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The poverty of mathematical and existential truth: examples from fisheries science

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Abstract

Several years ago I suggested that the harvesting of our commercial fisheries could be improved if the non-falsifiable models of a fisheries science were to be replaced with the falsifiable models of a fisheries economics. In an attempt to better explain this position I have returned to Aristotle's categorical propositions. It has not always been appreciated that Karl Popper's falsifiability or testability criterion, the criterion he uses to distinguish or demarcate between a science and a non-science is a modification of Aristotle's distinction between universal and particular propositions. While we cannot base our management decisions on fisheries models that are certain or known to be true we are, nevertheless able to guide our management decisions with those bold falsifiable models and policies that have been selected by a falsification of their competitors.

1. Introduction

Several years ago I (Corkett, 2002) suggested that the harvesting of our commercial fisheries could be improved if the non-falsifiable models of a fisheries stock assessment were to be replaced with the falsifiable models of a fisheries economics, two distinct disciplines with very different historical traditions. As the economist James Wilen (2006) points out:

> The disciplines of fisheries science and fisheries economics have been talking at cross-purposes for over 50 years. Ironically, this problem too reflects perverse incentives that many of us operate under within our own professional disciplinary settings. In both academic and management institutions, too much focus is placed on specialization

and discipline-based rewards and too little on learning each other's literature and trading of ideas.

My use of Karl Popper's demarcation criterion to distinguish between the disciplines of fisheries science and fisheries economics has been described by Sidney Holt (2004, p. 132) as involving 'a simplistic view of practical science-based management issues'. While this comment is not necessarily incorrect - any logic applying the law of the excluded middle can be said to be simplistic - it misses the point. In an attempt to better explain 'the point' I return to Aristotle's categorical propositions. It has not always been appreciated that Popper's falsifiability or testability criterion, the criterion he uses to distinguish or demarcate between a science and a non-science is a modification of Aristotle's distinction between universal and particular propositions.

2. Method

Mathematical truths and the laws of the sentential calculus are the very paradigm of necessary truth. We can illustrate a necessary truth by the validity of a simple deductive inference as:

If 'all swans are white' (All S is P) is true then 'black swans do not exist' (No S is non-P) is true (1)

Proposition (1) is necessarily true since every conceivable situation that makes 'All swans are white' true also makes 'Black swans do not exist' true. That is 'All S is P' entails its obverse 'No S is non-P' (Rescher, 1964, p. 133) which is the same as saying 'Black swans do not exist' is a valid deductive consequence of 'All swans are white'.

Under Karl Popper's demarcation criterion we can distinguish between a classical mathematical logic as characterised by necessary truth (illustrated by proposition (1)) and an empirical science as characterised by necessary falsity. We can illustrate a necessary falsity by the validity of the following falsifying inferences

If 'here is a black swan' is true then 'black swans do not exist' is false (2)

If 'black swans do not exist' is false then 'all swans are white' is false (3)

Propositions (2) and (3) combine to form the law of the retransmission of falsity, a deductive law that selects by elimination or falsification. This law is a necessary falsity since it retransfers falsity without any conceivable exception; that is every situation that makes ‘Black swans do not exist’ false also makes ‘All swans are white’ false. Of course we may have made a mistake in accepting ‘Here is a black swan’ as true in (2). However in no way whatever does this mistake diminish the validity of the law (Corkett, 2009).

Table 1 Aristotle’s and Popper’s modal criteria

Aristotle’s modality of existential import 1		Popper’s demarcation of falsifiability 2
Particular proposition	‘Some S is P’	‘At least one white swan exists’
Universal proposition	‘All S is P’	
Obverse form of a universal proposition	‘No S is non-P’	‘Black swans do not exist’

1 Aristotle’s modality is based on the absence (All S is P) and presence (Some S is P) of existential import

2 Popper’s demarcation is based on the presence (Black swans do not exist) and absence (At least one white swan exists) of falsifiability

Propositions (1) to (3) are given in a linguistic form that has often been the subject of ridicule. As Martin Gardner (2001) states: ‘I believe that Popper’s reputation was based mainly on his persistent but misguided efforts to restate common sense views in a novel language that is rapidly becoming out of fashion’. However this matter is easily cleared up when one realises that Popper’s black and white swans are proxies for the subject (S) (as swans) and predicate (P) (as black and white) of Aristotle’s categorical propositions (Table

1). We are particularly interested in the Aristotelian distinction between 'Some S is P' and 'All S is P' with respect to what is referred to as their existential import. The term 'some' as in 'Some swans are white' implicitly assumes at least one swan actually exists. 'Some swans are white' can be given as the existential proposition 'At least one white swan exists' (Table 1). By contrast the term 'all' in 'All swans are white' means 'all that there are' as in 'all swans that there are, are white' (Rescher, 1964, p. 115). There is no assumption of existential import. 'All swans are white' can be given as the non-existence proposition 'Black swans do not exist' (Table 1).

