REPORT OF THE SECOND WORKSHOP ON SCOTIA-FUNDY GROUNDFISH MANAGEMENT

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by

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TABLE OF CONTENTS

APPENDICES

ABSTRACT

Burke, D.L., R.N. O'Boyle, P. Partington and M. Sinclair. 1996. Report of the Second Workshop on Scotia-Fundy Groundfish Management. Can. Tech. Rep. Fish. Aquat. Sci. 2100:

The first Workshop on Scotia-Fundy Groundfish Management (Angel et al. 1994) was held in December 1993. The aims were retrospective in nature, searching for understanding of the underlying causes of the deficiencies in groundfish management between 1977 and 1992. Based on the findings of this initial Workshop, a second session was held in October 1995 to discuss additional gaps in knowledge, and to identify what can realistically be changed to improve the management system. An industry/DFO Steering Committee concluded that the focus of the Workshop should be on four categories of tools by which fishing effort can be controlled to meet the conservation objectives of management (quota, days-at-sea, closed areas, and restrictions on harvesting technology). Initial presentations addressed the DFO Ottawa perspective (i.e., headquarters) on the present government's objectives as they relate to groundfish management. The implications of the term "conservation for sustainable use" were discussed. Subsequently representatives of the fishing industry identified a range of issues that they feel are important for the improvement of the management process. This was followed by the presentation of 16 technical papers on diverse aspects of the tools for controlling fishing effort. The workshop ended with a discussion on whether there is a consensus on the need for modifications to the present management system. It was concluded that quota management should continue to be the core control mechanism of fishing effort, but that days-at-sea need to be monitored on a real-time basis in order to identify discrepancies between reported landings and fishing patterns. A two-level monitoring system (quota and days-at-sea) should allow improved identification of at-sea discarding practices and misreporting, which would help in deployment of enforcement activities. Increased use of seasonal closed areas were considered a useful tool for the protection of spawning components. With respect to restrictions on harvesting technology, a key conclusion was the need for a more responsible attitude on the part of industry with regard to fishing practices, rather than a change in present regulations.

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Based on the papers presented and the discussion at the Workshop, the Steering Committee made 32 recommendations grouped by eight interlinked components of a fisheries management model (strategic planning, resource analysis, business analysis, management planning, fishing entitlements, catch and effort monitoring, enforcement, and service delivery).

RÉSUMÉ

Le premier atelier sur la gestion du poisson de fond de Scotia-Fundy (Angel et al., 1994) a eu lieu en décembre 1993. Il revêtait par nature un caractère rétrospectif, puisqu'il avait pour but de comprendre les causes fondamentales des lacunes de la gestion du poisson de fond entre 1977 et 1992. On a tenu une deuxième rencontre, fondée sur les constatations de la première, en octobre 1995, afin de discuter d'autres lacunes dans les connaissances et de déterminer ce qu'il est réaliste de changer pour améliorer le système de gestion. Un comité directeur de l'industrie et du MPO a conclu que l'atelier devrait concentrer son attention sur quatre sortes de moyens permettant de gérer l'effort de pêche en fonction des objectifs de conservation de la gestion (quotas, jours en mer, zones de fermeture et restrictions sur les techniques de récolte). Les premières présentations portaient sur le point de vue de l'Administration centrale du MPO (Ottawa) quant aux objectifs du gouvernement actuel, en relation avec la gestion du poisson de fond. On a discuté de la portée des termes "conservation en vue d'une utilisation durable". Par la suite, des représentants de l'industrie de la pêche ont cerné un éventail de questions qu'ils estiment importantes pour l'amélioration de la gestion, puis on a présenté 16 documents techniques sur diverses facettes des moyens permettant de gérer l'effort de pêche. L'atelier s'est terminé par une discussion visant à déterminer si l'on s'entendait sur la nécessité d'apporter des modifications à apporter au système de gestion. On en a conclu que la gestion des quotas devrait rester le principal mécanisme de régulation de l'effort de pêche, mais que les jours en mer doivent faire l'objet d'une surveillance en temps réel, cela pour qu'on puisse cerner les écarts entre les débarquements déclarés et les activités de pêche. Un système de surveillance à deux niveaux (quotas et jours en mer) devrait permettre de mieux repérer les rejets en mer et les fausses déclarations, ce qui faciliterait la mise en oeuvre des activités d'application de la loi. On a envisagé un plus grand recours aux zones de fermeture saisonnière comme moyen de protéger les frayères. En ce qui concerne les restrictions sur les techniques de pêche, les discussions ont débouché essentiellement sur la nécessité, pour l'industrie, d'avoir une attitude plus responsable au sujet des méthodes de pêche, plutôt que sur l'apport de changements à la réglementation. En se fondant sur les documents présentés et les discussions tenues à l'atelier, le comité directeur a formulé 32 recommandations, regroupées selon huit éléments interreliés d'un modèle de gestion des pêches (planification stratégique, analyse des ressources, analyse commerciale, planification de la gestion, droits de pêche, surveillance des prises et de l'effort, application de la loi et prestation de service).

INTRODUCTION (N.A. Bellefontaine)

The first Workshop on Scotia-Fundy Groundfish Management was held in December 1993 (Angel et al. 1994). The aims of the workshop were:

i) to identify the degree to which the management objectives for groundfish fisheries in the Scotia-Fundy Region (see Appendix 1) have been met since the extension of jurisdiction to 200 miles in 1977; and
ii) to the degree that they have not been met, identify causes that prevented successful attainments of the objectives.

Thus, the workshop was retrospective in nature, searching for understanding of the underlying causes of deficiencies in groundfish management. One of the recommendations was to hold a follow-up workshop to discuss the identified gaps in knowledge and to identify what can realistically be changed to improve the management system. It was stressed that this second Groundfish Workshop should include representatives from the fishing industry.

To that end, in the autumn of 1994 I established an Industry/DFO Steering Committee under the chairmanship of Mike Sinclair, to oversee the preparatory work and to organize the workshop. Membership was comprised of:

Dave Bollivar, Seafreez Foods Inc.
Les Burke, DFO, Program Coordination and Economics Branch
Gary Dedrick, South West Nova Fixed Gear Association
Jim Fraelic, South Shore Gillnet Fishermen's Association
Brian Giroux, N.S. Mobile Gear Fishermen's Association
Seldon Keating, Fishermen and Scientists Research Society
Greg Organ, North of Smokey Fishermen's Association
Peter Partington, DFO, Fisheries Management Branch
Mike Sinclair, DFO, Science Branch
Roger Stirling, Seafood Producers of Nova Scotia
Klaus Sonnenberg, Grand Manan Fishermen's Association
Evan Walters, Scotia-Fundy Inshore Fisheries Association

The Steering Committee held its first meeting on October 20, 1994. The major conclusion of the meeting was to focus the second workshop on the tools by which fishing mortality can be controlled to meet the objectives of the annual groundfish management plans. In order to facilitate a consistent approach towards the preparation of background documentation on the range of regulatory tools, Bob O'Boyle and Greg Peacock were requested to co-chair a Tactics Working Group. The group was asked to consider the following questions:

- What are the strengths and weaknesses of quota control (IQ/EA and competitive)?
- Can effort management (access to time on the water) be a useful replacement or complementary tactic?
- What could be the role of closed areas or sanctuaries as a tactic to meet conservation objectives?
- Are further restrictions on harvesting technology necessary to achieve conservation objectives? If so, which ones?

The Tactics Working Group met on February 13, 1995 (Appendix 2 lists the participants). Following a general discussion, the Working Group broke up into two sub-groups ("quota/technology" and "effort/area") to discuss costs versus benefits of different tactics:

Benefits

- How well does the tactic that you are considering achieve the conservation objective? Consider this by its various aspects.
- What are the tactic's shortcomings regarding conservation?

Costs

- What are the information needs of this tactic? What specifically should be controlled?
- How much does this information cost? to industry? to management? to Science?
- What are the incentives to cheat? Can enforcement control this?
- How much does this enforcement cost?
- What other issues are relevant?
- What analyses should, and can, be done to address these questions?

These questions were subsequently used to prepare the agenda and the background documentation for the workshop itself (the agenda and list of participants are in Appendices 3 and 4)..

The presentations during the morning of the first day (October 4, 1995) addressed the DFO Ottawa perspective on the present government's objectives as they relate to groundfish management, as well as a range of issues that the fishing industry feel are important in order for us to improve the management process. This was followed by a summary of the conclusions of the first Groundfish Management Workshop. These introductory talks provided context for the subsequent more technical papers during the afternoon of day one and the morning of day two on the four "tools" for controlling fishing mortality (quota, effort, area, gear). During the afternoon of day two (October 5), there was the beginning of a discussion on whether there is a consensus on the need for modifications to the present management system. Due to the inevitable shortage of time, this discussion was not brought to the desired conclusion.

Subsequent to the workshop the session chairs provided a summary of the papers and their discussion. This summary was presented to the Steering Committee in February 1996, who made a series of recommendations. These recommendations are being considered during the ongoing modifications to groundfish management in the Scotian Shelf/Gulf of Maine area.

SUMMARY AND DISCUSSION OF THE PAPERS ON GROUNDFISH MANAGEMENT

D.L. Burke, R.N. O'Boyle, P. Partington, and M. Sinclair

The Context of the Workshop

The problems that have been experienced with the management of the groundfish resources in Scotia-Fundy are global problems. Most nations have failed to achieve the conservation objectives that were established subsequent to the extension of jurisdiction in 1977. The failures to effectively manage marine fisheries have led to discussions at the international level. These include the 1993 World Conference on High Seas Fishing and the 1995 Conference on Straddling and Highly Migratory Fish Stocks (during which a UN Convention was approved). Canada has stated that it adheres to the following general principles of the new Convention:

- ensure long-term sustainability - promote optimum utilization;
- use best scientific evidence (including environmental);
- assess impacts of fishing on target stocks, and non-target species;
- maintain populations above "levels at which their reproduction may become seriously threatened";
- minimize pollution, discards, catch by lost gear, catch on non-target species, etc.; protect biodiversity;
- prevent overfishing and excess fishing capacity;
- collect and share data on catches and fishing activities;
- conduct scientific research and develop technologies for conservation.

Canada also accepts the "precautionary approach" which is advocated in the Convention. The aims of the approach can be summarized as follows:

- to protect living resources and to preserve the marine environment;
- to be more cautious when information is uncertain;
- to improve decision making by sharing best scientific information and adopting ways to deal with risk and uncertainty;
- to adopt stock specific reference points;
- to take into account uncertainties (all types), as well as impact on non-target species;
- to ensure that reference points are not exceeded - emergency action may be needed.

Within the context of the above principles and the "precautionary approach" DFO has recently adopted the overarching objective of "conservation for sustainable use" for marine fisheries. To achieve this objective there is a need for a major reduction in fishing capacity in Atlantic Canada. A central issue is to establish a balance between harvesting capacity and productivity of the resource. As the productivity of the resource varies over time, and technological efficiencies in harvesting continually increase, there needs to be an ongoing adjustment to maintain the fishing capacity/resource balance. Also this balance needs to be achieved with a minimum of government intervention.

The government of Canada is in the process of reducing its annual operating deficit and eventually it plans to reduce the accumulated debt of the past several decades. This policy of debt reduction influences all sectors of government activities, including fisheries. The 1994/95 DFO expenditures were $750 million. By 1999 the annual budget will be reduced by about 40% to $450 million. Fisheries management activities (management consultations/plans, licensing, enforcement, etc.) will be reduced from the 1994/95 expenditure of $234 million to $122 million. To achieve these targets three strategies have been defined. First, DFO will focus on its core mandate - conservation for sustainable use. Other activities will be reduced or eliminated. Second, there will be consolidation of infrastructure and a reduction in the number of employees to reduce costs. Third, partnerships will be established with stakeholders to share the costs of management. To this end changes are being made to the Fisheries Act in order to devolve some responsibilities of management from the Minister to users and other stakeholders.

In sum, at a time period of transition in the government objectives of fisheries management, there is also a radical departure in the sharing of responsibilities of management between government and stakeholders. The context of the workshop is thus one of substantial policy change, at both the international and national levels. This change is being driven by both the recent history of failure to achieve management objectives (socio-economic as well as conservation) and the excessive costs of government.

The fishing industry welcomes the opportunity to change the fisheries management structure and function in Atlantic Canada, but also has major concerns with the scope of the changes. The following points were made by industry representatives:

- the fishery must be less influenced by social factors in order that it can be economically viable and compete in the global markets;
- enhanced security of access is essential for the development of sustainable fishing practices;
- Unemployment Insurance undermines the ability to achieve objectives of fisheries management;

- DFO must relinquish some of its authority and industry must be poised to receive it for real partnerships to develop;
- effective enforcement by DFO and significant penalties are essential for fisheries management;
- there is a need to maintain a strong science program within DFO in order to provide advice on the status of the resources;
- the role of FRCC was questioned within a management structure with well defined security of access.

The final points on the context of this second workshop on groundfish management are from the findings of the first workshop held in December 1993. It was concluded at that time that the tactic of quota management (including scientific advice, implementation of regulations, overcapacity, and enforcement constraints) did not effectively limit fishing effort to levels consistent with the strategic fishing mortality target of about 20% annually. Also there is strong circumstantial evidence that fishing practices under quota management have led to loss of spawning components in some management units. The results of inadequately restricted fishing effort under quota management led to both "growth overfishing" of most stocks and possibly "recruitment overfishing" for some. Why did quota management not work:

- the mismatch between multi-species harvesting technology and a single species management tool (quotas by species in defined geographic areas) made it difficult to stop fishing when one quota was reached;
- the at-sea fishing practices associated with quota management have been unenforceable;
- short-term actions to address socio-economic objectives undermined the ability of quota management to control fishing effort;
- the lack of an operational definition by science of minimum spawning stock size made it difficult to apply the "recruitment overfishing" prevention clause of Rule 8 in the Groundfish Management Plans.

That was the diagnosis based on a retrospective analysis of management practices between 1977 and 1992. However, between 1993 and 1995 there have been changes in the implementation of the quota management system in 4X and 5. Fishing effort has been declining and fishing mortality levels are moving towards the $F_{0.1}$ target. The challenge of the present workshop is to evaluate whether the recent changes that have been made to the implementation of quota management are sufficient to achieve the stated conservation objectives. Are there additional tools (effort, closed areas, and restrictions on technology) that should also be used?

In sum, the context of the workshop is:

- global failure of fisheries management;
- national transition in fisheries policy;

- financial constraint limiting public subsidies for management costs;
- transfer of some functions of management to users and other stakeholders;
- improved implementation of quota management at the regional level during 1993 to 1995 fishing years.

Quota and Effort Tools

The principle objective of introducing quasi-property rights in the Scotia-Fundy groundfish fishery (1984 for the "offshore sector" and 1993 for the small dragger fleet) is to reduce fishing capacity. A secondary benefit is the predicted change in conservation ethic that may occur with establishment of company and individual quotas. The 1993 Workshop indicated that the capacity reduction objective is being achieved for the offshore fleet following the introduction of Enterprise Allocations (EAs) in 1984. There has not, however, been a study on the degree to which EAs changed the conservation ethic. Such changes as the National Sea Products "compliance policy" suggest that fostering a conservation ethic has become a priority by this fleet sector in recent years. A sociological study of the impact of the 1993 change to ITQs for the small fleet on stewardship (or conservation ethic) in Pubnico and Digby Neck has been conducted. It is reported that compliance with regulations has improved. However, this improvement has not been due solely to ITQs, but rather to the combination of:

i) introduction of square mesh;
ii) an industry funded dockside monitoring program;
iii) tougher administrative sanctions;
iv) ITQs.

Furthermore, the widespread collapse of groundfish resources in the northwest Atlantic has changed the perspective of fishermen on the sustainability of the resource. Good fishing practices and enforcement of regulations are now considered essential for the future of the industry. There is an increased awareness concerning the fragility of the groundfish resource with present harvesting technology.

The following problem areas with quota management, and suggested remedies, were identified:

- Mismatch between TACs and the abundance of fish in the water - remedies include shorter time between stock assessment and TAC setting to increase accuracy of advice, allow some leeway in rolling over quota and quota deficits into next fishing year, inclusion of industry representatives in stock assessment process.
- Dumping of fish is still a problem in part due to the above stated mismatch between quota and relative abundance of fish in the water. Remedies include 100% observer coverage when industry suspects that dumping is significant.

- Lack of enforcement - Remedies include joint industry/fishery officer actions to catch known violators of regulations, identification of landing points of unreported catch, checking of trucks, checking for hidden fish while weighmasters are working.

In sum, it was concluded that EAs and ITQs have improved the conservation ethic but the conservation benefits still depend upon effective enforcement and strong sanctions. There is room for tightening up of enforcement.

The following are some additional changes that need to be considered in order to improve the implementation of quota management:

- respect present fleet sector shares;
- mandatory third party weighouts;
- daily logs for all vessels (electronic?);
- lifetime sanctions for repetitive misreporting and/or discarding ("three strikes and you are out");
- black boxes for positional information;
- eliminate trip limits:
- use a discard index from observer reports and at-sea monitoring to estimate accumulated discards in real-time and count against TAC;
- develop flexible small fish protocols that allow for changing the % of small fish depending upon relative year-class abundance;
- use deviations from expected mix of landings to target fishermen for observer coverage;
- include days-at-sea estimates for IQ and EA vessels based on quota shares and expected number of days needed to achieve the fishing mortality target. Vessels that have used up their days-at-sea allotment would be obliged to take an observer to sea at their expense;
- use video cameras on vessels connected to navigation instruments;
- for fleet sectors fishing from competitive quotas, limit number of vessels fishing at one time by odd or even months based on CFV number, in order to reduce effective fishing effort.

The introduction of "dockside monitoring" and "catch reporting" (fixed gear) has improved the timeliness (from 15 to 20 days to 3 to 4 days for data entry), completeness (mobile gear 100%; fixed gear up from 25 to 69% coverage) and accuracy of landings information. However, under the "Catch Reporting" system there is no verification of landings of the fixed gear sector, and the use of a weekly document (rather than a daily log) results in incomplete information on effort. Also under the present system, there is no information of price of fish landed. A price reporting system with the buyers would address this new deficiency.

Three changes in the quota system were described that would increase participation by fishers in management decisions:

- Carryover Allocations - Under this option fishers could carryover their uncaught quota to the subsequent year. The carryover would be depreciated to reflect non-fishing mortality. It would be further adjusted upwards or downwards consistent with any retrospective changes in the stock assessment. This modest change in managing the quota system would help rectify the problem of the mismatch between quota mix and relative abundance of fish in the water.
- Year-class Quotas - Under this option, each year-class that enters a management unit would be allocated to the participants. Fishers could choose the size and age at which they would like to catch their portion of the year-class. To counter the uncertainty in the estimate of year-class abundance at younger ages an increasing fraction of the year-class would be allocated as it recruits to the fishery. This option would potentially reduce gear conflicts, reduce "highgrading," and enhance fishers' involvement in resource husbandry. Fishers must have some allocation remaining of each year-class contributing to the fishery in order to have access to that fishery. This approach should generate incentives for self-control.
- Population Stewardship Rights - This approach allocates portions of the stock complex within a management unit to each fisher or small group of fishers. Depending on the annual fishing mortality exerted by each individual or group, their proportional share of the overall stock would either increase or decrease. Individuals that consistently fished at high partial fishing mortalities would run out of fish, whereas those individuals/groups who conserved their partial population would increase their resource share.

All of these three modifications to the present mixture of ITQ/competitive quota management system build in incentives at the individual or small group level to conserve the resources. The data needs for each option were estimated and not found to be much greater than the present approach.

The strategy adopted by Canada in 1977, i.e., to harvest the groundfish resources at the $F_{0.1}$ level, translates into a constant annual level of fishing effort. However, under quota management (the primary tool adopted to achieve $F_{0.1}$ harvest levels) days fishing by the several fleet sectors increased dramatically during the early 1980s and early 1990s. Quota management did not generate a fixed level of annual fishing effort. Data from the southern Gulf of St. Lawrence cod management unit (4T) illustrates that there is a very close relationship between fishing effort and fishing mortality, supporting the theory that these two processes are proportional. To achieve the fishing mortality target during the past decade, the fishing effort should have been about 65 to 75% less than actually occurred.

Direct restriction on days at sea is an additional tool that can be used to help regulate harvesting levels at the $F_{0.1}$ target. To use this tool, however, it is necessary to consider differences in the fishing mortality per unit of fishing effort both seasonally and between gear types. For example, in the Gulf of St. Lawrence the fishing mortality per days fishing (i.e., the catchability) is shown to be two to three times higher during the spring and fall migrations than during the summer months. Also, larger more powerful vessels generally have higher fishing mortalities per days fishing than do smaller vessels. These complications need to be taken into consideration if days fishing is going to be used as a management tool. Using the present TAC allocations between fleet sectors, and the historical proportionality between fishing effort and fishing mortality, the days fishing for each fleet can be estimated. For example, the mobile gear sector fishing effort target for southern Gulf cod would be about 2000 days annually, given that the same seasonal distribution of fishing was maintained. Greater concentration in the spring and autumn would require a reduction in this number. Once established, the days fishing by fleet sector would stay relatively constant between years, but might need to be adjusted if technology evolves and/or fishing patterns change.

The calculations for southern Gulf of St. Lawrence cod indicate that only 25% of the annual fishing effort recently used is required. This level of reduction is required for most groundfish management units.

A two-level control system using both catch and effort is proposed. Under this proposal for each management unit both a TAC and a days fishing projection would be provided in the stock assessments. Quota and effort would need to be monitored in real time. If days fishing is reached prior to the quota being taken, this would indicate either significant misreporting/discarding or an overestimation of abundance in the assessments. During such situations a risk averse approach would infer within year modifications of the annual fishing plan, such as re-directions in TAC or mandatory use of observers. The multi-species nature of groundfish fisheries requires careful consideration if days fishing is to be used as a complementary management tool. However, given that many fisheries are closed, this is an opportune time to evaluate how much effort will be allowed back into the diverse fisheries when quotas are re-established.

The fixed gear Groundfish Committee reported on the results of a separate workshop. With respect to management tools, a consensus was reached that:

- community-based management should have a greater role;
- time/area closures be used more extensively;
- direct effort controls complement quota management;
- latent fishing capacity needs to be reduced.

An example of how a community-based management system would implement effort control was provided. Each fishing vessel would be assigned a "fishing effort value" based on fishing power. The community management authority, within its allocation of overall fishing effort for the region, would assign days fishing to different vessels based on the landings and historical participation. The example illustrated the concept, and the difficulties, of moving from quota to effort regulations. In the discussion it was pointed out that the term "community" could refer to either a geographic area, or a "community of interest" such as a fleet sector.

An attempt was made to compare the costs of both quota and effort management systems. A Business and Information Model recently developed within DFO was used to examine the success of management, compared to regulatory costs, of each of these fisheries. This model consists of eight interlinked components including: strategic planning, resource analysis, business analysis, management planning, catch and effort monitoring, fishing entitlements, enforcement, and service delivery. The emphasis of this study was the comparison of the benefits (defined through strategic planning) of management to the costs of resource analysis (assessment) and protection and enforcement.

Except for offshore lobster, the catch-controlled fisheries have been managed to achieve $F_{0.1}$. The groundfish and herring fisheries have experienced fishing mortalities almost twice $F_{0.1}$ under quota management. Although fishing mortality has exceeded $F_{0.1}$ for the offshore scallop fishery, fishing effort has been declining over time since EAs were introduced. On the other hand, the two effort-based fisheries, inshore lobster and scallops, have no apparent goal by which the success or failure of management can be measured. Inshore scallop landings are currently declining, while lobster exploitation is about 80%. Therefore, while catch controls have worked for offshore scallops, they have not worked for groundfish and herring. On the other hand, effort controls have not worked for inshore scallops. Thus both control systems have their strengths and weaknesses.

Are the costs of the two systems dramatically different? Before making this comparison, it is necessary to adjust for the value of the resource. For instance, in 1993 the groundfish fishery in Scotia-Fundy Region cost $22.9 million to manage. This compares to $1.8, $6.0, and $8.3 million for herring, scallop, and lobster, respectively. These management costs are 18, 11, 6, and 6 percent of the landed value of groundfish, herring, scallops, and lobster, respectively. However, groundfish biomass is currently 50 percent of its 1970 to 1994 average, while lobster landings are now almost double the historical average. Management costs have to be considered in relation to the resource potential, not just current yield. If processed value is considered, the 1993 management costs are 7, 2, 4, and 5 percent for groundfish, herring, scallops, and lobster.

When the management costs are considered by the components of the Business and Information Model, it becomes evident that groundfish resource analysis costs are proportionately higher for herring, while enforcement costs for herring are a smaller percentage of the total, reflecting the few regulations in this fishery. Inshore lobster resource analysis costs are proportionately higher than for the offshore fishery, while enforcement costs show the opposite pattern. This situation is the same for scallops.

While the extent of the data limited analysis, it was apparent that both systems had difficulty in attaining their objectives, when these were explicitly stated. In all cases, management costs were less than 10 percent of the processed value. There were no obvious or large differences between the systems examined, particularly when the potential yield is taken into account. Based on these observations, it was concluded that the costs of a quota-based management system are not significantly greater than that of an effort-based system.

In summary, the following conclusions are drawn concerning the use of quota and effort as tools to achieve conservation objectives:

- under quota management between 1977 and 1992 effort was not constrained at a constant level that is consistent with the harvesting target of $F_{0.1}$;
- recent changes in the implementation of quota management in 4X and 5 are resulting in reductions in fishing mortality towards the target;
- controls on days fishing by fleet sector could be introduced as a complement to quota management, as part of a two-tiered system;
- to achieve this, the effort monitoring system within DFO would need to be refined to equal the timeliness of the present dockside monitoring program on landings; and science would need to estimate projections of annual days fishing by fleet sector and species mix;
- for EA and ITQ quota management, several refinements could be introduced;
  : carryover allocations between years;
  : year-class quotas;
  : population stewardship rights;
- a shorter time between stock assessments and setting of quotas is necessary. To achieve this, several management units could be better assessed in the autumn, with the results used for the fishery beginning in January;
- all groundfish sectors should be required to have mandatory third party weighouts and use daily log records (preferably electronic);
- a discard index should be developed to estimate catch in contrast to landings. This index could be used to adjust landings upwards in quota monitoring and be included in the assessments;
- vessels with low reported landings by fishing day, for which discarding and/or misreporting is suspected, could be required to take an observer at their expense;
- trip limits should be eliminated as a management tool;
- fleet sector quota shares need to be fixed and security of access more clearly defined;
- severe administrative sanctions are an essential component of quota management;
- the costs of quota and effort management are comparable.

Closed Areas

Closed areas are considered as a complement to quota and effort management systems, not a replacement. The objective of closing spawning areas during the season of spawning is to protect individual spawning components within a management unit that comprises a stock complex. This management tool assumes that individual spawning areas are to a large degree self-sustaining with limited exchange of individuals between spawning areas. It also recognizes that mobile gear, in particular, has the power to exert very high levels of fishing mortality on spawning aggregations that can lead to elimination of components. Closure of juvenile nursery areas results in greater realization of the growth potential of the recruiting year-classes and also allows a larger proportion of individuals to reach age-of-maturity. Both the conservation attributes of closed areas, and their costs to industry and the taxpayer, are evaluated.

Information from science research activities, as well as from interviews with fishermen, on the location and time of spawning for cod, haddock, and pollock was summarized. Plankton surveys of fish eggs and larvae on the Scotian Shelf are useful for identifying the season of spawning by area for these three species. Given that cod and haddock eggs cannot be differentiated until they are several weeks old, and that eggs drift with the currents, there are limitations to the use of the plankton data for precise definition of spawning areas. Nevertheless, the general areas of spawning can be described and compared to the areas identified by fishermen. The plankton surveys infer the following:

Species	Area	Peak Time of Spawning
pollock	The Gulley Middle Ground Western Bank Emerald Bank Lurcher/German Banks	November to January
haddock	Browns Bank Roseway Bank LaHave Bank Baccaro Bank Sable Island Bank Western Bank	April/May
cod	- all of the banks during the spring - 4 VW banks and Bay of Fundy/SW Nova coastal areas in the late autumn	March to May November to January

During the summer of 1995, 150 groundfish fishermen in Nova Scotia were interviewed on their knowledge of spawning times and areas for cod, haddock, and pollock. The study is not yet completed but the preliminary results are promising. Many of the areas listed above were repeatedly identified, as well as some precise locations in coastal waters. Experienced fishermen observed that some regular spawning areas, such as off Chedabucto Bay, no longer attract fishing activity presumably due to "recruitment overfishing." The interviews will be continued in 1996 with a particular emphasis on retired fishermen in order to derive an historical description of spawning areas.

