Plots of the length–age relationship for the Fraser region by year and sex are shown in Figure 15. The length–age linear relationship is poor across all years for both males and females.

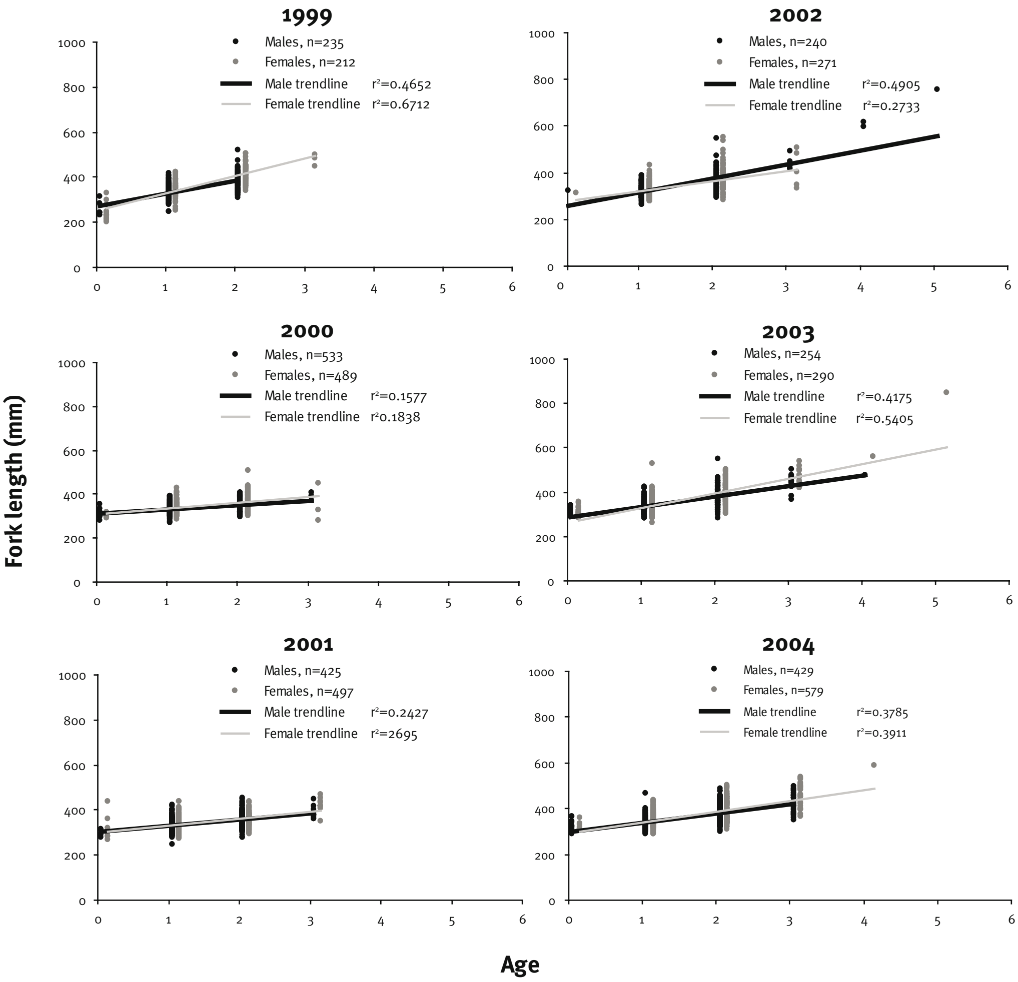

Figure 15. Tailor length at age by sex and year for the Fraser region, collected by the Long Term Monitoring Program from the recreational and commercial fishery.

Discussion

A majority of the tailor samples collected since 1999 have come from the Fraser region and are considered representative of recreational catch in this region. Samples from other regions are not large or comprehensive enough to be considered to be representative of the recreational or commercial catch of those regions and as such will not be discussed further in this report.

