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Theme Session on Cooperative Research
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CO-MANAGING THE SCOTIAN SHELF SHRIMP FISHERY - SO FAR SO GREEN

by

P.A. KOELLER

Department of Fisheries and Oceans
Invertebrate Fisheries Division
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2
Koellerp@mar.dfo-mpo.gc.ca

ABSTRACT

In recent years the Department of Fisheries and Oceans has been fostering co-operative approaches to the assessment and management of Canadian fisheries resources. In this paper I describe one such co-management program, the Scotian Shelf fishery for northern shrimp *Pandalus borealis*, and the role of science in it. Drawbacks and advantages of co-operative research are described from a personal perspective, with a view to glean basic principles. Predictably, problems fall into two main categories, including those associated with methodological compromises, and those stemming from conflicting objectives. Some examples are provided. A major benefit of conducting science within a co-managed program is that it stimulates new ways of viewing the process of fisheries science and management. The "traffic light" method of determining stock status is highlighted as a way to facilitate industry involvement in the final stages of the assessment/management process. As a result, the setting and enforcing management measures such as TACs, traditionally a government domain, becomes more of a co-operative action.

INTRODUCTION

At a catch of about 5,000 mt annually the eastern Scotian Shelf Shrimp fishery is relatively small compared to other fisheries for northern shrimp (*P. borealis*), yet the depletion of groundfish stocks in the area has made it an important alternative fishery for about 40 license holders. In 1995 the federal Department of Fisheries and Oceans entered into a co-management agreement with the industry that includes a multi-year plan that clearly outlines management objectives and the consultative process leading to decisions. Stock assessments are conducted using data from a government-industry survey and commercial catch sampling. This paper examines the advantages and drawbacks of co-operative assessment research on the Scotian Shelf shrimp stock, attempts to glean general principals, and define the role of science in a co-managed program.

THE RESOURCE

The eastern Scotian Shelf shrimp (*Pandalus borealis*) stock is a comparatively small one for this species, with long term yields in the order of 2000-5000 mt. It is situated near the southern limit of its global distribution where population dynamics are strongly influenced by environmental changes, especially water temperatures that appear to affect reproductive success and recruitment. In addition, because it is a prey species for many groundfish predators such as cod and American plaice, shrimp natural mortality varies with groundfish abundance. The recent increases in abundance of many shrimp stocks in the northwest Atlantic, including the Scotian Shelf stock, have been attributed to low water temperatures in the 1990s, decreasing groundfish stocks during the same period, or to a combination of both factors (Koeller, in press). In addition to the environmental and ecological influences which must be taken into consideration when evaluating the additional influence of fishing

pressure, the Scotian shelf stock is situated in a small area of suitable habitat which makes it more vulnerable to fishing and oceanographic influences than the vast shrimp grounds to the north (Figure 1). Shrimp in the southern areas like the Scotian Shelf also tend to undergo seasonal migrations because of marginal water temperatures. Trap fisheries have developed where large, mainly ovigerous females move into shallower, colder water during winter, for example off Canso, Nova Scotia. All this indicates the need for close monitoring of the fishery and resource, and rapid management action to take advantage of population surges and minimise downturns.

THE FISHERY

A shrimp trawl fishery has existed on the Scotian Shelf since the late 1970s, initially conducted by larger (>65ft) trawlers which came from the Province of New Brunswick in the Gulf of St. Lawrence. During this early period the fishery was of little interest to local Nova Scotia fishers from ports bordering the Scotian Shelf, as the lucrative groundfish fishery occupied them. In addition, shrimp were not particularly abundant and groundfish bycatch restrictions prevented catches from attaining levels beyond a few hundred metric tons. The fishery began to realise its full potential only in the early 1990s when the introduction of the “Nordmore grid” bycatch exclusion device (BED) virtually eliminated groundfish bycatches (Figure 2). At the same time, the groundfish fishery on the eastern Scotian Shelf collapsed and shrimp abundance increased to historic high levels. Strong interest from Nova Scotia fishers resulted in a Federal-Provincial-Industry agreement which shared the Total Allowable Catch (TAC) between the two groups, 75% going to 23 new Nova Scotia licence holders (vessels <65’) and 25% going to the existing New Brunswick fleet, which currently has 10 active licences (vessels >65’). When the TAC increased beyond expectations the government provided for additional temporary licences (currently 5) which will be discontinued if the TAC decreases to a certain level.

In addition to the trawl fishery about 10 fishers use traps to catch migrating females nearshore. This fishery is limited to a few specific sites where conditions are favourable for trapping and generally accounts for less than 5% of the total catch.

