FRCC Discussion Paper
Prepared by the
Management and Regulations
Subcommittee

December 1996
FRCC.96.TD.3

Quota Controls And Effort Controls: Conservation Considerations

Discussion Paper

Fisheries Resource Conservation Council

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1. INTRODUCTION

Fish in Canada are a common property resource, belonging to all Canadians. The Canadian government, on behalf of its citizens, has the responsibility of conserving fish resources now and for the future. It's a big task requiring the assistance of everyone who depends on the ocean's resources.

The key to successful fishery management lies in limiting the impact of the fishery on the resource. One approach to this -- used by most developed nations in recent years, and predominant in Atlantic Canada's groundfishery -- is quota management. The idea is to directly limit how much is taken from the sea, by setting Total Allowable Catches (TACs). These TACs are set based on available information and are supposed to reflect proper rates of harvesting that ensure sustainable spawning biomasses. A second major approach lies in directly restricting the intensity of fishing activities -- the fishing effort -- to ensure that the rate of exploitation is in keeping with the reproductive capability of the resource.

Both of these approaches have had their problems. Although TACs are meant to be limits on total catches, they create incentives for discarding, high-grading, mis-reporting and non-reporting, and the quotas most often did not account for these. In addition, it was difficult to determine how much fish should be taken in a given period, when no one knew with certainty what was there at either the beginning or the end of the decision making process. These difficulties led to some disastrous experiences, and in particular, appear to have contributed to the collapse of some Atlantic Canadian groundfish stocks. On the other hand, effort controls -- as practised in the Atlantic lobster fishery, for example -- have their own set of problems. In particular they cannot control every dimension of fishing activity (so the fisher has an incentive to look for other ways to increase fishing pressure). Also, effort is more difficult than catch to compare across gear types and vessel sizes.

The question before us is: "What best serves conservation?" Has a focus on quota management in the groundfishery led to success in conservation? Would a switch to effort controls improve conservation? Or would some feasible combination of the two approaches be most desirable? This discussion paper provides a look at the strengths and weaknesses of the various approaches, with the aim of providing us all with a clearer conservation vision for the fishery of the future.

2. QUOTA CONTROLS

Quota management is a common tool of fishery management. Over the last few decades, this has become an integral part of management in many locations around the world, in ground-fisheries as well as other finfish and some shellfish fisheries.

The essential idea of quota management is to limit the amount of fish killed, to ensure that enough of each stock is left to maintain or re-build the population. This does not mean that the quota will be constant from year to year. Instead, the principal stated goal of quotas in Atlantic Canadian groundfisheries -- the $F_{0.1}$ strategy -- was to try to harvest the same percentage of the biomass each year (usually around 16-22%, reflecting the desired rate of mortality); with this strategy, the allowable catch would rise and fall with the stock size.

The first Total Allowable Catch for Atlantic groundfish was established under the International Commission for the Northwest Atlantic Fisheries (ICNAF) in 1969. These global TAC's were subsequently subdivided into national allocations. On the domestic front, in Atlantic Canada, the first groundfish TACs were established in the early 1970s. Subsequent annual fishing plans gradually established TACs for most groundfish species. These TACs were then subdivided by fleet and/or gear sector, in order to spread the available catch amongst the various fleets. From the early 1980s onward, more and more fleet sectors have had their quotas further subdivided into individual vessel quotas (or "enterprise allocations" for offshore vessels).

Conservation Considerations

Quota management has the theoretical benefit of ensuring that only the desired amount of fish is removed from the biomass each year. However, in reality, several conservation concerns with quota management in Atlantic Canada have arisen:

(1) Effective TAC management requires precise annual assessments of stocks size, which is often difficult given the variability of abundance indices from research vessel surveys and commercial fisheries. Over-estimation of the biomass has led to the setting of excessive TAC levels. [On the other hand, if TACs are set independently of actual biomass, as was the case in the multi-year groundfish harvesting plans of the early 1990s, the conservation risk is that the pressure on the stocks will increase dramatically if stock levels decline.]