The majority of the results presented in this report represent the size structure of the recreational tailor fishery on Fraser Island during late winter to spring between 1999 and 2004.

The difference in sample numbers collected within various zones on Fraser Island could be due to the timing of some LTMP sampling trips coinciding with the seasonal spawning closure, thereby limiting the area being fished by the recreational fishers and the area sampled. Although this may have an impact, it is more likely that the main contributing factors are based around the geomorphological characteristics of each zone and the impacts that this has on the behaviour of recreational tailor fishers. The geomorphology of the zones could alter fisher behaviour due to the accessibility to the area, the physical size of the zone, or the weather influences and available protection within each zone.

Length frequency and length–weight relationships

There were no significant variations in length of tailor between years, sexes or regions. The modal length of tailor collected by the LTMP from the ocean beach fishery supports the previously documented information that tailor enter the fishery and spawn at approximately 300 mm in length[4] and two years of age (Kailola *et al.* 1993).

The length of tailor collected by the LTMP varied considerably within the winter sampling period from July to October, suggesting an earlier northward spawning migration for smaller tailor (July–August) than large tailor (September–October). Leigh and O'Neill (2004) suggested that larger tailor may be migrating offshore and are therefore inaccessible to the fishery until later in the year. However, research conducted by Brown *et al.* (2003) documented the average size of tailor offshore and inshore as similar and therefore migration offshore by larger tailor seemed unlikely.

Tailor length and weight are shown to be closely correlated. There was little difference in the length–weight relationship for tailor in each region or between males and females. However, there was only a small number of fish (254) collected by the LTMP in the years 1999 and 2000 that constructed the length–weight dataset.

[4] Length here is cited as total length, although the LTMP survey collects the fork length of tailor. According to Leigh and O'Neill (2004), 300 mm total length equates to approximately 268 mm fork length of tailor.

Age estimation and age frequencies

An investigation of the monthly frequencies of edge zone formation from tailor collected by the LTMP did not suggest that increment formation occurred during the sampling months of August, September and October. When using edge frequency as a means of validating increment periodicity, it is recommended that the cycle frequency should represent one year in true annuli (Campana 2001). Currently, tailor is only monitored for three months of the year. Previous work on age validation of tailor in Queensland indicated that each annulus represented a year's growth, and suggested increment formation occurred in late September (Brown *et al*. 2003).

Age frequencies for males and females indicated that tailor are not fully recruited to the ocean beach fishery until one and two years of age. This result supports the findings of previous research by Bade (1977). The LTMP surveys also found very few fish over the age of three years. This may be due to high natural mortality, high fishing mortality or that larger fish are migrating offshore out of the fishery (Leigh and O'Neill 2004). Research conducted by Brown *et al.* (2003) documented the average size of tailor offshore and inshore as similar and therefore migration offshore by larger or older tailor seems unlikely.

The age frequency of tailor from the Fraser region displays a slight increase in year class strength from 0 age class in 1999 to the 3 year age class in 2002. However, it is important to note that in 2001 the sample population size was double that of years 1999, 2000 and 2002 and may therefore bias the results.

Growth

The growth of tailor shown here is only representative of young tailor, and as such is not representative of tailor growth through their full life history. For this reason a linear curve has been used instead of a von Bertalanffy growth curve, which produces the maximum length attained by a species (Leigh and O'Neill 2004). Regardless of the poor length and age relationship, the growth was similar for each sex and region. The growth of tailor on the east coast of Australia has been discussed in several documents (e.g. Bade 1977; Dichmont *et al*. 1999). However, results were ambiguous and as such these reports have recommended further investigation into validating the growth of tailor.