In sum, the combined science/fishermen knowledge would allow general areas and times of spawning to be identified if additional spawning closures (i.e., in addition to the Browns and Georges closures already in place) are considered helpful in achieving the conservation objectives of management. Under the "precautionary approach" it would be prudent to protect individual spawning components even though we are not certain of their degree of independence.

A computer simulation was developed to explore the impacts of fishing with and without spawning closures on long-term annual landings from a management unit with three spawning components. The model also included the impacts of differences in fishing methods on their efficiency in exploiting spawning aggregations. The results indicate that the smaller spawning area, which was open to fishing, is susceptible to collapse; and that the component which was closed increases in abundance over time to equal the abundance of the third component (which was the larger area at the beginning of the simulation). The model also indicates that a small amount of exchange from a closed spawning area to an open one can generate some protection against collapse. The simulations are based on many assumptions about the real world, but nevertheless illustrate the principles of spawning closures and the potential benefits.

The enforcement of closed areas has proven to be effective if airplanes are used. The costs are high using the present methods of enforcement. The Browns Bank closure costs about $500,000 annually. However, to add additional nearby areas such as Roseway and LaHave Banks would not necessarily increase the costs substantially.

The costs to industry of fishing a given annual quota, with spawning closures compared to without closures, is higher because the catch rates are lower for at least part of the quota. Using data on costs of fishing and on revenues for the Scotian Shelf groundfish during 1990 and 1991, the impacts of additional closed areas were estimated. It was assumed that introducing more extensive closed areas would lower the average annual catch rate by 10%. Fleet costs under this scenario would rise by about $9 million. The method used, however, does not include any potential long-term benefits that may be generated by spawning closures that could increase mean annual catches at the $F_{0.1}$ harvesting level. The short-term costs to industry of spawning closures, however, would be significant given the present profit margins.

The accumulated 1970 to 1995 trawl survey data on the Scotian Shelf was analyzed in order to evaluate whether there are areas where immature cod and haddock are distributed in the absence of mature fish. Such areas would be cost effective candidates for "nursery" closures. Concentrations of 0-2 year old cod and haddock were observed west and northwest of Sable Island, and near the Gully. Large catches of juvenile haddock were also observed consistently on Browns Bank and south of Brier Island. The analysis did not reveal areas where juvenile cod and haddock were caught without significant catches of mature fish. There are, conversely, areas such as north of the Louisbourg Basin and along the Laurentian Channel where mature cod are caught in the absence of juveniles. Thus, there will be significant costs to industry if additional year round juvenile closed areas are implemented.

In summary, the following conclusions are drawn concerning the use of closed areas on the Scotian Shelf as a tool to achieve conservation objectives:

- closed areas are a complement to quota and/or effort management tools;
- most management units for cod, haddock, and pollock have several spawning locations which may be self-sustaining;
- the "precautionary approach" infers that, given uncertainty in knowledge, these separate spawning areas should be assumed to be self-sustaining until proven to the contrary;
- there is sufficient information on the time and area of spawning of cod, haddock, and pollock on the Scotian Shelf to implement additional spawning closures;
- enforcement of time/area closures is effective with airplane surveillance;
- the cost of enforcement of the Browns Bank spawning closure is about $500,000 annually;
- the short-term costs to industry of additional spawning closures for cod, haddock, and pollock is estimated to be in the order of $10 million annually;
- these costs need to be weighed in comparison to the potentially higher biomass levels that may be sustained with closures, and thus a higher long-term average annual TAC.
- there are no areas on the Scotian Shelf where juvenile cod and haddock are caught without significant catches of mature fish;
- additional areas to the Western Bank juvenile closed area, where consistently high catch rates of immature fish are caught, are Browns Bank and south of Brier Island.

Restrictions on Harvesting Technology

The working group on this issue focused attention on specific gear issues seen as currently important to Scotia-Fundy groundfish issues. Problems were considered in three categories:

- catch wastage;
- mortality incidental to the catching process;
- effects of gear on habitat.

They responded to the questions of whether additional restrictions on harvesting technology are necessary to achieve the objectives of conservation. Sixteen issues covering the three categories were evaluated. It was pointed out during the Workshop that the incidental capture of cod in lobster traps was sufficiently frequent to merit attention as an additional potential conservation problem.

The Working Group recognized that there was much scope for introduction of technologies which would improve species and size selection and reduce incidental mortalities and habitat damage. However, it recognized also that the past approach of controlling gear construction and usage through government regulation had been largely ineffective. A primary recommendation of the group was for a strong emphasis to be placed on education of fishermen and transfer of responsibility to them for the success of conservation projects. Success is dependent on fishermen being motivated to resolve conservation problems, and on their understanding of why particular gear modifications are necessary and how these work technically. Legal restrictions cannot be eliminated, as there will always be those who are prepared to engage in destructive practices, but these regulations should be minimized, kept simple, framed for maximum enforceability, and accompanied by severe sanctions for violations.

Another primary recommendation of the Working Group was for development of a strong organizational focus for delivery of a government/industry gear technology development program. The components of this program would necessarily include research, development, education/demonstration, and field evaluation. Government efforts have been ad hoc in the past and are currently minimal. Yet there is a growing tide of public opinion supporting adoption of more "conservation-oriented" gear technology which will become increasingly difficult to ignore. Very much to this point, the Working Group found many cases where problems were "perceived," but where there were no hard data or research results to establish whether a problem of any real importance exists. Furthermore, there are important program areas where large-scale, longer-term research is required if issues are to be satisfactorily evaluated and/or solutions found. These include development of species selective gears, and evaluation of gear effects on habitat. Failure to address these problems may ultimately result in imposition of harsh precautionary restrictions on certain types of fishing that will have severe adverse repercussions on the economics of fishing.

General Discussion

During the general discussion of the workshop papers, several conclusions were drawn. It was generally felt that although modifications to the present groundfish management system for the Scotian Shelf and Gulf of Maine are necessary in order to help achieve the multiple objectives, the tool of annual quotas for single species in specified areas should continue as a core regulatory component. A recurring theme, however, was that the full suite of potential management measures for any particular situation needs to be evaluated in a holistic manner. For example, one cannot evaluate if conservation objectives can be met by spawning closed areas without considering if quotas, effort restrictions, and mesh size regulations are also effectively applied. Another important theme of the concluding discussion was that solutions for one area or for one sector are not necessarily the same as those for another. The workshop provided good background information on the range of regulatory tools and the cost effectiveness of their implementation. What is needed now is focused evaluations of the best mix of tools for specific management units and gear sectors. Finally, it was concluded that an essential requirement for cost effective management of the groundfish resource is the internalization of the cost of enforcement of the diverse regulatory measures by the fishing industry.

RECOMMENDATIONS

The recommendations are grouped under the eight components of the "Business and Information Model" illustrated in Figure 5, page 71.

Strategic Planning

1. It is **recommended** that decision making on management be delegated closest to those most concerned with the particular management plan under consideration.

2. In order to transfer decision making to licence holders, there is a need to define the process for the division of responsibility. It is **recommended** that the division of responsibility and authority be clearly defined as part of the consultation process.

3. It is **recommended** that quota management continue to be the core regulatory measure to achieve the conservation objectives, but that it needs to be more effectively complemented by additional tools such as closed areas, effort monitoring and gear restrictions.

4. It is **recommended** that a real time, two-level monitoring system using catch and effort be explored for a selected fishery. The intent is to allow tracking of catch and effort during the fishing year in order to identify problems in the stock assessment or misreporting.

Management Planning

5. It is **recommended** that the existing spawning area closures be maintained and that new areas be defined to cover currently unprotected spawning components. The seasonal duration of the present closures on Browns and Georges Banks need to be reviewed with respect to optimal benefits.

6. It is **recommended** that there be no expansion of juvenile closures and that the Western/Sable Island closure be continued.

7. It is **recommended** that yearclass quotas be explored for a fishery in which different fleet components harvest different age classes.

Fishing Entitlements

8. It is **recommended** that existing shares be respected in order to enhance the cooperative approach by industry towards meeting conservation objectives.

9. It is **recommended** that DFO and industry set criteria for carryover allocations.

Catch and Effort Monitoring

10. It is **recommended** that industry-funded, independent dockside monitoring and logbooks, including data entry, be mandatory for all fleet sectors (i.e., "catch monitoring systems" should be replaced by full independent dockside monitoring).

11. It is **recommended** that a discard index from observer and other at-sea monitoring be used to estimate accumulated discards for possible reduction of the following year's TAC.

12. It is **recommended** that a real time, comprehensive effort monitoring system be undertaken in order to evaluate fleet dynamics.

13. It is **recommended** that DFO and industry develop a user friendly fishery information system to support real time management decision making by DFO and industry.

Enforcement

14. It is **recommended** that the industry develop guidelines for administrative sanctions.

15. It is **recommended** that sanctions for repetitive serious infractions may result in lifetime suspension from the fishery.

16. It is **recommended** that a mechanism be established whereby industry can advise DFO on improvements to enforcement.

17. It is **recommended** that deviations from the expected mix of landings, and unreasonable differences between reported landings and days at sea, be used to target fishermen for observer coverage or possible fishery closure. It is recommended vessels that fish beyond what is reasonable for their allocation be obliged to carry an observer for the remainder of the year.

18. It is **recommended** that for a competitive fishery, that easily monitored regulations, such as vessels fishing on alternate times (i.e., days, weeks, months) based on CFV, be considered.

19. Given that not all gear technology regulations are readily enforceable, it is **recommended** that industry promote self-regulation through education, a code of conduct and peer pressure.

Service Delivery

20. It is **recommended** that DFO refine its planning and financial system so that the fishery-specific costs of management can be attributed to DFO and industry with more precision than is currently possible.

Business Analysis

21. It is **recommended** that a price monitoring system be developed with the buyers.

22. It is **recommended** that there be an industry/DFO analysis of the cost and effectiveness of enforcement.

23. It is **recommended** that there be an evaluation of the degree to which there has been capacity reduction under the IQ and EA systems.

24. It is **recommended** that the costs of closed area and season regulations be evaluated.

25. It is **recommended** that the costs of the real time, two level monitoring system (catch and effort) be evaluated.

Resource Analysis

26. It is **recommended** that Science evaluate the optimal time during the annual planning cycle when to provide scientific advice on the status of the resource. The intent is to ensure that the resource prospects are based on the most up-to-date information available.

27. It is **recommended** that the data and monitoring needs for the year-class quota system be evaluated in support of recommendation no. 7.

28. It is **recommended** that Science provide estimates of minimum spawning biomass for as many of the management units as possible in order to 'prevent recruitment overfishing' (a key conservation objective).

29. It is **recommended** that closed areas and seasons to protect spawners be defined by Science in cooperation with industry in support of recommendation no. 5.

30. It is **recommended** that in order to reduce catch wastage, mortality incidental to the catching process, and negative effects of gear on habitat, a joint government/industry

gear research program be established. This program would support the activities under recommendation no. 19.

31. It is **recommended** that indices of discarding be developed in support of recommendation no. 11.

32. It is **recommended** that, where possible, Science estimate the days at sea needed by fleet sector to catch the quota share in support of the two level monitoring system (catch and effort), stated in recommendation no. 4.

PAPERS

FISHERIES MANAGEMENT OBJECTIVES AND STRATEGIES FOR THE NEXT DECADE

"Conservation For Sustainable Use," The DFO Perspective

L.S. Parsons And P. Chamut

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L.S. Parsons

In order to provide a broader context for the discussions on Scotia-Fundy groundfish management, some historical trends for Atlantic Canada groundfish are of interest. Figure 1 illustrates groundfish landings off Canada for the 1950 to 1994 period. Several points are significant. Since extension of jurisdiction in 1977, Canada has harvested the major portion of the annual landings. There were increases in landings during the late 1970s to levels that matched those experienced in the 1950s, prior to the build-up of the distant water fleets. These levels of landings, however, have not been sustainable and the groundfish fishery has essentially collapsed for most areas off Atlantic Canada (with the exception of the Gulf of Maine area). The collapse in the Canadian cod fishery from 1988 (with reported landings in excess of 500 thousand tons) to 1995 (with a TAC of less than 10,000 tons) is shown in Figure 2. The principle cause of the declines has been due to overfishing. In addition, environmental conditions and increases in predation by marine mammals may have made some of the stocks less productive over the past decade. The influences of environmental and ecosystem changes on cod productivity are illustrated in Figures 3 and 4. There have been declines in the weight-at-age of cod in all areas except the Gulf of Maine. For example, the weight of a seven-year-old cod on the eastern Scotian Shelf (4VsW) declined from over three kg to less than 2 kg between 1977 and 1991 (Figure 3). For the same geographic area, there has been a major reduction in average recruitment levels starting in the early 1980s, at a time period when spawning stock abundance was relatively high (Figure 4). In contrast on the western Scotian Shelf, weights-at-age did not decline during the 1980s and there has not been a change in mean recruitment levels. Environmental trends and associated changes in natural mortality and fish production appear to be acting in a variable manner by area. The present and near future situation is bleak:

Burke, D.L., R.N. O'Boyle, P. Partington, and M. Sinclair. 1996. Report of the Second Workshop on Scotia-Fundy Groundfish Management. Can. Tech. Rep. Fish. Aquat. Sci. 2100: vii + 247 p.

- moratoria in effect for most cod stocks;
- 1994 catches are the lowest on record;
- Northern cod (2J3KL) has collapsed and continues to decline;
- prospects for recovery in the mid-term are poor;
- future fisheries will have to adjust to lower catches.

A major cause of overfishing has been the gradual increase in Canadian fishing capacity since the extension of jurisdiction. Present capacity is two to three times that in place in 1980 (Figure 5). The processing sector, as measured by number of plants, has also increased (close to doubling in a decade, Figure 6). The combination of increasing harvesting capacity, and constraints on our ability to control fishing effort, has led to gradual increases in fishing mortality (Figure 7). The conservation targets for the fisheries management plans have consistently been exceeded.

The groundfish experience off Atlantic Canada exemplifies the general dilemma of fisheries management that is being experienced around the world. Common elements are:

- natural resource variability;
- a search for increasing efficiency of exploitation by the harvesting sector;
- the development of overcapacity for harvesting a common property resource, leading to overfishing;
- conflicting objectives for fisheries management that tend to undermine actions needed to achieve conservation;
- a need to manage despite uncertainty.

The parallel problems being experienced around the world with respect to management of marine renewable resources have led to discussions at the international level. These discussions include:

- the so-called Brundtland Report of the late-1980s World Commission on Environment and Development which led to the popularization of the term "sustainable use";
- the 1992 Earth Summit in Rio de Janeiro during which Canada provided leadership in sustainable development through its commitments stated in the Green Plan;
- the July 1993 World Conference on High Seas Fishing held at New York, during which Canada sought support for the application of more stringent conservation principles on straddling stocks;
- the 1995 Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks, during which a UN Convention was approved (to be ratified at the autumn 1995 meeting of the UN General Assembly).

Canada, because of the importance of our marine fisheries and the problems we have experienced since extension of jurisdiction, has played a strong role at the international level. We adhere to the general principles that were adopted at the 1995 Conference. These are:

- ensure long-term sustainability - promote optimum utilization;
- use best scientific evidence (including environmental);
- assess impacts of fishing on target stocks and non-target species;
- maintain populations above "levels at which their reproduction may become seriously threatened";
- minimize pollution, discards, catch by lost gear, catch on non-target species, etc.;
- protect biodiversity;
- prevent overfishing and excess fishing capacity;
- collect and share data on catches and fishing activities;
- conduct scientific research and develop technologies for conservation.

In addition to the above principles, the UN Convention advocates the use of a "precautionary approach" to the management of fisheries. The approach is summarized by the following points:

- aim is to protect living marine resources and to preserve the marine environment;
- shall be more cautious when information is uncertain;
- shall improve decision making by sharing best scientific information and adopting ways to deal with risk and uncertainty;
- shall adopt stock specific reference points;
- shall take into account uncertainties (all types), as well as impact on non-target species;
- ensure that reference points are not exceeded - emergency action may be needed.

To return to the theme of this talk, "sustainable use" from a DFO perspective, the following are some points to focus on during the discussions on potential changes for Scotia-Fundy groundfish management:

- since overcapacity still remains as a major problem, major capacity reduction is necessary for sustainable fisheries in future;
- there is a need for robust management strategies based on sound biological criteria and proven economic principles (e.g., diversification);
- "green" fishing gear is needed in order to avoid destructive fishing practices;
- there is a need for clear and strict re-opening criteria for those fisheries presently under moratoria.

It is important to stress the limitations to sustainability. Sustainability does not mean constant catch levels. Lobster landings off Atlantic Canada over the past 100 years are shown in Figure 8. Although sustainable, it is clear that there have been periods of variable production. Fisheries exploit components of dynamic ecosystems, most of which will never be controlled to any significant degree. Thus, the absolute levels of

To sum up, I want to repeat some points on how we can attain “sustainable use." We need:

- new biological references to avoid critical zones: e.g., spawning biomass (see FRCC Criteria for Re-opening);
- new conservation measures: e.g., for protection of small fish;
- better, more ecological fishing practices;
- simpler management system, with less government intervention;
- enhanced economic viability: e.g., diversity.

A central issue is the balance between harvesting capacity and productivity of the resource. However, as technological changes will not stop the day that new policies are put in place, there will be an ongoing need to actively maintain this capacity/resource balance.

Thank you for the opportunity to give these opening remarks as a context to your discussions on the strengths and weaknesses of various tools of management.

Figure 1

Growth changes for certain cod stocks

Changements de croissance pour certains stocks de morue

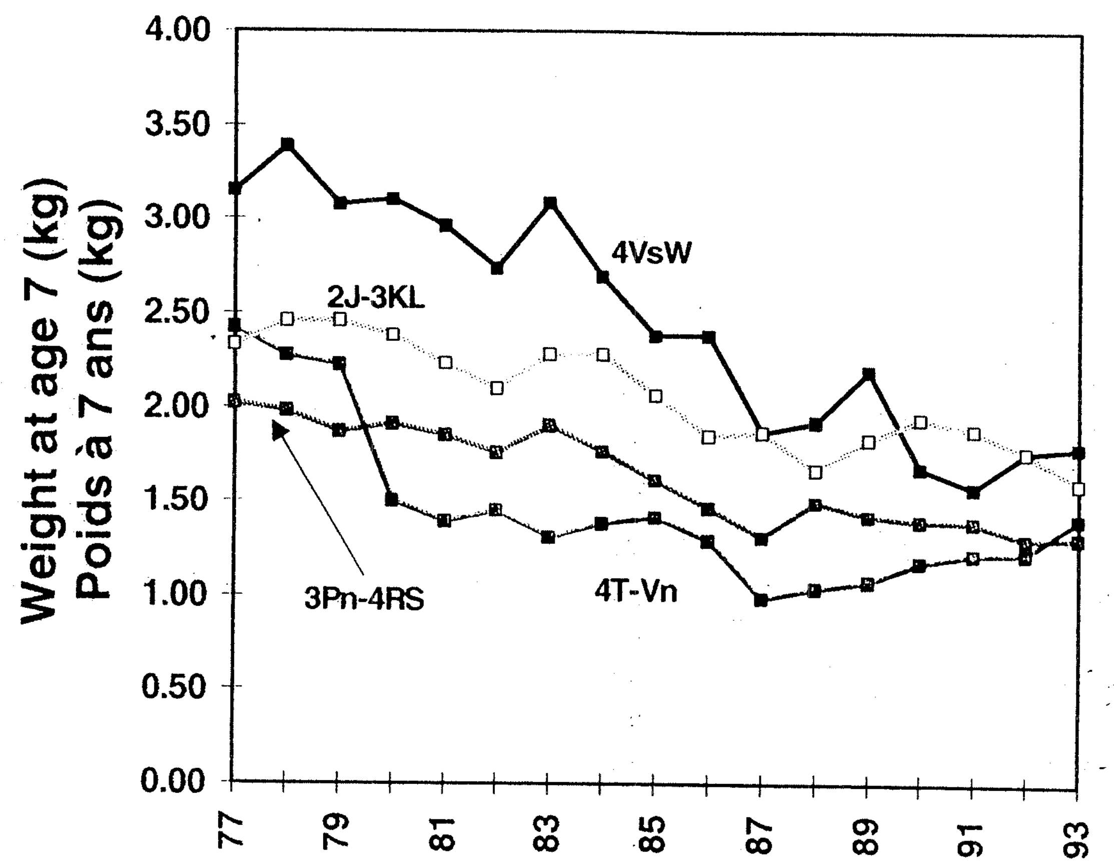


Figure 2

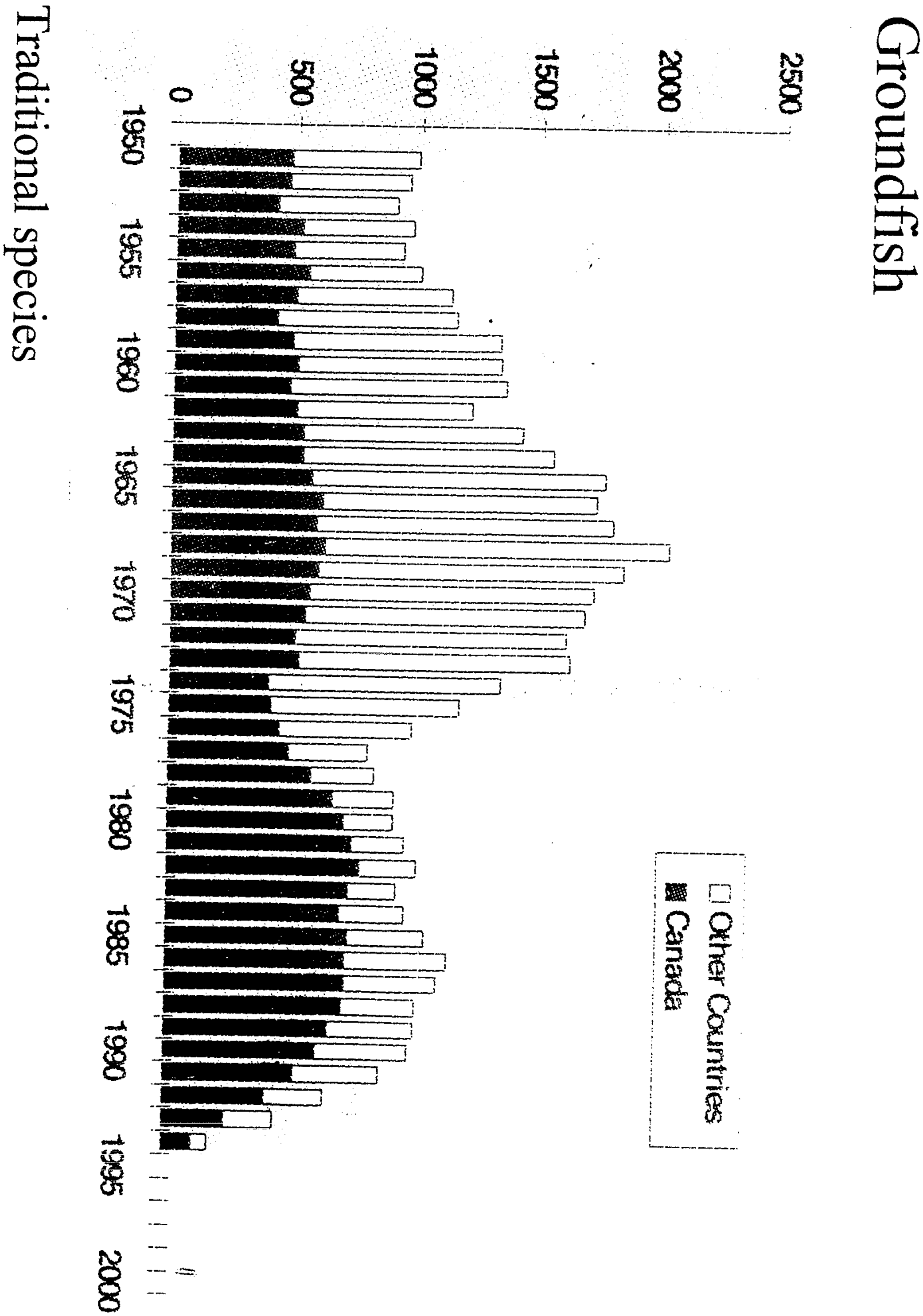

Groundfish
2500
2000
1500
1000
500
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Other Countries
Canada
Traditional species

Figure 3

Recent trends in cod catches

Tendances récentes des prises de morue

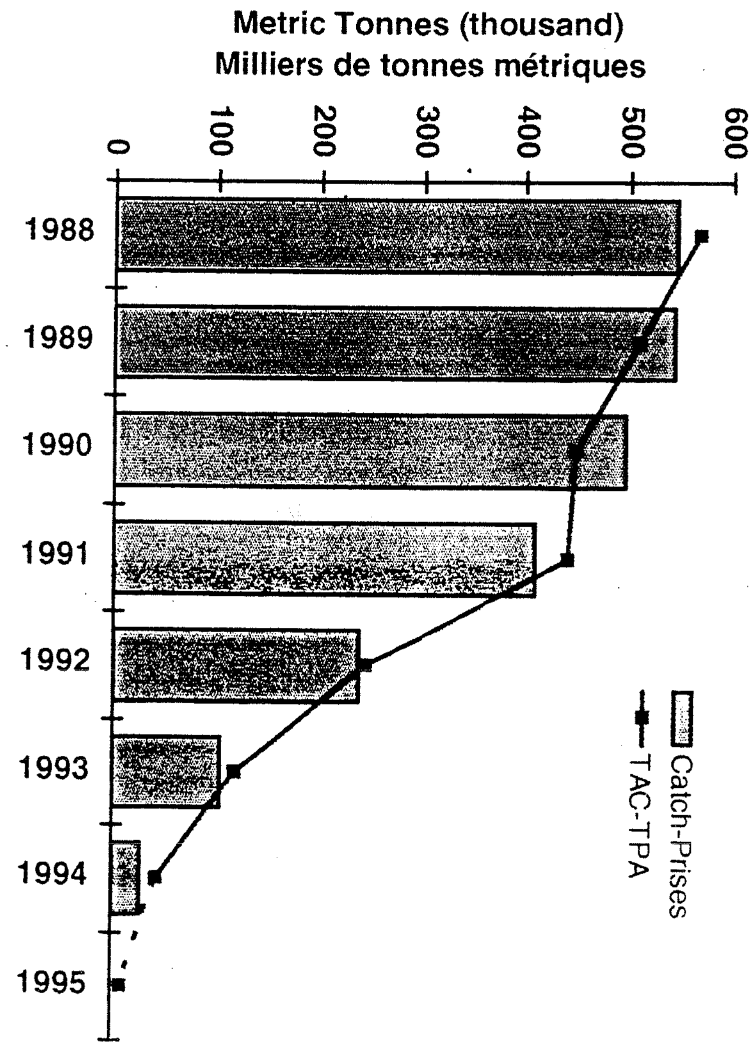
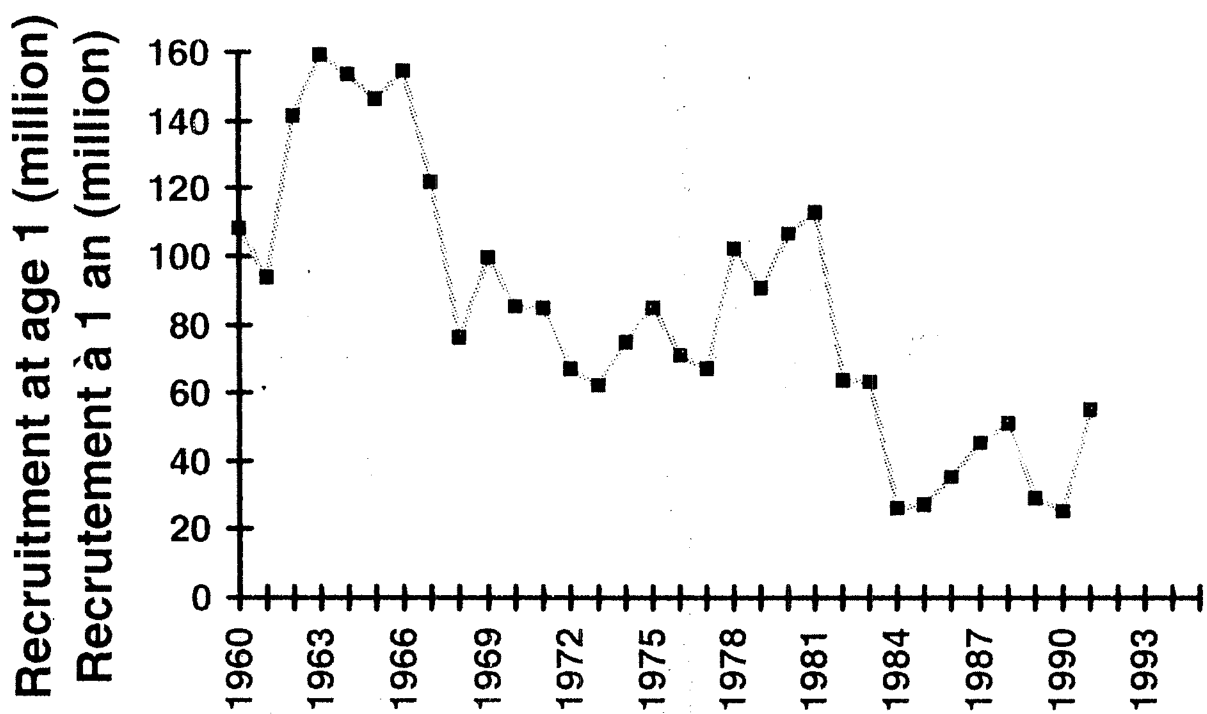


