	**2015–16**	**2016–17**	**2017–18**
Unlicensed & recreational	4670	4790	3189	2390	2090	2358	2471
Licensed commercial	1478	1654	452 (37 QA inspections)	402 (33 QA inspections)	461 (27 QA inspections)	569 (18 QA inspections)	428 (24 QA inspections)

Figure A5.1 below has been reproduced from the Department's Compliance Report – Abalone September 2018. It displays the frequency and the type of offences that have been detected in the commercial abalone fishery during the 2017–18 period. Compliance effort in the commercial sector this year has focussed on supporting the introduction of the Commercial Fisheries Business Adjustment Package, and the continued implementation of the online reporting systems. Fishers now are able to make online catch and effort reports and are required to make post-landing quota use reports in real time using the FisherMobile app. Furthermore, additional requirements have been put in place mandating a pre-fishing report, and prohibiting the 'hanging' of abalone. These are both sensible rule changes that make the quota system tighter and enable more efficient, targeted quota monitoring. The Department confirmed at the TAFC public forum that the offence data is consistent with this focus this year and do not represent 'slippage' in the quota monitoring system, which they still consider to be fundamentally effective.

Figure A5.1. Frequency of offences of different types detected in the commercial abalone fishery for 2017–18.



The ‘unlicensed & recreational’ compliance rate includes offending by fishers undertaking genuinely recreational fishing, either with or without a licence, as well as intentional illegal fishing of a commercial nature but that is unlicensed. The compliance rate (77%) is very similar to the previous year (73%) which is at the upper end of the range seen over the last ten years of 56%-75%.

Figure A5.2 has been reproduced from the Department’s Compliance Report – Abalone September 2018 and displays the frequency and the type of offences that have been detected in the recreational and unlicensed abalone fishery during the 2017–18 period. The top four recreational offences recorded in the period were ‘Possess prohibited size fish’ (28%), ‘Exceed possession limit’ (15%), ‘shuck unlawfully’ (13%) and ‘exceed possession limit aggravated’ (11%). These are serious offences that likely highlight unlicensed activity that is organised and intentional rather than inadvertent infringements.

Figure A5.2. Frequency of offences of different types detected in the unlicensed and recreational abalone fishery for 2017-18.