Distinguishing input controls from output controls in Atlantic Canada's fisheries: explaining the decline and collapse of Newfoundland's Atlantic cod stocks

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Abstract: The lobster and groundfish fisheries of Atlantic Canada have been managed in very different ways. The Atlantic lobster fishery has been managed by input controls in which regulations have been developed by *a posteriori* deductive argument to control the intensity of the gear used to catch lobsters. By contrast the Atlantic groundfish fisheries have been managed by output controls involving the *a priori* inductive arguments of stock assessment in which limits are put on the amount of groundfish coming out of a fishery. Karl Popper excludes induction from his theory of method since induction leads to logical inconsistencies such as a 'scientific' ethics (i.e. the notion that science can on its own tell us what should be done), a fisheries example of which is the use of reference points and harvest guidelines in an attempt to guide the normative use of data. It is my thesis that the prejudicial nature of a fish stock assessment with its embedded monism of 'scientific' ethics is to be held responsible for the overfishing and collapse of Atlantic goundfish fisheries including Newfoundland's Atlantic cod stocks. If Atlantic Canada's groundfish fisheries are to be managed by sound and rational decisions, they will have to join the Atlantic lobster fishery as a well regulated institution capable of controlling the levels of effort used to catch fish.

Keywords: Induction; fisheries management; input controls; output controls; 'scientific' ethics

1. Introduction

While the fisheries scientist has always realised the importance of distinguishing sound management strategies from unsound ones, it has always been assumed that this distinction forms part of our natural world, a position referred to as naturalism (Popper, 1959). For example: Myers et al. (1997) looked to explain the collapse of six stocks of Atlantic cod in the 1990's by analysing the quality and quantity of the data used in their stock assessments. This was done by comparing abundance trends for the six cod populations as determined by research surveys and as reconstructed from commercial catch at age data in a virtual population analysis (VPA). On the basis of this comparison it was suggested that the cod populations had collapsed in part because of an overreliance on commercially collected catch at age data, data that were not proportional to the true abundance. So how do you collect reliable (true) data on age specific abundance trends, or on commercial discard levels, or on misreported catches or on fishing mortality or on anything else pertaining to a cod fishery collapse? Under Karl Popper's non-inductive theory of method you can't and you don't, since the ability to avoid future fishery collapse does not depend on the reliability or certainty of the data. It depends on the soundness of the decisions that are taken. What is, or is not, a sound decision or sound argument is not a distinction discoverable by an empirical science; it is a logical distinction, a distinction applied to the natural world by a methodological rule or fiat such as Karl Popper's demarcation criterion[1] involving falsifications (Corkett, 2009). In my view we learn a lot if Popper's demarcation criterion is used to distinguish between the two traditional methods of fisheries management, referred to as fishing effort management (or input controls) and catch management (or output controls) (Pope, 2002). That is: I suggest Popper's demarcation criterion of falsifiability distinguishes between:

[1] Just as a classical mathematical logic demarcates between statements that are true and not true (false) so Popper's criterion of falsifiability demarcates between 'there-is-not' propositions (which can be falsified but not verified) and 'there-is' propositions (which can be verified but not falsified) (Corkett, 2012).

(a) The management of the Atlantic lobster fisheries by input controls involving an *a posteriori* deductive argument in which regulations have been developed to control the intensity of the gear used to catch lobsters, and
(b) the management of the Atlantic groundfish fisheries by output controls involving the *a priori* inductive arguments of stock assessment in which direct limits are put on the amount of groundfish coming out of a fishery

It is my thesis that the inductive arguments of output controls are to be held responsible for the collapse and decline that have occurred in Atlantic groundfish fisheries over the last few decades. After all, Atlantic lobster fisheries have been well managed and regulated by input controls for well over a century.