Conclusions

The results currently reflect ocean beach catches of young tailor predominately from the Fraser region. The data include only a limited number of samples from commercial catches from the Sunshine and Stradbroke regions. This is primarily due to limited accessibility to commercial samples by the LTMP and a spatial closure on commercial tailor fishing on Fraser Island (*Fisheries Regulation 1995*). However, it is recommended that future monitoring be expanded to include a larger proportion of samples from the commercial sector of the fishery. As the recreational tailor samples are currently collected only from the Fraser region, it is recommended that the sampling be extended to provide more representative sampling of the recreational fishery from both the Sunshine and Stradbroke regions. Leigh and O'Neill (2004) support the need to maximise the truly independent nature of the samples by separating them by either space (e.g. greater than 20 km) or time (e.g. more than a week). By extending the recreational and commercial sampling within the Sunshine and Stradbroke regions, the sample size for these regions would be increased and in turn potentially provide a more representative sample of the Queensland tailor fishery as a whole.

When modifying the survey design to include increased spatial and temporal sampling, it is important to bear in mind that even after further analysis of the sampling design it may still be necessary to maintain the same level of sampling within the Fraser region, in order to obtain a representative sample from that region. The degree to which this expansion would make the sampling more representative of the population available to the fishery is currently unknown (Leigh and O'Neill 2004). Leigh and O'Neill (2004) also noted that sampling at either of the other two regions may in fact lead to fewer schools being available for sampling. They therefore recommended continuing the sampling on Fraser Island, while focusing on taking the samples from the most widely spaced locations. However, they do suggest that the same level of sampling conducted at Fraser Island across the three regions would be preferable (Leigh and O'Neill 2004).

There were limited tailor collected larger than 500 mm (fork length) and at the age of three years or older. It is recommended that a component of the monitoring focuses on collecting larger tailor to help complete the growth curve.

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Appendix—Age estimation quality control measures

Quality control measures

Readability indices were recorded for all otolith readings from 1999 to 2004.

Age readings of tailor were tested for bias and precision.

Bias was tested using age bias plots, where the mean age for one reader was plotted against the age categories reported by another reader. In 2003, bias was tested between readers. In 2003 and 2004, age bias plots were constructed to test bias between the first and second readings by the one reader.

Precision is defined as the reproducibility of repeated measurements on a given structure or) the repeatability of individual readings or age estimates (Kimura and Lyons 1991; Campana 2001). Precision was determined by calculating average percent error (APE) and coefficient of variation (CV).

Beamish and Fournier (1981) recommended the use of APE:

$$APE_j = 100 \times \frac{1}{R} \sum_{i=1}^{R} \frac{\left| X_{ij} - X_j \right|}{X_j}$$

where R is the number of times the fish are aged. X_{ij} is the *i*th age determination of the *j*th fish and X_j is the mean age estimate for the *j*th fish. When APE_j was averaged across many fish it became an index of average percent error (IAPE) (Campana *et al.* 1995).

Chang (1982) devised the CV, expressed as the ratio of the standard deviation to the mean, calculated as follows:

$$CV_j = 100 \times \frac{\sqrt{\sum_{i=1}^{R} \frac{\left(X_{ij} - X_j\right)^2}{R-1}}}{X_j}$$

where R is the number of times the fish are aged. X_{ij} is the *i*th age determination of the *j*th fish and X_j is the mean age estimate for the *j*th fish. As with APE, the CV was averaged across the range of fish to provide a mean CV_j.

