

## **Trends in policing effort and the number of confiscations for abalone including compliance data until March 2013**

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### **Abstract**

GLM methods are applied to compliance data on confiscations (and abandonments) and on policing effort to estimate recent trends in the amount of abalone that is poached. The results suggest that poaching has increased substantially in the last year with poaching levels well above the required target.

### **Introduction**

To obtain overall annual rates of increase in number of confiscations (which throughout this paper include abandonments) and in policing effort in a manner that takes into account possible monthly effects and, in the case of policing effort, the fact that various types of policing exercises are carried out, Generalised Linear Models (GLMs) were applied to these data by Brandão and Butterworth (2011). In this paper, these analyses are updated to include further data now available.

### **Data**

Monthly data on confiscations and policing effort obtained from one of the Directorates within the CD (Directorate: Compliance) for the period of April 2008 to March 2013 are used in the present analyses. Data for the period April 2012 to March 2013 are new compared to those used for the analyses carried out by Brandão and Butterworth (2011) and data for the period of March 2012 has been updated.

Compliance data are available for the whole of the “South Coast” (Cape Town to Arniston) region including Saldanha Bay as well as disaggregated into two regions: Zones A-D and Zones E-G. No new data have been supplied for the Kleinmond region and therefore this region has not been analysed in this paper. The policing effort types included in the analyses are as selected by scientists from the

abalone working group as being those most likely to have resulted in abalone confiscations. These are: vehicles inspected, slipway inspections, coastal patrols, road blocks and sea patrols.

## Methods

GLMs are used to investigate the variation of the number of confiscations of abalone as well as that of the policing effort that has occurred. Trends in the number of confiscations and in the policing effort are modelled in two ways: one by having the covariate “year” which is a factor which represents the year (i.e. a categorical nonlinear relationship is assumed between the number of confiscations/policing effort with the time period) and alternatively by having the covariate “Time” (essentially the date) which represents a continuous value for the year and month for which the data record applies (i.e. a linear relationship is assumed between the number of confiscations/policing effort with the date).

The expected policing effort (assuming a linear relationship with time) is modelled as:

$$E(P) = \exp(\mu + \alpha_{month} + \beta_{type} + \gamma Time) \quad (1)$$

where

- $P$  is the policing effort, assumed to have an overdispersed Poisson distribution,
- $\mu$  is the intercept,
- $\alpha_{month}$  is the month effect,
- $\beta_{type}$  is the type of policing effect, where the “type” factor is associated with the different types of policing such as coastal patrols, permit checks, restaurant inspections, road blocks, sea patrols, slipway inspections and vessels inspections, and
- $Time$  is the time (date) representing the year and month to which the data applies, and  $\gamma$  is the associated coefficient.

When an other than linear (categorical) relationship is assumed between policing effort and time, the expected policing effort is modelled as:

$$E(P) = \exp(\mu + \alpha_{month} + \beta_{type} + \delta_{year}) \quad (2)$$

where

- $\delta_{year}$  is the year effect (2008 to 2013).

A weight is applied to each of the above GLMs to account for different levels of variance (beyond Poisson) in the data for the different measures of policing. The weight applied to the data is given by the inverse of the estimated overdispersion parameter obtained by fitting the GLM of Equation (1) (without the “type” factor) to each separate data set for the different types of policing employed.

The same procedure as for policing effort is applied to the number of confiscations. The one difference in the GLMs is that the  $\beta_{type}$  effect does not apply in this case. No weighting of the data is performed in this case.

Note that throughout “year” refers to Model-year, e.g. 2009 means the period October 2008 to September 2009.

## Results

Table 1 shows the parameter estimates for the GLMs fitted to the policing effort data and to the number of confiscations for the whole South Coast and Saldanha Bay.

For policing effort, whether a linear or nonlinear function is assumed over time, a slight positive trend is evident (Table 1 and Figure 1). An increase of 2.7% per year is obtained assuming a linear relationship. Under the categorical (other than linear) approach, a slight increase remains apparent.

For the number of confiscations, an increasing trend (25% per year) is obtained if a linear relationship is assumed (Table 1). Under the categorical analysis, an increase is also evident (Table 1 and Figure 1), although a substantial drop is estimated for 2012 as well as a substantial increase for 2013, though note the large CI for 2013 which consists of only six months of data.