(2) Quota management creates an inherent incentive to "beat the quota". This arises both by landing too much (which could be eliminated with complete dockside monitoring, or reduced through a combination of hailing and spot-checks) and by landing as valuable fish as possible (through dumping, discarding or high-grading, which it has not been possible to prevent). This incentive increases the more the quota is sub-divided (from a TAC into gear allocations, then into individual quotas), since the direct benefits of such practices to the fisher increase with sub-division of quotas. In the past, the effectiveness of TACs was greatly reduced by the ease with which the total amount of fish killed could be misreported.

(3) When TACs are reduced in a quota control system, this can create a desire to fish harder (in an attempt to catch the scarcer fish first) and to spend more time on the water selecting the most profitable fish to land (if the profitability of high-grading exceeds the costs of fishing). So as stocks decline, the actual pressure on the various resources in the ocean may be excessive, even though the "nominal" catch levels might seem appropriate.

(4) When a variety of species are mixed together in a fishery, TACs for the various stocks need to be compatible with each other. It may be impossible to catch a high TAC on one stock while limiting to a small TAC on another, without there being incentives for dumping and discarding. This is particularly a concern when the directed fishery for one of the stocks is closed for the year, or its quota has been caught. In this case, the ability to harvest the TAC of one stock will depend on its overlap with other stocks, since fishing can only take place if done "cleanly". It may be necessary to restrict harvesting to appropriate sub-areas, or even to close the fishery entirely.

There are a number of issues arising in mixed-stock fisheries: (a) determining the best management approach so that none of the TACs is exceeded, and dumping, discarding and highgrading are avoided, (b) choosing between setting an allowable catch for each stock, or using a form of "pooled" TAC that allows some flexibility on the species "mix", and (c) finding technically-feasible combinations of species quotas, overall or for each gear sector (e.g. determining, for a cod and haddock fishery, how much cod will be caught per tonne of haddock, and vice versa).

3. EFFORT CONTROLS

"Fishing effort" is the combination of all the inputs to fishing -- the number of vessels in the fleet, the dimensions and hold capacity of the vessels, the amount of gear used, fishing days at sea, etc. Effort controls aim to limit this total fishing effort, i.e. the overall impact of all inputs taken together, which in turn directly restricts the fishing mortality (exploitation rate). There is a fundamental difference between effort and quota controls. While the latter attempt to limit the output from the fishery, namely the catch, effort controls seek to limit the inputs. As a result, effort controls do not directly limit catches, while quotas do not directly limit effort and fishing mortality (although in both cases there may be indirect effects).

The term "effort control" is generally used to refer to controls on total fishing effort, by limiting the inputs used in fishing. However, controls are also often placed on how, when and where these inputs are used (e.g. through closed seasons, closed areas, restrictions on gear use, etc.). It is important to note that such controls may indirectly limit effort, but this tends to be coincidental to their primary purpose. For example, closed areas and closed seasons are typically designed to protect the fish at certain stages (e.g. through spawning or nursery area closures) rather than to limit effort; in fact, such closures may actually lead to increased effort at other times and places, rather than a reduction in total effort. Since the focus here is on direct effort control, designed to limit the total pressure on the resource, discussion of "how, when and where" controls (which are best viewed as "supplements" to both quota controls or effort controls) will be left to the next section of this paper.

The Atlantic Canadian Lobster Fishery. This fishery has been managed with effort controls, rather than quotas, for many decades. Although there are significant differences between the lobster and groundfish fisheries, it is useful to understand this local example of effort control. In the lobster fishery, the number of fishers remains the same, through limited entry, and the number of traps per license is regulated in each Lobster Fishing Area. Effort controls are complemented with biological regulations; mandatory lath spacing requirements allow small lobsters to escape, special escape mechanisms provide an additional stock protection measure, carapace sizes are set to ensure that at least the smallest of lobsters taken aboard are returned to the water, and berried females are released to allow both them and their eggs to be caught again in the future. However, while effort controls in the lobster fishery are generally accepted, improvements are needed, since over time, actual effort has increased enormously due to use of larger and more powerful boats, larger traps, increased numbers of pot hauls, improved navigation, and so on.