Figure 4

Poor Recruitment

Mauvais recrutement



Cod on Eastern Scotian Shelf

Morue de l'est du plateau scotian

Figure 5

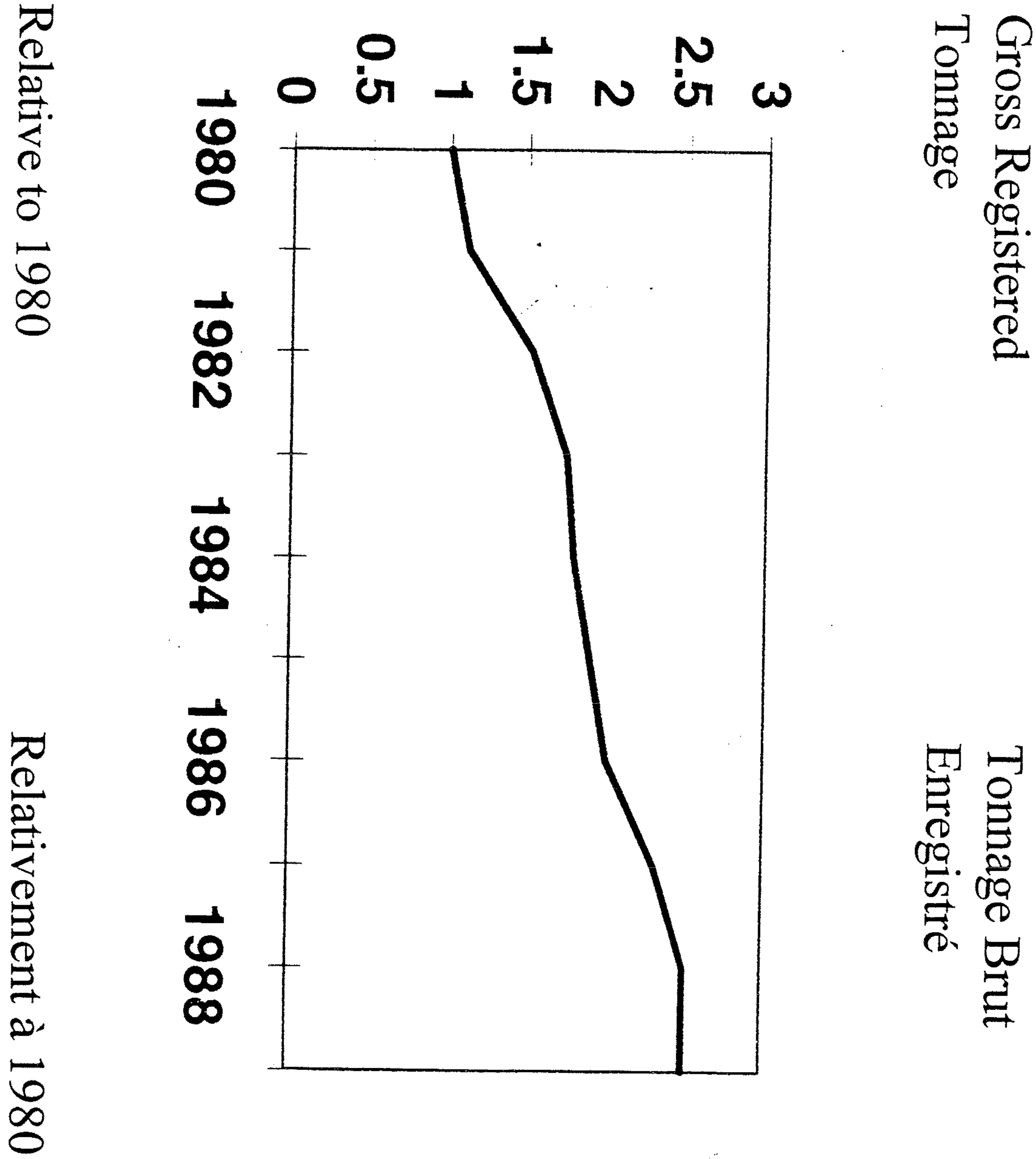

Gross Registered Tonnage
Tonnage Brut Enregistré
3
2.5
2
1.5
1
0.5
0
1980
1982
1984
1986
1988
Relative to 1980
Relativement à 1980

Figure 6

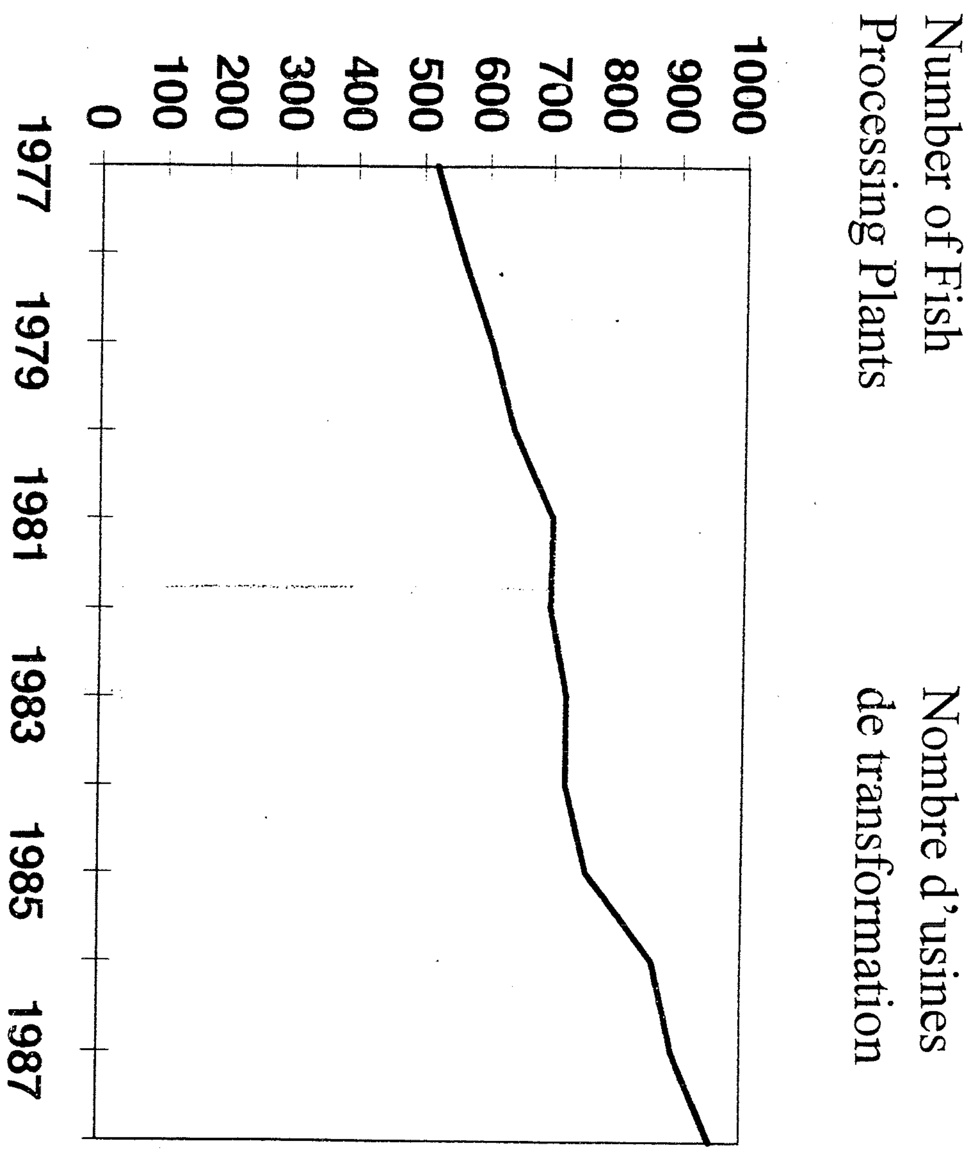

Number of Fish Processing Plants
Nombre d'usines de transformation
1000
900
800
700
600
500
400
300
200
100
0
1977
1979
1981
1983
1985
1987

Figure 7

Exploitation Rate of Major Roundfish Stocks

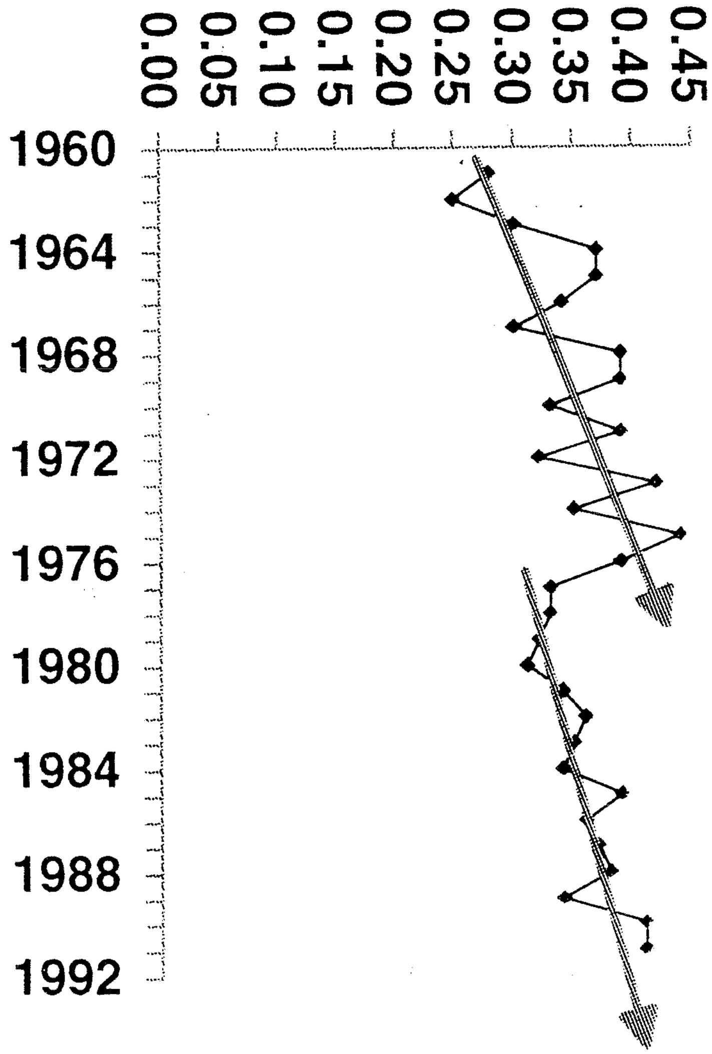
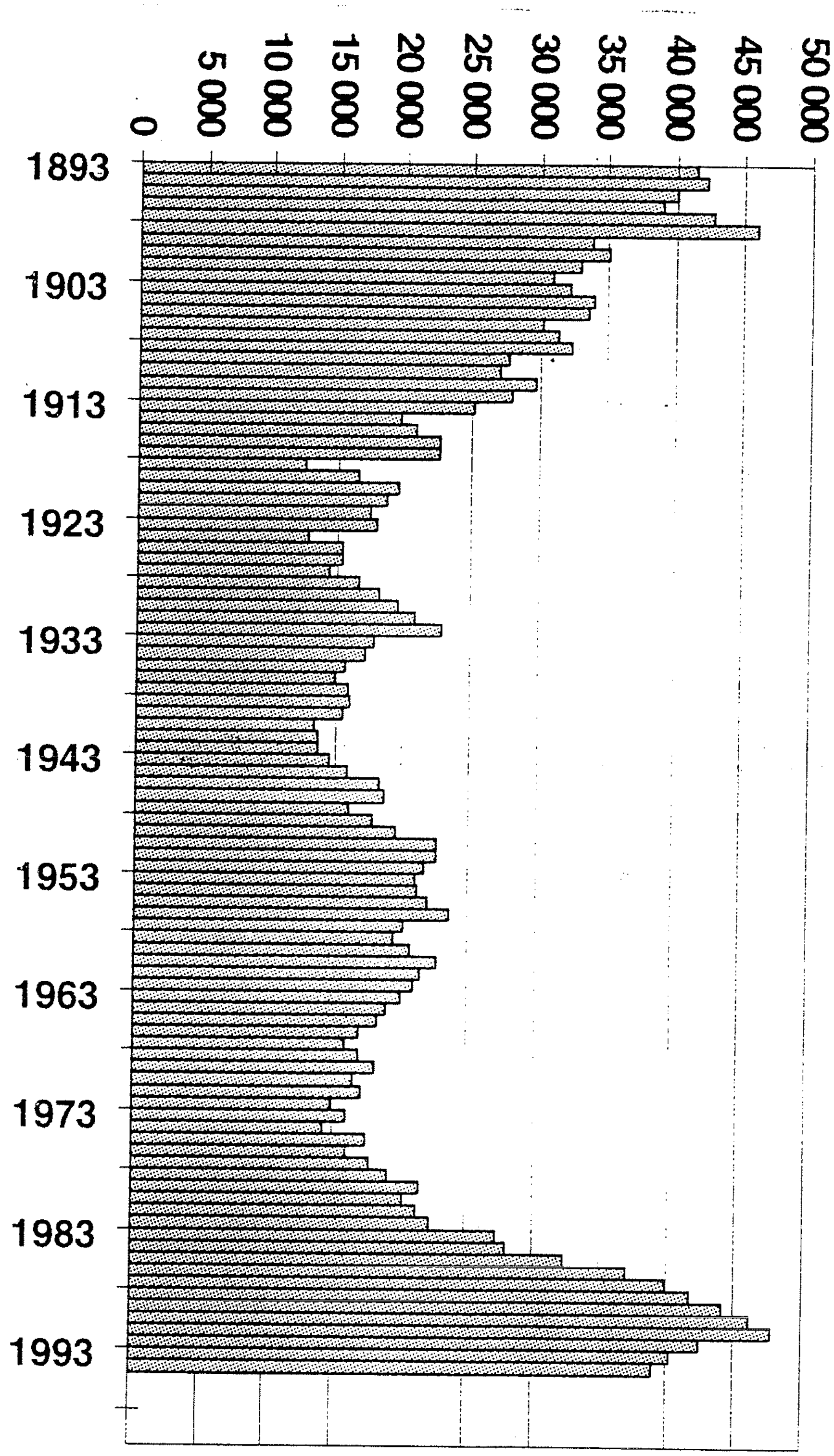


Figure 8



Lobster Landings (t)

Homard Débarquements (t)

P. Chamut

Thank you, good morning, etc. I am pleased to have the opportunity to participate with you at this workshop. A workshop on this topic is both **useful** and **timely**:

- **useful** as it provides an opportunity for a dedicated focus on groundfish management, in particular future direction;
- **timely** because we are facing a period of very dramatic change - unprecedented.

I recognise that change is a constant in this business; stability, though often sought, is a cherished myth. But, all can acknowledge that this has been and will continue to be a difficult period. We all are facing a very large array of choices and challenges, and this is equally true if you are a harvester, processor, or an official from DFO.

I am sure that we all sometimes feel overwhelmed by the pace and magnitude of the changes that must be confronted. So, in that context, it is useful to have an opportunity to take some time to reflect on where we have been and where we are going. If we can do that, I will judge the workshop a success.

My role here today is to discuss DFO's newly defined role:

"to ensure conservation and sustainable use."

It is recognized that this statement has biological and economic implications. I am to address the importance of this role for the objectives and strategies for groundfish management in Scotia-Fundy.

As you know, this newly defined role arises from the need to introduce significant reform to the Department's programs. So, I intend to provide some of the context for this statement and describe some of the changes underway for DFO. But, I think it is also recognized that there is another area of reform that is also underway which will also have significant implications for groundfish management - that is - the need to address a number of structural problems in groundfish. These two pressures for change may appear separate, but are really quite interdependent and one cannot properly deal with this general issue by only talking about one or the other.

Let me begin by addressing reform of DFO. We are looking at significant change to DFO. Change reflects the commitment of government, highlighted in the last budget, to reinvent its role in governance and how it operates. The central theme is for government to become smaller and less costly. Certainly DFO will become smaller and less costly. The following budgetary figures demonstrate:

For DFO:

- Expenditures in 1994/95 (last year) were $750 million - all programs (not including the Canadian Coast Guard).
- By 1999, budget will drop almost $300 million to around $450 million - reduction of 39%; significant reductions in personnel.

For Fish Management
(C&P, Ships Enforcement, Management Programs, Licensing, etc.):

- The budget in 1994/95 was $234 million.
- By 1999, budget will decline by close to 50% to $122 million

These reductions will require a very fundamental change in approach to resource management. More cuts are undoubtedly coming.

While budget cuts are driving the need for change, it is useful to emphasize that is not the only pressure. There is also a recognition that change is necessary to address deficiencies in past practices. Approaches have not been satisfactory to many of the Department's clients. There is sense of a need for more open and responsive decision making. The approach we are taking to reform, and to living within our budget, involves three broad strategies:

First Strategy: Focus on Core Mandate

- Core mandate is defined as "conservation for sustainable use."
- In short, we intend to look at the fishery from the resource up.
- In the past, we have had conflicting objectives in Fish Management.
- We have pursued a mix of biological, social, and economic objectives.
- We know that you cannot optimize all three objectives at the same time.
- We have made a choice and that is to focus on conservation of the fish.
- We must at the same time provide a policy framework for the achievement of economic objectives of the fishery, but our basic job - our accountability - is to ensure the long-term well-being of the fish.
- Our performance will be judged on the basis of success in conserving fish.
- You will have seen this emphasis in the past year on many fronts - East and West. Credit to Minister Tobin.
- For the Department, emphasis on conservation role means we will be getting out of certain activities: fish development; FVIP; bait; and other activities judged less relevant.

Second Strategy: To Streamline and Achieve Efficiencies

The second strategy will be consolidating - looking at ways to do things cheaper and more efficiently:

- consolidate offices;
- review fleet;
- assess technology;
- most important - reduce overhead - focus on most important jobs.

Third Strategy: Partnerships

- We are seeking to make significant change in our relationship with stakeholders.
- Move to a relationship where the stakeholders have a significantly increased role in decision making.
- Intend to work out formal agreements that will lay out arrangements for managing the fishery:
    : define roles and responsibilities;
    : resource access;
    : rules of conduct;
    : authority of the parties;
    : sharing of accountabilities and costs.
- Under these arrangements, will no longer take on all of the activities it has done in the past.

DFO will manage the resource risk - i.e., ensure stocks are sustained based on biological considerations. The industry will manage the economic risk - ensure that the fishery is conducted to meet economic and market demands, within a set of standards and responsible harvesting practices. As part of these arrangements, industry will be expected to assume a greater degree of accountability for decisions and a greater share of costs.

Current Status

- Cuts are being introduced; round one done and round two underway.
- Legislative amendments for partnership.
- Negotiations on Partnership Agreement underway.

I mentioned earlier that it is difficult to separate reform of DFO from reform of the groundfish sector. There is much interdependency and need for both reforms to proceed in complimentary fashion.

There have been a number of studies that have identified underlying problems in the fishery:

- excessive dependence;
- overcapitalization;
- unsustainable pressure on the resource.

This is not just in Atlantic. All of these factors have resulted in predictable outcomes in terms of profitability, income level, competitiveness, and impacts on the resource.

It is not my intent today to highlight the conclusions of these many studies. Suffice to say, I think that there is recognition that there is a problem and change is required. Beyond that consensus, recognize that there are many different views on what the fishery should look like in the future. Not surprising, given the many interests and the desire to ensure those interests are accommodated in the future.

While no agreement on specifics, I think there is general agreement that the fishery should have the following characteristics:

- **smaller number** of participants, with a better balance between the resource and harvesting capacity;
- **environmentally sustainable** conservation (responsible fishing practices - less wasteful);
- resilient and provide adequate levels of income to a core group of professional fishermen;
- self-reliant, competitive, and viable without subsidy.

There are a number of current initiatives that are underway to advance restructuring in the groundfish sector:

- licence retirement (HABs);
- Atlantic Licensing Policy Review.

So, what does this all mean for groundfish management in future. Difficult to predict future with certainty, but I would highlight the following:

- **Conservation** asserted as paramount priority: risk management; more precautionary approach;
- **Code of Responsible Fishing** - enforceable standards of behaviour worked out with harvesters;
- **Compliance** through sanctions:
  - : move from criminal court to Administrative Sanctions Board
  - : loss of licence privilege to create disincentive to cheat.

- Management through Partnership:
  - : cooperative management framework between DFO and industry
  - : DFO with more restrictive role, industry with more decision making and accountability
  - : DFO conservation; industry - business aspects.

Recognize that making change of the magnitude we are facing will be difficult. While most agree change is needed, there is no consensus. Better to say - diametrically opposed views on most issues. Makes it more difficult, but not an excuse to avoid change.

Change is happening and we can manage it or be swept over by it. Inaction would be a mistake. For the Department, unwillingness to change is an invitation to allow others to dictate how changes will occur. We are better off to work together and confront these difficult issues to ensure they meet our collective needs.

The Expectations Of Industry

Several industry participants were asked, some at the last moment, to provide comments on their expectations from management of the groundfish resource.

Jean-Guy d'Entrement

President, Inshore Fisheries Ltd., Middle West Pubnico, Yarmouth Co., N.S. BOW 2MO

First, I would like to thank the organizers for asking me to present my opinions of our expectations from the groundfish resource. For those who don't know me, my name is Jean Guy d'Entremont. I am currently the president of Inshore Fisheries Ltd., a medium-size groundfish processing and harvesting enterprise from West Pubnico, Nova Scotia. Personally, I have skippered an inshore dragger for seven years and fished extensively in the Gulf of Maine and Georges Bank. I have also fished along the Scotian Shelf to Banquereau Bank and in around Sable Island.

My family has been in the fish business for 50 years and has survived all the stock fluctuations, labour problems, currency fluctuations, and many different governments. We want the fishery to become a **productive** and **contributing** component of our economy and communities. We do not want the fishery to be the employer of last resort founded on social support systems.

The determining factor on participation in the fishery should be if it provides economic opportunities equal or better than others that are available. As with other Canadian businesses, there must be checks on international trading of these privileges. The fishery should evolve to become **self-sustainable** and **less reliant** on social interference; due to the present financial situation in Canada, we do not believe there is another option. Canada **must** be able to place fish on the **global marketplace** at **comparable quality** and **price** or we will fail as an industry.

The Treasury Department dictates the DFO budget, which is to be drastically reduced over the next few years. The budget may be the only **real** aspect of our fishery. The security of access by sector is vague and has been swayed in the past by politics. The capacity issue has still not been resolved in some sectors. The scientific assessments are only as accurate as the input data which varies by fleet and species.

There is also the Unemployment Insurance (UI) system which plays a major role in the Scotia-Fundy groundfish fishery and there is talk of reform. Finally, the recruitment of the stocks is unpredictable and is whatever hand Mother Nature deals us.

We can work at defining access through licence policy review. Once the access is properly defined and the sector shares are determined, the political interference will not be as pronounced. It is only with security of access, accurate monitoring, and less political intervention, that the industry will exercise true conservation and management strategies.

With the DFO budget being severely cut, I am afraid that the services it offers such as science, management, and enforcement will fall below the acceptable limits to curb large scale overexploitation of stocks. Certainly, there is uncertainty in our knowledge and information but that should not prevent us from managing effectively. Many businesses, like the oil industry, are managed under great uncertainty.

Co-management and **true partnerships** are the buzz words of today. To achieve this goal, **DFO must relinquish** some if its **power** and **industry must be poised** to receive this transfer of management responsibilities.

I will read to you a quote which we believe follows our logic:

> "Innovation depends on the use of ideas for the continuous improvement of products and services. It is the job of government not to protect entrepreneurs against all failure, but rather to create the best economic conditions and institutions to allow entrepreneurs to get on with the job."

Ironically, this is the heading of Chapter 3 of the Liberal Plan for Canada, Creating Opportunity. If this is a sound principle for Canadian business, why should it not apply to fisheries?

Eric Roe

Clearwater Fine Foods Incorporated, 757 Bedford Highway, Bedford, N.S. B4A 3Z7

I wish to thank the organizers for giving me the opportunity to make a few comments at the second Groundfish Workshop. I have taken the liberty of modifying the topic of this agenda item from "What are the expectations of industry from the groundfish resource?" to "What are the expectations of industry from our future groundfish management structure?" In my view, if we fail to get the right structure we can expect only to repeat the tragic folly of the past - too much of everything chasing too few fish about which not nearly enough is understood. My hope is that before the groundfish fishery re-opens we will introduce a groundfish management structure which will allow both the resource and the industry to prosper.

The right management structure is a big topic and there is only time for me to touch on several issues which I believe are integral to building a management structure which will foster a sustainable fishery and a self-reliant industry. The issues I will discuss are:

- Security of Access;
- The Role of DFO Scientists in Science;
- The Role of Industry in Science;
- The Role of the FRCC.

These issues are not meant to be an exhaustive list.

Security of Access

The establishment of secure harvest rights for licence holders must underpin our future groundfish management structure. It is my firm conviction that substantial progress on conservation will only be made when licence holders - be they mobile or fixed gear; large vessel owners or small vessel owners - have secure access to the resource.

We must not allow the endless maneuvering for quota share, which so characterized the past advisory process, to paralyze our future management system. Whether we wish to admit it or not, we all played the quota game at advisory meetings or in letters to Ministers. Science advice was routinely interpreted in such a way as to disadvantage some other user group; conservation measures were often used as just another argument to take fish away from someone else.

Burke, D.L., R.N. O'Boyle, P. Partington, and M. Sinclair. 1996. Report of the Second Workshop on Scotia-Fundy Groundfish Management. Can. Tech. Rep. Fish. Aquat. Sci. 2100: vii + 247 p.