MANAGEMENT

The TAC is divided equally among all licence holders as individual transferable quotas (ITQs). In addition to TACs other management measures designed to limit effort include limited entry and a minimum codend mesh size. The use of a BED is mandatory. Enforcement measures include radio hails upon completion of all fishing trips and 100% dockside monitoring (weighing) of the catch. Observers are taken on about 5% of all fishing trips. Effort controls in the trap fishery are limited entry and trap limits (100 traps/fisher).

In 1998 the Department of Fisheries and Oceans and the trawl fishery entered into a 5-year co-management agreement with the mobile shrimp fleet. An “integrated management plan”

describes this agreement in detail, including the consultative process, management objectives, enforcement, licensing, and science requirements, among others. The responsibilities, including financial, of all parties are clearly outlined in this document. The plan also details sharing arrangements between permanent and temporary license holders, including the conditions under which these temporary licences no longer have access to the resource. The table of contents (Table 1) provides an indication of the scope of this document. Annual amendments to appendices provide regular operational and financial updates. Management and enforcement costs are recovered through licence fees.

STOCK ASSESSMENTS

Since 1995 one research scientist and a part time technician have conducted research on the eastern Scotian Shelf shrimp stock, i.e. 1.5 person years. Assessment data consists of representative sampling of the catch, logbook information from all fishers and two annual surveys, including a summer biomass survey conducted with a commercial shrimp trawler (since 1995) and a winter recruitment survey on a government research vessel (since 1998). The stock assessment is peer reviewed during the Regional Advisory Process (RAP) which includes industry representatives. The rationale for the advice is detailed in a Research Document and summarised in a Stock Status Report. Advice is then presented and adopted at a Government-Industry Advisory meeting.

All costs (except the 1.5PY salaries) for the summer biomass survey and the commercial sampling program are covered by industry, which also contributes towards the winter recruitment survey. All expenditures on science (including salaries) required for delivery of the advice are approximately 2% of the landed value of the catch.

When shrimp catches began to increase after the introduction of BEDs in 1991 there was little basis for setting TACs except a historical (1982-88) series of research surveys conducted on a government vessel. An initial TAC set at 2150 mt in 1988 based on biomass estimates from these surveys and an exploitation rate considered reasonable for shrimp was still in effect in 1993. That year a contracted technician and several commercial vessels conducted a government industry survey. Survey and commercial catch data indicated a stable or increasing stock with no apparent detrimental effects of fishing and the TAC was increased to 3100 for 1994. There was no survey in 1994 and it was recommended that the TAC should be kept at 3100 for several years. In 1995 another co-operative government-industry survey was organised, this time with the intention of conducting the survey annually on a commercial vessel. Results from an expanded survey area indicated that the resource was larger than previously thought. This, together with increasing biomasses and commercial catch rates since the survey began resulted in a steady increase in the TAC to 5500mt in 2000. There was no analytical basis for the amount of these increases and a precautionary/experimental approach was adopted of relatively small annual increases and continued monitoring to gauge stock response.

SOME PROBLEMS WITH RESEARCH IN THE CO-MANAGEMENT CONTEXT

Interest by fishers in conducting the survey was assured by allocating the survey vessel an additional 70 metric tons, a 70% increase to the IQ at the time. This measure also had the effect of ensuring that a different vessel would do the survey each year, since all fishers wanted a chance at the additional quota. Having experienced first hand the data interpretation problems caused by changing even standardised government research vessels and fishing gear only once during a survey series, I was particularly concerned with this situation when I inherited the program. Understandably, the trawl fleet was reluctant to give up the bonus TAC, and perhaps somewhat mistrustful of a new player. I was assured that everyone uses essentially the same gear, and that changing vessels would make little difference to the results. A compromise was reached in which the 1996 survey would conduct a comparative fishing experiment with the vessel that completed the survey in 1995. A recommendation to eliminate the survey quota bonus was adopted beginning in 1997, when the survey was awarded to the lowest bidder. Catches from the survey, usually at least 10 mt since 1995, are sold by the fishers' association and proceeds (about CAN \$20K) put towards the cost of the science program. All licence holders pay for the difference between survey revenues and actual science costs equally.

The comparative fishing experiment conducted in 1996 was successful, despite the completion of only 10 side-by-side tows. Excellent co-operation by both crews and apparent spatial homogeneity of shrimp facilitated the demonstration of a significant difference in fishing power of about 50% between two similar sized vessels fishing trawls with nearly identical overall dimensions. The difference in catches was attributed to a number of subtle differences in the trawls, including mesh sizes, footrope construction and BED dimensions (Koeller et al 1997). This demonstration convinced fishers that a single gear should be used to conduct the survey, and a trawl was purchased by the association to that end for the 1997 survey.

