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Resharpening Ockham's Razor

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How did William, born around 1280 in the village of Ockham, in the hills of Surrey, southern England, manage to achieve eponymous fame among natural scientists over 700 years later?

First: he became a man of letters. In his time, this meant becoming a theologian-philosopher. So Ockham did, latinizing his name to "Occam" in the process.

Second: he then chose to write on the kind of topics that did not lead to one being promptly burnt at the stake, as happened to his contemporary Giordano Bruno who had suggested the stars may be suns, and that the Earth rotates around ours. Still, he barely managed to stay out of the line of fire, and once, he even had to swear, among other things, "that in future, I will [...] not adhere to the heresies, the errors, the opinions and the rebellions of Louis of Bavaria and Michael of Cesena against the Church...".[a] This gave William of Occam enough time to spin more strands for the dusty cobweb of scholastic philosophy, of which he wrote about one meter worth, before dying of the Black Death in 1347 or 1349.

Later, he became one of the authors that are most studied in Catholic seminaries (yes, nowadays, still!). However, natural scientists would not know about this nor indeed give a hoot about him, had he not written that:

> *"Frustra fit per plura, quod fieri potest perpauciora"* (It is vain to do what can be done with less); and *"Essentia non sunt multiplicanda praeter necessitateus"* (Entities are not to be multiplied beyond necessity[b]; see Fig. 1).

Over the centuries, these two phrases, increasingly separated from their original context, were distilled into what is now known as "Ockham's Razor": the injunction to scientists to keep their explanation of phenomena as simple or "parsimonious" as possible (Box 1), and to cut out from one's argument all matters not supported by strong evidence, or irrelevant to making one's point.

This now appears obvious — yet the consequences of this dictum for all sciences — including fisheries science — are enormous — whether they are left implicit (as is commonly the case) or made explicit.

Indeed, Ockham's dictum largely *defines* good science — that which offers concise explanations (or models) that are simple (= have few parameters) yet cover (i.e., explain) a wide range of phenomena and observations. Here, the alternative to good science is "adhockery", the generation of *ad hoc* hypotheses for every new realization of the same phenomenon, similar to the sausages that emerge each time the crank of a sausage machine is turned.

Adhockery is easy to detect; it is usually prefaced by sentences that start with

> "This may be so in theory; however, in the case of the [(taxonomic) group, process, place or period] I work on, things are more complicated ...".

...this being then followed by a complex hypothesis, backed by data for only the very group, process, place or period in question.

Yet, as the accounts of major scientific discoveries indicate, the key steps in making these discoveries has usually been the *simplification* of the problem investigated, i.e., the elimination of all "entities" not essentially related to the problem at hand (see Box 2).

This is not different in fisheries science; by choosing a certain tool, we also choose to ignore (except as "noise", or unexplained variance) all entities that

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BOX 1

Simplicity and Falsifiability

A lucid review of the relationship between the simplicity and accuracy of ecosystem models was presented by W. Silvert.[a]

My favorite phrase in this important review, and one which has inspired my work since I first read it is:

> *It is almost always possible to find a mathematical function with the appropriate qualitative behaviour which does not require any more parameters to fit when the more popular model appears inadequate.*

(and this is neatly illustrated in Fig. 2).

Perhaps I should also point out that the need to maintain the falsifiability of our models or theories provides, in itself, a good reason to keep these models or theories simple, as pointed out by K. Popper.[b]

[a] Silvert, W. 1981. Principles of ecosystem modelling, p. 651-676. *In* A.R. Longhurst (ed.) Analysis of marine ecosystems. Academic Press, San Diego.

[b] Popper, R.R. 1965. The logic of scientific discovery. Harper, New York.

