RESPONSES TO SOME COMMENTS IN ALTWEGG MCM/2010/SWG-PEL/23 REGARDING PENGUIN ANALYSES

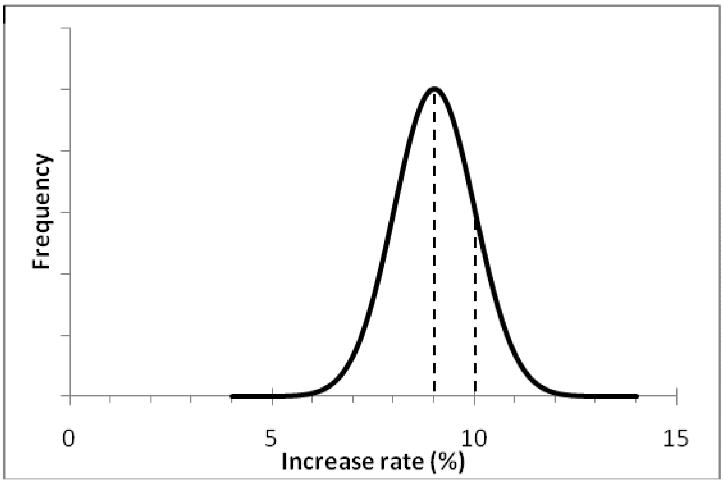
D S Butterworth

MARAM (Marine Resource Assessment and Management Group)
Department of Mathematics and Applied Mathematics
University of Cape Town
Rondebosch 7701

I) REGARDING THE IMPLICATIONS OF POINT ESTIMATES OF SURVIVAL RATE ON CONSTRAINT BOUNDARIES

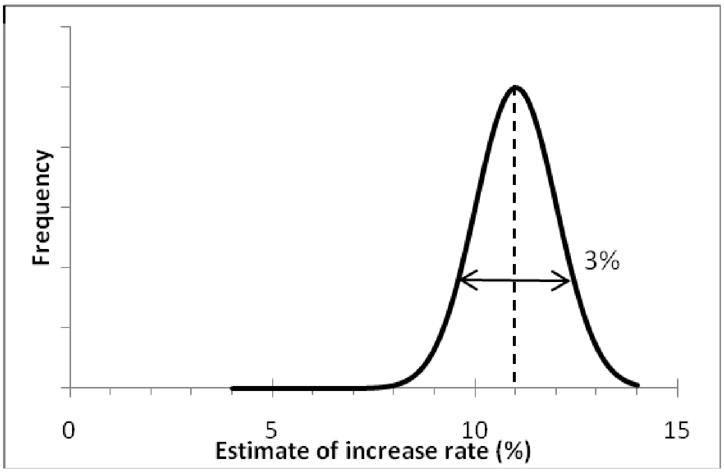
Consider the following illustrative example.

A population of a species which for demographic reasons cannot increase faster than 10% p.a. is being monitored.



Say the true rate of increase is 9% p.a., but the annual estimates of abundance from which trends are to be computed are subject to fairly large sampling error. Thus the distribution of results of estimated trends that might arise after 10 years is 9% ± 3%.

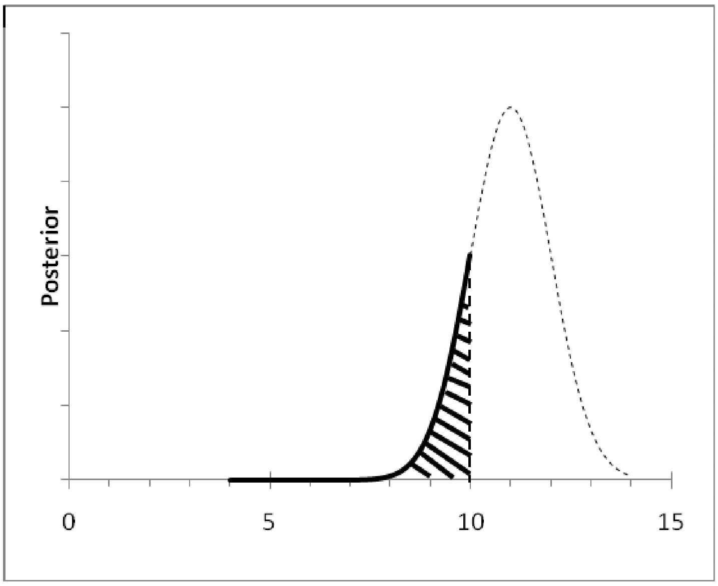
Note first that it **is** possible that data yield an estimate **<u>greater</u>** than the 10% which is known to be the maximum possible biologically.