Because any boat in the fleet was equally likely to conduct the survey, the choice of trawl was limited to one that could be towed even by the smallest vessel. The trawl chosen is used by many boats in the fleet, and was manufactured by a company supplying many of the vessels. Science requirements supplied to the manufacturer included among others, a small mesh liner in the codend to retain small shrimp. Due to a misunderstanding the trawl was delivered to the survey vessel without a liner and it was decided to fish without it that year. Comparative fishing with and without a liner in 1998 indicated that the liner was in any case ineffective in retaining small shrimp, consequently a liner has not been used in the surveys and other methods are being used to obtain early indications of year class strength.

During the winter of 1994-95 a co-operative research project between the Department of Fisheries and Oceans and an inshore fisher from Canso had demonstrated that commercial quantities of large *P. borealis* existed within a mile from shore in Chedebucto Bay and would support a winter trap fishery prosecuted by small lobster boats. This situation suggested migration of females inshore during winter as occurs off the coast of Maine. The first co-operative trawl survey in 1995 provided an opportunity to determine the source of the trapped shrimp and the extent of the inshore population. The extension of the survey area

into the unfished inshore in 1995 was initiated by the science program with the objectives of a) improving the overall biomass estimate of the stock b) obtaining a better understanding of the relationship between shrimp found by the trapping survey and those fished offshore by the trawler fleet, and c) estimate the biomass of the inshore component in order to determine the number of licences for the new trap fishery. The survey revealed that the distribution of the inshore component of the stock was quite large and extended from the immediate inshore nearly to the offshore holes fished by the trawler fleet. It provided a basis for issuance of licences for the new trap fishery in 1996. By 1997, after 3 annual surveys, it was clear that this inshore shrimp stock component was growing, with excellent catch rates and shrimp sizes that were comparable to the offshore holes. At the same time it also became clear that the success of the trap fishery is less dependant on the size of the inshore component than the rate that shrimp immigrate from this component into the relatively small, specific areas nearshore where they become trappable. Despite unprecedented biomasses, and access by trappers of the entire inshore area throughout the year, only a handful of licences fishing immediately off Canso eventually were successful in sustaining a trap fishery. By 1998 trawl fishers had moved into the inshore area and in 1999 took about 40% of the TAC there. While offshore catch rates and shrimp sizes continued to be good, the new grounds were only a few miles from markets, resulting in considerable savings in time and fuel. This development led to friction between the two gear sectors. Trappers believe that heavy fishing on the stock component which feeds their fishery will ultimately lead to its demise, although the evidence for a direct effect of inshore trawling on the trap fishery is not convincing to date. In addition, direct gear conflicts have been noted. The region adjacent to the inshore component is economically depressed and the pressure for increased inshore trap licences continues. Efforts to exclude the trawlers from the inshore have been unsuccessful and have met with strong resistance, including threats to discontinue funding the inshore component of the survey.

DISCUSSION

The above examples illustrate characteristics unique to the conduct of science within co-operative programs. Problems appear to fall into two main categories: those associated with methodological compromises; and those associated with conflicting objectives.

It is clear from the example that the methodologies adopted within a co-managed science program may not necessarily be those of first choice had the program been planned as an independent, government-funded initiative. The value of the 1982-88 government survey lies mainly in the standardisation of methods, including vessel and gear, as well as the conduct of two surveys per year (spring and fall) which has provided valuable seasonal biological information on the stock. The preferences and requirements of the scientist involved were in the forefront of the planning process. This was not the case for the co-operative survey, where monetary considerations initially overshadowed scientific requirements. The method of financing fishery independent surveys conducted by fishing vessels is an important consideration if the survey is to be truly independent. In the case of the co-operative shrimp survey, the financing scheme directly jeopardised the value of the survey by fostering annual gear changes. In addition, it caused additional work to

demonstrate a commonly known fact among fisheries scientists, the need for standardisation of survey vessels and gears. The new scheme is not ideal. While the concept of putting the proceeds of the catch towards the cost of the survey works well, awarding the survey to the lowest bidder is still a monetary, rather than a scientific consideration that can affect survey conduct and quality. Understandably, a small fishery is concerned with costs, particularly when the difference in survey catch revenues and actual costs come directly from each fisher's pocket. This may be easier to swallow when catch rates are high and overall profits are good, but when the fishery inevitably declines, survey costs will remain high and the expenditures will become more difficult to justify. A valuable data series may then be discontinued. While the use of a standardised gear has facilitated comparability of results between years the awarding of the survey to the lowest bid still encourages annual changes in vessels and crew, factors which undoubtedly affect operations and quality of results. The lowest bid is not necessarily the best for the job in terms of crew expertise, co-operation and vessel suitability.

