RESULTS

Temporal Changes in the Shark Control Program

The number of shark nets in each location changed over time in figures 3(a), (b) and (c). There was a general increase in the number of nets and the number of locations between 1962 and 1980, followed by a decline especially after the review in 1992.

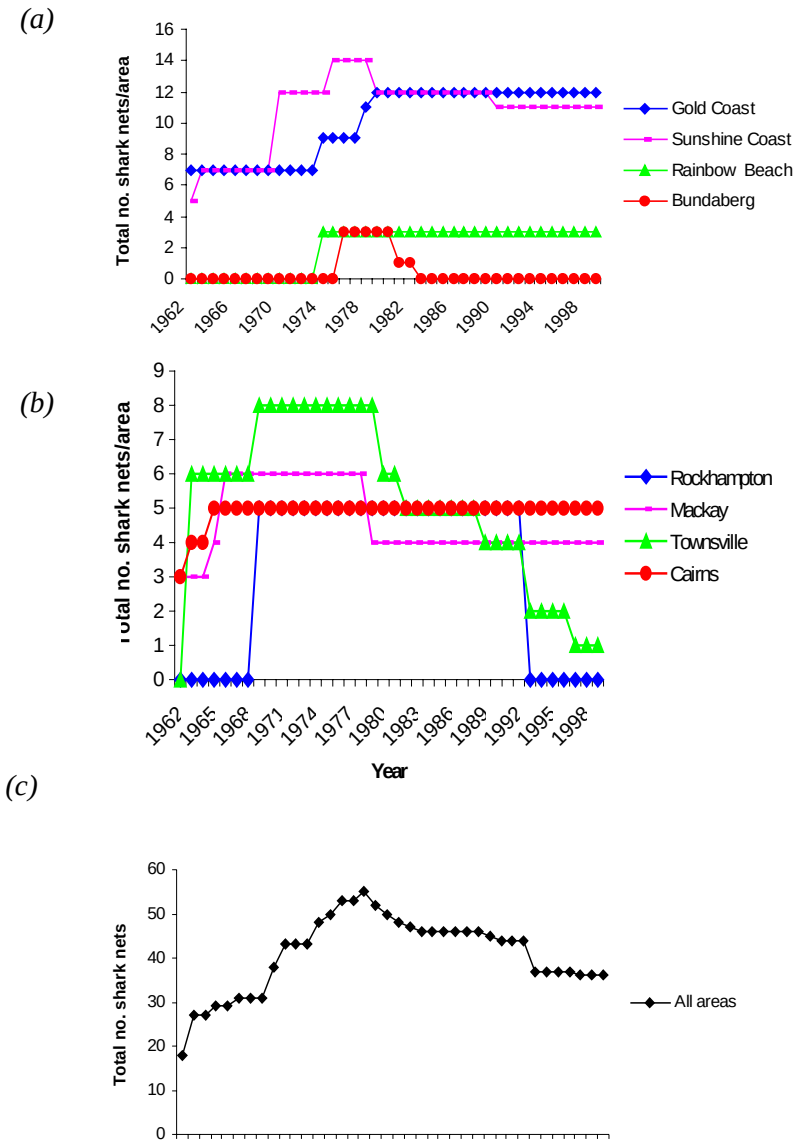

Figure 3. Temporal changes in the number of nets deployed by the Queensland Shark Control Program, a) southern Queensland contract areas, (b) northern Queensland contract areas, (c) all contract areas. Shark net usage steadily increased from 1962, peaked between 1975 and 1980, and has slowly declined to the present total of 36 nets.

Factors with the Potential to Affect the Capture Rate of Dugongs

The number of nets at a netted beach did not affect the number of dugongs caught (χ^2 = 0.10, d.f. = 1, p = 0.752). This surprising result is explained by the number of nets being confounded with beach and, to a lesser degree, year. Beach and year explain 89% of the variation in the number of nets. Hence, when we adjusted for beach and year, the power to detect the effect of the number of nets on dugong mortality is low.

The effect of the number of days fished at a beach in a given year was also non-significant (χ^2 = 2.74, d.f. = 1, p = 0.097). Over all beaches, every day of any given month was fished for 94% of months. When testing for the effect of the number of days fished, including months in the model adjusted for differences in month length (i.e. 28–31 days). We investigated whether this effect was masking the effect of number of days fished by dropping all fully-fished months from the analysis and repeating it. The effect was again non-significant (χ^2 = 0.022, d.f. = 1, p = 0.882).