2. Analytic method: problem solving by common sense

All life is problem solving (Popper, 1999) and the problems of a deductive science are solved in fundamentally the same way as our day to day problems are solved by common sense, the method of trial and error. That is we work by trying out solutions to our theoretical and practical problems and then discarding the ones that fail as erroneous. This non-inductive method can be described by the following problem solving heuristic:

$$P_1 \rightarrow TT \rightarrow EE \rightarrow P_2 \qquad (1)$$

Starting from some theoretical or practical (empirical) problem P_1, a tentative solution in the form of a tentative theory TT is proposed, which may be partly or wholly mistaken; in any case it is subjected to error-elimination EE in the form of a critical feedback that may consist of experimental tests; new problems P_2 arise from this critical feedback and the process is then repeated (Popper, 1979, p. 119). Corkett (2011) modified schema (1) to represent the decision-making framework of a fisheries management, as:

$$P_1 \rightarrow TD \rightarrow EE \rightarrow P_2 \qquad (2)$$

where, P_1 = the initial problems including the goal to be pursued (How do we obtain a sustainable fishery? How do we obtain further employment for our fish processors?); TD =

tentative decision, a tentative policy that reflects the chosen goal; EE = error elimination, objective feedback by which the effectiveness of the policy is assessed and P_2 = the new problems and consequences that arises as the result of the decision taken. In this problem solving heuristic, policy decisions (TD in schema (2)) are not derived from the data, facts or predictions of a fisheries science; decisions have to be taken.

3. Results

The lobster and groundfish fisheries of Atlantic Canada have been managed in very different ways. The lobster fishery has been managed by input controls in which regulations have been developed to control effort levels. By contrast the groundfish fisheries have been managed by output controls in which limits are put on the amount of groundfish coming out of a fishery

3.1. Managing the inshore Atlantic lobster fishery with input controls

Management decisions in Atlantic Canada's lobster fishery have never been based on output controls involving direct estimates of stock size or abundance levels (DFO, 2011). In my view the use of input controls (to control effort levels) rather than output controls (based on direct estimates on abundance) is the reason why the lobster fishery has had a long history of success in regulating its fishing capacity. How it is that regulations could have been developed to control effort levels (input controls) in lobster fisheries, without the need to base management decisions on estimates of current stock size (as in output controls) can be illustrated by a situational logic that is a modification of schema (2).

$$P_1 \rightarrow RP \rightarrow EE \text{ by } LL \rightarrow P_2 \qquad (3)$$

where P1, P2…represents the problems requiring solution. For example:

- How do we meet the goal of maintaining a sustainable lobster fishery by controlling fishing effort and overcapacity?

- How do we meet the goal of obtaining full (high) employment for inshore lobster fishermen?

RP = regulatory policy that attempts to meet declared goals by solving the appropriate problem; EE = error elimination by feedback from lobster landings (LL) by which the effectiveness of the regulation in solving the problem is assessed. In this schema objectives and goals (such as sustainability) form part of the problem situation (P_1, P_2 ... in schema (3)) requiring solution. For example: in a situation in which sustainability in the lobster industry was not being maintained (i.e. when the lobster landings were declining over time) regulations would have been put in place to reduce effort levels and overcapacity. If the lobster landings then failed to increase after these regulations had been put in place this would have indicated that the regulations were not effective; additional more effective regulations would be needed. In this way a record of effective regulations would have been built up by common sense over time. These regulations have included:

- prohibition against landing egg-bearing females and licensing of fishermen (limited entry);
- restriction of gear type and limitation of number of traps;
- division of the coastal area into fishing districts (LFAs) and fishing seasons determined by district

Some of these management measures have been in place for more than a century. For example: the protection of egg-bearing females and the establishment of closed seasons were introduced in the 1870s (FRCC, 1995, pp. 12-13).