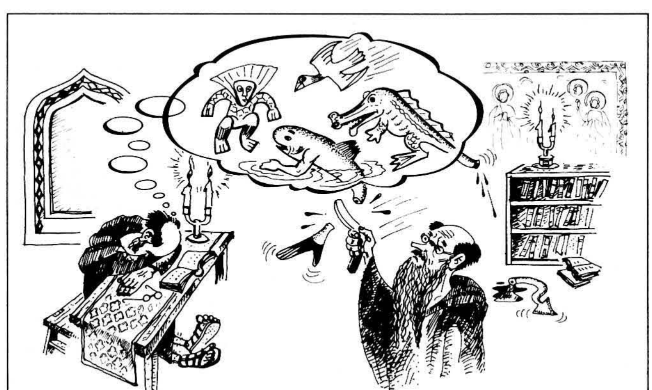

Fig. 1. ***William of Ockham wielding his razor against entities multiplied beyond necessity (from a woodcut of May 2, 1346).***

[a] An account of Ockham's life may be found in the Introduction of "Philosophical writings: a selection". 1990. Hackett Publishing Corporation. Indianapolis, Indiana.

[b] These and other illuminating quotations may be found in Mackay, Alan L., Compiler. 1992. A dictionary of scientific quotations. Institute of Physics Publishing, Bristol & Philadelphia. 297 p.

BOX 2

Creative Simplifications

- Galileo Galilei (1564-1642): the physicist who assumed that the free fall of *any* object, irrespective of its physical properties, could be simulated by balls rolling down inclined planes (and thus eliminating their shape, texture, color, "nature" and "purpose" from consideration);
- Carl von Linné (1707-1778): the taxonomist who forced all of earth's organisms into a system of unique binomial names [thus cutting away the often page-length bits of Latin prose (i.e., the *descriptions*) that were previously used instead of scientific *names*; Linné also cut away all special features of *Homo sapiens*, which he was the first to group with the anthropoid apes.
- Charles Lyell: the geologist who managed to cut (for a while) ancient catastrophies out of the geological discourse, leaving the same slow processes operating now as cause for past changes, and thus providing Charles Darwin with the deep time he needed for his version of evolution;
- Charles Darwin (1809-1882): the genius naturalist who cut the links between "design" and "function", and thus between Creator and Creation, leaving evolutionary biologists to sort out the details;
- R.J. Beverton and S.J. Holt: who showed that fisheries could be managed, or at least made to operate more rationally by optimizing yield *per recruit*. This obviated the need for predictions of *absolute recruitment*, until then (and, to many unfortunate colleagues still) the Holy Grail of Fisheries Science.

are not explicitly included in our model.

Estimating the parameters of a von Bertalanffy Growth Function, based on a set of trout length at age data from the Docken Water, Hampshire, southern England (Fig. 2) implies, for example, that we have cut out from our argument:

- the influence of sun spots on primary production in the world's rivers and hence on the growth of trout in Hampshire and adjacent Surrey;
- the warming of global climate, and the cooling of love;
- the reasons which led supermodel Naomi Campbell to leave in early October 1993, the Elite modeling agency;
- and many more tidbits and models that may or may not be related to the growth curves in question (Fig. 2).

Yet even the most ardent slasher of unnecessary entities will admit that something is amiss with Fig. 2A and its simple three-parameter model: there is a clear pattern of deviations of the data points. Thus the attempt in Fig. 2B to fit a series of growth curves to the data, resulting in a better fit, but a rather long chain of sausages (15 parameters).

This leads to Fig. 2C, which has five parameters, and which eliminates the seasonal pattern of residuals from the curve in A.

Apparently, we have succeeded here in cutting out *unnecessary* entities: we are on top of Ockham's Hill (Fig. 3).

Perhaps we should stop here: most readers will have gotten the point, and consider resharpening their own issue of Ockham's Razor.