The description of events associated with the extension of the shrimp survey area illustrates the problems that can arise when the parties in a co-management agreement have different objectives for the science conducted. To the scientist, the objectives of the survey extension were as stated above, and while these were acceptable and important to the industry, its unstated objectives were perhaps equally important, judging by developments. These included reconnaissance of a previously unfished but potentially productive area, establishment of ownership, and limiting the growth of a rival fishery. While the existence of these objectives did not compromise the conduct of the survey, the interpretation of results and formulation of advice, it was necessary to consider them in its delivery and elaboration. They undoubtedly had some influence in management decisions although the degree to which this occurred is difficult to establish. Nevertheless it illustrates possible repercussions of co-operative science that should be considered in program design. The discontinuance of inshore survey coverage in the event of unfavourable decisions would not have had been an issue in a solely government-funded program. Moreover, decisions regarding the disposition of this newly discovered resource may well have been different, for example, a more equitable distribution of wealth between inshore and offshore fishers may have been forthcoming, even if it did require development of a more effective inshore gear.

While the problems with co-operative science outlined above are relatively straight forward and manageable, the benefits beyond the most obvious (e.g. sharing of resources and responsibilities, better mutual understanding) are perhaps more difficult to frame succinctly or provide examples for without resorting to "motherhood" statements or personal judgements. The ultimate consequences are subtle and profound and whether these are beneficial or detrimental is still to be determined. This is currently a matter of some controversy and debate. In my opinion, which I will venture to elaborate below, the ultimate consequences will benefit fisheries science and management, and far outweigh the problems. In my opinion, the problems outlined above are benefits in that they force fisheries scientists to think differently about themselves and their discipline, an important step in moving beyond the paradigm of model-based fisheries science and management which has largely proved inadequate in application.

The major concern of many scientists with co-operative research is that it can compromise basic scientific principles of objectivity, impartiality and the freedom to clearly define hypotheses and execute the best programs to test them. In many respects this complaint is artificial and naïve. An extreme example of this type of reasoning is presented by Corkett (1997, 1999) who argues that because it uses precepts that are largely unfalsifiable as defined by the well known philosopher of modern science Carl Popper, fisheries science does not fall within the realm of science, but rather that of shamanism and witchcraft. This extreme view could only have been conceived during a period when fisheries science is rethinking its role within the scientific community, and in the absence of a defensible, clear definition of that role. The widespread movement toward co-operative research is an important part of that rethinking, and part of that, in my opinion, should involve rethinking the way that fisheries scientists think of themselves.

The underlying cause of both methodological compromises and conflicting objectives is of course the fundamentally different motivations of fishers and scientists: fishers want to catch lots of fish i.e. money, while scientists want to catch information, which is of equal value to them no matter how much fish is caught. These differences will always exist and require compromise in a truly co-operative program, no matter how educated or conservation-minded the fisher, or how “field-savvy” or practically-minded the scientist. There really is nothing new here. Industrial research has a long history of successes beginning with the Industrial Revolution, and while it has unique problems, there is no reason to think that research by the fishing industry, with or without the aid of government, should be any different. But what of the consulting or government scientists’ role in co-operative research? While Corkett’s comparison to witch doctoring is outrageous, I find the analogy to medicine useful because medicine combines elements of art and science in a way that is intuitively appealing to those tasked with marshalling disparate, highly variable and often conflicting fisheries data into defensible management advice. As fisheries scientists we are, after all, asked to assess the health of a patient, and to advise on her rehabilitation if it is found wanting. It is unavoidable, when taking this analogy further, to think of the medieval physician who bleeds a sick patient. While we have progressed beyond this basic model error, we continue to bleed our patients, often with woefully deficient knowledge of the systems within which they function. A more heartening analogy might be that of holistic medicine, as suggested by the “Traffic Light” approach described below. Regardless, medical ethics may be a useful reference when defining the role of the fisheries scientist within co-operative research.

If fisheries science is to be a truly co-operative venture, it must find ways to facilitate co-operation and understanding of the entire assessment and management process, especially the more complex final stages of formulating the scientific advice and translating it into management action. These aspects have traditionally been handled by “black box” population models and projections based on model-derived management concepts (ostensibly called objectives) such as MSY or $F_{0.1}$, and relatively authoritarian management regimes. The “Traffic Light” method is one way of empowering and involving industry more fully in these processes. Its strength lies in its simplicity, its ability to summarise observations from a wide variety of sources including traditional fisheries data and industry

