KARL POPPER'S ORGANON AND THE WORLD'S FISHERIES; FISH STOCK ASSESSMENT AS A PSEUDOSCIENCE, AN INDUCTIVISM THAT CAN BEAR NO FRUIT

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ABSTRACT

If a scientist can predict the weather (poorly)
Why cannot he predict fish yields (yet more poorly)? – a clerihew by Chris Corkett

Recent long term historical studies of commercial fisheries have pointed to a well established pattern of overfishing. Under the *principle of transference* – what is true in logic is true in psychology and scientific method – it can be demonstrated that many of the difficulties experienced in establishing sustainable fish stocks can be traced to a naïve attempt to reduce management decisions to facts or data; a monism or 'scientific ethics' in which modeled predictions *derived from data* mimic predictions in the physical sciences *derived from dual premises* (presented as a clerihew above). By applying Karl Popper's Organon to the world wide problem of how to maintain sustainable stocks of fish I show that, just as a civil society is built upon rules of law, a rational decision making in the form of managing a fishery, has to be built upon rules of method. The demarcation criterion – the chief procedural rule of Karl Popper's falsifiability calculus – forms the chief methodological rule of a rational based science; the application of this rule to the commercial fisheries demonstrates it is the irrational nature of the naïve empirical advice being proffered, and not the political decision-making, that ultimately has to be held responsible for the unhealthy state of the world's fish stocks – it is the inductive methods deployed by fish stock assessment, not the politics, that needs the drastic overhaul.

Keywords: Induction, Karl Popper, stock assessment, fisheries management

INTRODUCTION

Recent long term historical studies have demonstrated the widespread development of a prejudicial tradition of a over-fishing [1, 2, 3]. While such studies emphasise the importance of finding solutions to the problem of over fishing, they do not, and I assert *actually cannot*, provide solutions – solutions require changes to the irrational traditions of method that are presently being applied. But how do we assess a tradition of method? One way is to look at the historical evidence and make recommendations based on the historical facts – perhaps we can find a new paradigm for fisheries after the style of the philosopher Thomas Khun [4]. This is

not the approach taken here; here I do not search for *factual answers* but search for *analytic answers*.

Main thesis

It is the main thesis of my present research program [a] that a non falsificationist's view of fisheries management, a view with the logical form of a non falsificationist's inference, is responsible for the problems of sustainability and accountability faced by much of the world's fisheries. A non falsificationist's inference is sometimes referred to by the name of 'induction' or 'inductivism' but it is also referred to by other names as well. Martin Gardner [5], for example, uses the term 'confirmation'. [b]

METHODS

A classical two-valued logic

Under the conventions of a classical two valued logic to state a declarative sentence or statement as '*p*' is to express the idea it is true, as: '2+2=4' and 'London is in the Northern hemisphere' are true; to state the negation of a statement or '*not-p*' is to express the idea that the statement is false, as: '2+2≠4' and 'London is not in the Northern hemisphere' are false. However, if the statement '*p*' is in fact false, as are: '2+2=5' and 'London is in the Southern hemisphere', its negation '*not-p*' is true, as: '2+2 ≠5' and 'London is not in the Southern hemisphere'; otherwise its negation is false [6, p. 20]. A classical deductive logic is a non metric discipline that upholds the *law of the excluded middle*; the two contradictory statements '*p*' and '*not-p*' must be true or false (must be '*p*' or '*not-p*') there can be no situation under which a declarative sentence, statement or proposition can be regarded as neither true nor false (neither '*p*' nor *not-p*').

Karl Popper's Organon

Under the *principle of transference* – what is true in logic is true in psychology and method - the scientific evidence, takes the logical form of a *basic statement*; a singular premise upon which a science and management is 'based' [7]. Following the German philosopher G. W. Leibniz (1646-1716) we can distinguished between (i) the actual world and (ii) all possible worlds including the actual world [8, p. 8]. Using this terminology a basic statement can be said to exist as a premise in all possible worlds including the actual world and, as with any two valued logic (see

above) takes on two contradictory forms. These two forms, together with their associated inferences, can be represented in all possible worlds including the actual world by a simple sentential duality, as:

(a) a *potential falsifier* (black swan [c]), a '*p*' form of a basic statement, a premise that, *in all possible worlds including the actual world*, contradicts (falsifies) a universal law (all swans are white). If a potential falsifier is observed in *the actual world* then a universal law (all swans are white) is falsified and an existential statement (black swans exist) is verified.