Now move to the situation that could arise in reality where there is only a single data set available, but of course the actual underlying increase rate is unknown. Say this data set happens to yield an estimated annual increase rate of 11% with standard error of 3%. What inferences can be drawn given that this estimate is greater than the 10% known to be the maximum possible biologically?

A) **The frequentist:** argues that the estimate of 11% is not significantly > 10% at the 5% level. Accordingly there is **no evidence of any structural problem** with the model. (A simpler example would be monitoring a closed population subject only to deaths – because of sampling error, a time series of annual estimates of abundance would sometimes show an increase from one year to the next, yielding a negative estimate for the mortality rate for that year – such negative estimates, possibly taken to be bounded below by 0, do not invalidate the assumption of an exponential decline in numbers over time.) Naturally had the estimate been 20% with a standard error of 3%, there would have been a case to infer structural error.

B) **The Bayesian**: imposes a prior of U[0; 10%] on the annual increase rate. The posterior distribution for this rate is the triangle-like shaded region shown. The two-tailed 90% ("symmetric") PI might perhaps be about [8; 9.8%], which does not include the posterior mode of 10%. Again this provides **no evidence of any structural problem** with the model of an exponential increase which recognises the biological reality that this rate cannot exceed 10%.



It is important to realise that when population projections are calculated, they are generally (as should be the case) based on **distributions** of biological parameter values, not point estimates, with the Bayesian paradigm providing the most natural and appropriate framework. In other words, the value of the point estimate of a parameter is of little consequence in this context; **what is important is the distribution** for the value of the parameter.

Thus the fact that point estimates of some parameters of survival rates fall on constraint boundaries does **not** constitute a sufficient basis to conclude that there are structural problems with a model.

II) REGARDING ADVANTAGES FOR A PELAGIC FISH PREDATOR OF FISHING BREAKING UP SCHOOLS

Consider the following example.

For simplicity, assume schools are spherical.

Initially assume that there are 50 schools each of radius 100 m:

$$\text{Visible (detectable) area} = 50 \text{ x } 4\pi\ 100^2 = 6.28 \text{ x } 10^6 \text{ m}^2$$

Assume that fishing breaks these up into 250 schools. Since density tends to remain the same (related to fish length), this implies a new radius *r* given by:

$$50 \text{ x } \tfrac{4}{3}\pi\ 100^3 = 250 \text{ x } \tfrac{4}{3}\pi\ r^3$$

$$\Rightarrow\ r = 58.5 \text{ m}$$

Thus:

$$\text{Visible (detectable) area} = 250 \text{ x } 4\pi\ 58.5^2 = 10.74 \text{ x } 10^6 \text{ m}^2$$

i.e. the smaller but more numerous schools are about 70% more detectable, improving the probability of encounter by a predator, so that expected searching time **decreases**.

Similar results follow for shapes other than spheres – this is simply the consequence of a surface/volume trade-off. Naturally also removals by fishing will impact the numbers above – the point of this example is simply to isolate the size and direction of one contributing factor to the overall outcome.

The inference that smaller schools (given the same overall abundance) offer a feeding advantage to natural predators has long been recognised in the literature (see for example C W Clark. 1976. Mathematical Bioeconomics. John Wiley & Sons). This followed the sharp declines (primarily caused by fishing), without rapid subsequent recovery, in a number of small pelagic fish populations around the world in the 1960s and early 70s. This in turn led to suggestions of depensatory effects leading to predator pits, with the likely smaller schools associated with a reduced population being put forward as the possible underlying mechanism.