The Groundfishery. While in some fisheries, such as Atlantic lobster, effort control is the primary tool of management, some aspects of effort limitation are common even in TAC-oriented fisheries such as the Atlantic Canadian groundfishery. The most basic and most prevalent form of effort control may be limited entry licensing, which restricts the number of fishers and vessels. Yet limited entry is not enough on its own, since each fisher can still invest in his vessel, add more gear and fish longer hours to increase the impact of a single groundfish license. So restrictions have also been placed on other components of fishing effort, such as size of boats, amount of gear and days of fishing.

Limiting the total days at sea for fishing vessels is not a new idea, but it is gaining interest now, as the ability for effective policing improves. Such was not the case when this type of effort control was first seriously considered for use in the Atlantic groundfishery. In the 1970s, the International Commission on the Northwest Atlantic Fisheries (forerunner of the present Northwest Atlantic Fisheries Organization) realized there was a pressing need to control effort at sea. Controls on days fished, hours fished or "days on the ground" were all considered, with strengths and weaknesses assessed. At the time, "days fished" and "hours fished" were difficult to monitor with the mix of nations involved, and the fact that vessels could be on the grounds and not actively fishing. "Days on ground" was easier to monitor and had more general credibility. However, some of the progress at ICNAF in implementing effort control was lost when extended fisheries jurisdiction and the 200-mile limit came into being, and the Law of the Sea created a need to set TACs (since any part of the TAC not caught by the sovereign state was to be made available to others).

Today, considerable interest in "days at sea" controls has developed in both the U.S. and Europe. Here in Atlantic Canada, the FRCC has called, in both its 1995 and 1996 reports, for direct controls on "effort at sea". Such controls have been implemented in some fisheries and are being experimented with in others (such as the George's Bank groundfishery, where the use of an allowable number of days fishing, based on sector allocations and estimated catch rates, may supplement existing quota management). Of course, limiting days at sea alone is not sufficient; by limiting the time available for fishing, harvesters may be able to "fish harder" by increasing other inputs (e.g. horsepower). They may also

have an incentive to fish hard early in the season, when abundances are greater. So proper effort limitation requires that a range of inputs be controlled.

Conservation Considerations

Just as quota management has the theoretical benefit (noted above) of ensuring that only the desired amount of fish is removed from the biomass each year, direct effort controls have the theoretical advantage of directly limiting the fishing mortality (F). An $F_{0.1}$ strategy, based on maintaining a constant fishing mortality, can be achieved (in theory) by keeping effort constant, something that is less dependent than quota management on the accuracy of the biomass estimate. Indeed, the more uncertain is the biomass (e.g. due to uncertainties and high variability in fish growth and recruitment, and in research surveys and commercial fishery data), the better might we expect effort controls to perform compared with quota controls. [However, with effort controls, it is crucial to adjust for increases in fishing power over time due to technological improvements.]

Also, with a goal of maintaining constant fishing mortality, effort must be kept constant (i.e. with the same level of fishing each year), so we can expect less variability in the desired effort from year to year than in the desired TAC. For example, studies have shown that in the late 1980s and early 1990s, when fishing effort increased significantly, fishing mortalities followed suit (even though many stocks had already begun to decline). Then, with cuts in quotas and eventual closures of directed fisheries from 1992 on, effort fell dramatically, and so did fishing mortality. This suggests that fishing mortality is closely related to effort at sea.

While the above suggests that there are a number of potential benefits of effort controls, in reality a number of challenges must be faced:

(1) In theory, with effort held constant, catches will be high if the stock is healthy but lower if the stock declines. However, under some circumstances (for example, if schooling fish are targeted), the catch obtained by a unit of fishing effort can be kept high even as the stock declines. This would mean that effort controls would not be effective for conservation.