(b) a *non potential falsifier* (white swan), a '*non-p*' form of a basic statement, a premise that, *in all possible worlds including the actual world*, verifies a existential statement (white swans exist). If a white swan is observed *in the actual world* then an existential statement (white swans exist) is verified and a universal law (all swans are black) is falsified.

Just as conventions are used to distinguish between the '*p*' and '*non-p*' version of the statement or proposition of a deductive logic; so, Karl Popper uses his *falsifiability criterion* to distinguish between a falsificationist's view of science and a verificationist's view of science. That is the falsifiability criterion is a rule of method that asserts, *by convention*, the empirical evidence must form a premise with the logical form of a potential falsifier. This methodological or procedural rule turns the value free duality of the simple sentential system given above into an *organon of rational criticism* [d]. This Organon now distinguishes or demarcates between (a) the falsifiable sciences in which the empirical evidence takes the form of potential falsifiers, and (b) the non falsifiable sciences in which either (i) there is no empirical evidence, as in the mathematical sciences, or (ii) in which the empirical evidence is not represented by potential falsifiers as in the pseudosciences; for example, the inductive based decision making of a fish stock assessment (see under 'Naïve empiricism; an inductive view of decision making' in the Discussion below).

Induction

Induction is a form of inference in which given some singular premise (white swan) we are able to infer a universal conclusion (all swans are white). As with a verifying inference (see above) the premise of an inductive inference does not take the logical form of a potential falsifier (black swan [e]); as with a verifying inference an inductive inference cannot therefore *by definition or convention* belong to Popper's Organon.

MANAGEMENT AS DECISION MAKING

Just as laws are made by a collection of people in a parliament (or in some societies by a single Monarch); so regulatory fisheries policy is made by a collection of people (the decision makers) in a fisheries commission (or in some cases by a single Minister of the Crown). Scientific facts or data are one of the important inputs that are taken into consideration when managing a fishery.

### How are decisions based on scientific fact?

From a logical point of view there are two ways a decision can be based on facts or data or empirical evidence; two ways that can be put in the form of two simplified general schema:

$$\text{data (\textit{non potential falsifiers})} \rightarrow \text{ model} \rightarrow \text{positive prediction} \rightarrow \text{decision} \quad \text{(Eq. 1)}$$

$$\text{decision} \leftarrow \text{error elimination} \leftarrow \text{empirical evidence (\textit{potential falsifiers})} \quad \text{(Eq. 2)}$$

Under the schema of Eq. 1 it is very clear how the decision makers get their advice; scientists collect data that is used to form a model that is used to provide advice. This kind of decision making is illustrated in Fig. 1B where a Schaefer model [f] fitted to data from the International Pacific Halibut Commission (IPHC) gives a value of about 30 million pounds for the Maximum Sustainable Yield (MSY). Clearly, if the data is uncertain the prediction or 'parameter' will be uncertain and the advice will be uncertain; sometimes summarized as: 'Garbage in; Garbage out'. This is the type of scientific modeling used by a fish stock assessment and the type of advice it produces will be called *positive political advice* The advice is referred to as being 'political' since it is not neutral in policy terms. It describes a decision, a political or policy decision to be taken as, for example: 'The total allowable catch (TAC) should be x million pounds'. This kind of positive predicted 'decision' or 'parameter' cannot be falsified [9]. Less clear is how scientific decisions and facts are related in Eq. 2.