input, and its ability to facilitate consensus building among diverse stakeholders. The method has long been used in environmental impact assessment and generally takes the form of a matrix. Table 2 gives an example from the Scotian Shelf shrimp stock assessment document (Koeller et al 1999). This technique is now used for all shrimp stocks on the Canadian Atlantic coast and has been well received by industry and managers alike. While the main critics have come from within the scientific community itself, it is now being considered as a potential approach for other stocks, including groundfish. Although the method facilitates industry involvement in the assessment process, the lack of a direct link between the results of a traffic light analysis and management action such as setting a TAC means that this final step is still relatively arbitrary and authoritarian. Fisheries scientists and managers are currently discussing the use of pre-agreed harvest rules, which define management action under specific conditions of stock health. Koeller (in press) suggests one way of linking “traffic light” results to management action. In this method some annual mathematical summary of traffic light scores, in this example the arithmetic sum of the red, yellow and green (1, 0, -1) scores from the matrix, is associated with a specific, pre-agreed change in the stock’s exploitation rate (rule). Modelling studies suggest that this approach is more precautionary than traditional methods in terms of risk (Figure 3) and provide a way to distance the assessment and management process from model error (Figure 4). The creation of a link between the assessment results and the management action would then result in industry involvement and input throughout the assessment-management process. The setting and enforcing of management measures, traditionally a government domain, then becomes more of a co-operative action.

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APPENDIX 7 Diagram: Acceptable Groundfish Separator Grate for the Scotian Shelf Shrimp Fishery.

Table 2. Traffic Light Analysis for the Scotian Shelf shrimp stock. 1-green, 0-yellow,-1-red.

	1995	1996	1997	1998	1999
<i>FISHERY DATA/DONNÉES DE LA PÊCHE</i>					
CPUE - KG/HR/PUE KG/H	1	1	1	1	1
Spatial pattern/Profil spatial	1	1	1	0	0
Temporal pattern/Profil temporel	1	1	1	1	1
Age/length composition Composition âge/longueur	1	1	1	1	0
Industry counts/Comptes de l'industrie	1	1	1	1	1
<i>SURVEY DATA/DONNÉES DU RELEVÉ</i>					
Biomass/abundance index/Indice de biomasse/d'abondance	1	1	1	1	1
Spatial pattern/Profil spatial	1	1	1	1	1
Age composition/Composition selon l'âge	1	1	1	1	0
Recruitment (juveniles)/Recrutement (juvéniles)	1	1	1	0	-1
Recruitment (males)/Recrutement (mâles)	1	1	1	1	1
Spawning stock (females)/Stock de reproducteurs (femelles)	1	1	1	1	1
Exploitation rate/Taux d'exploitation	1	1	1	1	1
<i>OTHER DATA/AUTRES DONNÉES</i>					
Predation (cod stock)/Prédation (stock de morue)	1	1	1	1	1
temperature/Température	1	1	0	1	0
Industry perspective/Point de vue de l'industrie					
<i>SCORE</i>					
t + 1	13	13	12	12	9
t + 2	1	1	1	0	-1