(2) While limits on "sea days" are becoming increasingly popular worldwide, the fishing mortality per boat caused by a single day of fishing can increase if fishers can change other dimensions of their fishing activity. For example, conservation may be equally well served by allowing a certain number of sea days at a given mesh or hook size, or allowing a greater number of sea days at a larger mesh or hook size.

(3) Since changes are likely in the composition of each fleet sector, reflecting differences among types and sizes of vessels, and in the technical efficiency (catching power) of the fleet (due to technological improvements such as larger engines, more efficient harvesting and fish finding equipment); measurement of "effort" (which is meant to allow for all these) must be updated regularly or total effort may actually be increasing while it is thought to be constant.

(4) Effort controls must also take into account changes in the seasonal allocation of fishing effort (due perhaps to more effort exerted in certain times of the year), and changes in the "catchability" of the fish (which depends on behaviour and distribution, with a strong seasonal component for many species, as fish become more aggregated and thus vulnerable to fishing during spawning and migratory periods, and less vulnerable to fishing during feeding periods when they are more dispersed).

(5) Effort controls must be designed particularly carefully in multi-species fisheries (such as the 4X cod-haddock-pollock fishery). On the one hand, there may be a built-in tendency for conservation in such a fishery, if fishers switch their effort away from depleted stocks to more plentiful and easily-caught ones. On the other hand, if the depleted species has a much higher price than others, and if the high price outweighs the scarcity from the harvester's viewpoint, then effort may remain too high on that stock. To overcome this possibility may require more specific limitations -- controls on the effort of each gear sector fishing in a particular area at a particular time. (Such controls could take advantage of the fact that catch compositions in these fisheries are fairly constant over time, so the impact on each species can be predicted.) In multi-species fisheries, if the allowable effort is set at the level desired for fishing a particular set of stocks (eg. 4X cod, haddock and pollock, then an adjustment is needed to measure effort spent targeting on a different species (eg. monkfish); the latter could be counted as less than a full day for accounting purposes.

All this suggests that measuring and monitoring "effort", an amalgamation of all the various inputs to fishing, can be complex. Furthermore, determining what should be the target effort level is a challenge. If effort controls are to be implemented, there is a rather urgent need for scientists and managers to design the tools to accomplish these

4. LIMITING THE "HOW", "WHEN" AND "WHERE" OF FISHING

As noted earlier, fishing effort directly affects how much pressure is placed on the resource (the fishing mortality rate); "effort" is made up of all the various fishing inputs, including vessels, gear, days of fishing and so on. Just as the total fishing effort cannot be properly controlled through TACs, neither can it through controls on how fishing takes places, where it occurs and when it is allowed. Nevertheless, such conservation tools as closed areas, closed seasons and restrictions on types of fishing gear play an important role in determining exactly how fishing impacts on the resource (e.g. whether spawners are targeted or avoided, what size and quality of fish are caught, etc.). Looking specifically at groundfish, a variety of control measures have been implemented; some of these are described below.

How: Gear Restrictions

Great progress has been made in a number of Atlantic fisheries with mesh size increases and shifts to square mesh from diamond, especially for cod, haddock and pollock. Gillnet effort can be curtailed by limiting soak time and the numbers of nets and fathoms in them, while hook sizes and number of tubs of trawl can be factors considered for longliners.

Gear restrictions form a useful part of a conservation toolkit. However, it should be noted that (i) by themselves, they are unlikely to be able to produce major reductions in fishing effort at sea, (ii) there are considerable difficulties enforcing gear restrictions at sea, and (iii) changing gear selectivity to avoid catching small fish means that effort is concentrated on larger fish, increasing the rate of fishing mortality on those fish (if the TAC is unchanged).

A conservation perspective on gear restrictions could focus on "fish maturity targets", to ensure a suitable structure of the catch in terms of age, size and/or maturity. One way to consider this is the idea of "letting most fish spawn at least once"; for example, management could set the target that a certain percentage of the catch, on average in any year, must be sexually mature fish. This could be applied immediately or phased in over several years. For example, one might start initially saying that at least 50% of total catch, by numbers, should be sexually mature, with this percentage rising to 90% sexually mature within 3 years.