Since we are making use of logical analysis we do not answer the question 'How are scientific decisions made?' with the obvious 'Scientific decisions are made by scientists' but rather re-phrase the question to read: 'How are decisions made in the physical sciences?' and turn to a physical engineering on which to base our answer**.**
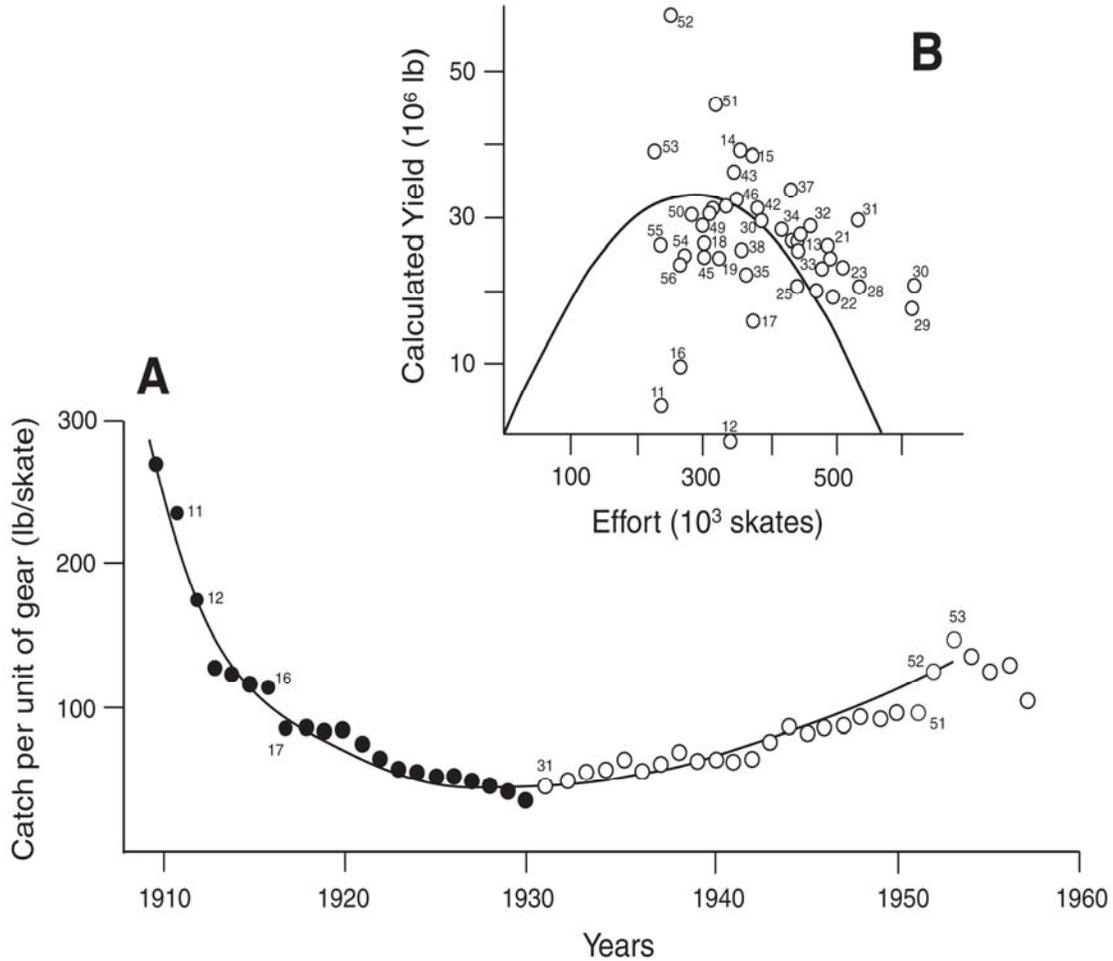
Figure 1. One database: two (falsifiable and non falsifiable) interpretations.

(**A**) F. W. Thompson's *falsifiable* commercial catch (in lbs)-per-unit-effort (in skates) (CPUE) index for the Area 2 stock of Pacific halibut; solid points (●) represent the historical record of over-fishing before the 1931 formation of the IPHC; open points (o) reflect a trial and error social engineering in which the IPHC developed regulatory policy in an attempt to control over fishing; points marked 11, 12, 31, 53 represent years 1911, 1912, 1931, 1953 etc.; the line is fitted by eye (from [10, Table 13.1]).

(**B**) Stock assessment's *non falsifiable* version of the Schaefer model in which a GM regression line is fitted to points representing yields derived from the same IPHC data base used in (A); plots show the relationship between surplus production (yield, in millions of pounds) and effort (thousands of skates); as in (A) plots marked 11, 12, represent years 1911, 1912, etc; no distinction being made between the pre and post 1931 historical record. The fitted parabola gives an optimum 'parameter' of about 30 million pounds for the MSY (from [10]).

How are decisions made by the engineer?

The engineer makes decisions all the time and this is done by *trial and error*; that is, a decision is taken (trial) and factual feedback is obtained by 'seeing what happens' (error elimination). In the early days of the International Pacific Halibut Commission (IPHC) regulatory policy was guided by a *social engineering* with feedback from a commercial catch-per-unit-effort (CPUE) index under the direction of R.W. Thompson. This *objective* form of managing can be represented by Karl Popper's [11, p. 126] analytic problem solving schema, as:

$$P_1 \rightarrow TP_1 \rightarrow EE_1 \rightarrow P_2 \rightarrow TP_2 \rightarrow EE_2 \rightarrow P_3 \rightarrow \dots \qquad \text{(Eq. 3)}$$