3. Results

3.1. The logistic growth law as a mathematical truth

The Verhulst-Pearl logistic growth model describes a symmetrical parabola where the maximum natural rate of increase occurs at a value half way between zero and the maximum population value (Schaefer, 1954, his Fig. 1). This parabola is described by a general law of population growth given by equations (1) and (2) of Schaefer (1954). While the precise shape of this parabola depends on the values assigned to the variables this shape can nevertheless be said to form a mathematical or necessary truth since there are no conceivable circumstances of which it would be false. That is the maximum natural rate of increase will always occur at half way between zero and the maximum population value.

3.2. The equilibrium catch as a historical or existential truth

The sustainable yield curve forms a parabola that is essentially the same as the logistic growth parabola except that it has been fitted to a time series of data on fishing effort and catch. Using a time series of Yellowfin tuna data (Schaefer, 1957, his Table 1) the equilibrium catch for a population of Yellowfin tuna was estimated to be about 193 million pounds (Schaefer 1957, his Fig. 2). The time series used in Schaefer's figure 2 forms a trend and as any cautious statistician knows a trend cannot be interpreted as a scientific prediction; that is a prediction made by a universal law. A proposition asserting the existence of a trend at a certain time and place would be a single historical proposition not a universal proposition (Popper, 1957, p. 115). We can put Schaefer's estimate of the equilibrium catch in the form of a single historical or existential proposition

> At a certain time and place there existed an equilibrium catch of about 193 million pounds for Yellowfin tuna. (4)

Proposition (4) cannot be selected by falsification since there is no conceivable situation under which it could be falsified. Why this is so can be illustrated in a simple way. Say, for the sake of argument, the next 10 years of catches for the population of Yellowfin tuna were much larger than the original equilibrium estimate of 193 million pounds. This would increase the estimate for the equilibrium catch. However, this new higher estimate could never falsify the old lower estimate of 193 million pounds since it is possible to conceive of a situation where a further 10 years of very small catches would reduce the new estimate for the equilibrium catch by an amount that returns it to its original value of 193 million pounds.

3.3. The maximum sustainable yield (MSY) as a bold non-existence truth

A proposition asserting the existence of a trend is existential ('At least one white swan exists' Table 1). This contrasts with a universal law that does not assert existence; on the contrary it asserts the impossibility of something or other ('Black swans do not exist' Table 1). When the sustainable yield curve incorporates the economic law of diminishing returns a parabolic pattern is formed (Corkett, 2002, his Fig. 1 (a) reproduced from Cunningham et al., 1985, their Fig. 2.6) and like any universal law this pattern can be put in the form of a bold non-existence proposition

> There are no conditions under which the greater the diminishing returns the shorter it will take to reach the MSY and the shorter it will take to decline afterwards. (5)

Proposition (5) is falsifiable in principle since by asserting the impossibility of finding certain conditions, it would be contradicted or falsified if these conditions were to be found. That is proposition (5) has the potential to be selected by falsification under the law of the retransfer of falsity (see section 2).

4. Discussion

Karl Popper suggests falsifiability or refutability or testability be accepted as the distinguishing characteristic of an empirical scientific theory. If this definition is accepted then a fisheries science could not include mathematical and existential truth as outlined in sections 3.1 and 3.2. However, it is my view that fisheries science is largely comprised of just such a mathematical and existential tautology. It is my view that if management decisions are to be consistently based on valid argument a non-science of mathematical modeling will have to be replaced with a science of rights-based models such as those involving catch share (Costello et al., 2008). Like the economic law of diminishing returns (see section 3.3) rights-based models are not only falsifiable in principle but have had a long history of being tested in practice (Scott, 1989).

One of the main rationales underlying a modeling based on mathematical and existential truth is the implicit assumption that the better management decisions will be those based on a knowledge that is true or certain or nearly true and certain. That is the more certain and truthful our knowledge the better will be our management decisions based on this knowledge. However under a falsifiable view of fisheries science, the better models and policies will be those bold imaginative ones that have survived a Darwinian falsification of their competitors. As Popper (1957, p. 134) explains 'In order to make the method of selection by elimination work, and to ensure that only the fittest theories [and policies] survive, their struggle for life must be made severe for them'. It is boldness in the form of falsifiability that ensures models and policies 'struggle for life'. From an ethical point of view, the hope of the fish stock assessor that some argument or model can be found to share responsibility for the taking of management decisions is one of the basic motives for a fisheries version of monism or scientific ethics (Corkett, 2005).

Conclusion

I suggest Popper's demarcation criterion of falsifiability or testability separate an applied fisheries science from its mathematical or metaphysical complement, a complement that is valueless (or so I believe) for an applied fisheries science. It is my view that if management decisions are to be consistently based on valid argument universal rights-based models will have to replace a historicism of existential truth, a non-science that can bear no fruit.

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