In implementing fish maturity targets, a number of issues arise, including:

- Should the percentage maturity target apply to each sector of the fishery separately, or could it be determined as an overall average? The former would provide an incentive for each sector to comply, or be forced to stop fishing, while with the latter, sectors doing "more than their share" to achieve the overall goal could be rewarded.
- How should the target be achieved (e.g. mesh or hook limits, etc.) in each sector? What is an estimate, for each stock of interest, of what size of fish this approach implies being targeted, and what mesh and hook sizes would achieve this?

When: Closed Seasons

Closed seasons are a common management tool, and serve a variety of objectives:

(1) to avoid fishing a stock during part of its life cycle or when it is most vulnerable,

(2) to keep exploitation rates within desirable levels,

(3) to protect spawning and nursery areas, as with haddock on the Scotian Shelf.

(4) from an economic perspective, to extend or adjust the available fishing time, so that the fishery operates at the most opportune time for markets, minimizing quality problems or avoiding a bad mix of fish or a high bycatch.

(5) from a conservation perspective, to minimize resource waste by adjusting the timing of harvesting, so as to ensure the least conservation impact for a given level of catch.

The latter approach might be based on spawning closures (if the condition of fish is less than desirable during spawning) or based on choosing when during the year the individual fish is in best condition (greatest fitness). However, socioeconomic and market issues must clearly be considered in setting fishing times; one approach might be to set quotas in terms of the NUMBER of fish killed. Fishers could then be given a choice: what time of year do you want to catch your certain number of fish? At one time of year (perhaps spring), this might give a higher weight of the catch than at another time, but the industry could make this choice taking into account several questions: What are desirable harvesting times from a conservation perspective? What are the conservation benefits (i.e. reduced numbers of fish killed) if harvesting is restricted to

certain times of the year? How do these times work from socioeconomic and marketing perspectives? What about the weather?

Where: Closed Areas

Closed areas come in many forms, and serve many purposes. They are typically defined by geography (e.g. as a box or block), they can be short-term, long-term or permanent closures, and they can be for all gear types or just specific ones. Closed areas exist for some of the same reasons as do closed seasons. They can help to protect juvenile and spawning fish, and provide refuges for the fish, in untouched ecosystems. This can be especially important in protecting the smaller or weaker among a stock's multiple spawning components. In addition, closed areas can serve a role beyond conserving a single species -- marine protected areas are designed to conserve parts of the ecosystem the fish live in, as well as the stocks themselves.

Many different designs are possible; for example, the Silver Hake Box on the Scotian Shelf is interesting since it is the area inside the box which is designated for fishing, while rigid limitations exist on silver hake fishing outside of it.

In examining potential new closed areas, it must be recognized that conclusive proof of their benefits is impossible, so there need only be persuasive suggestion of the benefits. There must be broad (although not necessarily unanimous) support from stakeholders to make closed areas work. A number of points must be decided in each case:

- whether the area will be closed to all gear or certain gear types; this depends on assessing the impact of the various gear types, and on the implications for compliance by each sector;
- whether areas are permanently or temporarily closed -- e.g. whether areas closed during the spawning season should be re-opened outside that season; and
- how to deal with migratory behaviour, since in such a case, closing a portion of the area to fishing would only protect stocks from exploitation for the time they are within that area.

5. COMPARISON OF CONSERVATION IMPACTS: QUOTA VS. EFFORT CONTROLS

Catch and Effort Monitoring. It was noted earlier that incentives to under-report and mis-report landings are greater under quota controls than effort controls, while incentives to under-state effort and to exceed limits on gear use (e.g. trap limits in the lobster fishery, number of hooks allowed on a long-liner) are most serious under effort controls. However, all of these various problems can be dealt with; through complete dockside monitoring, or combined hailing and spot-checks, for the former, and through suitable monitoring of boats and gear, together with hail-out and hail-in arrangements, for the latter.