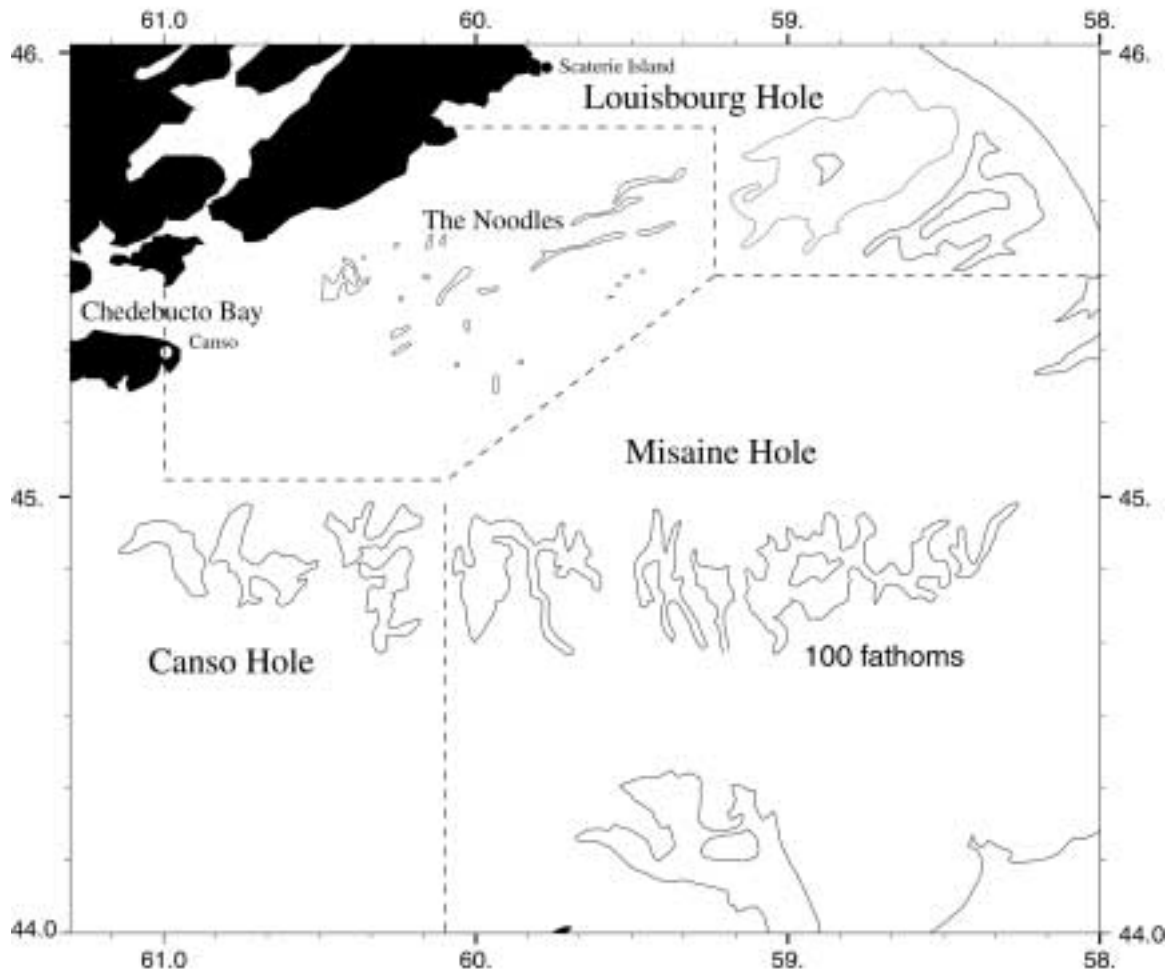


Figure 1. Eastern Scotian Shelf showing the offshore shrimp holes (Canso, Misaine and Louisbourg) fished by the trawler fleet and the inshore area fished by trawlers and trap fishers.