The instantaneous annual rates of increase obtained from the linear GLM are:

Confiscations: 25% (s.e. = 8.5%)  
 Policing effort: 2.7% (s.e. = 2.0%)

**Together these suggest that removals from poaching have been increasing at an instantaneous rate of 22.7% p.a. (s.e.=8.7%) over the last three years. This corresponds to a net increase of 25.5% over one year, 58% over two, 98% over three, and 148% over four.**

## Disaggregated by Region

The analyses above pool data across all regions. Results might be biased if there has been a shift in policing effort allocation across regions over time. This has been addressed by disaggregating the compliance data by regions (Zones A-D and Zones E-G) and repeating the GLM analyses.

The results of these further GLMs are shown in Table 2-3 for Zones A-D and Zones E-G respectively. Figure 1 shows the results for the categorical analysis for Zones A-D as well as for the “South Coast” as a whole (Cape Town to Arniston plus Saldanha Bay). The lowest row of plots in this Figure show the poaching level index as the ratio of the categorical factor estimates for confiscations and for effort each year, normalised as the average over the 2008 and 2009 years, together with the targeted decrease in poaching for 2010, 2011, 2012 and 2013 under the current abalone recovery plan. Figure 2 shows the similar plots for Zones E-G.

For Zones A-D there is an estimated decrease in effort over the last three years, but with a very slight increase since 2010, with a peak in 2012. However in broad terms for both A-D and the region overall there is an estimated approximate doubling of poaching over the 2010 to 2011 period though there is an appreciable (though not statistically significant) drop in poaching in 2012, followed by an estimated large increase in 2013. Results in Table 3 and Figure 2 similarly indicate a large increase in

poaching in Zones E-G until 2011 and a large (though not statistically significant) drop in 2012 again followed by a large increase in the last year. For all regions, the estimated poaching levels are well above the target poaching level required under the abalone recovery plan, with levels in the last year having drastically increased.

### **Reference**

Brandão, A. and Butterworth, D.S. 2011. Trends in policing effort and the number of confiscations for abalone. FISHERIES/2011/AUG/SWG-AB/08.

**Table 1.** GLM parameter/coefficient (and standard error) estimates for the whole South Coast (Cape Town to Arniston) and Saldanha Bay.