where P_1 represents the initial problem situation, TP = decision in the form of a trial policy developed by the IPHC to solve the initial problems, and P_2 the new problem situation generated by the search for contradictions (falsification, criticisms) and their elimination (EE = error elimination given by *potential falsifiers* in Eq. 2). Under this objective feedback, *normative laws* (norms for short) representing goals, ends and objectives (such as sustainability), standards (such as the precautionary principle) and policies (such as a TAC) constitute part of the problem situation (P in Eq. 3), as: 'How do we establish and maintain a sustainable fishery?' 'What policy should we adopt to achieve sustainability?' In order to achieve our chosen goals, such as sustainability, *creative* regulatory policies with potential contradictoriness (in the logical form of potential falsifiers) are required. It is the creativity of our potential solutions not the 'certainty' of some 'force of nature' that allows us to solve our problems.

DISCUSSION

**Naïve empiricism: an inductive view of decision making**

One of the more undesirable consequences resulting from an inductive view of science and management is that it readily leads to a naïve empiricism in which decisions are based on facts or data; find the better facts and we have the better decisions. Conversely, if a database is poor (inaccurate, uncertain) so will be the decisions. However, if we represent a database by an observational or *basic statement* (a premise upon which a science and management are to be *based*, see Methods) and represent this basic statement with the symbol '*p*'; then, if we adopt the position of the naïve empiricist (that *p* needs to be fully supported by the data or the facts or the measurements before it can be accepted as a premise in an

argument) this would require us to reject the law of the excluded middle (see Methods) since it must usually be the case that neither *p* nor *not-p* can be fully supported by the available evidence [11, p. 128].

The reason naïve empiricism is so damaging is that it puts the emphasis in entirely the wrong direction; instead of understanding that all decisions *have to be taken* (Eq. 2) we are now led to believe that decisions can be *reduced to facts* (Eq. 1). However it is a matter of elementary logic that policy decisions together with goals (such as sustainability) and standards (such as the precautionary principle) cannot be produced from, or be reduced to, facts or data; *decisions have to be taken*. The reduction of decisions to facts reaches the height of total absurdity when the standards (values) of a fishery science are determined by exploitation rates or points, such as the F_{max} , F_{msy} and $F_{0.1}$, points that are derivable from fishery data. If, under this 'scientific' view of a fishery ethics [12, 13], we wish to improve our management standards by, for example, a more vigorous application of the precautionary principle, then we simply look up a more suitable reference point in 'normative' tables, tables readily available from agencies such as the Fisheries Department of the Food and Agricultural Organization (FAO) of the UN [14].

Reducing uncertainty: a naïve empirical view of predictability

One of the aims of this conference is to understand how we can make management decisions in an uncertain environment; perhaps by reducing the level of uncertainty. But what does a reduction in uncertainty aim at; at providing us with accurate or certain predictions *that tell us what to do*?
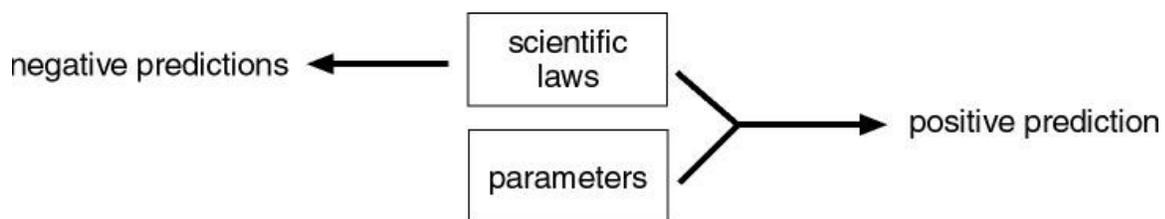
Figure 2. An analytic illustration of how the laws of physics (i) predict the weather with positive predictions, predictions derived from the dual premises of scientific laws and their parameters and (ii) guide an engineering with negative predictions, predictions deduced from the scientific laws themselves (after Popper [7]).

How absurd there are no predictions derivable from the facts of nature that can tell us what to do, scientific laws tell us *what we should not do*!

Positive predictions derived from the laws of physics such as a prediction of the weather ('positive prediction' in Fig. 2) are derived [g] from dual premises ('parameters' and 'scientific laws' in Fig. 2); while values assigned the parameters needed for this prediction may be said to have been derived from facts, the second premise involved in the derivation of a prediction ('scientific laws' in Fig. 2) is *not* derivable from these facts! The empirical evidence corroborating a theory takes the form of singular premises referred to as a potential falsifiers (see Methods), the larger the number of potential falsifiers that contradict a scientific law or theory, the more the theory 'goes beyond the actual world' and the more the information about reality a theory says. It is this potential contradictoriness that allows a theory to solve its problems, as illustrated by Thompson's management of the Pacific halibut (Fig. 1A); a social engineering involving decisions (TP in Eq. 3) and error elimination (EE in Eq. 3) based on potential falsifiers (Eq. 2).