3.2. Managing the Atlantic groundfish fisheries with output controls

A decision-making for Atlantic groundfish fisheries has traditionally been built around output controls in which direct limits are put on the amount of groundfish coming out of a fishery. For example: total allowable catches (TACs) were determined as fractions of the fish stock biomass (Charles, 1998). Clearly, if the measurements of biomass and abundance are uncertain, that is if there are uncertainties in data quality and quantity, the scientific advice will be uncertain – a situation sometimes crudely summarized as: 'Garbage in: garbage out' (Corkett, 2011). However and at a more fundamental level, sound decisions together with objectives and goals (such as the requirement for a sustainable fishery) can under no circumstances be produced from, or be reduced to facts. Norms such as goals, objectives and standards reflect the values of the proponents and form part of the problem situation requiring solution (P_1, P_2… in schemata (2) and (3)). Solving the problems of any fishery (including how to maintain standards by applying the precautionary principle) requires the corroboration[2] of bold imaginative policies by *a posteriori* critical feedback (EE in schemata (2) and (3)) and not the inductive collection of facts (data), even if the data were 'certain' and 'reliable'.

3.2.1. Replacing the output controls of Atlantic groundfish with input controls

Just as the Atlantic lobster fishery has been managed successfully with input controls (illustrated by the situational logic of schema (3)) a similar trial and error method involving the control of effort levels should, in my view, be involved in managing the Atlantic groundfish fishery. This suggestion can be illustrated for a theoretical groundfish fishery by a common sense situational logic similar to that given in schemata (2) and (3) involving feedback from a catch-per-unit (CPUE) index, as:

$$P_1 \rightarrow RP \rightarrow EE \text{ by CPUE} \rightarrow P_2 \qquad (4)$$

[2] Popper's non-inductive theory of method is not based on the meaning of certain words. It is based on the well-known fact that an 'all' proposition (universal categorical proposition) has no existential import. That is a universal law (all swans are white) does not assert the existence of swans; from this it follows: 'All swans are white' cannot be verified or confirmed by finding a white swan; it can only be corroborated by the failure to find a black swan (Corkett, 2012, section 6).

where P1, P2…represents the problems requiring solution. For example:

●How do we maintain a sustainable groundfish fishery?

●How do we obtain full employment for groundfish fishermen?

RP = regulatory policy that attempts to solve the problem at hand; EE = error elimination by feedback from a CPUE index, by which the effectiveness of the policy in solving the problem is assessed. Schema (4) would operate in the same way as the trial and error management of the lobster fishery and, as for this fishery regulations would be required to control effort levels. What is, or is not a suitable regulation for a groundfish fishery would be developed by trial and error guided by universal rules of thumb. Such a rule might be:

> You cannot control fishing effort in a groundfish fishery without deploying a version of catch-shares (PERC, 2012).

Rights-based models (of which catch-shares are an example (Costello, et al., 2008) are particularly appropriate for guiding the development of fishery regulations since they have undergone long periods of testing (criticism) in many different disciplinary settings (Scott, 1989).

4. Discussion

The driving force behind the idea that the role of a fisheries science is to 'turn data into advice' (DFO, 2012) is the inductive assumption that collecting data that is certain and accurate can be translated (predicted) as scientific or political advice that is certain and accurate. However under Karl Popper's non-inductive theory of method, inferences are never drawn from data or observations in the form of a singular premise (I in Table 1A) to a predicted conclusion (Pr in Table 1A). Scientific predictions such as those of meteorology involve a tripartite deductive schema (Table 1B) containing dual premises in the form of some observational or factual experience formulated as initial conditions (I in Table 1B) plus some universal theories (U in Table 1B). The entailment[3] of the initial conditions (I in Table 1B) and the prediction (Pr in Table 1B) by these universal theories is essential in arguing from the past to the future; but these universal theories are not in turn inferred from observations, facts or data. They are independently tested conjectures (Popper, 1978).

One of the more unfortunate consequences of the inductive arguments of a fisheries science is that it gives rise to a monism (Table 1A) of 'scientific' ethics. As Karl Popper (1963, p. 237) explains:

> 'Scientific' ethics is in its absolute barrenness one of the most amazing of social phenomena. What does it aim at? At telling us what we ought to do, i.e. at constructing a code of norms upon a scientific basis, so that we need only look up the index of the code if we are faced with a difficult moral decision? This clearly would be absurd; quite apart from the fact that if it could be achieved, it would destroy all personal responsibility and therefore all ethics.