The effect of months was non-significant, although this effect was marginal (χ^2 = 19.15, d.f. = 11, p = 0.058). The largest difference between any two months was between June and July with a 65% increase in the latter (figure 4). Catch rates were lower in the first half of the year than the second (χ^2 = 7.05, d.f. = 1, p = 0.008).

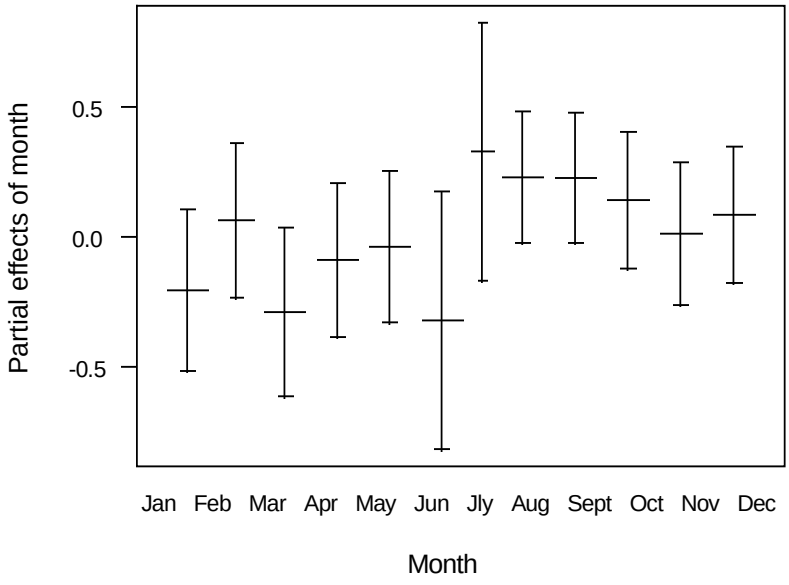

Figure 4. Partial effects plots for month adjusted for year, beach, number of nets and number of days fished on the number of dugongs caught in the Shark Control Program. The largest difference occurred between June and July (a 65% increase). Catches were significantly higher in the second half of the year than in the first half.

There was no detectable effect of previous net removal on the number of dugongs caught in the nets. We compared dugong catches for one month pre and post net removal (χ^2 = 1.02, d.f. = 1, p = 0.353), and for the corresponding three month periods (χ^2 = 1.32, d.f. = 1, p = 0.250). Net removals tended to be systematic at a given beach, but varied between beaches. Adjusting for the effects of beach and month weakened the power of the tests.

The Profiles for Contract Areas

The variation of profiles for beaches within contract areas was small compared to variation between areas (figure 5). Area profiles accounted for 34.9% (d.f. = 17) of the model deviance, whereas beaches within profiles accounted for 21% (d.f. = 75). This gives an approximate F-test [F = 7.33, d.f. = (17, 75), $p < 0.001$] to compare the effects of area profiles to the profiles of beaches within areas. Thus, if we accept that the beaches are representative of their areas, then there are significant differences between area profiles (figure 5). This is confirmed by inspection of the bootstrap confidence intervals for the area profiles (figure 6).