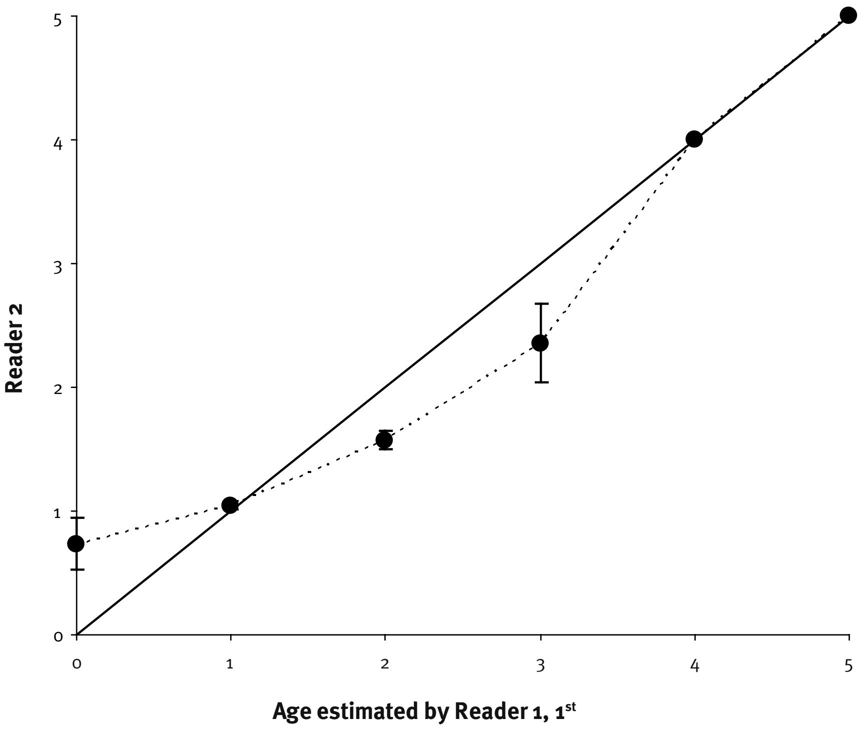
Both inter- and intra-reader precision levels were calculated for 2003 and 2004 age readings.

Quality control results

Since 1999, otoliths from 5916 fish have been examined. The majority of otoliths (44%) were assigned a readability of four (readable but not totally confident). Readers assigned approximately 14% of the otoliths with a readability of five (able to be read with total confidence).

Bias and precision

Age bias plots showed some deviation between readers and readings. In 2003, deviations were seen between readers for the ages of zero and again for two and three years (Figure 16). The magnitude of biases that existed between reader 2 and reader 1, 1st reading, and between reader 2 and reader 1, 2nd reading were relatively small (½ year).



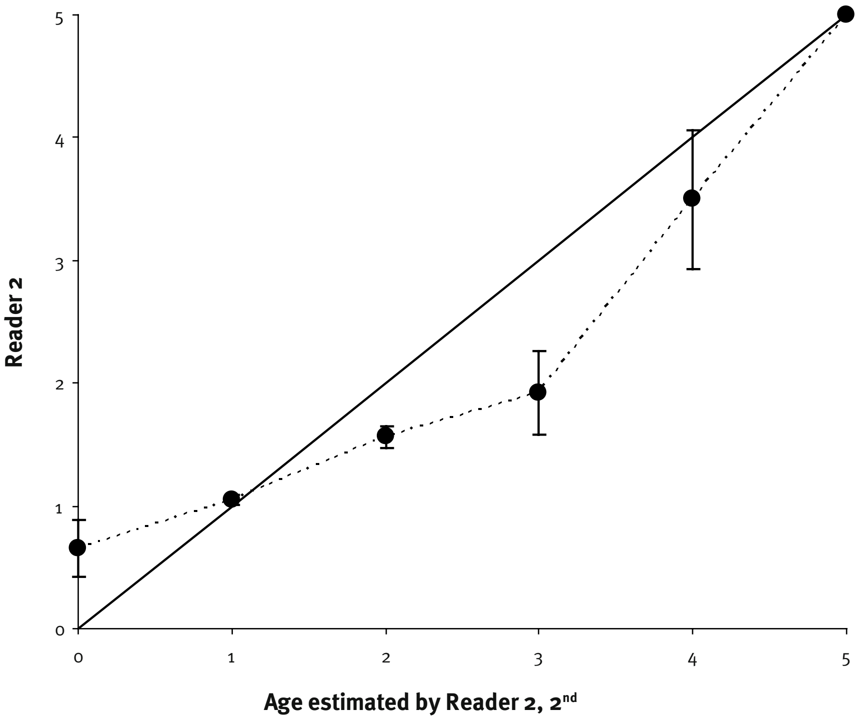


Figure 16. Age bias graphs between readers for 2003. Each error bar represents 95% confidence interval. The 1:1 equivalence line (solid line) is also indicated.