Fisheries examples of a 'scientific' ethics include:

●the inductive assumption that goals such as the maximum sustainable yield (MSY) and optimum yield (OY) can be treated as scientifically achievable predictions rather than normative laws (Corkett, 2005).

●the widespread use of biological reference points and harvest guidelines in an attempt to guide the normative use of data (Beddington et al., 2007, their Fig. 1); (Hutchings et al., 2012, their Fig.12.2).

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[3] Under the Law of Tripartite Entailment a universal law is logically stronger than a singular proposition; that is a universal law entails singular propositions in the form of initial conditions (I in Tables 1B and C) (Corkett, 2012, section 5). By contrast, a singular proposition could never entail a universal law.

Clearly a deductive approach to the management of any fishery would avoid the inductive arguments of a monism with its consequence of 'scientific' ethics. With this in mind a monism (Table 1A) can be replaced with a dualism (Table 1C) in which the trial and error of a fisheries management is incorporated as a modification of the initial conditions of Table 1B. Particularly important is the fact that in this dualism, normative laws in the form of goals such as MSYs and OYs (N in Table 1C) form part of the problem situation needing solution (P_1, P_2 … in schemata (2), (3), (4)); that is: the norms forming the conclusion of Table 1C have to be chosen by the proponents. This is another way of saying management decisions have to be taken.

Consider the task of managing a fishery. From a logical point of view what are provided are the goals (norms) to be attained (such as the requirement for a maximum sustainable fishery) (N in Table 1C) together with some universal theories or rules of thumb (U in Table 1C). What remains to be found by the fisheries manager are the initial conditions (I in Table 1C) that have to be realised by trial and error in such a way that the normative goals (N in Table 1C) are entailed by the theories and initial conditions.

Table 1. Schematic relationships of consequence: A, Inductive monism; B, Scientific prediction as a dualism, C, Fisheries management as a critical dualism (from Corkett, 2012).

	A Monism	**B Scientific prediction**	**C Fisheries management**
Universal premise	NA	U Universal Law	U Rules of thumb
Singular premise	I Data (observations)	I Initial conditions	I Trial & error management
Conclusion	Pr Predictions	Pr Prediction of event	N Normative goals

Ulltang (1998) states: that in a fisheries science the emphasis is on predictions but the kinds of predictions will be determined by the extent to which we are able to formulate universal laws and their initial conditions. However it is important to distinguish between the predictions of a natural science in which universal laws and initial conditions form traditional premises (Table 1B) and the 'predictions' of a social science in which the initial conditions are replaced with the trial and error heuristic of schema (2) (Table 1C). From a logical perspective a fisheries science is a social science in which a clear distinction has to be made between normative laws (N as the conclusion in Table 1C), which are manmade and changeable, and universal laws (U as a premise in Table 1C) which are conjectures about an unchangeable reality. Understanding that this distinction has to be made gives rise to a philosophical position referred to as a critical dualism (Corkett, 2005).

While management decisions have to be taken (TD in the heuristic of schema (2)) they can still be guided by the deductive arguments of a universal law. For example: a universal law (all swans are white) takes the logical form of a 'there-is-not' statement (non-white/black swans do not exist)(Corkett, 2012); that is: natural laws (such as the law of gravity and the economic law of diminishing returns) can be compared to 'proscriptions' or 'prohibitions'. 'They do not assert that something exists or is the case; they deny it' (Popper, 1959, p. 69). In the case of a fisheries science this 'denial' takes the form of a rule of thumb that guides the trial and error of the fisheries manager by explaining what cannot be achieved. Corkett (2011) gives several examples of such universal rules including:

> One cannot obtain a sustainable fishery (goal) while at the same time providing unlimited jobs for fishers (social objective).
>
> One cannot obtain a sustainable fishery (goal) without controlling the prejudicial behaviour of fishing derbies (unintended consequence).

While we live in an uncertain world, we can still guide the trial and error of the fisheries manager (I in Table 1C) with the 'prohibitions' of the best tested theories (U in Table 1C), a non-inductive position known as critical rationalism (Corkett, 2002).