Insecurity of access was the root cause of these mindless games which distracted all of us from building a sustainable fishery which could sustain an economically viable industry. Insecurity of access also created an uncertain policy environment which encouraged stupid public and private decisions, the sum total of which ultimately became a bloated, uneconomic industry. We had a system which permitted relatively easy access but which had perverse barriers to exit. We had employment maximization as a stated policy objective. I would argue that employment maximization is counter-conservation. As a policy objective, it is clearly inconsistent with economic viability. Secure harvest rights, on the other hand, will over time encourage resource stewardship and, if these rights are tradable, will enable the industry to reduce capacity to better match the resource.

I am not promoting security of access as the answer to all of our many challenges in the groundfish industry. I am convinced, however, that long-term security of access is a vital first step towards building a sustainable fishery and a viable, self-reliant industry.

The Role of DFO Scientists

The next issue could and perhaps should be the subject of a workshop - the role of DFO scientists in science. The reason for including this issue in my comments - besides the fact the room is full of scientists - is because the role of science in resource management is so fundamentally important.

If we could settle the security of access question, we might all begin to actually listen to and work with DFO Science to develop a sustainable fishery. Science advice will only be accepted, however, if the industry trusts and respects the objectivity of the source of the advice. In this regard, and without overstating the point, I have become concerned by a growing tendency within DFO Science to stray from science into resource management areas. Admittedly, there are at times gray areas between scientific advice and management strategies, however, DFO Science must remain objective and not become or be seen to become advocates for particular user groups or management models.

Industry Role in Science

If war shouldn't be left to the generals, then it only follows that science shouldn't be left to the scientists. I believe licence holders must participate in and contribute towards the costs of science for the following reasons:

1. The licence holders benefit from the resource and should therefore be expected to contribute something back towards the cost of science (and management generally). Lest there be any doubt, I am in no way endorsing the Department's access fee proposal. The access fee proposal is unacceptable because it is based on no principle and relates to nothing other than the Department's desire to raise $50.0 million from the industry. What I am endorsing is a collaborate effort, a

partnership if you like, in which licence holders play a responsible role in their own management - including science - and accept some of the costs.

2. The other reason I believe industry should participate in and contribute towards science is that two very interesting things happen when one begins to pay for professional advice:

You demand the very best.
You are less prone to ignore the results.

The Role of the FRCC

The final issue I wish to raise is the role of the FRCC in our future management structure. I wonder what role the FRCC, as currently constituted, could play in the context of a management structure in which quota games had no place and in which licence holders played a meaningful role in their own management. I'll leave it as a question because we are some distance from creating the kind of management structure I think we need.

To return to the theme for this agenda item, I have high hopes and low expectations for the groundfish fishery and will continue to feel this way until we make fundamental changes in the management structure.

The Fisheries of the Future, Starting Now!

Evan Walters

S-F Inshore Fisheries Association, P.O. Box 158, Barrington, Shelburne Co., N.S. BOW 1EO

If one takes 1995 as a complete picture and tries to describe the net gain from it as a fisheries' year, what could one say? My God, what a mess; or, How on earth did we get to this?; or, What else could go wrong? I will not say that. What I will say is that two things are evident:

1. It was the best we could do with the fish we had; and
2. We have learned that we can NOT do this again.

What changes do we make? What immediate problems do we seek to re-dress? Do we fish without the benefit of TAC management plans? Do we fish without trip limits? Do we further separate out the interest groups? The answers are Yes, Yes and Yes!

TACs identify safe fishing mortalities, but are impossible to fish around for most species in an interactive multi-species fishery. Trip limits on one species are barely survivable; on four, it is impossible to fish without conservation problems. Further separation of fishing interests allows us to manage the interests of specific and of smaller community/area fisheries. How do we do this? We identify non-threatening conservation-wise fisheries and put them on an allowance fishery program. We initiate, encourage, develop, and enforce a determined controlled transfer, ITQ fishery for larger members of the fleets. We identify and develop a competitive fishery based on something other than a trip limit, one that does not count each species in its catch effort. We immediately open all areas of Atlantic Canada to a controlled fishery by vessels less than 45 feet on a scientifically measured basis for handline fishing only! Mobile gear and other gears would be operated for some days per month on a predetermined basis and by area so as to get the best possible data on the resource. At no time would we close a fishery.

It has been proven quite well, I believe, that industry is willing to manage its own affairs. What has also been proven is that it is essential that DFO maintain a real presence in the enforcement of industry, science, and DFO agreed management objectives. It is clear to most of us that there is a core of determined and aggressive outlaws in the fishery that must go and that those who are determined to operate in a manner dangerous to the resource can no longer be allowed to do so.

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Education of fishermen, a code of fishing conduct, and a sense of caretaker responsibility has to be built into our fishermen, schools, and communities. Will it be easy? No, but it can be done. Thank you.

Summary of Conclusions of First Scotia-Fundy Groundfish Workshop

M. Sinclair

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Introduction

The December 1993 Workshop analyzed the degree to which the objectives of management were achieved between 1977 and 1992. In the context of the present Workshop during which we are discussing possible improvements to the 1995 groundfish management system, it is important to note that there have been several important changes in the management system during the past three years (1993 to 1995). Thus, some of the conclusions of the first Workshop concerning deficiencies in management may not be applicable under present circumstances. In this paper, I will summarize the findings of the first Workshop and briefly address the degree to which recent management changes are better meeting stated objectives.

The 1993 Retrospective Evaluation

I will focus on the conservation objectives because they are the key concern of the present Workshop, and also we have better documentation of this component of groundfish management. The objectives from the 1976 policy paper were to rebuild the depleted stocks of the time and subsequently to prevent both "growth" and "recruitment" overfishing. These objectives are specifically identified in rule 8 of the recent annual groundfish management plans. The strategy chosen in 1977 was to harvest at a constant exploitation rate. The harvesting level chosen was $F_{0.1}$, rather than F_{MAX}. This was considered to be a cautious approach compared to the previous ICNAF strategy. The tools (or tactics) to achieve this harvesting strategy were annual limitations of landings of diverse groundfish species from particular geographic areas (i.e., the primary tool chosen to achieve the conservation objective was quota management). The process involved annual groundfish management plans within which the Minister of DFO set species/area TACs following rule 8.

A comparison of scientific advice, TACs, and reported landings for the groundfish management units in the Scotia-Fundy Region leads to three general observations:

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- TACs were frequently set higher than scientific advice, particularly during periods when stocks were declining;
- landings were frequently higher than TACs (the over-runs partially due to permitting bycatch fisheries to continue when a quota for one or more species in a geographic area had been taken);
- the scientific advice and TAC were frequently too high such that the TAC was not a limiting factor (in hindsight this occurred when the scientific advice over-estimated stock abundance).

This analysis indicates that during the implementation of quota management between 1977 and 1992 there were some persistent deficiencies.

It is common knowledge that reported landings which are the source of data for regulation of fishing mortality through quota limits, as well as a key component on stock assessments, underestimate actual catch. However, the degree that reported landings underestimate actual catch is difficult to quantify. The first Workshop took four approaches to evaluate the accuracy of reported landings:

- an analysis of weekly reports of the Science Branch of port technicians who are aware of fishing practices (this analysis indicated large scale misreporting by area where one area was "quota poor" relative to a contiguous area);
- an analysis of the annual Groundfish Subcommittee Reports of CAFSAC within which misreporting practices were qualitatively assessed over time (these reports indicated persistent problems with catch statistics due to misreporting practices);
- an analysis of the accumulative trip reports of the Observers on the large trawlers of the offshore fleet (again the reports of fishing practices on vessels without Observers indicate persistent misreporting);
- an analysis of a DFO questionnaire survey on the efficacy of the new Dockside Monitoring Program for the ITQ small dragger fleet (the study indicated that during the 1977 to 1992 period about 30% of landings were misreported by species, 30 to 40% of the landings were misreported by area, and about 25% of landings not reported at all).

The questionnaire also indicated that DMP had improved the accuracy of data on species and weight (but not by area of catch). Also, it was considered that at-sea practices of discarding had not been improved by the ITQ and DMP programs.

The above conclusions on the degree of inaccuracy of reported landings were consistent with the perceptions of the DFO Area Managers and two sociological studies, one by C. Creed (off SW Nova) and the other by P. Sinclair (off the west coast of Newfoundland). They were not consistent with an analysis of Nova Scotia export data or with a comparison of incomes and reported landings for selected fishers. In sum, in spite of a broad-based approach to evaluating the degree of inaccuracy in reported landings (compared to actual catch), the Workshop could not quantify the problem. It was, nevertheless, concluded that reported landings seriously underestimate actual catch, and that discarding/highgrading practices are high under both competitive quotas (with trip limits) and EAs/ITQs. Industry has been very innovative in finding ways to circumvent quota restrictions in order to stay on the water throughout the year. There has been a poor match between scientific advice, TACs, and reported landings for all groundfish management units in the region.

Analyses of fishing effort trends, trips per year by gear sector, indicated that effort did not track either stock abundance trends or quota trends. For trawlers over 65 feet (tonnage class 4 and 5), there was a sharp reduction in trips per year in 1984 due to allocation shifts between gear sectors when EAs were introduced following the so-called Kirby Report. From 1984 to 1992 effort has been relatively stable. For tonnage class 2 and 3 draggers (less than 65 feet), there was a steady growth in effort between 1977 and 1986, with relative stability between 1986 and 1992. Fishing effort for longliners (less than 65 feet) increased steadily over the 1977 to 1992 period.

In sum, the collective groundfish annual fishing effort increased steadily over time as the resource declined since the mid-1980s. Management units were rarely closed when a TAC or seasonal quota was reached. Fishing continued under trip limits and bycatch rules. Thus, during the 1977 to 1992 period, the tactic (or tool) of quota management did not restrict fishing effort to levels that would generate a constant harvesting rate (the strategy chosen by Canada in 1976).

There have been multiple objectives of groundfish management in Atlantic Canada. Measures taken to achieve the economic and social objectives undermined the ability of the management system to achieve the conservation objectives. An excess in harvesting capacity developed between 1977 and the mid-1980s due to the combination of the common property aspect of competitive quotas and easy access to investment capital (including provincial subsidization). The EA (1984) and ITQ (1992) initiatives reduced the growth in capacity, and in some cases reduced actual capacity within fleet sectors. Fixed gear sectors, which have been under competitive quotas throughout the 1977 to 1992 period, have grown steadily in fishing capacity.

The actions taken by the government of Canada to support seasonal workers under the Unemployment Insurance (UI) program have also undermined the actions taken to achieve conservation. The analysis for Nova Scotia fishers indicates that an increasing percentage of their annual income came from UI between 1977 and 1992. In contrast, for other Nova Scotia workers the percentage has been stable. Also, the combined average annual salary for a fisher in Nova Scotia (earnings from fishing plus UI) results in total earnings higher than the average Nova Scotia income. Thus, there has been an incentive for fishers to stay in the fishery irrespective of declines in the stocks and in quota. In theoretical terms, government subsidization of fishing capacity and incomes, combined with a policy that encourages increases in technological efficiency, moves the open access equilibrium point of the Gordon/Schaeffer bio-economic model to higher effort levels and concomitant lower stock levels. In other words, fishers can still make a "profit" at very low stock levels.

An analysis of the ability of DFO to enforce the fisheries' regulations led to the following general conclusions:

i) there has been good success in enforcing regulations on foreign vessels fishing in Scotia-Fundy waters;
ii) there has been good success in enforcing the Canada/US boundary in the Gulf of Maine area;
iii) there has been moderate success in enforcing closed areas (particularly since the institution of air surveillance);
iv) most regulations associated with quota management for the domestic fleet have proven to be unenforceable.

With respect to the fourth conclusion, dockside monitoring has improved enforcement of regulations at landing points, but at-sea fishing practices (discarding, highgrading, transshipping, misreporting by area) are still a major challenge to enforcement.

The response of the groundfish resource to fishing practices between 1977 and 1992, with the regulatory framework and enforcement capability summarized above, indicates that there has been growth overfishing for most groundfish management units. As the stocks declined in the late 1980s and early 1990s, fishing mortality rose sharply to very high levels. The quota management system (including scientific advice, implementation of regulations, overcapacity, and enforcement constraints) responded too slowly to the resource declines. There is some evidence that there has also been recruitment overfishing for several management units. In sum, the conservation objectives under the tactic of quota management during the 1977 to 1992 period were not achieved. Rule 8 of the plan was not implemented effectively.

Why did the tactics used not achieve the desired result? There was not a consensus arrived at during this Workshop, but the Steering Committee made four general points:

i) There is a fundamental constraint to the use of a single-species regulatory tools (i.e., single- species quotas) for a fishery with multi-species harvesting technology. The mismatch has made it difficult to stop fishing when one quota is reached. Also, there will always be an imbalance between the relative abundance of the diverse species within an area, the accuracy of the scientific advice leading to TACs, and the price differential. For example, even for management units with no quota, such as 4X haddock for several years during the late 1980s, bycatch fisheries led to fishing mortality levels considerably higher than conservation targets, as well as high levels of discarding.
ii) The incentives under quota management are to misrepresent catches in order that a vessel can always stay in the water. Given that at-sea activities related to quota

control are largely unenforceable, fishing effort was effectively unrestricted during the 1977 to 1992 period, except for the small dragger closure in 1989. In sum, the combination of the incentive structure under quota management combined with limits to enforceability of at-sea fishing practices led to ineffective implementation.

iii) The short-term actions taken to address socio-economic objectives of groundfish management, such as subsidization of fishing capacity and of incomes, undermined the ability of quota management to meet the conservation objectives. In the trade-offs made between 1977 and 1992, socio-economic issues frequently overruled conservation concerns.

iv) The lack of an operational definition of minimum spawning stock size made it difficult to apply the "recruitment overfishing" prevention clause of Rule 8. There was also little attempt to protect individual spawning components within a management unit under quota control. The overestimation of stock abundance during declines contributed to sharp increases in fishing mortality, and possibly recruitment overfishing in some areas.

The overall result can be illustrated using the Gordon/Schaeffer bio-economic conceptual model of fisheries management. Ineffective implementation of quota management allowed fishing effort to grow to the so-called open access equilibrium point (OAE) at which the costs of fishing equal the collective revenue. Furthermore, subsidization and technology-led increases in efficiency further pushed this point to occur at higher levels of effort and lower levels of stock abundance. In some cases, the resultant stock abundance at which the OAE occurs is below that required for moderate to good recruitment and we have a collapse situation with the prognosis of very slow resource recovery.

<u>Changes to Groundfish Quota Management in 1993 to 1995</u>

Since the collapse of most of the cod stocks off Atlantic Canada, and the associated moratoria, there have been changes in the implementation of quota management that suggest that some of the problems identified in the first Workshop can be solved. Amongst the changes, the most significant is the change in practice associated with a quota being reached in a particular area. When one quota in an area is taken, the fishery within the area for other species is closed. Fisheries do not continue on a bycatch or trip limit basis. This has been particularly significant for the fixed gear sector, as it has resulted in the elimination of a 3,300 lb. trip limit that had been permitted when the quota had been reached. Dockside monitoring is becoming mandatory for all gear components, including inshore fishers with handlines. The change in how sanctions are administered has resulted in stiffer penalties and thus greater compliance with regulations. Industry appears to be able to better avoid catching stocks that it needs to avoid because of quota restrictions. ITQs have led to a reduction in harvesting capacity for the small dragger gear component. Scientific advice more explicitly incorporates the so-called retrospective problems in the provision of advice. In sum, there has been a tightening up of the implementation of quota management.

These changes suggest that improvements in the present tactics may allow the conservation objectives to be attained. Figures 1 to 5 show the trends in fishing mortality for 4X cod, 4X haddock, 5Zj+m cod, 5Zj+m haddock, and Scotian Shelf pollock. For all five management units, F has declined in recent years under quota management regimes. This conclusion is consistent with the declines in trips per year by all gear sectors in 4X and 5 (Figures 6, 7 and 8).

These are positive signs. The negative development, however, has been the expansion of fishing effort on alternative groundfish species for which there is not much information on the effort required for sustainability. Research vessel survey estimates indicate declining trends for some of these species (Figure 9 provides an example, skate biomass).

Concluding Points

The 1993 Workshop came to some strong conclusions concerning the ineffectiveness of quota management for groundfish between 1977 and 1992. The challenge of the present Workshop is to identify the degree to which the recent changes are adequate to achieve the conservation objectives. Are there additional actions, both improvements to implementation of quota management and new tools, that will further improve our ability to generate "conservation for sustainable use"? The focus of the following papers will include costs of management tools (which was not considered in 1993) in relation to effectiveness.

Figure 1

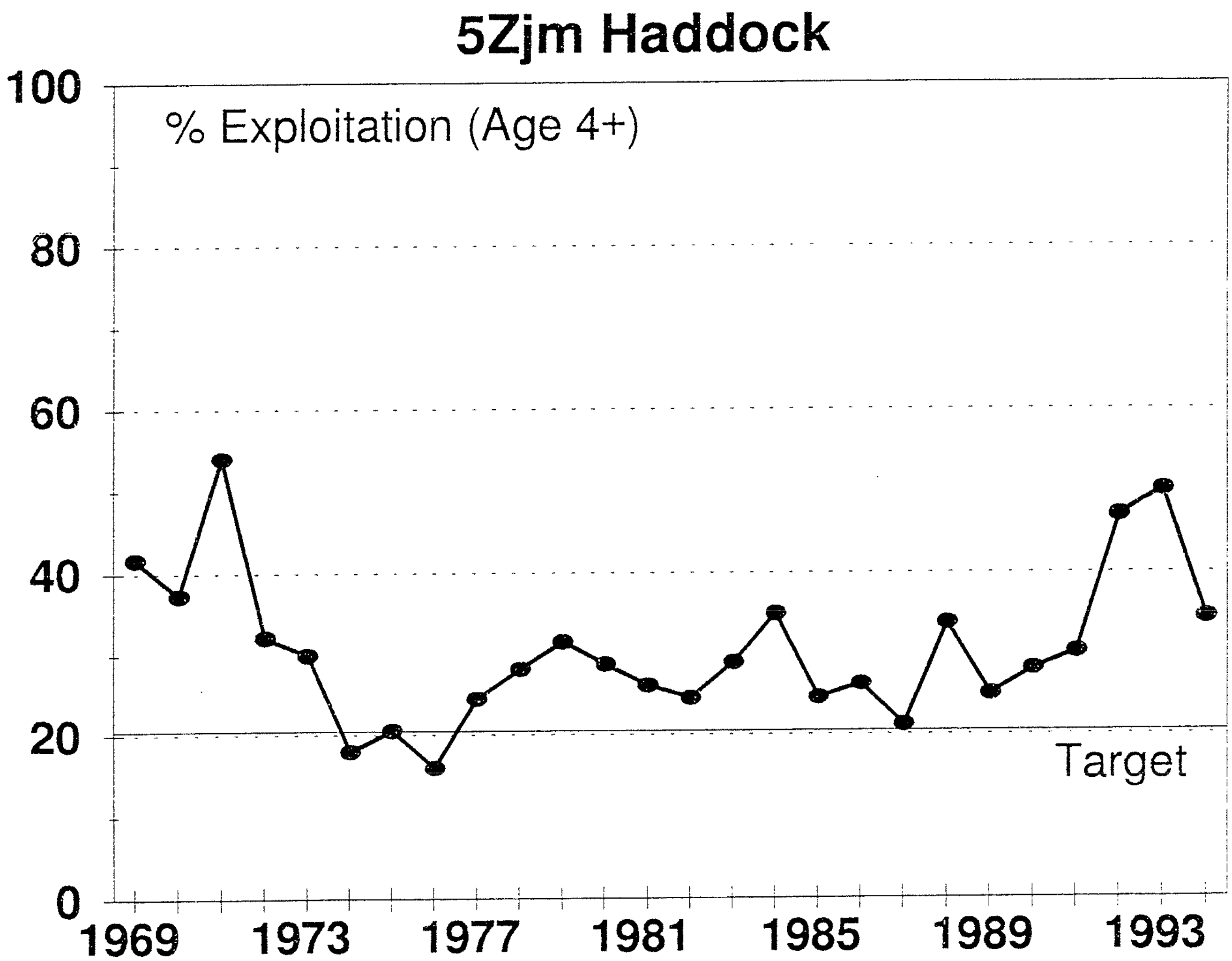

5Zjm Haddock
% Exploitation (Age 4+)
Target
100
80
60
40
20
0
1969
1973
1977
1981
1985
1989
1993

Figure 2

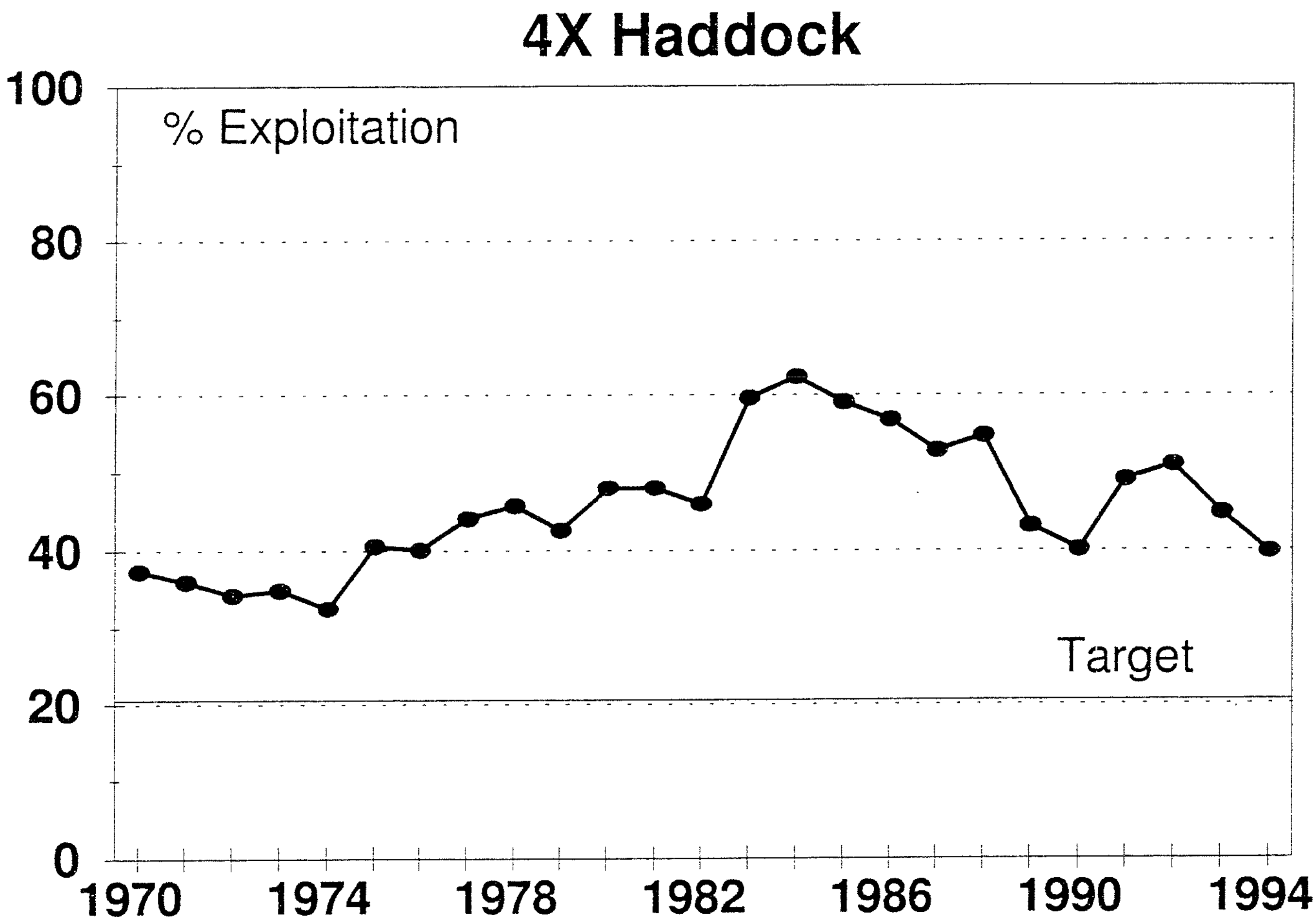

4X Haddock
% Exploitation
Target
100
80
60
40
20
0
1970
1974
1978
1982
1986
1990
1994

Figure 3

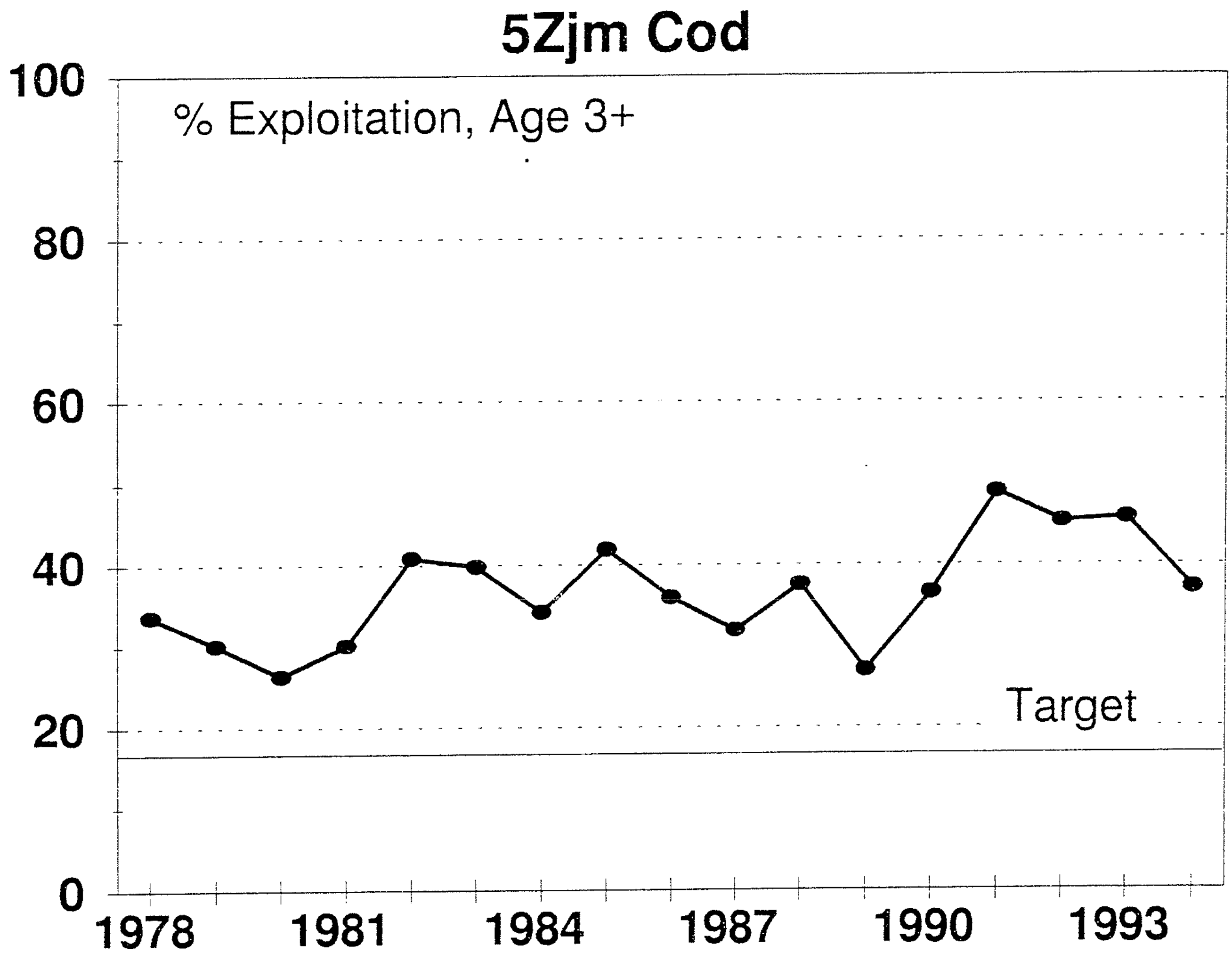

5Zjm Cod
% Exploitation, Age 3+
Target
100
80
60
40
20
0
1978
1981
1984
1987
1990
1993