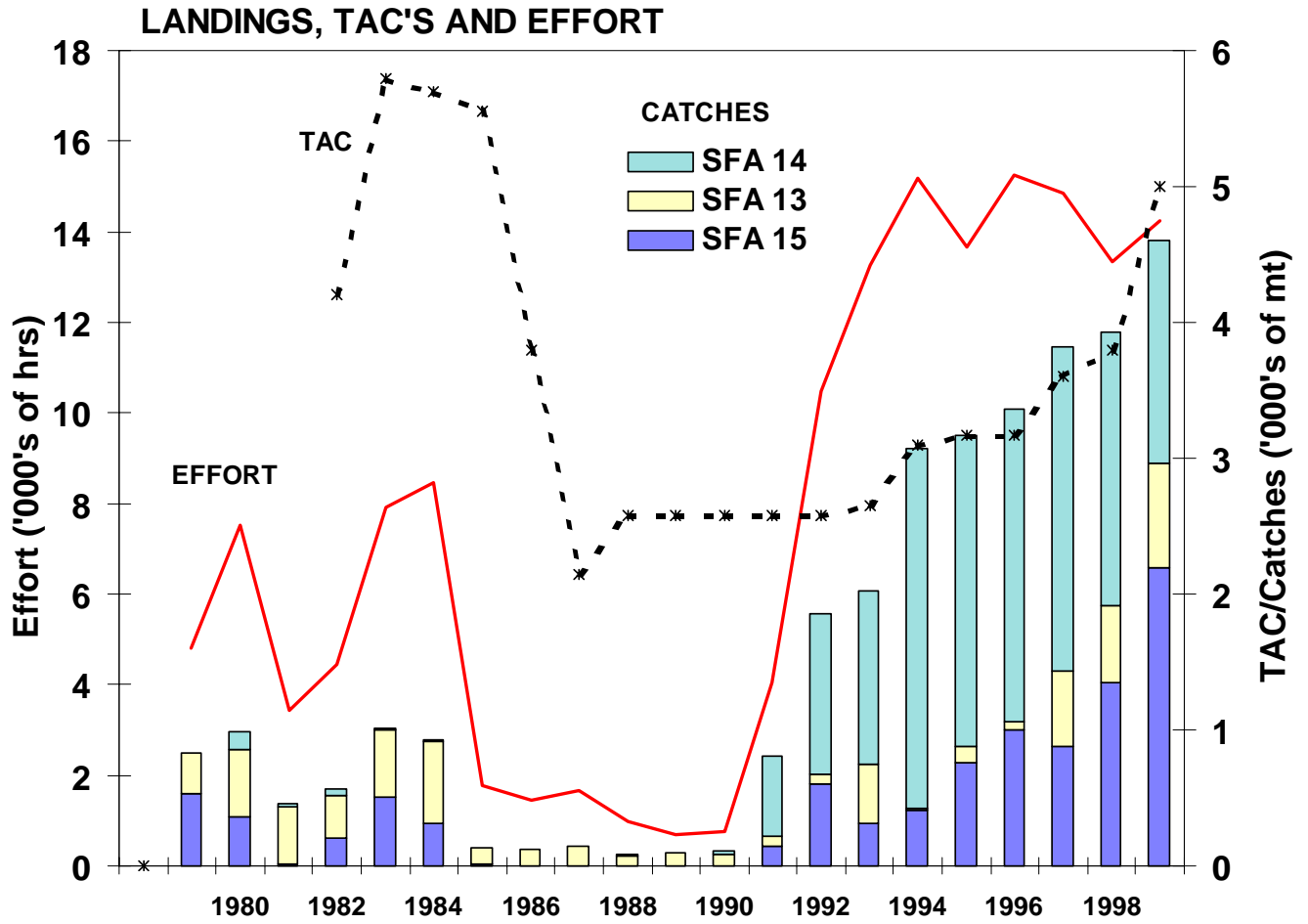


Figure 2. Landings, TACs and effort of the Scotian Shelf shrimp fishery 1978-99. SFA 13, 14 and 15 correspond to the Louisbourg, Misaine and Canso Holes in Figure 1. The inshore area is included here in SFA 15.