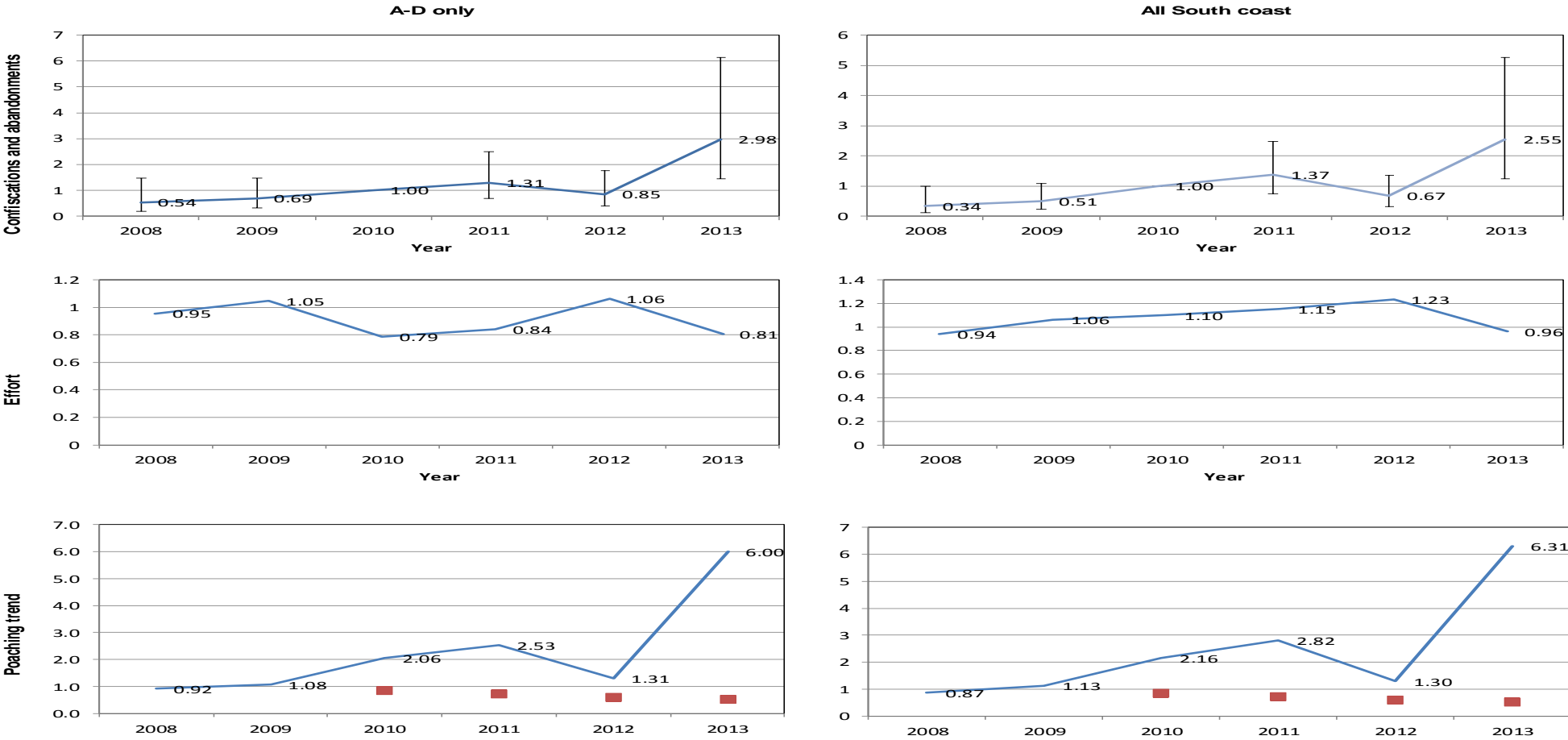
	<b>Policing effort (year factor)</b>	<b>Policing effort (linear)</b>	<b>Confiscations (year factor)</b>	<b>Confiscations (linear)</b>
<b>January</b>	0.462 (0.133)	0.460 (0.133)	-0.455 (0.677)	-0.476 (0.739)
<b>February</b>	0.115 (0.143)	0.111 (0.144)	-0.124 (0.616)	-0.167 (0.672)
<b>March</b>	0.051 (0.145)	0.044 (0.146)	0.190 (0.570)	0.126 (0.623)
<b>April</b>	0.207 (0.142)	0.221 (0.141)	-0.161 (0.724)	-0.440 (0.778)
<b>May</b>	0.137 (0.144)	0.149 (0.144)	0.951 (0.552)	0.650 (0.585)
<b>June</b>	0.102 (0.145)	0.112 (0.145)	0.760 (0.573)	0.438 (0.607)
<b>July</b>	0.255 (0.141)	0.262 (0.140)	0.963 (0.551)	0.619 (0.582)
<b>August</b>	0.420 (0.136)	0.425 (0.135)	0.698 (0.580)	0.333 (0.615)
<b>September</b>	-0.224 (0.158)	-0.221 (0.157)	1.158 (0.534)	0.772 (0.562)
<b>October</b>	0.232 (0.139)	0.236 (0.140)	0.528 (0.532)	0.571 (0.581)
<b>November</b>	0.156 (0.141)	0.158 (0.142)	0.666 (0.519)	0.687 (0.566)
<b>December</b>	0	0	0	0
<b>Time (yr<sup>-1</sup>)</b>	—	0.027 (0.020)	—	0.255 (0.085)
<b>2008</b>	-0.157 (0.117)	—	-1.072 (0.541)	—
<b>2009</b>	-0.034 (0.088)	—	-0.679 (0.394)	—
<b>2010</b>	0	—	0	—
<b>2011</b>	0.049 (0.086)	—	0.314 (0.301)	—
<b>2012</b>	0.114 (0.085)	—	-0.397 (0.361)	—
<b>2013</b>	-0.134 (0.115)	—	0.937 (0.370)	—
<b>coastal</b>	0.137 (0.091)	0.137 (0.091)	—	—
<b>road</b>	-3.803 (0.139)	-3.803 (0.139)	—	—
<b>sea</b>	-4.958 (0.146)	-4.958 (0.147)	—	—
<b>slipway</b>	-0.078 (0.085)	-0.078 (0.086)	—	—
<b>vehicles</b>	0	0	—	—