Figure 4

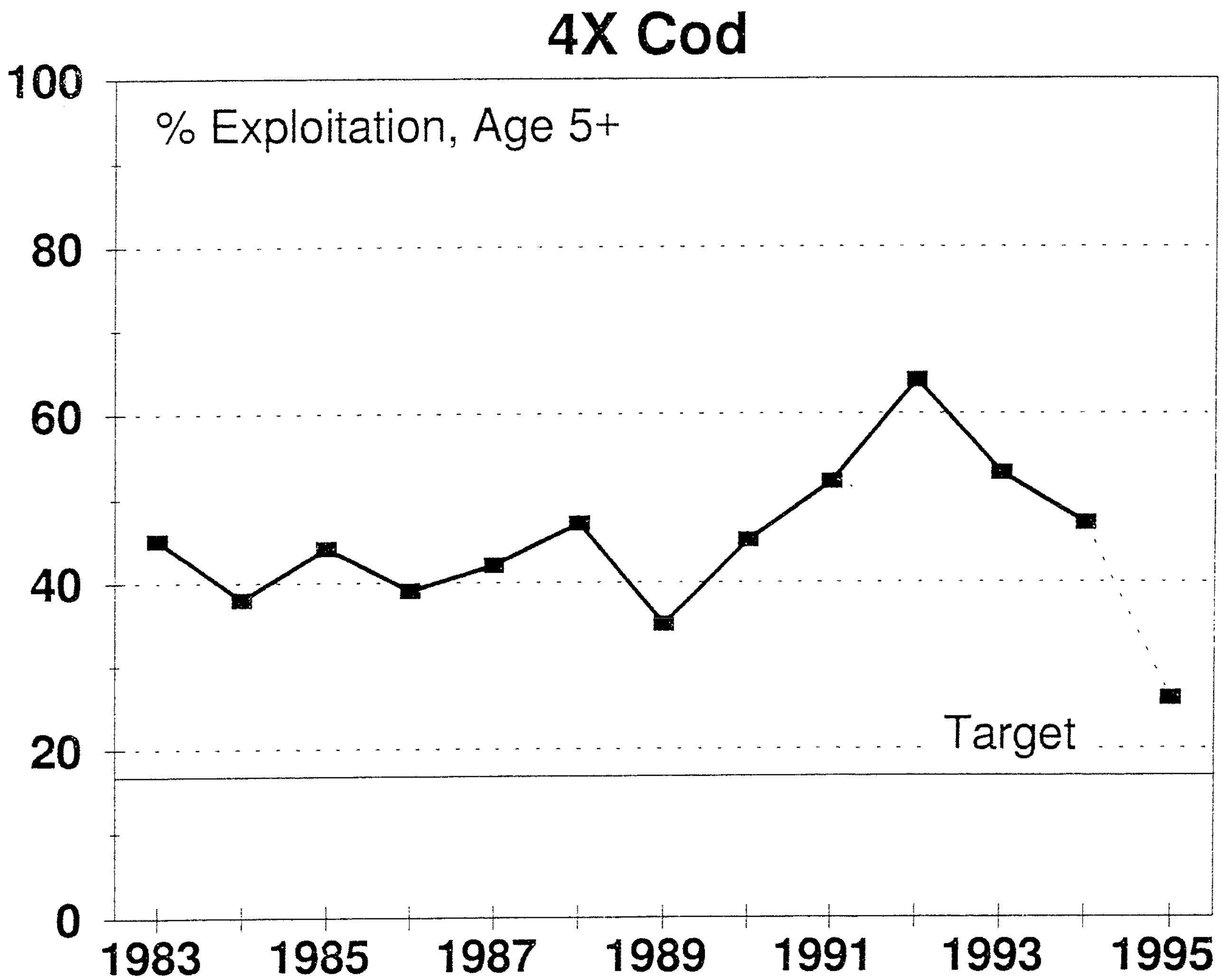

4X Cod
% Exploitation, Age 5+
100
80
60
40
20
0
Target
1983
1985
1987
1989
1991
1993
1995

Figure 5

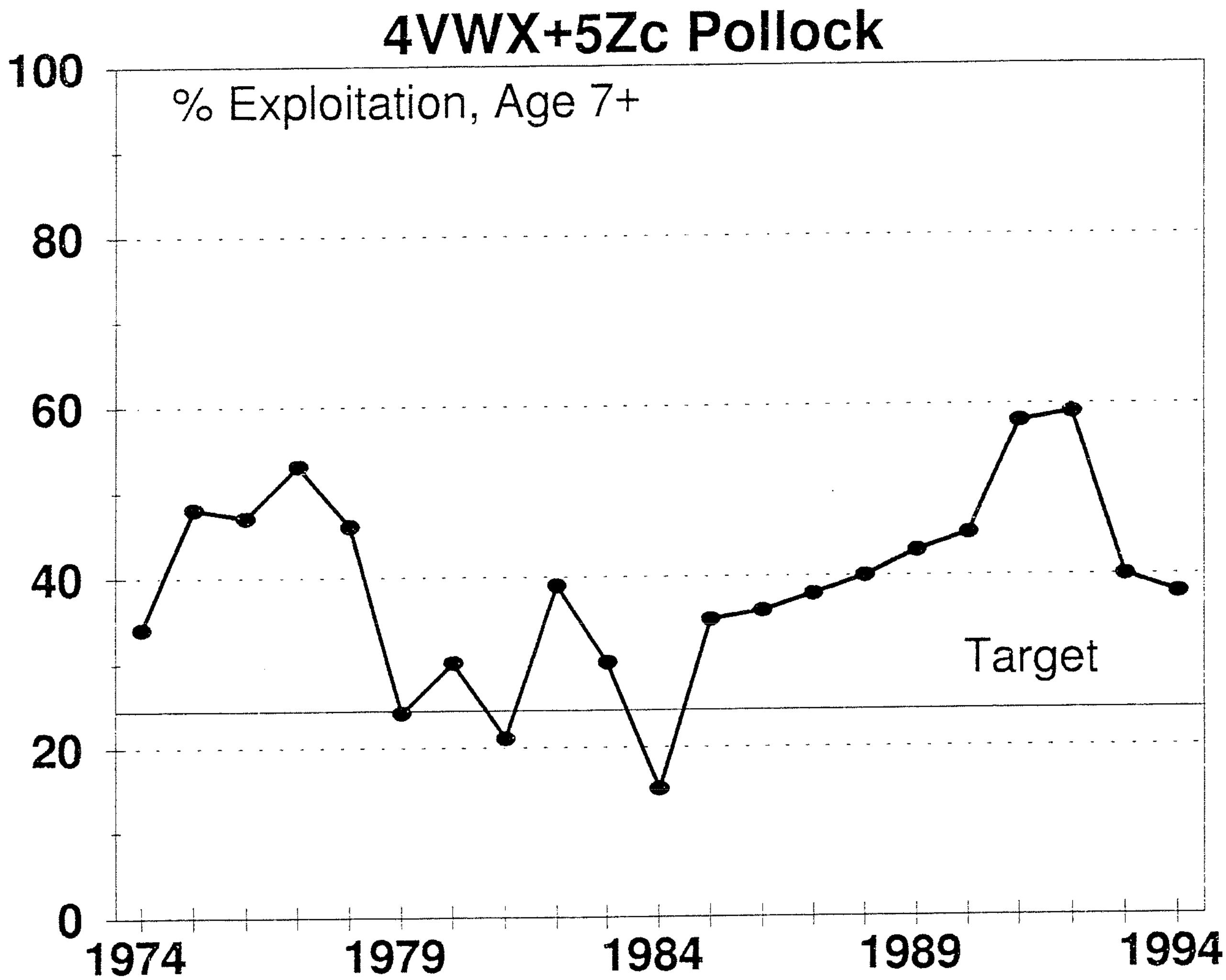

4VWX+5Zc Pollock
% Exploitation, Age 7+
Target
100
80
60
40
20
0
1974
1979
1984
1989
1994

Figure 6

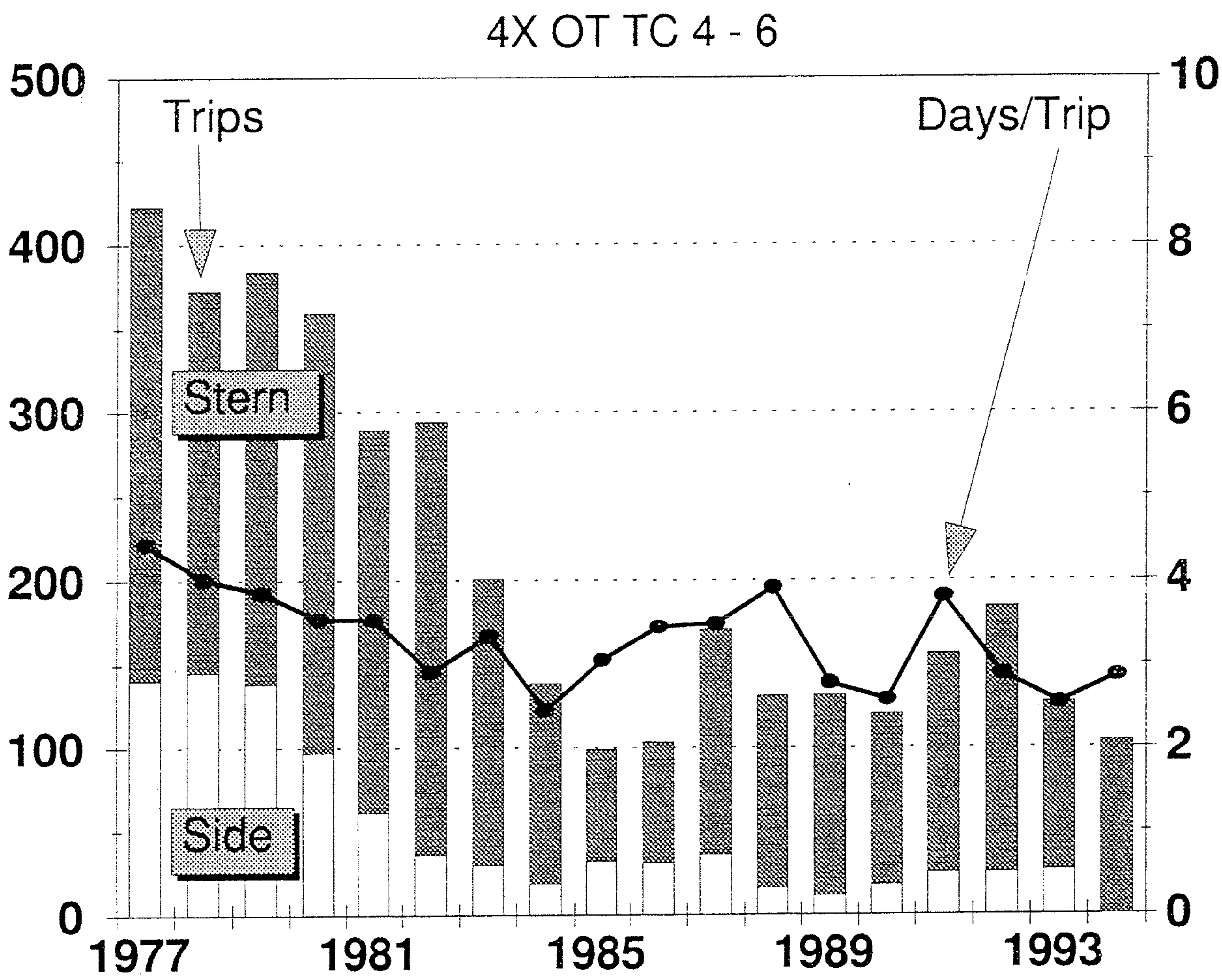

4X OT TC 4 - 6
Trips
Days/Trip
Stern
Side
500
400
300
200
100
0
10
8
6
4
2
0
1977
1981
1985
1989
1993

Figure 7

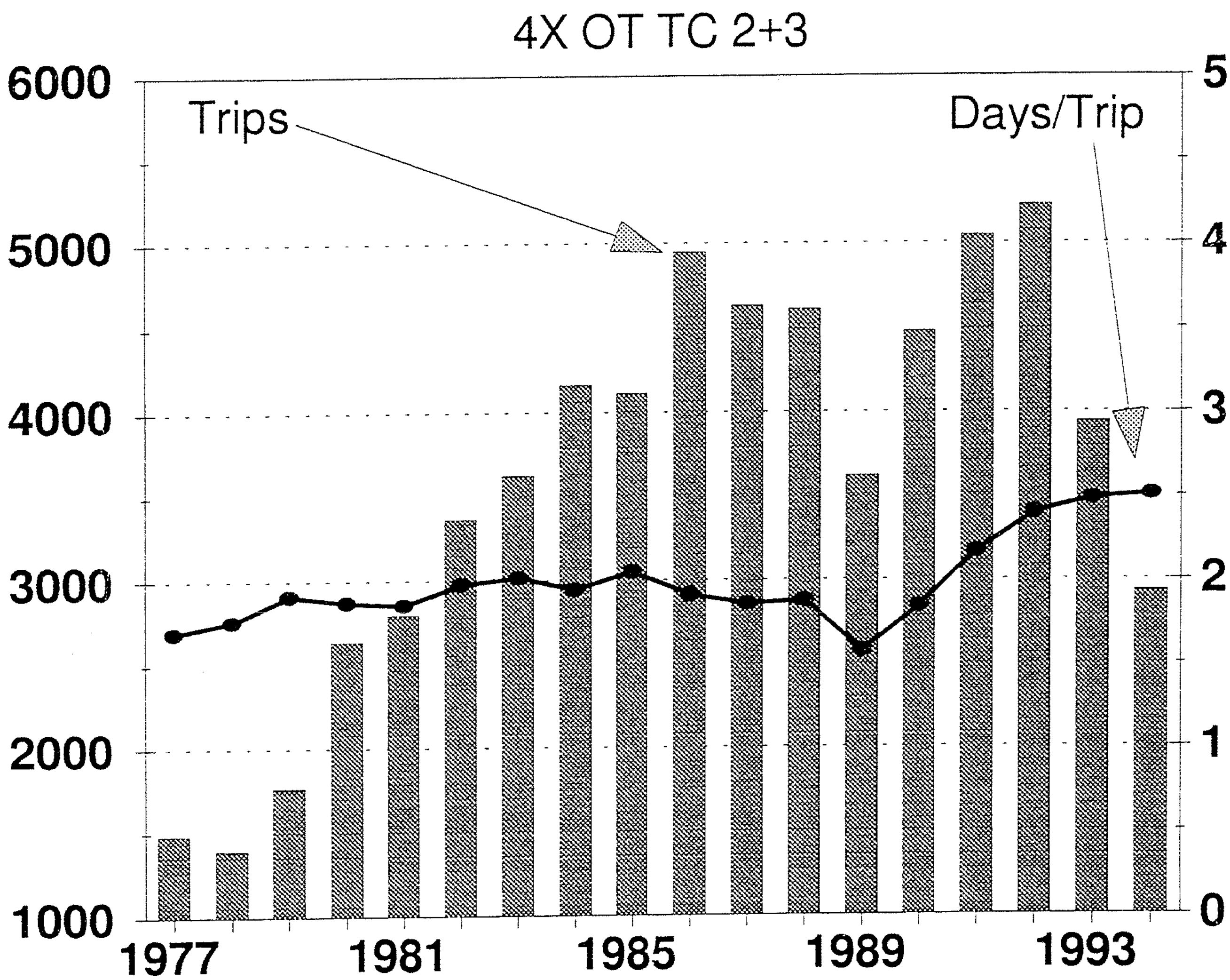

4X OT TC 2+3
Trips
Days/Trip
6000
5000
4000
3000
2000
1000
5
4
3
2
1
0
1977
1981
1985
1989
1993

Figure 8

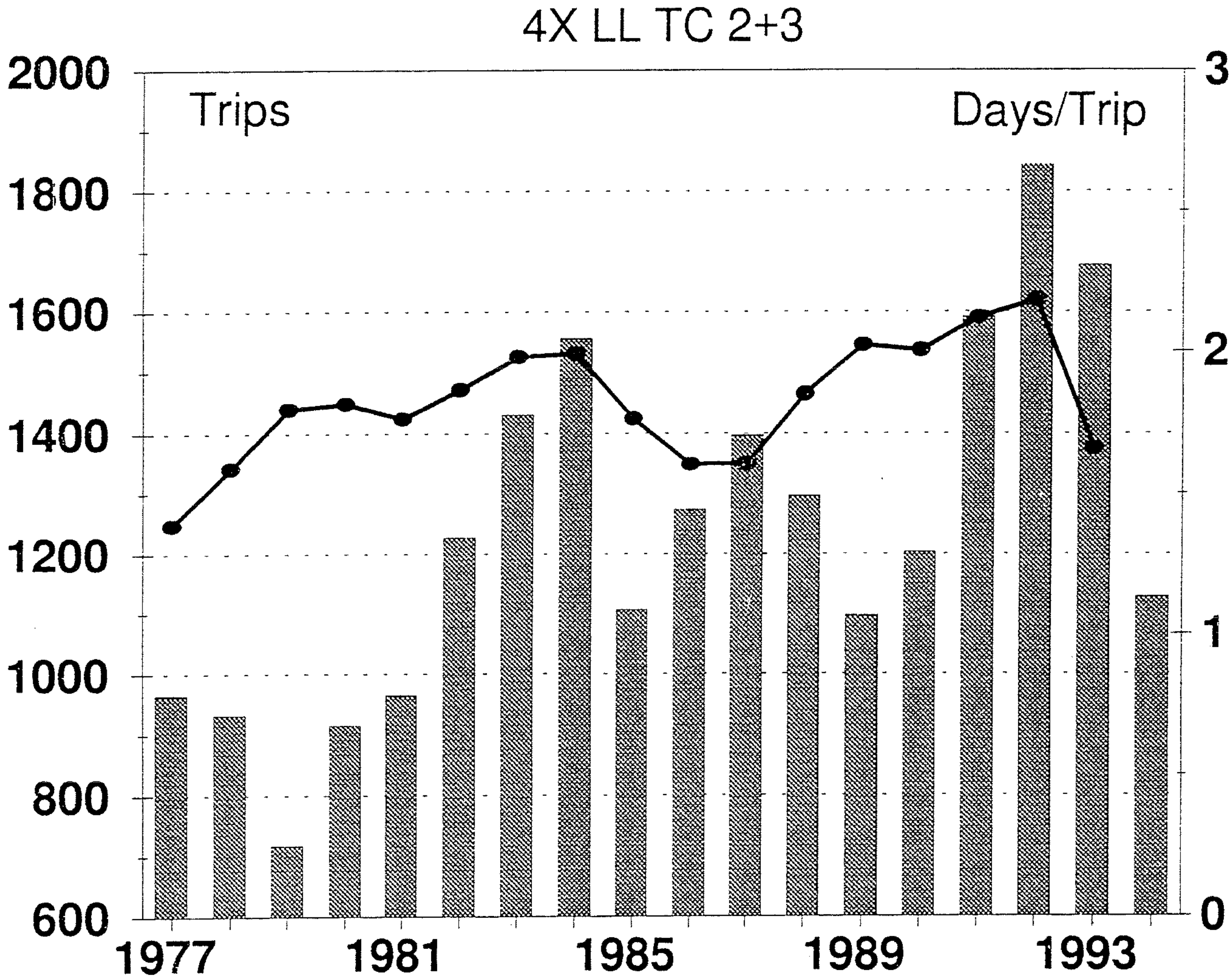
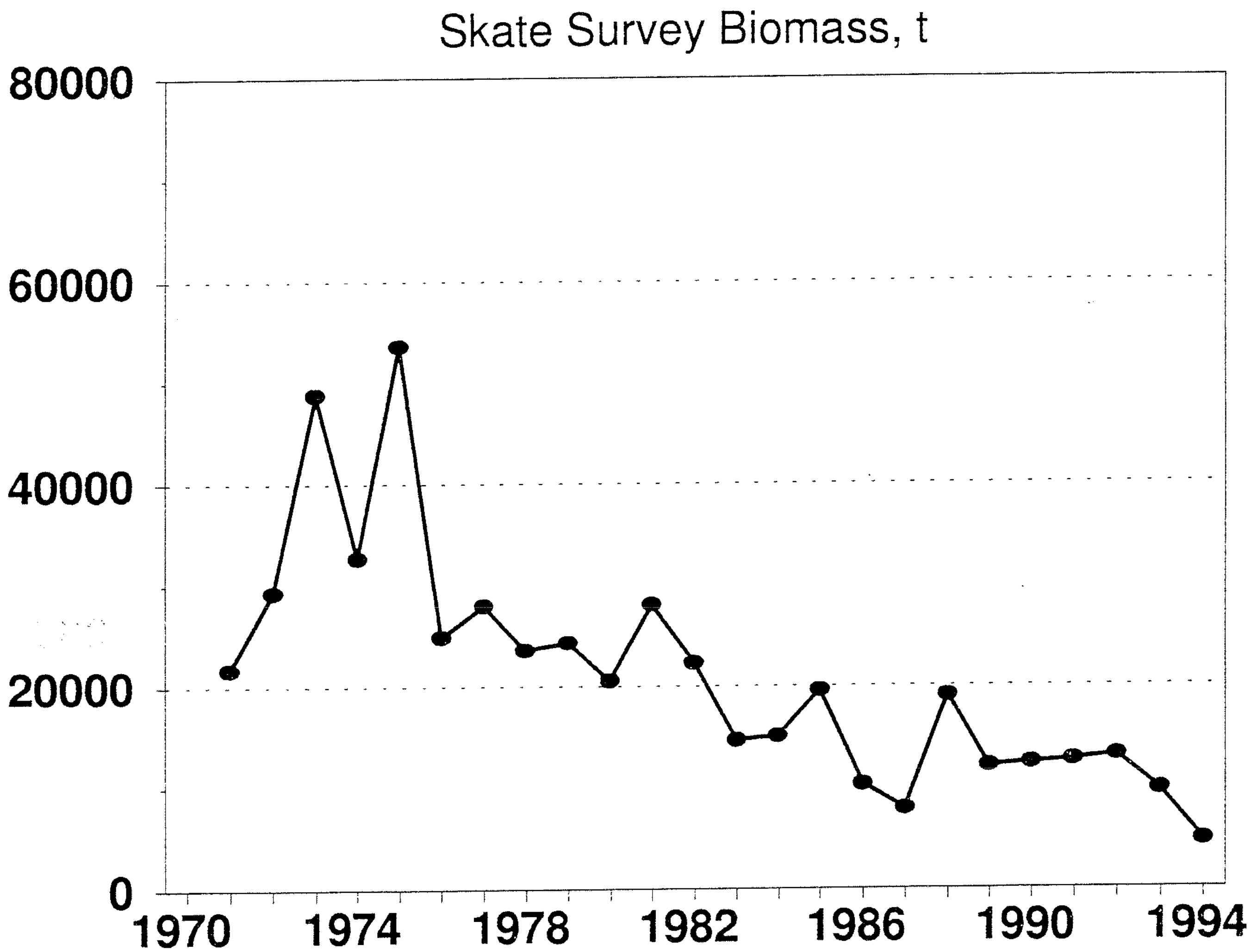

4X LL TC 2+3
Trips
Days/Trip
2000
1800
1600
1400
1200
1000
800
600
3
2
1
0
1977
1981
1985
1989
1993

Figure 9


Skate Survey Biomass, t
80000
60000
40000
20000
0
1970
1974
1978
1982
1986
1990
1994

+ problem = categorizing fisheries as either catch or effort - offshore lobster call catch - but quota capped at 700 mt - too many variables - i.e. offshore lobster also uses fixed - what about employment in the inshore lobster

TACTICS TO IMPLEMENT THE MANAGEMENT STRATEGIES

Quota Management

A Comparison of Catch and Effort-Based Fisheries Management

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Introduction

The collapse of groundfish fisheries on Canada's East Coast in the early 1990s has prompted some to call for the abandonment of catch or quota management and the adoption of an effort-based system, similar to that used in lobsters. However, evidence from fisheries both in Canada and elsewhere suggests that effort-based management is not without its problems. The problems in the effort-based US groundfish management system are a case in point. Each system of management has its strengths and weaknesses and is likely best suited to the particular circumstances of each fishery. Perhaps a more pertinent question to ask is how much does each system cost, relative to the benefits that it generates. With this in mind, the First Groundfish Workshop held in December 1993 (Angel 1994) made the following recommendations:

- conduct further analyses of the costs and effectiveness of the enforcement in order to draw conclusions on what activities can realistically be enforced;
- conduct further analyses of the total costs of management broken down by the categories of objectives (conservation, economic performance, and employment).

In the Department of Fisheries and Oceans (DFO) Scotia-Fundy Region, the groundfish, herring, offshore lobster and offshore scallop fisheries are traditionally considered as being managed by catch controls, whereas those of inshore scallop and lobster resources are managed by effort controls. In support of the two recommendations stated above, this paper presents an analysis of these fisheries, first examining the degree to which they can be classified as being catch or effort-based, and then comparing their success in achieving stated goals relative to their overall costs. General observations on the utility of catch versus effort-based management are made.

A Definition of Catch and Effort-Based Management

Before classifying the management of a fishery as being catch or effort-based, it is essential to define what constitutes each system. Consider a stock that is being exploited

Burke, D.L., R.N. O'Boyle, P. Partington, and M. Sinclair. 1996. Report of the Second Workshop on Scotia-Fundy Groundfish Management. Can. Tech. Rep. Fish. Aquat. Sci. 2100: vii + 247 p.

(Figure 1). Of the total stock biomass, only a fraction is available to fishing due to the regulation of gear selection. This is intended to limit exploitation on particular life history stages, such as juveniles and spawning adults. Regulations on mesh, hook and vent size, restrictions on animal size caught, and closed areas and/or seasons are often employed. Note that the regulation of gear selection is common to both catch and effort-based management systems. The fraction of the stock left for exploitation is referred to as the fishable biomass. Fishing activity takes a fraction of the fishable biomass, this being termed the fishing mortality. The size of the fishing mortality can be regulated either through the catch (catch-based management) or through the fishing effort (effort-based management). The main difference between the two approaches is the need to account for gear efficiency under an effort system (Table 1). Gear efficiency regulations often involve restrictions on the overall size of boats and/or gear. It is evident that the regulation of catch is a more direct way to control fishing mortality than is the regulation of fishing effort.

This description of catch and effort-based management was used to classify the 1995 groundfish, herring, lobster, and scallop fisheries of the Scotia-Fundy Region. Interviews were held with the lead biologist for each resource to define the set of regulations used in each fishery. These were then categorized as per Table 1 (Table 2 - shading indicates presence of regulation).

There is a considerable amount of commonality among the regulations employed in traditionally considered catch (groundfish and herring) and effort (inshore scallop and lobster) managed fisheries. Except for herring, all fisheries have some form of regulation.

Table 1. Regulatory Features of Catch versus Effort-Based Management Systems

Catch Management	**Effort Management**
Gear Selection • mesh/hook/vent size • animal size/berried females(lobsters) • nursery/spawning areas	Gear Selection • mesh/hook/vent size • animal size/berried females(lobsters) • nursery/spawning areas
Catch • TAC • ITQ/EA • Dockside Monitoring • Discard/Bycatch	Effort • number of licenses • gear quantity • area closures • season closures • trip limits
	Gear Efficiency • boat size • gear size

Table 2. Classification of Scotia-Fundy Fisheries

	Groundfish	Herring	Offshore Scallop	Offshore Lobster	Inshore Scallop	Inshore Lobster
Catch Management						
Mesh/hook/vent size	■			■	■	■
Animal Size/Berried Females			■	■	■	■
Nursery/Spawning Areas	■			■		■
TAC	■	■	■	■		
ITQ/EA	■	■	■	■		
DMP	■	■	■	■		
Discard/Bycatch	■					
Effort Management						
Mesh/hook/vent size	■			■	■	■
Animal Size/Berried Females			■	■	■	■
Nursery Areas	■			■		■
No of Licences	■	■	■	■	■	■
Gear Quantity						■
Area Closure	■			■	■	■
Season Closure	■			■	■	■
Trip Limits	■					
Boat Size	■		■		■	■
Gear Size				■		■

on gear selection. As expected, the groundfish, herring, offshore scallop, and offshore lobster fisheries all employ regulation of catch. However, these fisheries also employ effort-based regulations, similar to those used for the inshore scallop and lobster resources. The main difference between the traditionally considered catch and effort regulated fisheries is that the latter have a preponderance of effort controls and no control on catch.