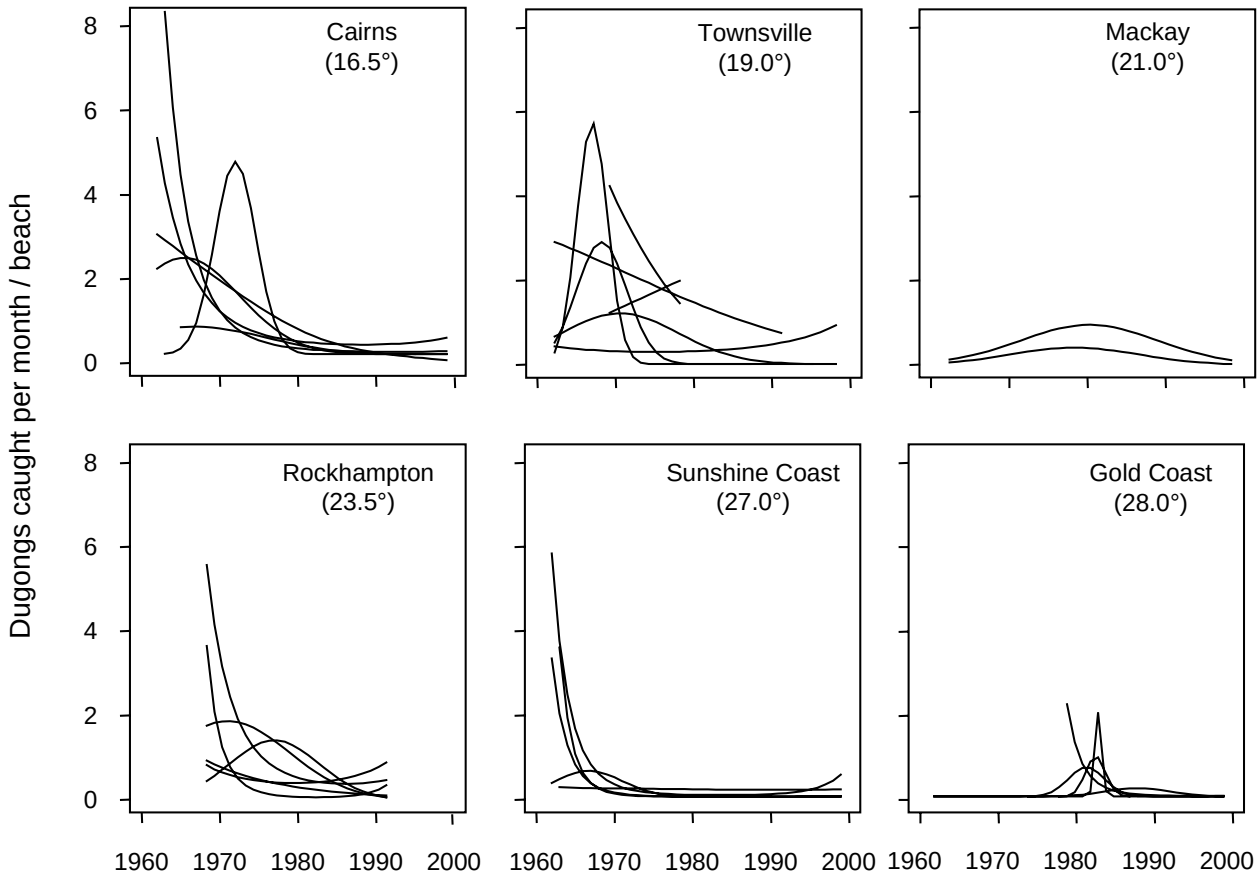

Figure 5. Profiles of the annual estimated mean numbers of dugongs caught at each beach for each of six contract areas for the period 1962–1999 based on the reduced data set. These profiles were estimated by log-linear models with linear and quadratic terms in year. The variation between beaches within areas is relatively small compared to the between-area variation. This result suggests that beaches are representative of their areas, and that there are significant differences between area profiles of the number of dugongs caught.

The Overall Profile

The overall profile for the reduced data set (figure 7) shows a strong decline. Over the period 1962–1999, the capture rate declined at an average of 8.7% per year 95% CI = 7.1, 0.6)]. This corresponds to an overall decline from 100% to 3.1% (7.1, 10.6) or a halving in the catch rate every 8.0 years (6.5, 9.8). The rate of decline increased over time, starting at about 5% in 1962, and increasing to 14% in 1999 (figure 8).

For the full data set, the overall capture rate declined at 8.2% per year (6.8, 9.7), only marginally lower than for the reduced data set. The rate of decline also increased over time, starting at about 6% in 1962, and increasing to 14% in 1999 (figure 8). Because of the changes introduced into the Shark Control Program as a result of the review in 1992 (*Review of the operation and maintenance of shark meshing equipment in Queensland waters*, 1992), we compared the profile for the full data set for 1962–1999 with the corresponding data set for the period 1962–1991. There was no significant difference in the two profiles. If the significant quadratic term is ignored and only a linear term fitted, then we get estimates of 8.7% per year for the full data set and 8.5% per year for the pre-1992 data. The difference is not significant. Thus there is no statistical evidence for a different pattern of decline for the periods pre and post 1992.