**Table 2.** GLM parameter/coefficient (and standard error) estimates for Zones A to D.

	<b>Policing effort (year factor)</b>	<b>Policing effort (linear)</b>	<b>Confiscations (year factor)</b>	<b>Confiscations (linear)</b>
<b>January</b>	0.455 (0.174)	0.455 (0.176)	-0.561 (0.713)	-0.581 (0.744)
<b>February</b>	0.018 (0.192)	0.019 (0.194)	-0.086 (0.623)	-0.126 (0.649)
<b>March</b>	0.003 (0.192)	0.006 (0.195)	0.266 (0.572)	0.206 (0.597)
<b>April</b>	0.160 (0.187)	0.185 (0.187)	-0.017 (0.707)	-0.297 (0.724)
<b>May</b>	-0.032 (0.196)	-0.005 (0.195)	1.140 (0.546)	0.840 (0.552)
<b>June</b>	0.049 (0.192)	0.076 (0.191)	0.949 (0.564)	0.628 (0.570)
<b>July</b>	0.217 (0.185)	0.245 (0.184)	0.286 (0.650)	-0.054 (0.662)
<b>August</b>	0.340 (0.180)	0.369 (0.179)	0.932 (0.565)	0.571 (0.571)
<b>September</b>	-0.295 (0.210)	-0.266 (0.209)	0.475 (0.621)	0.094 (0.630)
<b>October</b>	0.134 (0.186)	0.132 (0.189)	0.766 (0.521)	0.806 (0.544)
<b>November</b>	-0.079 (0.196)	-0.080 (0.199)	0.857 (0.514)	0.877 (0.535)
<b>December</b>	0	0	0	0
<b>Time (yr<sup>-1</sup>)</b>	—	-0.011 (0.027)	—	0.240 (0.082)
<b>2008</b>	0.194 (0.152)	—	-0.610 (0.514)	—
<b>2009</b>	0.285 (0.119)	—	-0.365 (0.388)	—
<b>2010</b>	0	—	0	—
<b>2011</b>	0.064 (0.125)	—	0.267 (0.331)	—
<b>2012</b>	0.299 (0.119)	—	-0.157 (0.367)	—
<b>2013</b>	0.023 (0.159)	—	1.091 (0.370)	—
<b>coastal</b>	0.288 (0.117)	0.288 (0.118)	—	—
<b>road</b>	-3.768 (0.183)	-3.768 (0.185)	—	—
<b>sea</b>	-5.117 (0.189)	-5.117 (0.191)	—	—
<b>slipway</b>	-0.087 (0.112)	-0.087 (0.113)	—	—
<b>vehicles</b>	0	0	—	—

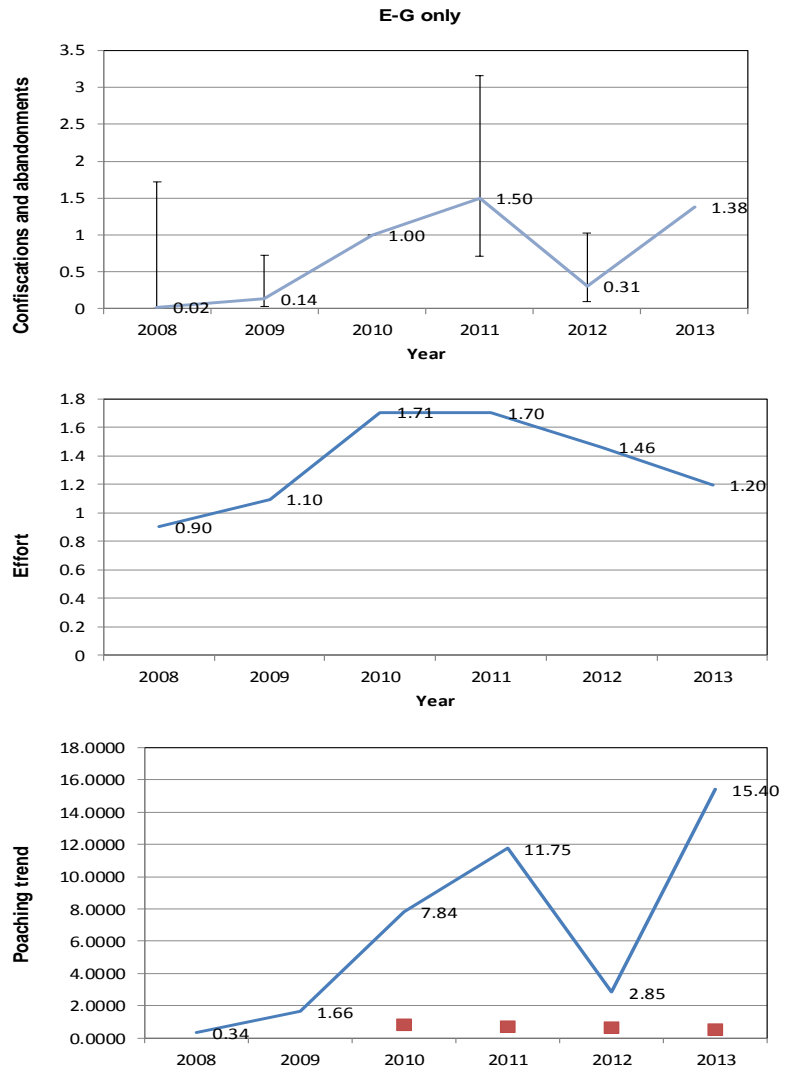
**Table 3.** GLM parameter/coefficient (and standard error) estimates for Zones E to G.