Dumping, Discarding, High-grading. Practices "at sea" are much more difficult to control. In quota-managed fisheries, catch controls create a built-in incentive to "get the most" out of a given quota, and as a result, dumping, discarding and high-grading are major challenges to conservation. For example, a pound of large fish may be worth much more than one of small fish, yet both may count equally against an individual's quota, or toward a global quota; this incentive leads to high-grading. Under quota controls, fishing in mixed-stock fisheries often hits up against quota limits on one of the species (the less-abundant), leading to dumping and discarding of that species in order to be able to keep fishing for others. Since dumping, discarding and high-grading take place rapidly at sea, there is little chance that spot checks could solve the problem. Full-time observers on all vessels would presumably prevent such actions, but are often seen as too costly. Recently, other approaches are being tried; for example, a comparison of catch composition at dockside and on "observed" vessels allows the calculation of a Discrepancy Index to assess whether illegal practices have taken place.

Controls on total effort (e.g. fishing time, etc.) may present less incentive to dump, discard or high-grade. The focus of effort controls lies in limiting total fishing pressure directly, regardless of the species targeted, so regulations under effort controls do not give the fisher a reason to dump, discard or highgrade. It is in the interests of the fisher is land everything that is caught, as long as it is marketable and the vessel's hold capacity has not been reached.

Avoiding "How, When and Where" Restrictions. Controls on how, when and where to fish are in place, for conservation reasons, under both effort and quota control systems. Furthermore, they can be thwarted at sea equally under quota and effort controls. This might include fishing out-of-season or in closed areas, or use of illegal gear. The implications of this behaviour may be more severe under effort controls, if these measures form crucial parts of the overall effort management scheme, in other words if their violation dramatically increases overall effort levels.

Long-term Implications. Both quotas and effort controls have long-term effects. The major criticism of controls on fishing inputs (such as days at sea, length of boats, hold capacity of boats, gear use, etc.) is that fishers can eventually circumvent these controls over time by using more uncontrolled inputs (e.g. electronics). For example, early attempts to control effort in Atlantic Canada's groundfishery focused on "limited entry", controlling the number of fishers. However, this actually increased the incentive of those already in the fishery to invest heavily in their boats and gear – in the end, total potential fishing effort increased dramatically. This also occurred more recently in the Atlantic lobster fishery, and shows clearly that the key conservation challenge is to control total fishing pressure at sea, rather than just the number of people taking part in the fishery. This might involve, for example, controls on sea days and amount of gear used, as well as the number of vessels involved.

Of course, part of the problem lies with inadequate research to understand and predict this process. It is necessary to correct for technological and other change over time by (a) ensuring that the key components of effort are controlled, (b) limiting actual effort at sea, and (c) reducing the allowable effort year by year as efficiency of gear use increases.

With quota controls, experience indicates that long-term implications are due primarily to the difference between fish killed at sea and landings actually reported, caused by incentives to under-report and to discard/highgrade (see above). This results in direct over-harvesting, as well as a reduced quality of scientific data, which leads to the potential for over-estimation of biomass and allowable catch levels. Under-reporting can be (and to some extent has been) dealt with through dockside monitoring or other measures, but dealing with at-sea practices remains a challenge. The use of observer programs or a "discrepancy index" to detect illegal activity are important tools, but the key may well lie in a fundamental shift in thinking within the fishing industry – so that anti-conservationist activities become simply unacceptable.

6. CONCLUSION: COMBINATIONS OF QUOTA CONTROLS AND EFFORT CONTROLS

It is clear from the above discussion that both quotas and effort controls have drawbacks. In theory, quotas should be enough to ensure conservation -- if the biomass is known with certainty, if TACs are set at the "right" level, if built-in incentives to dump, discard and highgrade can be avoided, if quotas are enforceable, and if all fishers act in a conservationist manner. But the dramatic collapse of the Atlantic Canadian groundfishery suggests that the past package of management measures, focused on quota controls, was not enough to meet the needs of conservation. Indeed, problems remained even when TACs were combined with controls on the how, when and where of fishing (regulating the size or age of fish harvested, the type and size of gear used, the protection of spawning and/or nursery areas, etc.).