Regardless of how effective each approach is, these differences could have serious implications for the costs of the management system. For instance, catch-based management requires the annual calculation of quotas, which in turn requires annual estimates of stock biomass and fishing mortality. Effort-based management in principle only requires annual estimates of fishing mortality. Therefore, stock assessment costs under the latter system should be lower. Costs involved in the distribution of fishing rights to fishers should also be lower under an effort-based system. These rights may have to be annually adjusted under a catch system but not under an effort system. Enforcement activities are also different. Catch-based management should require relatively more monitoring of the catch. However, management systems are complex and without a systematic analysis of the costs of each system, one cannot say with certainty how these costs will compare. This analysis is undertaken later in the paper. First, we will review how successful catch and effort-based management has been in attaining the stated goals of each fishery.

Management Success under Catch and Effort-Based Systems

Since 1977, the Canadian groundfish fishery has been managed under a catch-based system to limit fishing mortality on each stock to the level of $F_{0.1}$. The latter was designed to not only conserve the resource but also to provide high catch rates and thus generate economic benefits (Gulland and Boerema, 1973). However, on the Scotian

Shelf, as elsewhere off Canada's East Coast, fishing mortality has consistently exceeded the $F_{0.1}$ target (Figure 2). While the reasons for this are many (Angel et al 1994), quota management has often been singled out as the main cause for this failure to attain the stated conservation target.

The situation in the herring fishery is similar. The management of this fishery has also been catch-based, with the conservation target again being $F_{0.1}$. Problems in the enforcement of quotas in this fishery have been well documented as part of the annual assessment process. While precise estimates of the fishing mortality are not available, they have likely exceeded the $F_{0.1}$ target. There are current concerns that the resource is in rapid decline (Anon 1995).

The experience with the offshore scallop and offshore lobster fisheries appears to be quite different (Anon 1995). Both fisheries have been managed under a quota system. In the case of the former, the management target of $F_{0.1}$ has for the most part been achieved (Figure 3). In the case of the latter, while a conservation target such as $F_{0.1}$ has not been established, an annual quota of 720t has been set as a pragmatic cap to exploitation. This level has not been exceeded. For these fisheries then, quota management has been successful in achieving the stated goals.

The situation is less clear for the inshore scallop and lobster fisheries, both of which have been managed under effort-based systems. In both cases, there have been no explicitly stated objectives to management. Thus it is not possible to state whether or not a management target has been achieved. Notwithstanding this, the inshore scallop fishery has experienced declining catches and increasing effort in recent years. There are concerns that the resource is in serious decline (Anon 1995). While inshore lobster landings remain at historical highs, exploitation rates are also exceptionally high, with 80 percent of the resource harvested each year (Figure 4). Recent assessments (Anon 1995) of this resource have raised concerns that the apparent high productivity cannot continue in the face of such high exploitation rates.

It is therefore not possible to categorically state that effort-based management has been more successful than catch-based management in attaining conservation objectives. While quotas have been problematical for groundfish and herring, they appear to have been successful for offshore scallop and lobster. On the other hand, the effort-based system used for inshore scallop has been unsuccessful in preventing resource decline. The situation in inshore lobster is less clear. Resource productivity has been high, even in the face of high exploitation. It is not possible to determine the effect of management, if any, in this situation.

It is evident then that catch-based management can work in some situations, but not in others. Some understanding of the differences among these systems - and thus perhaps the reasons for success - can be obtained from a detailed analysis of the distribution of management costs in each fishery. To facilitate this, it is necessary to have a model of a management system.

A Model of a Management System

Organizational models of fisheries systems are relatively rare. This is unusual given the complexity of these systems and the need to rigorously define concepts and definitions. Halliday and Pinhorn (1985) present one of the first such models. It emphasized the need to explicitly consider the fisheries objectives, the strategies adopted to attain these objectives, and the regulatory package, termed the tactics. O'Boyle (1993) developed these concepts further, pointing out that for a management system to be successful, all elements [objectives, strategies, regulations or tactics, and monitoring (assessment)] need to be working together as a unit. This in turn called for effective management structures or institutions. The latest, and perhaps most comprehensive, organizational model proposed to date is that of the Business and Information Model. This model (Figure 5) was developed as part of internal DFO discussions on organizational change in the Department. Its intent is to ensure that not only are all elements of the management system present but also that they function together effectively. This model is therefore ideally suited for use in the comparison of the Scotia-Fundy fisheries.

An effective management system starts with strategic planning. This is where the management institutions and their support, including the legislation for all elements of the system, are created. This module also defines what the objectives and strategies of fisheries management are. From this module flows information into the management planning module. Activities here are associated with the annual prosecution of a fishery, including the development of seasonal harvest plans , including details of the regulatory package. This module is comparable to the Tactics of Halliday & Pinhorn (1985) and the Regulations of O'Boyle (1993). The results of management planning feed into both the fishing entitlements and protection and enforcement modules. The former is involved with licensing and the coordination and administration of fishing entitlements, such as ITQs. The latter monitors compliance with the regulations and takes action against violators.

There are three monitoring modules essential to the planning module. The first, catch and effort monitoring, plays a central role in providing the management planning module with information on the use of fishing entitlements in relation to the harvest plans. Business analysis is the second monitoring module and provides the planning modules with advice and information on all aspects of the economic, social, and business issues relevant to the fishery. Finally, the resource analysis module undertakes the biological stock assessment and associated research.

The last module is that of service delivery. Activities undertaken here involve the management and monitoring of the budgetary resources used throughout the management system. This function is often either ignored or forgotten. However, it is the product of this module that provides us with the information which allows us to compare and contrast the costs of managing the fisheries on the Scotian Shelf.

The Costs of Managing the Scotia-Fundy Fisheries

It is sometimes stated that fisheries generate less wealth than the resources used to manage them. To evaluate whether or not this is true, the Scotia-Fundy Regional statistics on landed and processed value for the groundfish, herring, scallop, and lobster fisheries in 1993 and 1994 were summarized and compared to DFO's Regional costs of managing these fisheries (Table 3). The latter include all aspects of the management system as outlined in the Business and Information Model, but do not include any overhead from non-regional sources.

Table 3. Comparison of Management Costs and Gross Revenue by Scotia-Fundy Fishery

		1993			
Fishery	Landed Value	% Proc	Mgt Costs	% of Land	% of Proc
Groundfish	$126,600,000	262%	$22,854,529	18%	7%
Herring	$16,400,000	717%	$1,778,507	11%	2%
Scallop	$105,500,000	140%	$6,005,897	6%	4%
Lobster	$135,600,000	128%	$8,317,375	6%	5%
		1994			
Fishery	Landed Value	% Proc	Mgt Costs	% of Land	% of Proc
Groundfish	$92,700,000	248%	$18,192,373	20%	8%
Herring	$12,800,000	753%	$2,268,587	18%	2%
Scallop	$115,400,000	140%	$5,070,074	4%	3%
Lobster	$163,400,000	134%	$8,377,240	5%	4%

The landed value of the groundfish fisheries was $127 million and $93 million in 1993 and 1994, respectively. Processed value was about 2.5 times this each year. DFO management costs were $23 million and $18 million in 1993 and 1994 respectively and thus were about 18-20% and 7-8% of the landed and processed value respectively. In comparison, the herring fishery generated relatively low landed value ($13-16 million annually). although processing increased this value by over seven times. Management costs in this fishery were 11-18% and 2% of the landed and processed value, respectively. For scallops, processing increased the landed value of $106-115 million by 1.4 times.

Management costs are 3-6% of the landed/processed value. Finally, the most lucrative fishery in the Region, lobster, generated a landed value of $136-163 million with management costs being 5-6% of this - and even lower when considering the processed value.

Therefore, management costs for all fisheries were not in excess of the value, either landed or processed, of the resource. In addition, if one considers these costs as a fraction of the processed value, the differences in these costs among fisheries are not significant.

These comparisons do not take into account the current state of these resources. In the case of groundfish, resource biomass and thus yield is about 50% below the 1970-1995 average. The decline has been particularly precipitous since 1990 and has not allowed time for the management organization to adjust its overhead costs. In contrast, lobster landings have recently been almost twice the long term. A better measure of the comparison among these fisheries is to consider not the current yield, but the resource's long-term potential (Figure 6). Taking these observations into account, the relative costs of management among these fisheries are very comparable.

What about the distribution of these costs among the various management activities as outlined in the Business and Information Model? To examine this, the detailed expenditure information for 1993/94 and 1994/95 was classified according to the modules of the Business and Information Model. For the purposes of this exercise, the percent distribution of costs by fiscal year were averaged to provide one estimate per module for each fishery. Understandably, the expenditures were not initially recorded with the Business and Information Model in mind. This made classifying the information difficult and, as a consequence, some of this was necessarily subjective. Notwithstanding this, in the case of resource analysis and protection/enforcement, the two main modules in all these fisheries, the classification is relatively accurate. The problem in expenditure classification s outlined here underlines the need for an effectively designed service delivery module.

When comparing the distribution of management costs for groundfish to those of herring (Table 4), it is clear that the resource analysis costs for herring are relatively high. Indeed, this resource exhibited the highest relative expenditure on resource analysis of all the fisheries examined. In contrast, the protection/enforcement costs were relatively low and again were lower than for the other fisheries. This is consistent with the relatively lean package of regulations employed in this fishery (Table 2).

Table 4. Distribution of Groundfish and Herring Management Costs by Module of the Business and Information Model

	Groundfish	Herring
Strategic Planning	3.37%	1.37%
Business Analysis	3.56%	6.24%
Resource Analysis	30.96%	56.45%
Service Delivery	12.99%	12.24%
Management Planning	1.92%	0.90%
Fishing Entitlments	0.11%	0.16%
Catch/Effort Monitoring	2.52%	2.81%
Protection/Enforcement	44.58%	19.84%

The distribution of management costs of the inshore and offshore lobster fishery are given in Table 5. Resource analysis costs are 15% of the total for the inshore resource and 9% of the total for the offshore. The protection/enforcement costs appear to be relatively high, being 58% for the inshore and 67% for the offshore resource. In comparing the resource analysis costs for the lobster fishery with those of groundfish and herring, one could conclude that effort-based management is less costly. However, this is not a fair comparison. It is more appropriate to compare the resource analysis costs between the inshore (effort-based) and offshore (catch-based) fisheries. When this is done, it appears that relatively more costs are incurred in the effort-based fishery, contrary to the notion that catch-based systems require relatively more funding on resource analysis. The relatively high enforcement costs of the offshore are in line with expectations although those of the inshore are not insignificant and indeed exceed those of groundfish on a proportional basis.

Table 5. Distribution of Lobster Management Costs by Module of the Business and Information Model

Business Analysis		1.23%	3.89%
Resource Analysis		14.68%	8.73%
Service Delivery		12.57%	12.60%
Management Planning		2.70%	2.80%
Fishing Entitlments		0.64%	0.01%
Catch/Effort Monitoring		7.20%	1.21%
Protection/Enforcement		57.73%	67.30%

In the scallop fishery (Table 6), the resource analysis costs for the effort-regulated inshore fishery are higher than for the quota-based offshore fishery. This is again contrary to expectations. Here too, a relatively high percentage of funding is directed towards enforcement. Overall, the distribution of costs in the inshore fishery is not dissimilar to those in groundfish, with apparently the same net result in resource management.

Table 6. Distribution of Scallop Management Costs by Module of the Business and Information Model

	Inshore Scallop	Offshore Scallop
Strategic Planning	2.52%	3.10%
Business Analysis	2.93%	1.70%
Resource Analysis	27.61%	18.03%
Service Delivery	14.03%	12.52%
Management Planning	2.08%	2.55%
Fishing Entitlments	0.27%	0.04%
Catch/Effort Monitoring	4.02%	2.01%
Protection/Enforcement	46.53%	60.05%

In summary, the distribution of resource analysis costs between comparable catch and effort-based fisheries was not in accordance with expectations while those for protection/enforcement were. Indeed, for those fisheries that have been management successes, a relatively high proportion of funds have been expended on enforcement. This could be a reason for this success. However, this would require further examination. No comment could be made on the distribution of costs among the other modules due to the subjective nature of the classification.

Concluding Remarks

It was apparent that management under either catch or effort regulations had difficulty in attaining conservation objectives, when these were stated. It is interesting that the two fisheries that have been relatively successful have been under catch-based management. Therefore, one cannot say categorically that effort-based management is superior to that of catch. Also, the overall costs of managing either system were in general less than 10% of the resource's processed value, indicating that either approach can be cost effective. Regarding the distribution of these costs, there was a slight tendency for resource analysis costs to be higher under effort-based management. This was unexpected and the reasons for this are unclear. Further examination of the information is necessary to validate this observation. While there is a hint of a direct relationship between enforcement costs and management success, it is by no means strong. Certainly, effort-based management appeared cheaper to enforce than the comparable catch-based system. However, the latter appeared to be achieving their management objectives while this was not so obvious in the case of the former. Again, further investigation of the information is required to confirm this observation.

It is evident then that catch-based management can be a cost effective means to manage fisheries. What is important is getting the balance right among all the interacting elements of the management system. The observations made here give some clues as to what the appropriate balance is but need to be validated through further examination of the Scotia-Fundy information and expansion of the analysis to other fisheries elsewhere.

Acknowledgements

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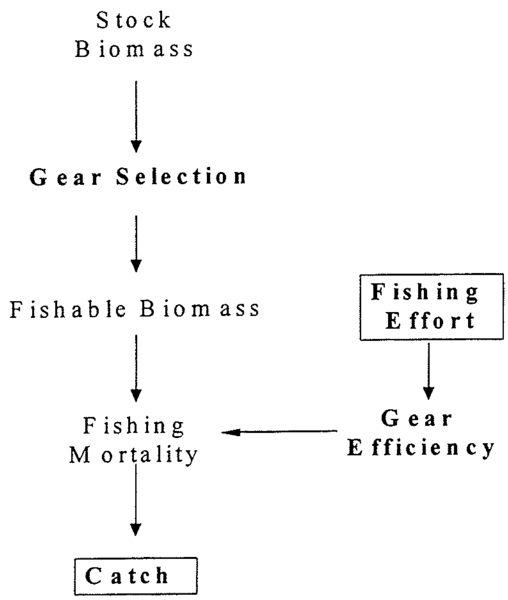

Figure 1. Features of a Regulated Fishery

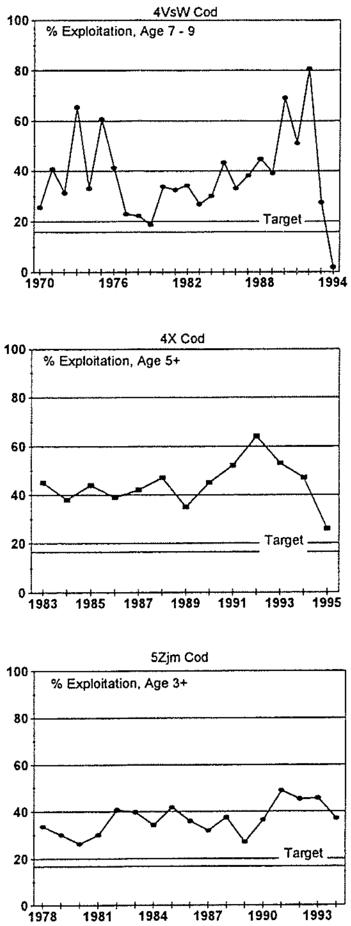

Figure 2. Fishing Mortality Trends for the Scotian Shelf Cod Resources

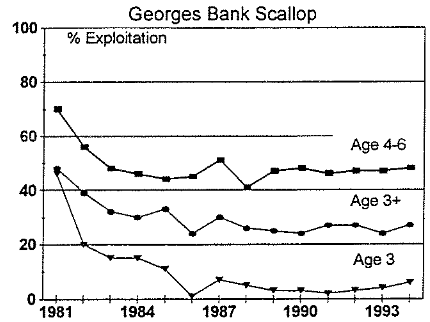

Figure 3. Fishing Mortality Trends for the Offshore.

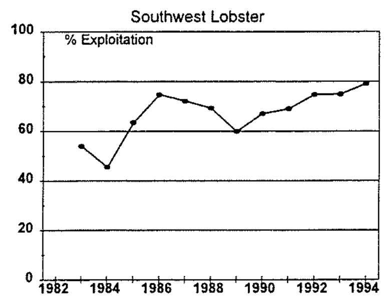

Figure 4. Exploitation Rates Trends in the Inshore Lobster Resource

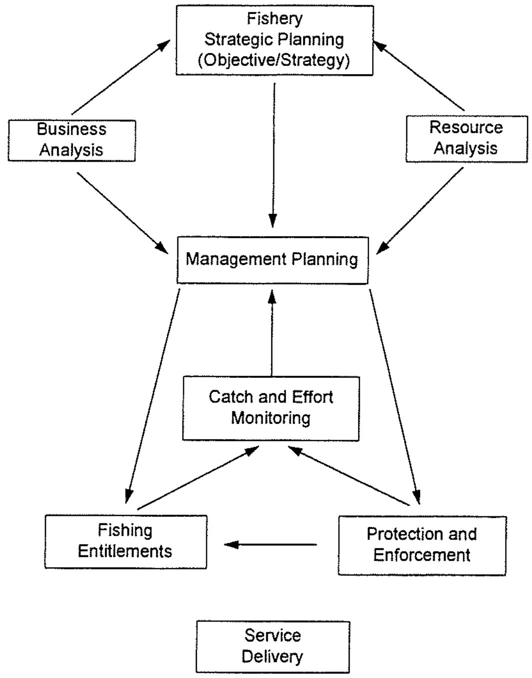

Figure 5. The Business and Information Model

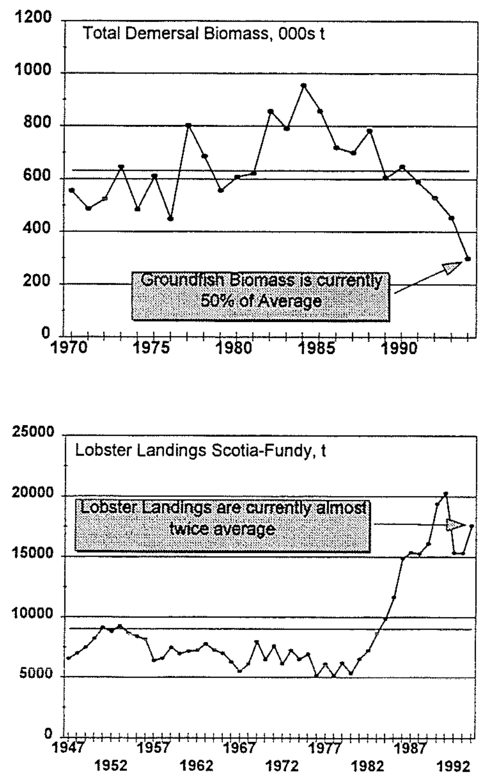

Figure 6. Trends in Resource Potential of Scotia-Fundy Groundfish and Lobster Fisheries

Social Responses to ITQs: Cheating and Stewardship in the Canadian Scotia-Fundy Inshore Mobile Gear Sector

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Introduction

Assessments of twenty years of quota management in the Scotia-Fundy Region presented at a 1993 Department of Fisheries and Oceans (DFO) Workshop concludes that management failed to prevent overfishing (Angel et. al. 1994). The report cites a number of factors, including: conflicting management goals that were sometimes unspecified; limits of information about the dynamics of stock recruitment; ecological changes affecting recruitment success; rising mortality from seal predation in some areas; and quota busting because of high levels of cheating that DFO could not control. This study addresses the cheating issue with a case study focusing on social responses to the individual transferable quota (ITQ) system for the inshore dragger Scotia-Fundy fishery.

Overfishing has threatened most of the world's commercial fish stocks. We need to identify the strategies to prevent overfishing and restore our stocks to their former abundance. A successful fishery management strategy must build in individual incentives to comply with limits on effort. In small-scale fisheries, local-level social controls and highly effective information systems assure that individuals find it in their own best interest to limit use to levels the community prescribes and the ecology dictates (see for example McCay and Acheson 1987). In modern complex fisheries, however, there are significant incentives and many opportunities to cheat federal regulations. Moreover, the mythology of fishing supports a "chaos view" of the fish as unlimited and subject to Nature's, not Man's, control, contrary to the models fishery managers use (e.g., Smith 1995). The fishermen's chaos model ratifies cheating as a morally and pragmatically sound strategy for fishers. Therefore, the problem for federal fishery managers is to design a system that increases incentives for individuals to comply with regulations, given the limits of social control and the incentives and opportunities to cheat in a modern, complex fishery.

The aim of this study is to identify and analyze how the rules for fishing affect levels of cheating with a case study of the inshore mobile gear ITQ fleet. This study focuses on the relationship between rules and behavior on the assumption that individuals consider the law and the norms of their society when deciding on actions they believe to be in their own best interest. A fishery managed by ITQs was chosen because proponents claim that ITQs can prevent overfishing by changing individual incentives so that fishers gear sector radically changed the rules that affect how people can make a living in this fishery. This study focuses on how people are adapting to those rules and how as they adapt they either promote or frustrate the fishery management plan's goal of restoring the fish to sustainable levels.

This is a follow-up to last year's community study of social responses to ITQs in the Scotia-Fundy inshore mobile gear fishery. That study had three important results: (1) ITQs were concentrating into the hands of those who had the capital to buy them; (2) the resulting shift in economic power was straining social relations in the village; and (3) many owners, captains and crewmen said that cheating was dropping. People attributed reduced levels of cheating to introduction of square mesh, the dockside monitoring program, tough administrative sanctions, and the incentive to save fish for the future that the ITQ system made possible. It appeared that the ITQ system made it easier to comply with the rules and very costly not to. In addition, captains, owners and crew said that the closures in the Atlantic Canada and United States groundfish fisheries made them feel, for the first time, that fish were a limited resource that needed to be husbanded if they were to have a future as fishers. This latter result indicates that fishers can change their models of the resource, exchanging the more traditional "chaos model" for a view of the resource as limited, fragile, and in need of husbanding.

What is interesting about these findings is that it suggests that fishery management rules can reduce levels of cheating, if effective rules can be identified. The study also suggests that there was some credence to the claim that ITQs foster stewardship, even among those who are not IQ owners, the crew and the captains. These results need to be tested, given the sorry state of fisheries around the world and the controversy over whether ITQs will prevent overfishing, as well as overcapitalization.

Methodology

Open-ended and semi-formal interviews were conducted in a one-month period between the middle of August and the middle of September in three Southwest Nova areas: West Pubnico, Digby, and Digby Neck. Most interviews were with vessel owners and captains, although a few crew, fishery managers, industry managers, plant workers, and other fishers were also interviewed. People were told that the results would be presented to DFO and that the purpose was to give people in the fishing industry an opportunity to suggest ways to improve sustainable management in this and other fisheries.

The research method used is called Rapid Assessment. Rapid Assessment is a qualitative analysis used to identify attitudes and predict social responses to change. Studies comparing rapid assessment with more traditional and costly surveys show that rapid assessment brings in the same results with the same degree of dependability as statistical analysis. Indeed, Rapid Assessment is more effective for revealing "off the record" information that is actually shaping choices people are making (NAPA 1991, Chambers 1992, US Forest Service 1992). This makes Rapid Assessment especially suited to the subject of this study.

Both group and individual interviews were conducted. In addition, there was a good deal of "participant-observation": participating in discussions about cheating and the ITQ system. Individual interviews lasted between 30 minutes and an hour and a half. Although interviews were open-ended discussions, there were a few set questions asking people to evaluate the ITQ system and discuss specific kinds of cheating. People did not always answer these direct questions. People were not pressed for specifics, given that they were being asked to talk about violations that carry severe sanctions. By combining these fairly informal methods, people were able to specify the relationships between attitudes, practices, norms, and the law. This must be done if you are going to identify how management rules will be perceived and responded to. The other check on accuracy was the practice of "hanging out" while people talked; anecdotes and jokes contain a lot of truth about how people are responding to the rules of their society.

A total of 61 individuals were interviewed, of which all but seven were captains for vessel owners. Sixteen were part of group interviews (two or more jointly answering the questions). There were 56 interviews, 36 of which were with individuals who discussed cheating at length and in some detail.

Although this is not a quantitative study, qualitative research requires that sources be representative. The criteria selected were the home ports of the vessels and the active vessels in each port (and then the owners of ITQs who have inactive vessels). There were 14 Digby interviews, 20 Digby Neck interviews, 20 Pubnico interviews, and two Yarmouth interviews. Interviews with owners and/or captains were conducted with 16 of the 18 active boats in the Digby or the Digby Neck areas. Four people who were selling quota and had tied up their Digby or the Digby Neck boats were also interviewed. In West Pubnico, two captains and at least one owner of each of the four plants were interviewed, along with two of the independent owners/operators.

Captains and vessel owners were targeted in order to get the most information in the short time available for the study. If there had been more time, crew would have also been targeted. The other interviews were with people in the following categories: crew, plant workers, groundfish generalists, government employees, industry representatives, and managers. The information from all these interviews is used to contextualize what the captains and vessel owners said.

Because the same questions were not asked in each interview (as in a survey), this is not a statistical analysis; but as part of the analysis, interview data were quantified for analysis. Where there is a significant finding among the 36 captains and owners interviewed alone and at length, these will be noted. These findings are generalizable, since they are based on representative samples.*

Summary of Results

There is good news and bad news from this study. The good news is that most people felt that cheating in general has dropped in the last year. There is also good news in the fact that people were in general agreement that fishing effort must be controlled and that the days are over when fishing can be an extraordinary game in which the highliner captains compete for the most pounds of fish and highest success at circumventing the law.

The bad news is that these changes are largely driven by enforcement and the regulatory environment. Two major reasons for the drop in cheating are the strong sanctions and dockside monitoring. A number of people have said that cheating was down partly because the fleet has shrunk as the TACs have been reduced, indicating that the rates of some kinds of cheating may not have changed. Thus, one conclusion we can draw is that sustainable management depends on a fishery management regime that increases fishermen's certainty that they will get caught if they cheat, and if they get caught they will get sanctions that hurt. The relationship between the culture of fishing and the regulatory environment is summed up by a captain and plant owner who agreed that: "It wasn't cheating when there were no sanctions."

There is other goods news regarding the effect of rules on levels of stewardship. Those who want to husband fish like ITQs because they know someone else cannot catch (or at least land) the fish that conservation-minded fishermen leave in the water. In addition, the square mesh net very much helped captains motivated to reduce their dumping by letting small fish, and to some extent unwanted species, escape from the net.

I now turn to details of the study, beginning with more discussion of people's views of the ITQ system.

The ITQ System in the Context of Sustainable Management

Most people think that the ITQ system has benefited the fishery by saving fish and helping to improve the price of fish. Those who dislike ITQs feel strongly that the system is fostering a concentration of power into companies' hands, and some feel that ITQs have increased incentives to highgrade or dump fish. Of the 36 individual lengthy interviews, 91% thought that overall the ITQ system was better for them or both better and worse than a competitive system. A few (19%) stated specifically that ITQs had "saved the fishery" by cutting back on overfishing.

The most prevalent reasons for liking ITQs were that owners and captains could decide when to fish so as to avoid bad weather and market gluts. Digby and Digby Neck vessel owners liked knowing that they could wait until summer to catch their fish because they knew the larger Southshore boats could not catch up the quota during the winter months, as they had done in the competitive fishery. Those who had dual licences or lobster boats liked knowing they could choose when to catch their ITQ species, based on their fish portfolio in both fisheries.

Although not directly related to the ITQ system, there was a generally positive view of the trend toward giving the industry a greater voice in setting TACs. The industry resource survey was often mentioned as an indication that the government biologists might be willing (at last) to incorporate industry's knowledge of how fisheries function into the biologists' models.