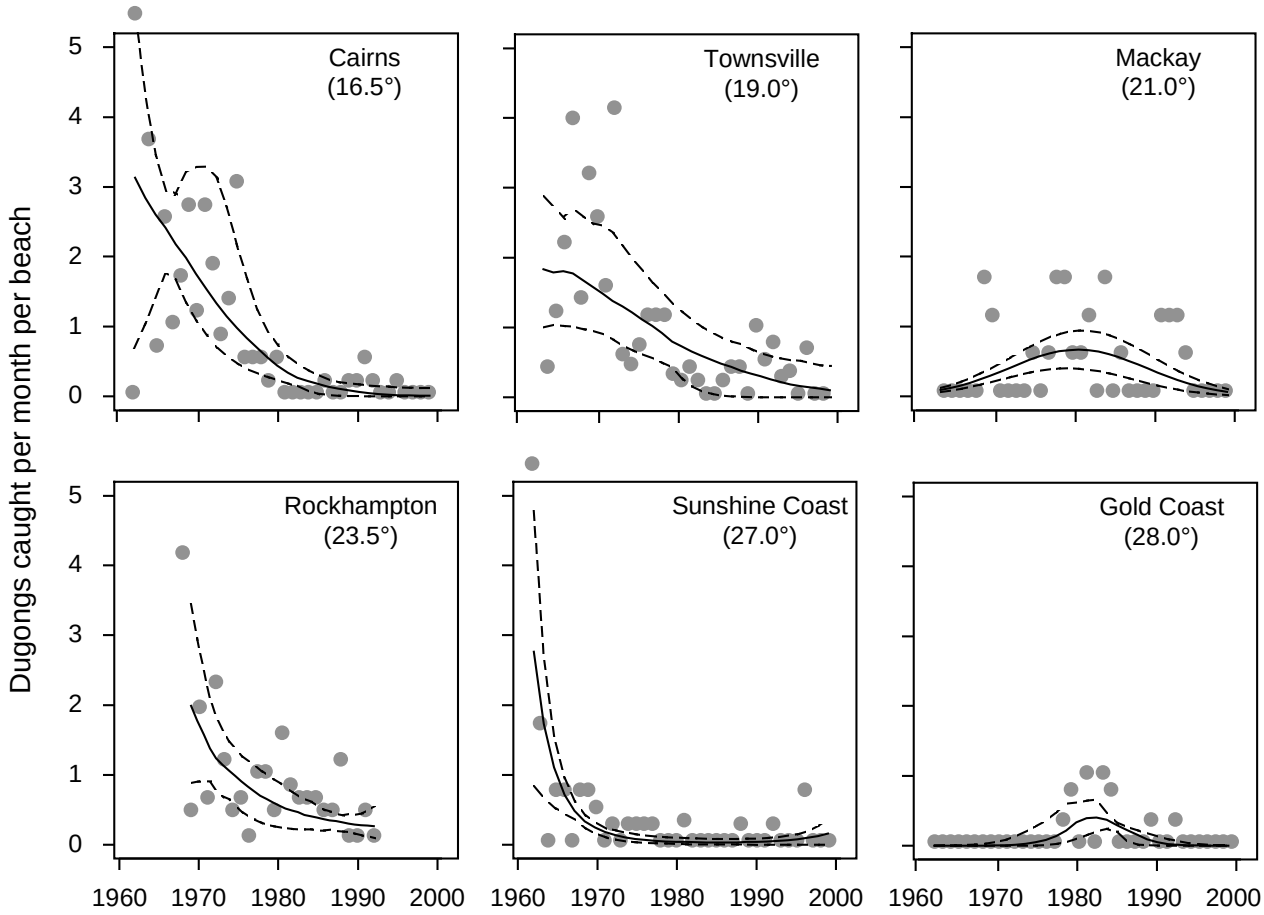

Figure 6. Profiles of the annual estimated mean numbers of dugongs caught per beach in each of six contract areas for the period 1962–1999 for the reduced data set. The profiles were estimated by bootstrapped fits of log-linear models with linear and quadratic terms in year. The bootstrap samples were generated by stratifying on beach within area, thus, for any sample, a beach was either completely included or excluded. Four of the six areas show strong declines, whereas the remaining two have low modal catches centred around 1980–1982. In all areas, catches in the period 1990–1999 have been very low. The confidence intervals have 95% pointwise coverage. Out of range points for Cairns and the Sunshine Coast had values of 6.5 and 6 dugongs caught per month / beach respectively.