5. Conclusion

More than twenty years ago on July 2, 1992 the Newfoundland cod moratorium came into effect that put an end to the inshore cod fishery and a 500-year old way of life that was at the basis of Newfoundland culture and society. There are some signs that cod populations will eventually return to Atlantic waters since the Scotian Shelf ecosystem is beginning to return to its earlier structure (Frank et al., 2011). While this is encouraging, it does not answer the question why a fisheries science was unable to stop the overfishing and collapse of Newfoundland's Atlantic cod stocks. By contrast, the Atlantic lobster fishery has been well managed, regulated and sustained for over a century by input controls (see section 3.1) involving trial and error 'common sense' (see section 2). In my view the prejudicial nature of the inductive arguments of a fisheries science with its embedded monism of 'scientific' ethics is to be held responsible for the overfishing, decline and collapse of Newfoundland's Atlantic cod stocks. If Atlantic Canada's groundfish fisheries are to be managed by sound and rational decisions, they will need to join the Atlantic lobster fishery as a well regulated institution capable of controlling the intensity of the gear used to catch fish.

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Glossary

critical dualism (in fisheries) an understanding that a clear distinction must be made between normative laws or norms (N in Table 1C) and universal laws (U in Tables 1B and C); *contrast with* **'scientific' ethics**.

critical rationalism (in fisheries): the observation that while we live in an uncertain world we can still guide our management decisions with the best tested natural laws such as the economic law of diminishing returns and the rights based models of a fisheries economics.

closed society: a primitive or tribal society that exists in an unchanging world of taboos, of laws and customs which are felt to be as inevitable as the rising of the sun, or the cycle of the seasons (Popper, 1963 , p. 5); *contrast with* **Open Society**.

dualism: a deductive argument with dual premises; one of which is a universal law (Tables 1B and C).

groundfish: fish that live on or near the bottom of the body of water they inhabit. Examples of salt water groundfish species are: cod, sole, flounder, and halibut,

input controls: controls that place limits on the total intensity of use of the gear fishers put into the water in order to catch fish (also referred to as fishing effort management); *contrast with* **output controls.**

monism: an inductive argument with a single premise (Table 1A).

natural law or **law of nature 1**: a strict unvarying regularity which either holds in nature (in this case the law is a true proposition) or does not hold in nature (in this case the law is false). A law of nature (such as the law of gravity or the economic law of diminishing returns) is unalterable; there are no exceptions to it (Popper, 1963, pp. 57-58); c*ontrast with* **normative law.**

normative law or **norm 1**: such rules as forbid or demand certain modes of conduct, such as a rule of law. Unlike a natural law a normative law is enforced by men. It can be changed and it can be broken (Popper, 1963, p. 58). **2**: (in fisheries) (i) regulations governing the input controls of fishing effort management (ii) norms involved in catch management such as goals and standards; c*ontrast with* **natural laws** and **universal laws**.

Open Society: a society in which individuals are confronted with personal decisions especially moral decisions in which rational personal responsibility is recognised (Popper, 1963, p. 173); *contrast with* **closed society**.

output controls: controls that place limits on how much fish can be taken out of the water (also referred to as catch management); *contrast with* **input controls.**

'scientific' ethics: **1**: an argument in which norms are reduced to facts (Popper, 1963, p. 73). **2** the hope that some scientific argument or theory can be found to share our moral and ethical responsibilities, (Popper, 1963, p. 237, note18); **3**: (in fisheries) a version of 'scientific' ethics in which norms such as the maximum sustainable yield (MSY) and optimum yield (OY) are treated as a scientifically achievable predictions rather than normative laws (Corkett, 2005).

universal law or theory 1: A law or theory with the logical form of a universal categorical proposition 'All S is P' where 'S' is the subject (often represented by 'swans') and 'P' is the predicate (often represented by 'white'). The universal law 'All swans are white ' can be given as the 'there-is-not' proposition 'Non-white/Black swans do not exist' (Corkett, 2012, his Table 2). **2**: (in fisheries) a universal theory given as a 'there-is-not' rule that advises the fisheries manager what cannot be achieved and should not therefore be attempted (Corkett, 2011).