A major objection to ITQs is the concentration of quota, mentioned by half of those who said they either disliked ITQs entirely or had mixed views. As in the 1993-94 study, crewmen and captains did not like "armchair fishermen" making money from selling quota which crews paid for through reduced crew share.

In addition to social concerns, another minus for the ITQ system directly impacts on sustainable management. The system's vastly improved capacity to control landings has not been matched with a similar increase in ability to set TACs that match the mix of fish in the water. This problem is made worse because initial ITQ allocations were sometimes based on false landings reports, so that at least some and maybe many ITQ holders have fish portfolios that don't match what they historically caught and need to catch now. These problems have become worse as the TACs have been cut. Those who made these points reiterated them when discussing rates of dumping in the fishery.

Remedies

- Shorten the government's response time in adjusting TACs to match information about the stocks.
- Include industry in the assessment process (as is already being done).
- Allow individual quota holders some leeway in rolling over quota and quota deficits into the next fishing year, based on industry input on what will not threaten effective quota management.

Cheating

In general, levels are dropping overall because of vessel sanctions, dockside monitoring, or stricter enforcement of the fish plants. Other factors cited were the introduction of large square mesh requirements and a change in attitude among vessels and fishermen. However, a few said that the reason was that there were fewer boats fishing, indicating that they thought the rates of cheating may not have changed as much as the number of cheaters.

Dumping Fish (Quota Dumping)

There is less dumping this year than last year, but dumping remains a significant problem in the fishery. There are mixed views on whether introduction of ITQs increased dumping, since people were able to land just about all they caught under the competitive system. Sanctions, square mesh net, and an increasing willingness to "fish the mix" of fish all contributed to the trend in reduced dumping.

Dumping levels are very much influenced by the current match of ITQ allocations and the mix of fish in the ocean. Thus, there may be very little dumping during some times of the year and much more at other times. While some captains may move off the grounds to avoid dumping, their place may be taken by other captains who are willing to dump. As one captain put it, "it only takes a few to ruin it".

Norms

No one likes to kill fish and throw them overboard; everyone makes that clear. Digby and Digby Neck fishermen point out that transshipping, illegal since the early 1980s, nevertheless was better than dumping, since the dead fish were sold rather than dying in vain. But people also make it clear that people will dump if they feel they have no choice. Captains point out that their first duty is to their crews, themselves, and (in the case of company boats) the boat. Some individuals and some companies are more prone to dumping; others try to make sure their boats dump as little as possible. Dumping is likely to rise when an individual has run low on quota and cannot or will not buy any; so that TACs must be crafted to match the mix of fish in the ocean.

Given these problems, why is dumping decreasing? The trend is driven by changing skills, attitudes, and the introduction of large square mesh cod ends.

Captains are learning to "fish the mix" (by targeting non-ITQ species and getting a bit of CHP each trip), to avoid fish so they have quota for later in the year, and to use their knowledge of historical patterns to fish for a mix of fish that more closely matches their portfolios. Some captains are farther along this learning curve than others, and these strategies require sufficient ITQ in the first place. "Paper trades" of quota make it easier to decide to bring in fish you were not targeting, rather than dump them.

Attitudes are changing because people are finding that they can make a good living catching fewer fish for the market - timed landings to higher prices. This realization makes it easier to practice husbandry, since conservation practices go hand in hand with savvy business practices.

Square mesh make a significant contribution to this calculus of what constitutes a fishing business or captain's self-interest. The square mesh net helps to make "fishing the mix" possible by culling out small CHP.

Remedies

- The government must also improve its skills, learning how to adjust TACs to match the fish in the water.
- The more flexibility in transferring quotas for fish caught the better.
- Should fixed gear sectors be put on ITQs, allow trades between individuals from any sector with an ITQ system.
- Require 100% observer coverage when industry and government know dumping has been historically high (such as the fall spawning tow), but allow those with sufficient quota to continue fishing.

Highgrading

Highgrading is driven by the market. Square mesh, used properly, does a lot of "highgrading" in the water, so that fish there are far fewer small fish that come up in the net. But there is highgrading if there is a demand for very large fish, like "steak cod" or if the Boston market is offering significantly more for pound for very large whole fish.

Because of the sanctions, people are not telling if they are highgrading fish, so it is difficult to get a solid sense of how much is going on. Highgrading appears to be down, compared to last year, largely because there is not a sufficient price difference in the legal sized and very large size fish.

Square Mesh

Square mesh is universally cited as "the best thing they have done" for the fishery. As already discussed, square mesh:

- reduces dumping and highgrading;
- "straightens the price right out" by keeping small fish off the market;
- is integral to the changes in attitudes that go hand in hand with reduced levels of cheating.

Square mesh proponents generalize what they have learned about selectivity with square mesh to discuss how other gear types could reduce unwanted mortality with the right size and type of gear.

Square mesh proponents would very much like the EA fleet to have similar square mesh requirements so that fish the inshore fleet saves are not caught by the offshore fleet before they reach their maximum potential value.

Transsshipping

Transshipping has dropped this year because of sanctions and more effective monitoring of fixed gear landings and a current climate of distrust between the mobile gear and the fixed gear fleet. However, transshipping was a significant problem in some ports until this year, not only between fixed and mobile gear boats, but between different kinds of fixed gear. Because of sanctions, it is difficult to assess the actual levels of transshipping.

Based on stores about transshipping in the early 1980s, it seems that transshipping has been a significant part of fishing in Southwest Nova since the introduction of quota regulations. Transshipping may have increased after ITQs were instituted as a way to circumvent the dockside monitoring program. As already noted, transshipping has a positive side in that transshipping stops the dumping of dead fish.

Remedies

Improve enforcement and monitoring of all sectors, as discussed in the enforcement section below.

Filleting

If people are filleting fish and sneaking them past the weighmasters, they are not talking about it, so people say it is hard to know just how much is going on. Nevertheless, there seems to be a general trend downward.

One reason why filleting may be on the decline is that there are fewer buyers. Large square mesh has just about eliminated the small fish used in the past for unreported sales of "popcorn fillets" to local smoking plants. Sanctions on plants for buying illegal fillets had an effect; and crews who might in the past have filleted fish, now must measure those dollars against the possibility of having the boat tied up if they get caught.

Coming in Without a Hail

This is the least likely violation of the ITQ regime. The chances of getting caught are high and the sanctions are severe. There are some regional differences, depending on the likelihood someone will see a boat landing without a weighmaster present, report it, and the fishery officers can catch the offender. People say there has been "practically no" or "no" landings without a weighmaster in Pubnico this year or last year, few if any in Digby Neck this year, and some this summer in Digby (and in other areas not studied).

<u>Enforcement</u>

Views on the effectiveness of enforcement differed greatly by region and according to whether people were talking about on-land or at-sea enforcement. People judged the fishery officers by the way they were enforcing all fisheries, not just the inshore mobile gear sector. Thus, discussions of the effectiveness of the fishery officers often moved to discussion of enforcement in the fixed gear and lobster fisheries.

People in Digby Neck were the least happy with enforcement. Captains said that they had not seen a fishery officer since the weighmasters were hired, except when the officers ride around in their trucks. People also noted that it is difficult to enforce in an area where there is one main road, so that the fishery officers are "outgunned" by the fishermen with a cellular telephone. At the time of the interviews, there was a good deal of criticism in Digby and Digby Neck of the enforcement officers because they had not caught a known violator who had been reported frequently.

In Digby, there were fishery officers regularly at the wharf, especially this summer. Like those in Digby Neck, people felt officers spend too much time riding around in their trucks.

Pubnico is a port where the fishery officers are "right next door," so that land-based enforcement is very effective. Also, the wharf used by the draggers is very busy, so it would be very unlikely anyone could come into the port without it being noted. Although not everyone would report violators, it is pretty certain that someone would. Although land-based enforcement is highly effective in Pubnico, at-sea enforcement is not because the helicopter is either not operating or unable to operate often.

<u>Remedies</u>

- Fishery officers would be more effective on Digby Neck if they did "undercover observations" in the small ports where the boats normally do not land which therefore provide a good place to land illegal fish.
- Fishery officers should also check trucks for illegal fish.
- Fishery officers should not rely on weighmasters for uncovering fishery violations; they can be checking for hidden fish while the weighmasters are working.
- Reinstate an active helicopter based in Yarmouth to reduce at-sea violations (but this assumes that people cannot warn boats via the cellular phone that the helicopter is coming).
- Compare the fishing trip records ("lat-lines") and weigh-out data from vessels towing in the same areas at the same times. Those who have been dumping will have a different mix of fish. Those suspected of dumping would be required to have observers onboard.

Dockside Monitoring

As already noted, the weighmaster program has been highly effective at keeping track of landings. Weighmasters are generally judged to be doing their job, although they are sometimes too rigid (according to some fishermen) and they could be fooled about whether or not there are illegal fillets on board.

Remedies

Fishery officers should continue to take responsibility to inspect vessels, even though the weighmasters are weighing out the fish.

Conclusions

The rules for fishing that were designed into the ITQ system for the inshore mobile gear fleet have changed attitudes and practices so that, overall, cheating is dropping. Although much of these changes are driven by the regulatory environment, captains and vessel owners are learning that stewardship can be profitable. Several suggestions for further reducing cheating have been suggested by industry members. These should be discussed further to identify those strategies on which there is an industry and government consensus that they would be effective.

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* Rapid Assessment techniques can be used as the first step in designing a survey.

Potential Improvements to Groundfish Management

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The current management system is based on a species quota system with a fixed (any given year) percentage for each fleet sector. This requires accurate monitoring of all fish killed for each vessel.

Many have argued the quota system hasn't worked and that effort-based systems should be introduced as a replacement. The ability to monitor the fishing mortality is what has failed as opposed to the quota system itself. The amount of resource that is removed in any given year from any stock has to be limited and there appears to be few other methods that can accomplish this without significant increases in workload either by DFO or the industry.

In the past couple of years, the fishing mortality in 4X has decreased along with a decrease in the fishing effort due to the decreased quota and the stricter enforcement of the actual quota. Prior to 1994, the quotas were not adhered to as bycatches were permitted when the quota was reached and at times a specific gear quota could be exceeded by more than the quota itself.

Even under an effort system, the landings would still have to be counted and there is no saving of resources by assuming that the quota system would no longer be required. There is minimal debate on what a pound or kilo weighs, yet artificial effort units would be cumbersome to define and easy to circumvent by industry. Under deck tonnage, fishing days, horsepower, number of crew, size of hooks, etc., would surely be impossible to track or monitor. One simply has to look at the effectiveness of the US system which relies on stock rebuilding by reducing the effort days.
The ultimate effort control system remains the amount of quota that is available.

The following represents some of the solutions that have been suggested or proposed by DFO and industry members to improve groundfish management and are presented today to stimulate discussion.

Burke, D.L., R.N. O'Boyle, P. Partington, and M. Sinclair. 1996. Report of the Second Workshop on Scotia-Fundy Groundfish Management. Can. Tech. Rep. Fish. Aquat. Sci. 2100: vii + 247 p.

Potential Improvements

1. Quota Shares

    - Resolve the current preoccupation about fleet sector shares to allow industry to focus on conservation issues.

2. Reporting System

    - Landing data has improved significantly in the last number of years with the implementation of dockside monitoring programs and the fixed gear reporting system.

    Further improvements could involve:

    - mandatory third party weigh outs;
    - detailed daily logs for all vessels;
    - lifetime sanctions for deliberate misreporting and transhipping;
    - provincial licence sanctions for processors that collaborate in misreporting catch of the fishermen;
    - electronic logbooks and black boxes.

3. Discards

    - Unreported discards compromises a quota system and increases the fishing mortality by an unknown factor; industry in cooperation with DFO must find a workable solution to solve this wasteful practice.
    - Education of the fishermen and the development of a strict code of conduct will help eliminate this practice.
    - Prohibit any trip limits and encourage a land-it-all policy.
    - Develop a discard index through observer reports and at-sea monitoring and close the fishery prematurely to account for discards.
    - Impose a lifetime licence suspension for any discard offence.
    - Eliminate the authorized discarding of some species to simplify enforcement of no discards.
    - Develop flexible small fish protocols that allow for changing the % of small fish depending on year-class abundance.
    - Develop computer models that identify size and species mix anomalies in landings to target individuals for observer coverage.
    - Include days-at-sea requirements for IQ or EA fleets based on an expected average catch per day. Any vessel that did not catch its quota within the allotted days could continue by paying for an observer. Allotted fishing days would be transferable with appropriate quota. Would require a vigorous check in and out system paid for by industry.

- Require video cameras on vessels connected to navigation instruments.

4. Improved Gear

- Review the conservation aspects of each gear type and change the non-desirable aspects.
- This may mean that gillnets may have to be tended at all times to reduce lost nets and also to eliminate waste from dead fish resulting from infrequent tending.
- Mobile gear may have to modify the "road kill" aspects of the rollers, while longline gear may have to improve the size selectivity.
- Review biodegradable measures for gear.
- Further use and studies of grates and square mesh for species such as redfish.
- Combination of mesh size and grates could exclude both large spawners and juvenile fish.
- More tests on use of horizontal panels to separate species.
- Test fisheries prior to any opening.

5. Capacity Reduction

- Overcapacity is not a concern as long as it doesn't compromise conservation goals or ability to monitor.
- In reality, overcapacity does compromise conservation through overcapitalization which in turn results in an individual misreporting to pay for their investment.
- Monitoring is also compromised as fishers seek to recoup costs as their demands are more than the resource can stand.
- Rights-based fisheries can reduce capacity.
- Capacity can be reduced by doubling licences where an individual must have two licences on one boat to fish or even three (industry buy-out).
- Limit number of vessels fishing at any one time or take turns on even or odd months depending on CFV number.

6. Gear Conflict

- Gear conflict should be resolved by the industry itself similar to the "rules of the road" for seamanship. Good code of conduct on the water should be developed.
- Develop gear zones.
- Prohibit mobile gear in nearshore areas based on depth corresponding to maximum depth of light penetration.
- Revoke small dragger exemption order and prohibit stationary gear in offshore areas.
- Separate monthly fishing times for different gear types where smaller vessels fish only during summer months while larger vessels fish winter months.
- Most of the above measures are outside of the core mandate for DFO and industry would have to develop and police gear zones.

7. <u>Management</u>

- Smaller government infrastructure with more regional or area control.
- Local management of smaller groups may result in greater industry control of fishing practices and greater respect for harvesting plans.
- Partnerships would help achieve greater industry control and allow for more self-policing.
- With partnerships, DFO has to be willing to let go of some of their past responsibilities and be confident that industry is more than capable of handling the task.
- All measures or problems mentioned above could benefit significantly by increased communication and education. After all these years, we assume that industry is aware of the concerns yet we are constantly reminded that there are still many out there that have their heads buried in the sand. Fishermen need stronger associations and a more united industry, which includes cooperation among all gear sectors.
- In the words of an industry representative, "Even ostriches flock together when they remove their heads from the sand," which is not the case with the current industry.

Recent Changes in the Management and Handling of DFO Landings and Effort Data in the Scotia-Fundy Fisheries - Maritimes Region

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Introduction

Back in the late 1980s there was agreement by both the Department of Fisheries and Oceans (DFO) and the fishing industry that the landings and effort data collected was problematic (see Table 1). The data was not timely; it was not complete (documents were missing some information and documentation was missing for entire trips); and the accuracy of the data provided to the Department was questionable. There have been major changes in the management and handling of landings and effort data from groundfish fleets in Scotia-Fundy in the past five years to address these problems.

Table 1. DFO Data Problems Identified in the Late 1980s

1.	Timeliness
2.	Completeness
3.	Accuracy

Onset of DMP and CR

The changes in data handling that have occurred have been made possible with the onset of industry funded data management programs. In 1991, the Dockside Monitoring Program (DMP) was introduced for both the IQ and the Generalist fleets and in 1992 for the EA vessels. In 1995, the remainder of the vessels fishing groundfish (fixed gear <65') went on a Catch Reporting (CR) system. Both of these programs require that industry fund an independent monitoring company to collect the landings and effort data and enter this data into the DFO Catch & Effort computer system.

These programs have allowed for the transfer of responsibility of many of the data collection and entry functions (previously done by the Department) to the monitoring companies. The following table shows the data handling tasks required, who was responsible for these tasks prior to the onset of DMP & CR (THEN) and who is responsible for their completion in 1995 (NOW).

Burke, D.L., R.N. O'Boyle, P. Partington, and M. Sinclair. 1996. Report of the Second Workshop on Scotia-Fundy Groundfish Management. Can. Tech. Rep. Fish. Aquat. Sci. 2100: vii + 247 p.

Table 2. Data Handling Responsibilities of the DFO Landings and Effort Data Before and After DMP and CR were Introduced

DATA PROCESSES	THEN	NOW
1. Document collection		
- physical collection	DFO	MC
- preliminary check/edit	DFO	MC
- delivery to data entry location	DFO	MC
2. Data entry of document		
- secondary check/edit	DFO	MC
- entry into DFO computer system	DFO	MC
- check/edit of computerized data	DFO	DFO
3. Reporting		
- quota monitoring	DFO	DFO
- ad hoc reporting	DFO	DFO

All of the document collection and data entry functions (except the final checking and editing of the computerized data) were DFO's responsibility and are now done by monitoring companies for all of the groundfish fleets (see Table 2.). The checking of computerized data has become much more sophisticated and comprehensive over the past three to four years, thereby increasing our confidence in the accuracy of the data. The reporting on the data which is done by both DFO Statistics and Science personnel continues as a DFO responsibility. The quota monitoring function has changed from its reliance on estimation techniques to using a combination of hail and hard data. The adhoc reporting and requests for information in 1995 are more complex than those in 1990 because of the increase in the amount and variability of the data captured today.

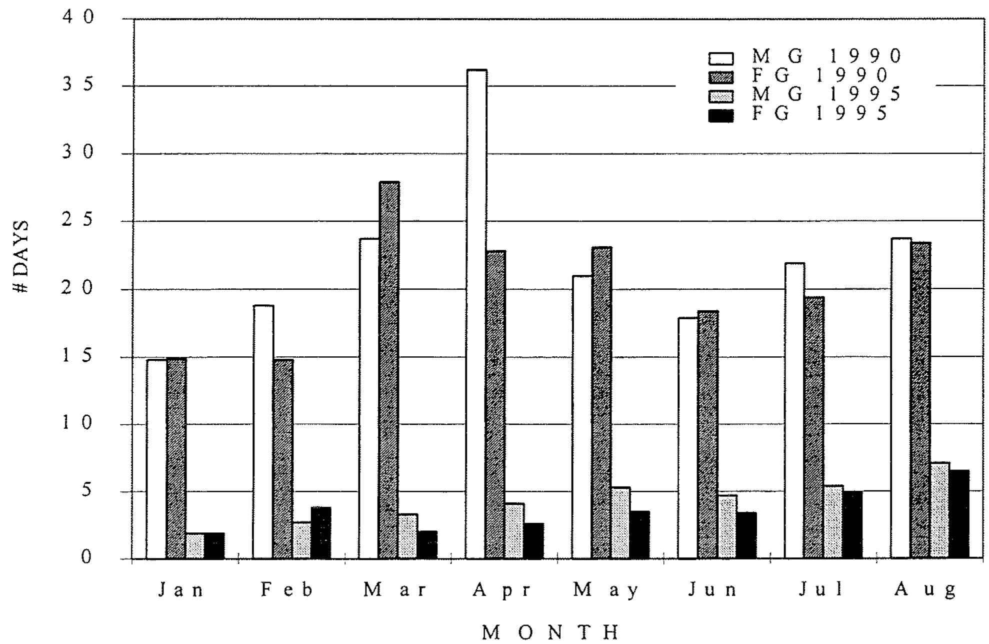
Timeliness

Pre-1991, when all data documents were handled and managed by DFO, there were ongoing problems with the timeliness of the data. Fishery officers would visit fish buyers on a regular basis and collect whatever slips were given to them at that time. There were several problems with this process. In a fishery managed by competitive quotas there was incentive for the buyer to hold back slips and not give them to the fishery officer until a much later date. This was a fairly common occurrence. Also the collection of documents from the buyers was one of many priorities on the fishery officer's work schedule, often making collection an irregular activity. Because of these actions, large batches of slips were collected at a time, creating a backlog in the data entry process. At certain times, it could have been six to eight weeks from the date the fish was landed to the date it was entered into the computer system.

It is now the fisher's responsibility, not the buyer's as it was in the past, to complete the documentation and get it to the monitoring company within a specific period of time. The documentation is handed directly, faxed, or mailed to the company. The monitoring company is also required to enter the data within a specified time period. All of these result in more timely data.

Figure 1 shows the average time it took in 1990 and what it takes today to enter a slip into the DFO system. This graph indicates the difference in the number of days from the day the vessel landed the fish to the day the fish was entered in the system averaged on a monthly basis. The average has decreased from approximately 15 to 20 days when DFO was responsible for data collection and entry to three to four days today. Timeliness has increased greatly under DMP & CR because of these process changes.

Figure 1. Average Number of Days to Collect and Enter Data into the DFO Catch and Effort System (DFO - 1990 / Monitoring Companies - 1995).



Completeness

Another aspect of the data targeted was its completeness. The problem was in trying to determine if all trips were being reported to DFO. It was difficult to tell in past years; since the data was not timely, fishery officers could not be sure if there were documents to cover all trips and the general attitude of many fishers was that there was no harm in not reporting their landings. Since 1991 that attitude has changed.

Today it is the fisher's responsibility to ensure that documentation of the landings gets to DFO, while in 1990 it was the buyer who supplied this information. Each fisher today must hail to a monitoring company their landing time, port, and an estimate of the fish they have on board. This is a requirement of their licence condition. If they don't do this or give false information they are subject to the sanctioning process. This seems to be a powerful deterrent for most participants. With complete hail information, it is an easy step to ensure that DFO gets the documentation and therefore the full coverage of the landings.

A problem has arisen because of this change from buyer to fisher that results in less accurate price data. Since the documents are now collected from the fisher, the price information is often not available at the time of collection. The Department therefore has had to depend on a combination of random price slip collection and average pricing, which are less accurate than the previous system which maintained direct contact with the buyer. To address this problem, it may be necessary to set up a regular price reporting system with the buyer.

Although the completeness (coverage) has improved, there still remains a problem with the completeness of effort information collected for some vessels types. Effort information is defined for this instance as the presence of a log document.

Table 3. Groundfish <65' Trips and Landings and the Percentage With Effort in 1990 and 1995

1990

FLEET	TRIPS		LANDINGS	
	#	% with effort	(t)	% with effort
MG <65'	9740	64%	51090	80%
FG <65'	36840	11%	67490	25%
TOTAL	46580	22%	118580	49%

1995 (As of Sept 30/95)

FLEET	TRIPS		LANDINGS	
	#	% with effort	(t)	% with effort
IQ/GEN	3100	100%	16200	100%
FG - trip	2490	100%	10580	100%
- week	10680	0%	4850	0%
- both	13170	19%	15430	69%
TOTAL	16270	34%	31630	85%

Table 3 shows the number of trips and landings of fish by fleet prior and post DMP & CR and the percentage of these that have effort information. This table shows that the effort coverage has increased in all fleets. The mobile fleet is now at 100%. The fixed gear fleet has increased from 25 to 69% coverage of landings. In 1995, the fixed gear fleet used two documents: a trip document which captured detailed effort data and a weekly which did not. The table shows no effort information for those vessels on a weekly document, which consist largely of the smaller vessels. The weekly document they used isn't formatted to capture effort data. The solution may be to get all of the fixed gear groundfish fishers to complete the individual trip document, which has a better format to capture effort, or to modify the weekly document to capture complete effort information.

Accuracy

If we compare DMP and CR, we see that both of these programs require a hail in from all fishers. The monitoring company under both programs receives the hail information and enters it into the DFO computer system, collects the documentation of the actual landings, and enters the landings and effort data into the computer. There is however one major difference between these programs. DMP requires that a dockside observer complete a weighout at the wharf as the vessel is offloading and verify the landings; CR does not.

Table 4. Summary of Dockside Monitoring and Catch Reporting Programs

DOCKSIDE MONITORING	**PROGRAM**	**CATCH REPORTING**
IQ *(1991)* GENERALIST *(1991)* EA *(1993)*	**FLEETS**	FG <65' *(1994)*
1. Hail In 2. Dockside Weighout 3. Data Entry	**PROCESS**	1. Hail In 2. Data Entry
- Price information	**PROBLEMS**	- No catch verification - Weekly document - Price information

CR, which has no dockside observer requirement, has no method of verification of the landings. This implies that while we can say that the accuracy of the landings has improved for the fleets under DMP because of the presence of dockside observers, we cannot say anything on the accuracy of landings under a CR system.

There have been allegations in the past few years raising questions on the independence of the dockside monitoring companies and their dockside observers and therefore the accuracy of the verification of landings data. This has initiated a field audit program conducted by DFO. This audit process includes the checking of dockside observer procedures while verifying their numbers. While the audit process is still in its infancy, several audits have taken place this year and all of the numbers verified by fishery officers were found to be very accurate. This initiative will continue and expand in the future.

Summary

There has been an improvement in the three characteristics of DFO-required landings and effort data outlined at the start of this paper. Timeliness has improved most noticeably of the three. With completeness and accuracy we see definite improvements, but problems still remain that must be addressed.

Under Catch Reporting, there is no catch verification which questions the accuracy of these landings. A full dockside monitoring requirement would address this problem. Because of the format of the weekly document, the effort information for some fleet sectors is incomplete. Requiring all of the fixed gear less than 65 feet to use the trip document would solve this. Under both Catch Reporting and Dockside Monitoring Programs, the accuracy of price information is jeopardized. A price reporting system with the buyers may be the answer.

Phased Implementation of Local Fishery Management Opportunities Under Conservation Constraints

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Introduction

One of the available measures for implementing fisheries management strategies is quota regulation. Typically, quota regulation involves granting of a privilege or right to harvest a specified bulk weight during an identified period, generally a calendar year for groundfish in Scotia-Fundy. The groundfish quota systems in Scotia-Fundy involve a high degree of centralized decision making. Though the Department of Fisheries and Oceans employs a consultative process to achieve consensus on management issues, its authority is often used for conflict resolution. Generally, local circumstances cannot be considered in this framework. Fiscal constraints on government departments and the desire of fishers to have a greater say in their industry is moving us towards greater participation by fishers in the management process. This can be good, but fishers must be ready to take responsibility and to accept accountability.

It is often desirable to reach consensus on a common approach for management of a resource. With the number of fishers involved in any fishery and the diversity of local circumstances that they face, it is likely that a common approach will often not make sense. It should not be necessary to insist on a common approach in all instances. We explore opportunities for localizing the management process in order to permit decisions to be made at the most local scale which is practicable. To be ecologically acceptable, these local fishery systems must incorporate conservation constraints. Specifically, the systems should provide adequate incentives for sustainable practices and include effective rules for conserving the productive potential to ensure that future generations are not deprived of opportunities from these fisheries resources because of inconsiderate actions by present users. To be operationally acceptable, these local fishery systems must provide sufficient protection to fishers from the impacts of others' actions. If this is not achieved, then local decision making cannot be permitted and broader consultation and agreement must be sought.

We examine three changes to quota systems which aim to increase participation by fishers in management decisions and which are designed to enhance the scope for local variation in options. By bringing decisions to a local scale and allowing for

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variation in approach, we can accommodate consideration of local circumstances. These modifications also have the potential to convey a greater appreciation of long-term considerations, thereby promoting enhanced husbandry of the resources and introducing suitable incentives for sustainable fishing practices.

It is important to recognize that we are not starting with a blank slate. We cannot simply wipe out what is there. Rather, modifications must be introduced in a manner which permits them to be incorporated in or replace what already exists. The options we outline could logically be phased in successively, evaluating at each step whether the increased scope for local management is worth the cost of change. We favor a deliberate and slow evolution, perhaps on a pilot stock or area, with monitoring to check that we have not introduced a serious unforeseen complication in attempting to fix some other problem. Though this work has general application, we consider implementation for the eastern Georges Bank haddock fishery conducted by Canada in order to provide some concrete results.