If the status quo has not offered adequate conservation protection, what else is needed? While TACs have been, and may well remain, the principal tool of Atlantic Canadian groundfish management, it is also necessary to control fishing pressure more directly -- through effort controls. Adding effort controls to the conservation toolkit, in conjunction with TACs, gives an upper limit on fishing effort as well as the upper limit on catches provided by the TAC. Experience suggests that neither limit can be relied upon alone, so that using both provides a "double check" safeguard, reducing the risk that conservation could be compromised.

The idea is that if an end to fishing in a season is "triggered" either when the TAC is reached, or when the effort limit is reached, whichever comes first. This gives a built-in approach for "erring on the side of caution". If the allowable effort was set too high, the TAC will be the limiting factor. If the TAC was set too high, the effort limit will prevent there being too much catch. (Ideally, these limits would be reached at the same time, but this is not likely given the uncertainties in stock size, possible changes in technology, etc.)

Another important reason to combine effort controls with quota management is that with stocks in a depressed, fragile state, fishing pressure (fishing mortality) will have to be much lower than in the past. This means that total fishing effort will need to be much lower, perhaps as little as 1/4 of the average levels of the late 1980s and early 1990s. To achieve this reduction, and to successfully maintain a reasonable level of fishing mortality, direct controls over effort will play a crucial role. At the same time, there is an additional benefit through improvements to our knowledge base, since the process of setting both TACs and effort limits inherently gives two independent indicators of stock abundance.

A combination of effort and quota controls not only overcomes some of the problems with quota management, it also deals with shortcomings of effort controls alone -- such as the incentives to invest in unregulated inputs, to "fish harder" for each unit of allowable effort (such as a "sea day") and to concentrate fishing early in the season, when a unit of effort may be more productive. Using effort controls in conjunction with quotas also means that it is not necessary to deal with all possible effort components; instead, it would be sufficient to control only one or two elements of effort for each fleet. These should be determined within each fleet sector; for example, one sector might choose to control the total amount of gear and the total number of "sea days", while for another, other measures may be appropriate.

The technical details of implementing joint quota and effort controls clearly need attention. For example, if a sea days limitation is desired, there are various options to determine how the allowable number of sea days might be set, such as using historical catch rates (with suitable adjustments for changes in the effectiveness of fishing gear). The challenge of implementation is particularly great in multispecies groundfisheries, although such fisheries are likely the ones to benefit most from a combination of quota and effort control. A key challenge lies in determining how much of the total fishing effort should be "assigned" to each species in the fishery (for example, how many "sea days" were used to catch cod vs. haddock?). This may require (a) research to determine how fishing effort affects each single-species fishing mortality, (b) monitoring, as part of regular assessments, to see how total effort impacts each of the species, and then (c) limiting total effort through specific conservation targets, so no species is overfished relative to its quota.

It should be noted that implementing a combination of effort controls and quotas can be done flexibly, to meet the needs of each sector of the fishery. If a sector wishes to rely primarily on quota management, then it can set the quota stringently, to be the limiting regulation, and use effort controls as the "safeguard" measure. On the other hand, a sector wishing to focus on effort controls would set such controls to act as the limiting factor in their fishing, with the sector quota serving as the "safeguard". In each case, fishing would, in most cases, be controlled through the desired means (effort or

quota), with the other measure being in place in case the primary control turns out not to have been set appropriately.

Overall, the challenge for the groundfishery of the future is to create a reliable package of conservation measures that is also affordable and manageable. That is certainly a difficult balancing act, but it is clear that controls over both catch levels and fishing effort must play a role, if we are to properly err on the side of conservation. Such a combination of conservation tools provides a necessary safeguard, to give us the best chance possible of achieving a sustainable groundfishery in the future.