	<b>Policing effort (year factor)</b>	<b>Policing effort (linear)</b>	<b>Confiscations (year factor)</b>	<b>Confiscations (linear)</b>
<b>January</b>	0.470 (0.158)	0.465 (0.166)	-0.185 (0.947)	-0.210 (1.130)
<b>February</b>	0.205 (0.166)	0.195 (0.176)	-0.254 (0.965)	-0.300 (1.150)
<b>March</b>	0.070 (0.172)	0.056 (0.181)	-0.090 (0.923)	-0.170 (1.100)
<b>April</b>	0.206 (0.170)	0.203 (0.178)	-0.940 (1.400)	-1.120 (1.670)
<b>May</b>	0.271 (0.168)	0.263 (0.175)	-0.240 (1.100)	-0.440 (1.290)
<b>June</b>	0.115 (0.174)	0.102 (0.181)	-0.430 (1.170)	-0.660 (1.380)
<b>July</b>	0.253 (0.168)	0.236 (0.176)	1.805 (0.739)	1.554 (0.852)
<b>August</b>	0.458 (0.161)	0.435 (0.168)	-1.250 (1.590)	-1.530 (1.880)
<b>September</b>	-0.168 (0.187)	-0.196 (0.195)	2.005 (0.727)	1.704 (0.835)
<b>October</b>	0.334 (0.162)	0.344 (0.171)	-1.230 (1.340)	-1.170 (1.600)
<b>November</b>	0.327 (0.162)	0.332 (0.171)	-0.380 (1.000)	-0.350 (1.200)
<b>December</b>	0	0	0	0
<b>Time (yr<sup>-1</sup>)</b>	—	0.059 (0.024)	—	0.302 (0.146)
<b>2008</b>	-0.638 (0.148)	—	-3.790 (2.210)	—
<b>2009</b>	-0.442 (0.104)	—	-1.992 (0.850)	—
<b>2010</b>	0	—	0	—
<b>2011</b>	-0.002 (0.092)	—	0.402 (0.382)	—
<b>2012</b>	-0.155 (0.096)	—	-1.168 (0.607)	—
<b>2013</b>	-0.354 (0.132)	—	0.321 (0.688)	—
<b>coastal</b>	-0.058 (0.115)	-0.058 (0.121)	—	—
<b>road</b>	-3.842 (0.155)	-3.842 (0.163)	—	—
<b>sea</b>	-4.811 (0.178)	-4.811 (0.188)	—	—
<b>slipway</b>	-0.068 (0.113)	-0.068 (0.119)	—	—
<b>vehicles</b>	0	0	—	—



**Figure 1.** Comparison of estimates of annual factors from the categorical model of equation (2) where these are estimated for each Model-year. Results are shown for confiscations (and abandonments) and for policing effort, with the lowest pair of plots reflecting the ratios as an index of the annual level of poaching, and the squares reflecting the 15% annual decrease in poaching sought under the current abalone recovery plan. The left side plots are for Zones A-D only, whereas the right side plots are for the whole South Coast. The confiscation plots are normalised to the 2010 values with 95% CIs shown for the other Model-years. The effort and poaching index are normalised to their 2008-2009 average values.





**Figure 2.** Comparison of estimates of annual factors from the categorical model of equation (2) where these are estimated for each Model-year. Results are shown for confiscations (and abandonments) and for policing effort, with the lowest pair of plots reflecting the ratios as an index of the annual level of poaching for Zones E-G only. The confiscation plots are normalised to the 2010 values with 95% CIs shown for the other Model-years. The effort and poaching index are normalised to their 2008-2009 average values.