In 2003, when both readings from the same reader were compared, a slight deviation existed for those tailor aged zero years in reading 1 (Figure 17). In 2004, when readings from the same reader were compared, deviations were evident between reading 2 and reading 1, with an overestimation for ages of zero and one years and an underestimation for ages of two and three years (Figure 18).

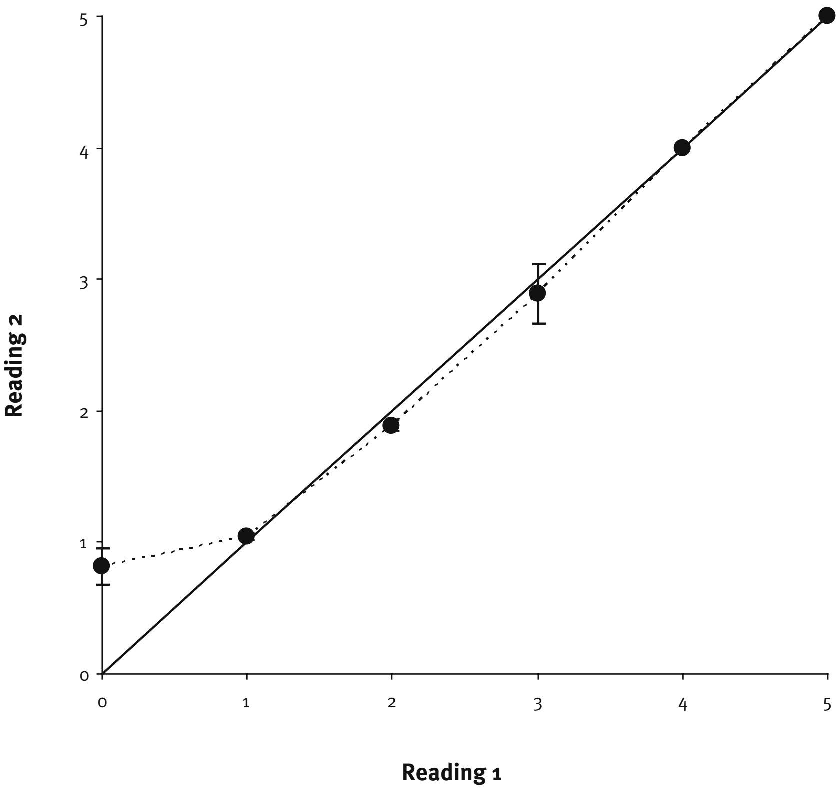


Figure 17. Age bias plots between reading 1 and reading 2 for reader 1 for 2003. Each error bar represents 95% confidence interval. The 1:1 equivalence line (solid line) is also indicated.