Under a falsificationist's view of fishery management, decisions are not based on 'accurate' or 'certain' predictions or 'parameters' but, as with the physical sciences, are guided by limits to what might be achieved ('negative predictions' in Fig. 2), for example:

'Regulatory policies should *not* be based on the assignment of TACs without also controlling fishing effort'

'Fishing effort *cannot* be controlled effectively without assigning property rights in some form'

Unlike a fish stock assessment in which modeled predictions are (i) *positive* (ii) *not universal* since they are only applicable to the particular fish stock or region from which the data have been collected, and (iii) can be said to be 'political' or policy based. Models of a theoretical economics guide management decisions by predictions that (i) *negatively* set limits on what can be achieved (ii) *universally* go beyond any particular spatio-temporal region of the world, and (iii) are *politically neutral*. The models of a theoretical economics guide the decision takers by outlining what they should *not* do. Economic models leave the decision taking and *the responsibility that goes with the decision taking* entirely in the hands of the decision takers.

CONCLUSION

Fisheries Commissions charged with the responsibility of managing the world's great fisheries have largely based their decisions on predictions or 'parameters' derived from fishery data. This naïve empiricism has prejudicial consequences

predicated under the *principle of bareness*: 'Irrational scientific methods can bear no fruit'.

If the world's fisheries commissions are to possess the potentiality of solving their problems the present naïve empirical approach of fisheries management will have to be replaced by one that meets the procedural rules of Karl Popper's Organon.

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ENDNOTES

a. The first publication of my new research program [15] has a number of errors and confusions; some of these have been corrected in the relevant corrigenda [16]. However one particular error must be mentioned here since it represents the same kind of mistake Martin Gardner makes (see endnotes b and c below). Corkett [15, p. 166] referred to an assertion involving 'pink swans'. A situational logic involving the existence of (i) black, (ii) white and (iii) pink swans cannot belong to a two valued logic.

b. Martin Gardner [5] would point out his confirmation is not an induction; quite so but this is beside the point. Concepts such as verification, confirmation and the like are excluded from Popper's Organon not for *what they are*, but *for what they are not*. They take the form of an inference that does *not* represent the empirical evidence in the form of a potential falsifier.

c. Martin Gardner [5] would point out that a black swan obviously confirms the assertion that all swans are black. Quite so, but in this context the black swan is no

longer a potential falsifier; continuing the argument along these lines, it is a white swan (potential falsifier) that would falsify all swans are black.

d. The discipline of logic originates with the Greek philosopher Aristotle (384-322 B.C.) whose writings are contained in a group of treaties that later became collectively known as the Organon. Karl Popper's Organon (the term has come to mean a non metric tool for acquiring knowledge) involves a science of science (a metascience) in which the contradictive consequence of a classical two-valued logic is taken as the instrument of rational criticism.

e. See also endnote c

f. The Schaefer fishery model is named after the fishery biologist Milner B. Schaefer (1912-1970). It is important to distinguish between two versions of the Schaefer model. The version used by fish stock assessment and reproduced in Fig. 1B is fitted to data and *cannot be falsified* [9]. This naïve empirical version of the Schaefer model is to be contrasted with economic versions, such as the Gordon-Schaefer version named after the Canadian economist H. Scott Gordon. Like any economic model, fishery economic versions of the Schaefer model are not fitted to data. They are universal models of a situational logic in which the empirical evidence is represented by 'premises'. Like all theoretical economic models, fishery economic versions of the Schaefer model, *can be falsified*.

g. Corkett distinguished between two forms of rational scientific prediction; referred to as 'positive' and 'negative' in Fig. 2, unfortunately the terms used to describe this distinction were not applied consistently [12]. I now refer to positive scientific predictions as being *derived* from dual premises and negative scientific predictions as being *deduced* from a single premise [13]. In using the term 'deduction' I do not, of course, mean to imply that my use of this term should be assigned the same meaning as its use in a classical logic. The important point is that a distinction has to be made between two forms of scientific prediction; then, having made this distinction, the terms used to describe this distinction must be consistently applied.

The widespread failure of fisheries management to distinguish between a pseudoscientific prophecy derived from data and a rational scientific prediction derived from dual premises is represented as a clerihew at the beginning of this paper.