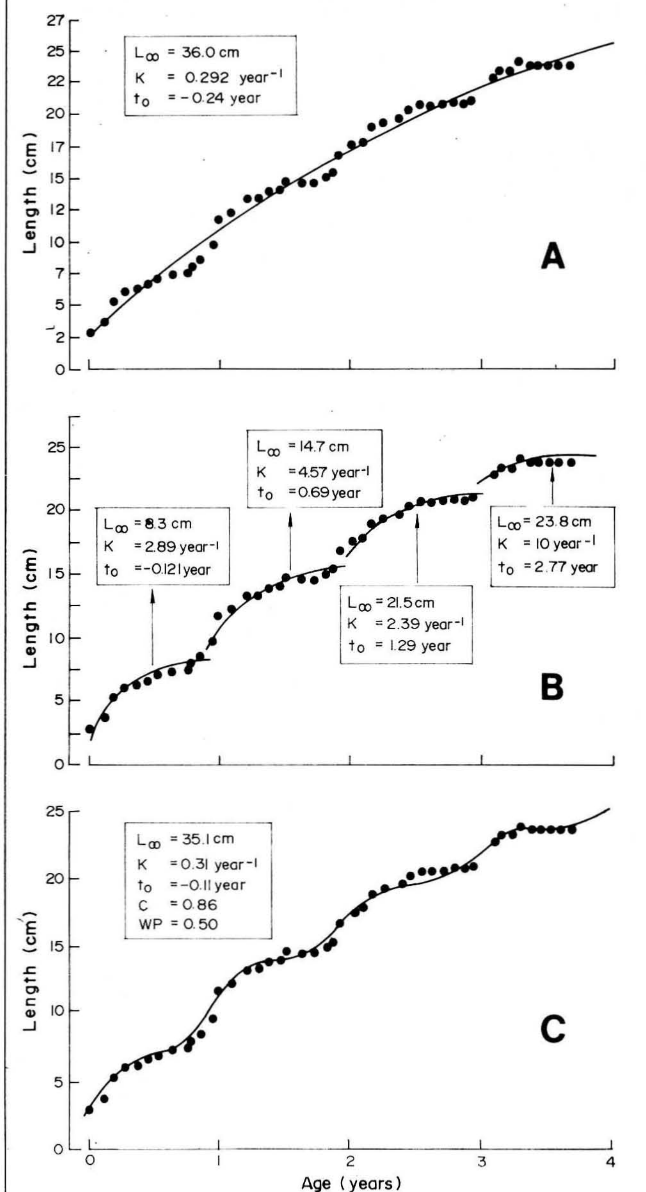

Fig. 2. ***Simplicity vs adequacy in successive fish growth models:***

A. A standard von Bertalanffy growth curve, fitted to length-at-age data of trout (*Salmo trutta*) from an environment with strong seasonal oscillations (data from Mann, R.H.K. 1971. J. Anim. Ecol. 40:155-90). The model, which has only three parameters, or "entities", clearly underfits the pattern.

B. The solution proposed by S.J. Lockwood, 1974 (J. Cons. CIEM 35(2):175-79), consisting of one von Bertalanffy growth curve per year. The four curves used here imply 4x3 entities plus at least three entities for specifying the transition between curves. Ockham is very unhappy.

C. A seasonally oscillating variant of the model in A (with five entities, all biologically interpretable (see D. Pauly et al. 1992. Austr. J. Mar. Freshwat. Res. 43:1151-1156). The pattern of the data is fitted, with one-third of the entities used in B. (There is a hint of a shift by a few months in the growth of the 2+ fish, worth being followed up.) Ockham is very happy, and so should be W. Silvert (see Box 1).

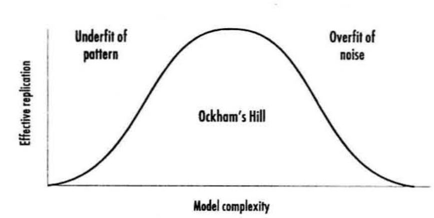

Fig. 3. ***Representation of "Ockham's Hill", as suggested by D. Mackay, Cavendish Laboratory (from Gauch, H.G. Jr. 1993. Prediction, parsimony and noise. Am. Sci. 81:468-78).***

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