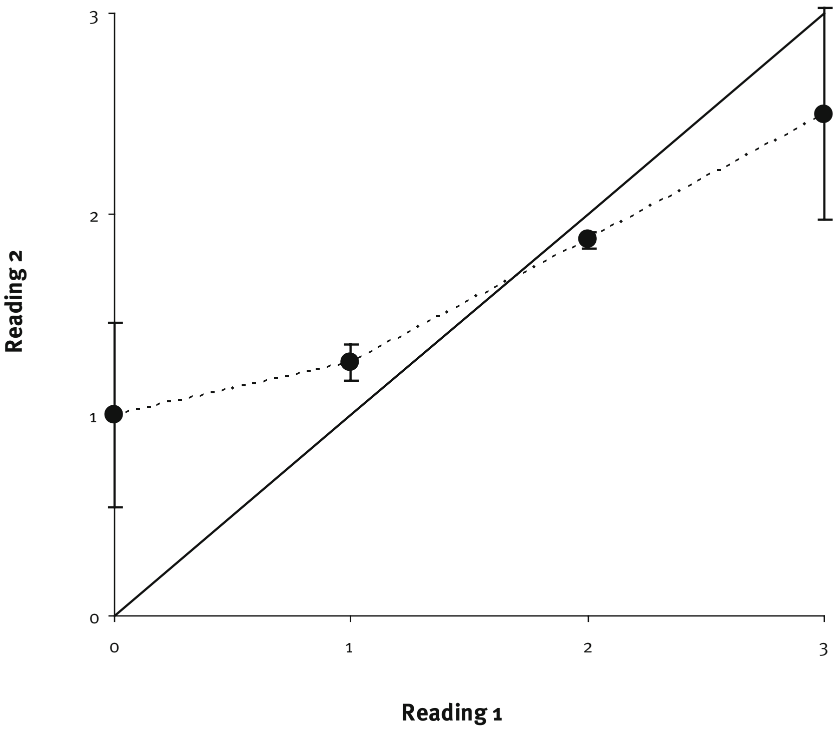


Figure 18. Age bias graph for reading 1 and reading 2 in 2004 (n = 277). Error bar represents 95% confidence interval. The 1:1 equivalence line (solid line) is also indicated.

Inter- and intra-reader precision levels were calculated for 2003 and 2004 (Table 3). Inter-reader APE levels for 2003 ranged from 16.66 to 17.94%. Intra-reader APE levels were 7.67% in 2003 and 10.81% in 2004.

Table 3. Levels of inter- and intra-reader precision for tailor otolith readings.

Statistic or index	Reader 1, 1st v Reader 2 (2003)	Reader 1, 2nd v Reader 2 (2003)	Reading 1 v 2 (2003)	Reading 1 v 2 (2004)
APE	16.66	17.94	7.67	10.81
CV	23.55	25.37	11.27	15.28
n	1038	1038	1040	277

APE = average percent error

CV = coefficient of variation

n = sample size

Quality control discussion

The age estimation of tailor is a challenging process, this being reflected by the low levels in reader confidence. From 5916 otoliths in total, only 14% were classified as being clear (obvious) to read.

The quality control monitoring indicated that some bias existed between readers in 2003. Yet the magnitude of the bias, as indicated by the vertical interval between the 1:1 line and the data points, was relatively small (½ year).

A certain amount of bias was exhibited by reader 1 in 2003 and again in 2004 for the zero-year-old fish. These biases are a reflection of the complex internal structure of tailor otoliths, where some otoliths have several spurious annuli, including a false or first check, inside the first annulus (Brown *et al.* 2003). It is known for many species that the identification of the first annulus is often more problematic than that of the first check, since the latter is often clearly visible as it represents a hatch check (Campana 2001). An ageing protocol for whole tailor otoliths has been developed through an age validation project in Queensland (Brown *et al.* 2003). The LTMP readers have followed these guidelines, which divide the internal structure into regions preceding the formation of the first annulus to aid with interpretation.

The measures of both inter- and intra-reader precision indicated good reproducibility and consistency for the ageing of this species. The intra-reader APE levels were seen to be lower in 2003 compared with 2004. The increase in APE levels may have been due to the shift in methods in 2004, with reading two representing a 25% re-read rather than the entire sample. The large reduction in numbers being analysed in 2004 most probably inflated the APE levels. All measures of precision are artificially inflated by any bias that exists (Campana 2001). Therefore, when all bias is eliminated the precision levels will improve even further.

It is envisaged, with the recent construction of a reference collection, that quality assurance protocols will be carried out annually. Reference collections are mandatory as a first step for quality assurance in any ongoing ageing program and must be used continuously to ensure that age interpretation remains consistent over time and between different readers (Campana *et al.* 1995; Gröger 1999; Campana 2001). In future age estimation of tailor within the LTMP, otoliths from the reference collection will be read prior to the readings of the current year's otoliths. Bias will be looked at initially, as the presence of bias will confound the interpretation of most measures of precision (Campana *et al.* 1995). Following this, precision levels will be calculated using index of APE and CV. If unacceptable levels of error are encountered, these will be addressed with training and the reference collection will be re-read.

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