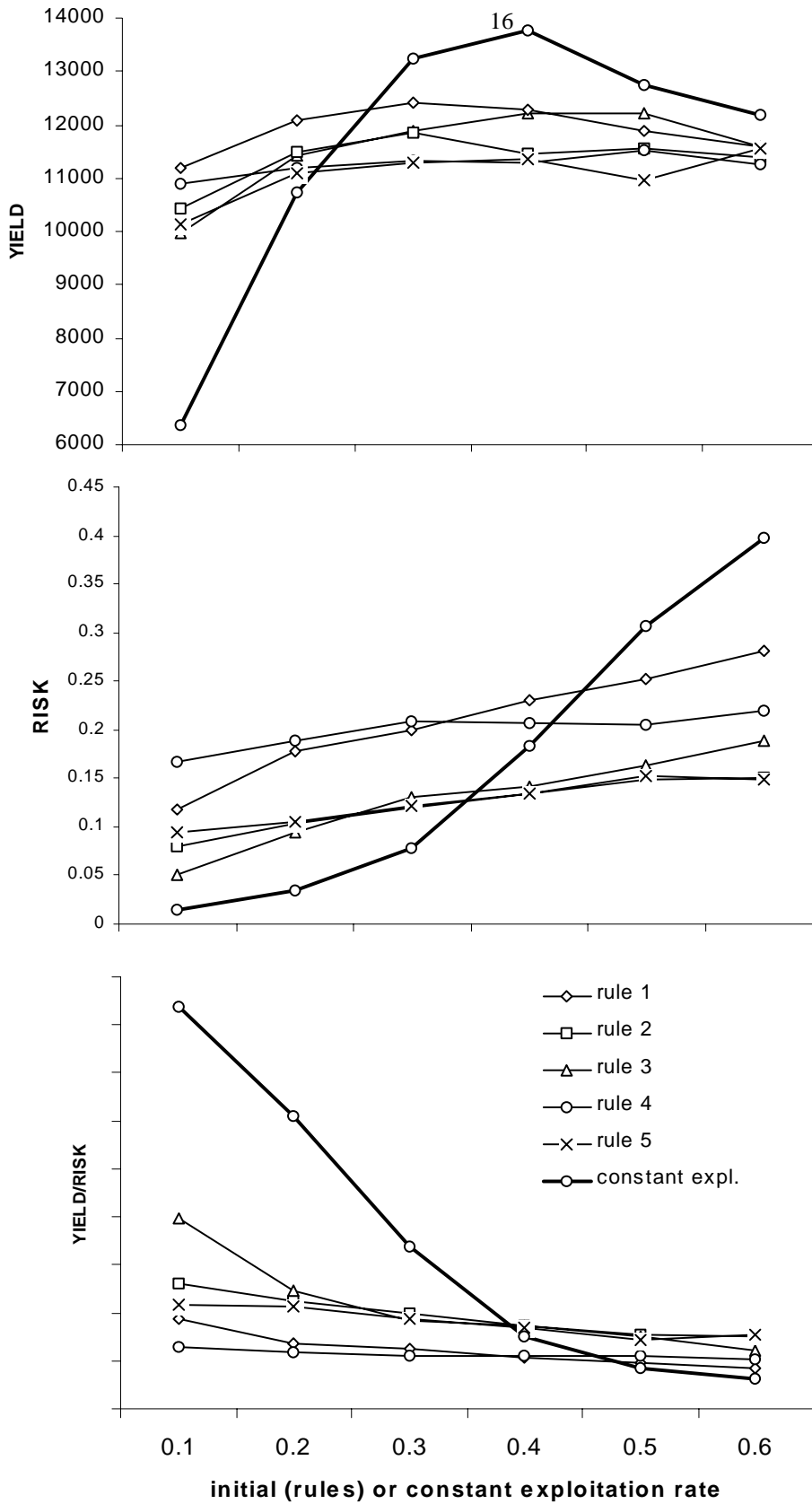


Figure 3. Modeling results from a hypothetical shrimp stock in which a traditional, constant exploitation management scheme is compared to various rules that link exploitation rate to traffic light scores. Rule 1 uses only three stock indicators to set exploitation rates, while the others use six. Rule 4 is more “aggressive” i.e. increases in exploitation rates are greater with better scores. Rule 3 weights all 6 indicators equally, while Rule 5 gives 3 times as much weight to information from surveys.

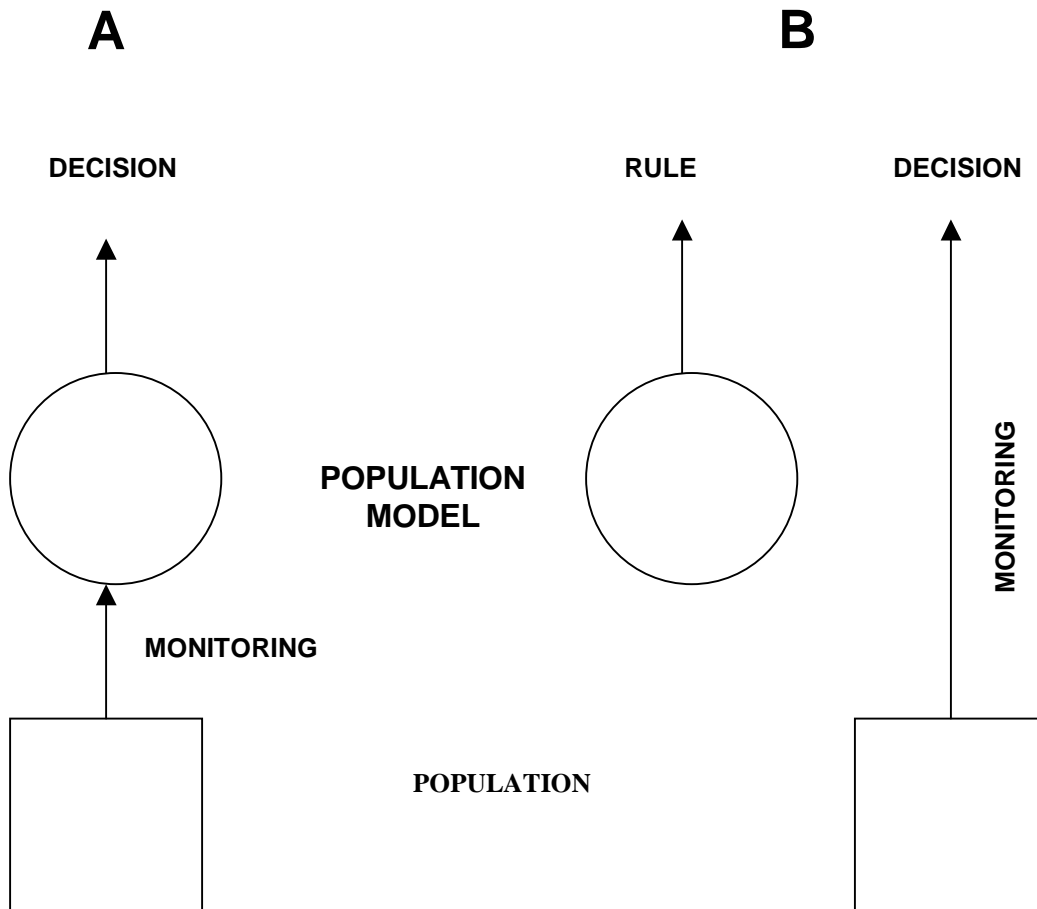


Figure 4. Schematic depicting A. a traditional approach to assessment and management where monitoring results are used as input parameters to a population reconstruction model. Results are then projected to the future, usually the next fishing year, by applying a model derived management concept (“objective”) such as *MSY* or *F0.1*, and B. An assessment and management scheme where traffic light results are linked to pre-agreed harvest rules. The rules are derived from a population model only once, and are then applied according to monitoring results.