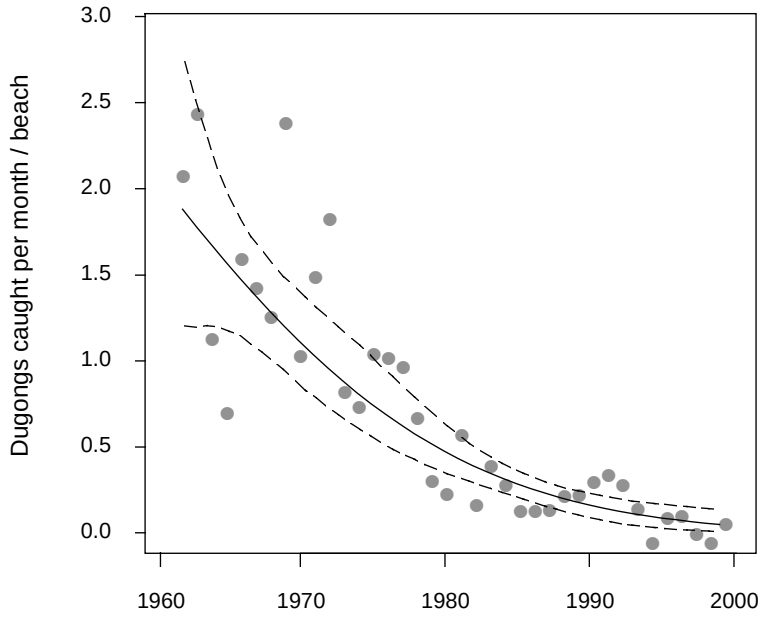

Figure 7. Profile of the annual estimated mean numbers of dugongs caught for the period 1962–1999 for the reduced data set showing a strong overall decline in the number of dugongs caught per month per beach. The profile was estimated by bootstrapped fits of log-linear models with linear and quadratic terms in year for each beach. The bootstrap samples were generated by stratifying on beach within area, thus, for any sample, a beach was either completely included or excluded. The confidence bands have 95% pointwise coverage.

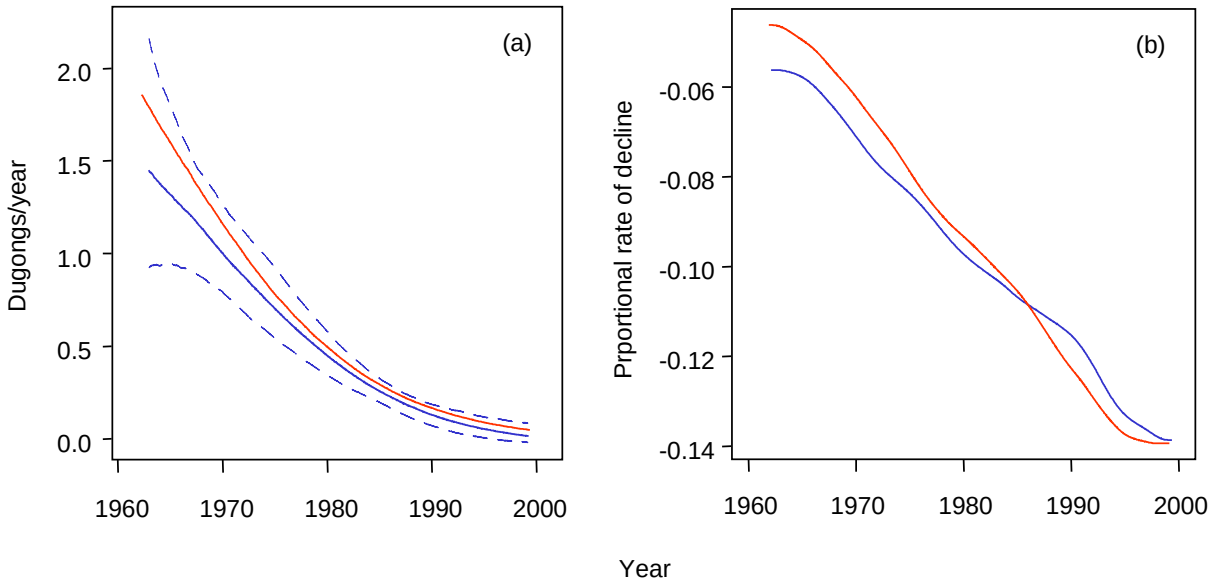

Figure 8. Profiles of the annual estimated mean numbers of dugongs (a) caught for the period 1962–1999 for the full data set (blue solid line) with 95% confidence bands (dashed), and the reduced data set (red solid line). Both data sets show strong overall declines. The profiles were estimated by bootstrapped fits of log-linear models with linear and quadratic terms in year for each beach. Proportional rates of decline for the period 1962–1999 (b) for all data (blue solid line) and the reduced data set (red solid line).