Description of Fisheries and Current Management Regime

The haddock on eastern Georges Bank have supported a commercial fishery since the early 1920s and since 1969 landings have ranged between 2,500 and 25,000 t, fluctuating around 5,000 t in recent years. Since 1977, with the extension of jurisdiction by coastal states, only Canada and the USA have conducted haddock fisheries on Georges Bank. A Total Allowable Catch was introduced in 1970 by the International Commission for the Northwest Atlantic Fisheries. Seasonal closures of haddock spawning areas were also instituted in that year as an adjunct and have been retained by Canada and the USA. Following the establishment of a maritime boundary in 1984 by the International Court of Justice, the Canadian and USA fisheries have been restricted to their respective jurisdictions. Since 1984, Canadian landings have accounted for over 60% of the total, reaching about 90% in recent years.

In the absence of consistent management by Canada and the USA, there was reluctance to impose restrictive measures. Until 1993, quotas on the Canadian fishery were not very restrictive and exploitation rates were high. An evaluation of distribution and migration indicated that more restrictive Canadian management actions could result in benefits given current USA practices. Under increasingly restrictive management, total Canadian landings decreased to 2,411 t in 1994 and exploitation rates are showing a decline. Bottom otter trawl and longline have been the predominant gears in the Canadian fishery. The majority of longline vessels are in tonnage class 2 with a few tonnage class 3 vessels. Tonnage classes 4 and 5 were dominant prior to the mid-1980s but the majority of the otter trawl catch is presently taken by tonnage classes 2 and 3 vessels.

The Canadian groundfish fishery operates under a limited entry licensing system but this measure is not considered restrictive as it has been determined that the licenced capacity exceeds the resource supply. Enterprise allocations were introduced for vessels over 100 feet in the mid-1980s. Vessels between 65 and 100 feet participate in competitive fisheries with separate allocations for fixed gear and mobile gear. Individual quotas for mobile gear vessels less than 65 feet were introduced in 1993 with the restriction that no quota may exceed 2% of the total allowable catch or 600t of all stocks under the individual quota system. Fixed gear vessels less than 65 feet participate in competitive fisheries with separate allocations for gillnetters, 45 to 65 foot longliners and less than 45 foot longliners. The 1995 allocations for DFO administered quotas are given in Table 1. For 1995, the less than 45 foot longliners introduced an industry administered boat quota of about 35,000 lbs.

Trawlers are required to use 130 mm square mesh or larger and longliners must use large hooks. Observations in recent years suggest that the size selectivity for these two sectors is similar with few age 2 haddock being captured. Recent management measures have also included monitoring of catches for small fish, with sector closures if the proportion was found to be high.

Carryover Allocations

Through management measures such as the trimester system or through individual quotas, it has been possible to give fishers some say on when during the year they can catch their allocations. Why not extend this flexibility beyond the year? By not catching their complete allocation before the end of the fishing year, a fisher has not inflicted any damage to the resource. Why should that fisher lose the privilege to catch that allocation just because the fishing year has passed? In the present management regime, allocations are generally granted for a calendar year and unused allocations are simply erased at the end of the year. Discreet, well-defined quota periods have been used in fisheries management because of their administrative convenience and because they simplify fisheries management models. This feature of quota systems, however, compels fishers to view their quota as a limit which they must reach even if it doesn't always make sense. One way around this seemingly unnecessary rule is to permit fishers the option to carryover unused allocations. Any uncaught allocation could be taken in the subsequent fishing period.

We should recognize though that there is a kind of "depreciation" for uncaught allocation because fish are dying from natural causes. This "depreciation" can be offset by the growth of fish. This balance between losses and gains is dependent on the age structure of the population and on the fishing mortality rate. To protect against situations where fish are dying at a faster rate than they are growing we can introduce a conservation check. We limit the amount that is carried over to that which the uncaught fish would represent in the subsequent fishing period after accounting for these population dynamics. This check should maintain the spawning biomass near or above that which would have occurred if the allocations were caught within each year. Carryovers then should be marginally positive or neutral in relation to spawning biomass. The depreciation of uncaught allocation may be a disincentive to carryover, especially of large quantities, however costs of harvesting and price considerations would influence such decisions. Uncertainty in assessments will also impact on carryover allocations as a revised assessment update is involved in computing the adjustment to a carryover. A downward revision in the assessment would probably increase the downward adjustment in the carryover, while an upward revision in the assessment might reduce or eliminate any downward adjustment.

Aside from giving fishers more say on when to catch their allocations, carryover may offer other benefits. Quota management of mixed fisheries poses the challenge of achieving the specified balance of catch between species. Variation in species selectivity and availability, in combination with "wrong" quota mixes due to assessment uncertainties, can result in difficulties when attempting to exhaust allocations for several species simultaneously. Carryovers may ease these difficulties and have the potential to reduce year-end discarding in the process. Carryovers offer more flexibility in developing fishing plans and allow fishers to be responsive to changing conditions. This can introduce greater scope to capitalize on economic opportunities like higher market prices or to avoid economic disincentives like poor catch rates. Finally, carryover allocations can begin to instill a different outlook on fisheries harvesting, one of continuity with an increased sense of responsibility for past actions.

Eastern Georges Bank Haddock Example

To see how this would work, consider the example where the 46 to 65 foot FG fisher group caught only 50 t of their 85 t allocation for 1995. What would they be able to carryover and add to their 1996 allocation? The table below shows how we would determine this. Using the available port sampling information, we would determine the number of fish caught at each age. (Note: port samples for 1995 have not been processed yet and we use the 1994 information for the example) The weight caught is simply the sum over all ages of the number caught multiplied by the average weight at age. Note that it is 50 t. The fish left uncaught is found by multiplying the number caught by the ratio of 35/50, i.e. the weight left uncaught divided by the weight caught. Note that the weight left uncaught summed over all ages is 35 t. The permitted carryover in numbers is found by projecting the number left uncaught to the next age and diminishing that number according to the assumed natural mortality rate of 0.2. Applying the average weight at age, we determine that the permitted carryover in bulk weight is 33.186 t.

Age	Avg. Weight (kg)	Caught		Left Uncaught		Permitted Carryover	
		Nos.	Weight(t)	Nos.	Weight(t)	Nos.	Weight(t)
1	0.4	0	0	0	0	0	0
2	1.1	2109	2.320	1476	1.624	0	0
3	1.7	13435	22.840	9405	15.988	1209	2.055
4	2.2	3671	8.077	2570	5.654	7700	16.940
5	2.6	1172	3.046	820	2.132	2104	5.471
6	2.8	703	1.968	492	1.378	0672	1.880
7	2.9	2734	7.928	1914	5.550	403	1.168
8	3	547	1.640	383	1.148	1567	4.701
9	3.1	703	2.179	492	1.526	313	0.971
Total			**50.000**		**35.000**		**33.186**

Year-Class Quotas

Quota management using bulk weight allocations works best when all users harvest fish of similar size and age. It is worth considering if we can give fishers more say on the size of fish that they catch. If we were only concerned with trying to get the most bulk weight from a fishery, it would be possible to determine the "best" size fish to capture; but, getting the most bulk weight isn't the only consideration. There may be better markets and prices paid for smaller or larger fish than the "best" size; or, it may cost more to harvest the fish of the best size because they are not bunched up as much or because those schools are more distant from port. Fishers must deal with these economic considerations, but what complicates the matter further is that these factors are influenced by local circumstances and differ from one fisher to the next. These factors might also change over the fishing season in an unpredictable fashion. One possibility for giving fishers some flexibility to deal with these issues on a local scale is to allocate year-class quotas.

We can determine how many fish of an incoming year-class should be caught over the years that they contribute to the fishery assuming that the target strategy $F_{0.1}$ was followed. Harvest rights for those fish could then be granted to the fishers at the time that the year-class recruited to the fishery. Fishers must plan their harvest from this year-class recognizing that this is all the fish of that year-class which will be allocated. An immediate conservation concern is that estimates of abundance are least precise at younger ages. As a conservation measure to counter that uncertainty, we can allocate only a fraction of the year-class quota, say one-half, in the first year the fish recruit to the fishery. This allocation can be updated in subsequent years based on revised estimates and the fraction can be gradually increased to the full amount. Some guidance on how much to "hold back" may be obtained by considering the estimated precision of the abundance.

A side benefit of year-class quotas is to reduce gear conflict without needing to resort to gear regulations. Under high exploitation rates, substantial differences in the size of first capture between gear sectors has resulted in "interception" of the fish by the sector catching them at a smaller size. The abundance of fish has been depleted to the extent that the gear sector which has a larger size of first capture experienced poor catch rates. Additionally, year-class quotas may reduce "highgrading" which has sometimes been a consequence of fish size regulations. Year-class quotas also further enhance the involvement of fishers in resource husbandry, as they are entrusted with responsibility and accountability to harvest each year-class in a manner which it can sustain over its effective fishery life span. Fishers must have some allocation remaining of each year-class contributing substantially to the fishery in order to have access to that fishery.

Eastern Georges Bank Haddock Example

From the yield-per-recruit model we determine that about 50% of age 3 haddock should be caught by the fishery to be consistent with an $F_{0.1}$ strategy. So, for example, the abundance of 1992 year-class in 1995 at age 3 was estimated at 9.6 million. To be consistent with an $F_{0.1}$ strategy, we can expect that about 4.9 million of these haddock should be caught by commercial harvesting. We will use the percentage allocation from Table 1 to allocate the year-class among the fisher(s). So the 45 to 65 foot fixed gear group would be allocated 3.4% of the estimated 4.8 million which are to be caught or 165,750 haddock from this year-class. In subsequent years, we would monitor the removals of this year-class by this group of fishers using available port sampling information. While this year-class was effectively contributing to the fishery, which would be until about the year 2002, this fisher group would be expected to have some haddock of this year-class remaining uncaught in order to be permitted to make a trip. Each year-class which recruits would be allocated and monitored in the same way.

Recall that we recommended earlier that only a part of the allocation be granted at younger ages until the estimates of year-class abundance become more stabilized. For eastern Georges Bank haddock we suggest that one-half of the full allocation be identified at age 3, three-quarters of the full allocation at age 4, and the full allocation at age 5. So, for the 45 to 65 foot longliner group, we would set the allocation of the 1992 year-class at 82,875 haddock in 1995. This would be increased to the full allocation by 1997 based on the current year-class estimate. To introduce a year-class quota system in 1995, we could determine how many haddock at each age should be caught through their effective life span to be consistent with an $F_{0.1}$ strategy. The following table shows how we would work out the year-class allocations for the 45 to 65 foot longliner group based on their percentage share of the Canadian total allowable catch in 1995 (3.4%). Using the abundance estimated for each year-class from the current assessment, we determine the number of haddock to be harvested from each year-class over their life span, consistent with an $F_{0.1}$ strategy. The 45 to 65 foot longliner group's share of that harvest is 3.4%.

The full amount is identified as the 45 to 65 foot longliner year-class allocation for ages 5 and older, but only one-half and three-quarters were identified at ages 3 and 4, respectively. These would be updated to the full amount based on revised year-class estimates in ensuing years. This latter precaution should not be restrictive, as these allocations must be managed over the life span of each year-class.

Age	**Abundance**	**$F_{0.1}$ Harvest**	**45'-65' %**	**45'-65' Harvest**	**Allocation Portion**	**45'-65' Allocation**
3	9635000	4875000	3.4	165750	1/2	82875
4	2374000	1311000	3.4	44574	3/4	33431
5	292000	163000	3.4	5542	full	5542
6	95000	52000	3.4	1768	full	1768
7	71000	39000	3.4	1326	full	1326
8	177000	96000	3.4	3264	full	3264
9	27000	13000	3.4	442	full	442

Population Stewardship Rights Fishery System

The present management regime grants rights to fishers to harvest specific quantities which are determined by the central authority, DFO. Based on yield under steady state conditions and a simple cost structure, an $F_{0.1}$ exploitation strategy was determined to be a suitable average target. Fluctuating market prices, variation in price for different size fish, departure from steady state age structure and changes to operating costs, could motivate deviation from the average target. Further, it is conceivable that these forces are not the same for all fishers and what may seem appropriate on average may not make economic sense in a specific local situation. Deviations are difficult to entertain in quota systems because the consequences of permitting a fisher or group of fishers to deviate is dissipated among all others. That is, a fisher who deviates is not accountable for those actions. Therefore, the only deviation for which there is any incentive for a fisher or group of fishers to pursue is an increase in their allocation. To permit local deviation, fishers must be ready to accept accountability for their actions and the system must provide adequate protection from the consequences of others actions. One way to do this is to allocate not just the fish to be harvested but a conceptual partial population to be entrusted to the care of fishers, thereby virtually creating stocklets to be managed locally.

We refer here to an elementary management unit, EMU, as any fisher or group of fishers operating under common rules. A population stewardship rights system is based on evaluation of each EMU's conceptual partial population. Consider one year-class. The partial population abundance at age 1 of some year-class for any EMU is the total population abundance at age 1, estimated from the most recent assessment, multiplied by that EMU's share of that year-class. The abundance of that EMU's conceptual share of this year-class is diminished each year by the number which died from natural mortality and the number caught by that EMU. Therefore, the partial population abundance of that year-class for the EMU can be computed for any age up to the current year by sequentially removing the catch by that EMU and the natural deaths. The total stock natural deaths are partitioned among EMU's according to the magnitude of their partial populations. The total stock natural deaths are obtained from the stock assessment results.

Doing this for all year-classes in the fishery and applying what we know about growth, we can determine the biomass of each EMU's conceptual partial population. We can partition an incoming year-class among the EMU's based on the relative magnitudes of the adult biomass of their conceptual partial populations. Incoming recruitment is earned by each EMU according to their stewardship of the partial population endowed to their care. An EMU's share of a recruiting year-class is set equal to the fraction of the total adult biomass contributed by that EMU's partial population in the year they were spawned.

It is possible for an EMU to exert a sufficiently high fishing mortality to exhaust their partial population of a year-class yet continue to capture fish of that year-class from the total population. That EMU is held accountable for the removed fish by having their catch of an adjacent younger age augmented. Say that the number of age 10 fish caught by an EMU is in excess of their partial share of that year-class, the adjusted catch at age 9 would augment the age 9 removals by the number equivalent to the excess biomass of age 10 fish caught.

Practical rules for conserving the population should be implemented, even when strong relationships between spawning stock and recruitment have not been identified, to ensure that the management actions taken by EMU's do not put the future viability of the stock at risk. Actions by EMU's which result in maintenance of an adequate adult stock biomass could turn off or limit the safety reserve mechanism, thereby promoting conservative practices which consider longer time horizons. One approach for implementing a conservation reserve is described in the example below.

<u>Eastern Georges Bank Haddock Example</u>

We start by defining a practical conservation rule. When the population is initially partitioned between the EMU's, an arbitrary portion is reserved for conservation purposes. First, let us assume that the year-classes presently in the fishery had been exploited at the $F_{0.1}$ level. Almost 15 million fish of ages 3 and older would have survived to the beginning of 1995 and their age structure is shown in the table. During the early 1970s, the number of fish of age 3 and older reached a low of about 2.5 million fish from which the population subsequently increased. We will reserve 2.5 million fish distributed among ages according to the age structure we would have had if the observed year-classes had been fished at $F_{0.1}$. The remaining fish are available to be partitioned amongst EMU's. For the example, again consider the 45 to 65 foot fixed gear EMU. We use the percentage allocation in 1995 to partition the total population into conceptual partial populations. The 45 to 65 foot fixed gear receive 3.4% of the fish at each age.

Their conceptual partial population at the beginning of 1995 would be about 350,000 fish. This is the portion of fish which they can harvest from, but it is also the portion of fish which they must manage and care for in order to provide them with catches into the future. As an example, let us assume that this EMU chooses to fish at F=0.25, the $F_{0.1}$ fishing mortality rate. This EMU should then aim to capture about 80 t during 1995.

Age	**$F_{0.1}$ Pop.**	**Conserve**	**1995 Pop.**	**Available for EMU**	**45'-65' %**	**45'-65' Partial Pop.**	**45'-65' Yield at $F_{0.1}$**
3	9635000	1631000	9635000	8004000	3.4	272136	48.404
4	2840000	481000	2374000	1893000	3.4	64362	26.176
5	565000	96000	292000	196000	3.4	6664	3.057
6	404000	68000	95000	27000	3.4	918	0.463
7	120000	20000	71000	51000	3.4	1734	0.954
8	1142000	193000	177000	-	3.4	-	-
9	63000	10000	27000	17000	3.4	578	0.361
Total	14769000	250000				346392	79.415

As each subsequent year-class recruits, a portion of it is reserved as the conservation segment. The amount of recruits reserved varies, depending on the adult biomass present in the total population at the beginning of that year. That is, if the fishery EMU's are exerting a sufficiently moderate exploitation rate to maintain an adequate spawning potential, few or no recruits will be reserved. If the fisheries are depleting adult biomass, a greater amount will be reserved. Since 1968, this population had average recruitment of about 8.5 million fish and the adult biomass had ranged between 2,000 t and 43,000 t. The following rule is used:

Biomass for ages 3 and older	**Recruits Reserved**
greater than 30,000 t	0
between 30,000 and 10,000 t	1 million
between 10,000 and 5,000 t	1.5 million
less than 5,000 t	2 million

So, the subsequent allotment of incoming recruitment to the 45 to 65 foot fixed gear will not be the constant 3.4%, but will be based on how big the adult biomass of the 45 to 65 foot fixed gear partial population is compared to the partial population of other EMU's. That is, if they choose actions which increase their adult biomass while others choose actions resulting in decreases, the 45 to 65 foot fixed gear EMU will get an increased percentage of recruits.

Implications for Change

We do not consider it appropriate to be advocates of the proposed modified fishery systems, of the present fishery system, or of any other fishery systems. Rather, we are of the opinion that selection of the appropriate fishery management system should be the result of a cost/benefit consideration. The benefits and opportunities offered by a fishery management system must be weighed against the cost of implementation. We may devise a system which everyone would like but if the associated costs for scientific evaluation, monitoring, and enforcement are prohibitively expensive, then we cannot proceed with that system. Also, what is prohibitively expensive today may be possible in the future because of some technological innovation. Therefore, a fishery system which appears attractive but seems too expensive to implement may spur some innovation which overcomes the obstacles. Our purpose with this paper is to explore the possibilities for fishery management systems which enhance local involvement.

A cost analysis for implementation of these modifications is beyond the scope of this work but we summarize the necessary changes. For our purpose here, it is convenient to classify the components of a fishery system into monitoring, scientific evaluation, and enforcement.

The monitoring functions can usefully be grouped into three categories, at-sea activities, quantity caught, and size composition of the catch. The requirements for monitoring at-sea activities and quantity caught are similar for all quota managed fisheries and for the population stewardship rights fishery system. That is because there are benefits to be gained by misrepresenting the catch to the authorities or to others, though the benefits accrued by such misrepresentation can vary among these fishery systems. Monitoring of fishers' activities may be more effectively done by local observation than by government authorities. With increased appreciation that abuses of common fishery resources will impact others' futures, there may be more incentive to promote ethical behavior within the fisher communities by peers and neighbors.

For monitoring of size composition, year-class quotas and a population stewardship rights fishery system could be more demanding. Though the removals by year-class or the computation of conceptual partial population abundance can be conducted with the data which are currently available for stocks where analytical assessments are conducted, it has to be recognized that the precision of that estimate is influenced by the precision of the EMU's catch at age, which in turn is a function of the degree of sampling of the landings for size of fish caught. In part, the benefits to EMU's of a year-class quota system or a population stewardship rights fishery system hinge on reliable information on the size of fish caught by the identified EMU's. If an EMU considers that the size composition of their catch is dissimilar to that of others, then their catch composition should be based on the more representative but limited samples from their own fishery. To achieve the desired precision, sampling for size composition of that EMU's catch may have to be enhanced. In instances where it is reasonable to assume that the size composition of the catch by several EMU's is comparable, it may be estimated by pooling samples, thereby needing additional sampling. Other techniques, such as grading of landings by size, e.g. small, market, large, etc., can also be employed to reduce the sampling requirements. Fishers must weigh the additional costs for more sampling and/or monitoring which may be required if they break up into many small EMS's versus the costs of negotiating consensus rules about harvest practices within larger EMU's.

All quota systems and the population stewardship rights system require regular evaluation of the status of the resource. Quota systems are very dependent on determination of a single "best" number so that harvest quotas can be established. The carryover system and the year-class quotas offer some, but not a great deal of, relaxation of this demand by permitting deviation from an annual harvest limit. Year-class quotas, however, may place some demand for increased precision of abundance estimates. Population stewardship rights do not establish any harvest regulation. Rather, the evaluation of resource status can be used along with other information to permit the EMU's to make informed management decisions. In this regard, the trends from the analysis may become more relevant. Population stewardship rights need evaluation of partial populations, however, and this requires some additional analyses. Finally, the estimates of partial populations need to be used as absolute estimates when it is required to determine that an EMU has exhausted their partial population, at which time the precision of estimates becomes more important. All these modifications have additional administrative costs for keeping track of allocations or population from year to year.

In quota fisheries, regulation involves annual closures of fisheries when the allocation for a group of fishers is reached. Additionally though, since the actions of any fisher impact on all others, there are generally several other regulations on gear, size of fish caught, area closures, season closures, etc. Carryover allocations and year-class quotas share these features, though it should be possible to reduce or eliminate gear regulations and fish size regulations with year-class quotas. In a population stewardship rights based fishery, regulation might be limited to occasionally revoking an EMU's fishing privileges if that EMU has exhausted their conceptual partial population.

The following table summarizes the shift in emphasis of these principle activities for each of the modifications relative to the existing quota system.

Activity	Carryover Allocations	Year-class Quotas	Population Stewardship Rights
Monitoring			
- at sea	similar	similar	similar
- landings	similar	similar	similar
- length composition of catch	similar	possibly increased depending on number of EMU's and on differences in fishing practices	possibly increased depending on number of EMU's and on differences in fishing practices
Scientific evaluation			
- of stock status	similar	greater reliance on precision of year-class estimates	decreased reliance on absolute estimates except when determining if EMU has exhausted their partial population
- of status of conceptual partial populations	not required	not required	additional new function which is principally required by EMU's to base management decisions; required by DFO to determine if EMU has exhausted their partial population
Regulation	similar	similar with possible elimination of regulations relating to gear and size of fish	possibly limited to only granting or revoking fishing privileges

Note: Although we indicate that the requirement for some activities is similar to that for the existing quota system, we do not mean to imply that we consider the current conduct of those activities is adequate.

Table 1. DFO administered quotas (kg) for eastern Georges Bank haddock.

Fisher(s)	**1995 Allocation**	**Fisher(s)**	**1995 Allocation**	**Fisher(s)**	**1995 Allocation**
<45’ GNU	31000	**GRO00711**	2559	**GRO01924**	14241
<45’ LL	476000	**GRO00714**	6056	**GRO01940**	1698
45’-65’ FG	85000	**GRO00727**	2648	**GRO02084**	2686
65’-100’ FG	25000	**GRO00737**	10681	**GRO02089**	11960
65’-100’	25000	**GRO00743**	2648	**GRO02173**	1584
MG		**GRO00765**	7070	**GRO02243**	25
Sea Freeze	83000	**GRO00771**	8464	**GRO02281**	2357
Nat. Sea	313000	**GRO00823**	3015	**GRO02369**	10085
Fish. Prod.	4000	**GRO00837**	16104	**GRO02424**	6728
>100’ other	190000	**GRO00844**	4891	**GRO02569**	6145
GRO00031	1609	**GRO00846**	8704	**GRO02672**	1824
GRO00152	19410	**GRO00868**	10440	**GRO02882**	570
GRO00163	89	**GRO00890**	456	**GRO02891**	6284
GRO00193	13151	**GRO00893**	9541	**GRO02973**	6082
GRO00215	1368	**GRO00894**	9629	**GRO03004**	2800
GRO00229	1698	**GRO00896**	684	**GRO97486**	1951
GRO00232	2889	**GRO00953**	1609	**GRO99575**	2838
GRO00233	2496	**GRO00984**	4409	**GRO99666**	139
GRO00234	6500	**GRO00989**	7779	**GRO99927**	7665
GRO00277	9819	**GRO00996**	1951	**GRO99949**	4232
GRO00282	114	**GRO01004**	17320	**GRO99954**	8970
GRO00301	431	**GRO01022**	9338	**GRO00009**	23820
GRO00304	7425	**GRO01028**	3725	**GRO00011**	405
GRO00311	570	**GRO01030**	1102	**GRO00020**	7298
GRO00319	11568	**GRO01080**	3370	**GRO00021**	76
GRO00322	2002	**GRO01138**	8451	**GRO00024**	1939
GRO00331	4143	**GRO01144**	2775	**GRO00025**	12328
GRO00387	6563	**GRO01147**	12987	**GRO00029**	2749
GRO00427	7779	**GRO01189**	1014	**GRO00030**	2724
GRO00451	836	**GRO01226**	3484	**GRO00037**	7019
GRO00454	710	**GRO01256**	1520	**GRO00045**	4295
GRO00472	13139	**GRO01260**	481	**GRO00048**	1495
GRO00479	2268	**GRO01283**	1166	**GRO00050**	15293
GRO00494	12049	**GRO01322**	8654	**GRO00051**	18397
GRO00502	6196	**GRO01704**	6145	**GRO00057**	8365
GRO00685	13684	**GRO01721**	11897	**GRO00063**	1520
GRO00687	17028	**GRO01791**	900	**GRO00064**	11846
GRO00690	4625	**GRO01810**	431	**GRO00074**	15939
GRO00701	15356	**GRO01873**	11517	**GRO00086**	101

Table 1. continued

Fisher(s)	1995 Allocation
GRO00089	3535
GRO00090	8337
GRO00095	3256
GRO00098	5689
GRO00116	14875
GRO00309	15483
GRO00342	1242
GRO00539	29166
GRO00564	494
GRO00577	1926
GRO00581	17333
GRO00584	5537
GRO00587	4650
GRO00592	10136
GRO00593	15052
GRO00598	6259
GRO00602	1672
GRO00606	3282
GRO00607	4295
GRO00608	2445
GRO00609	6588
GRO00611	51
GRO00612	9579
GRO00613	6335
GRO00615	14368
GRO00622	9604
GRO00624	16053
GRO00625	57623
GRO00626	7121
GRO00628	9148
GRO00631	6892
GRO00632	4118
GRO00633	3839
GRO00635	165
GRO00639	10554
GRO00640	8894

Fisher(s)	1995 Allocation
GRO00649	5461
GRO00650	16294
GRO00651	12695
GRO00652	9300
GRO00653	3231
GRO00654	11365
GRO00663	8818
GRO00670	13367
GRO00671	4523
GRO00674	13646
GRO01070	6766
GRO01090	3877
GRO01099	13658
GRO01133	3510
GRO01150	4688
GRO01163	1318
GRO01176	4270
GRO01191	29546
GRO01192	24592
GRO01193	20133
GRO01298	11137
GRO02200	16800
GRO02901	25974
GRO05009	11327
GRO97986	13139
GRO98911	2065
GRO99807	963
TOTAL	**2500000**

Establishing Fishing Effort Targets for Groundfish Fisheries

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Abstract

Large reductions in fishing effort are needed to ensure sustainable groundfish fisheries in the future. Recent trends in fishing effort and fishing mortality provide a unique opportunity to determine quantitative relationships which may be used to estimate fishing effort targets for groundfish fisheries. It is doubtful that closed areas, catch quotas, and technology restrictions alone will be sufficient to meet fishing effort targets. Direct effort controls are needed. We suggest a combined catch- and effort- based management system which will provide complementary information on stock status as well as explicit fishing effort targets.

Fishing Effort and Fishing Mortality

The rate of fishing mortality exerted on Atlantic Canadian groundfish stocks during the 1980's was not sustainable. Throughout this period, recruiting year-classes were unable to replace the spawning stocks that produced them (Hutchings and Myers 1994; Shelton 1995). This was due to a combination of a high rate of fishing and slow growth rates of the fish. The low growth rates meant that individual fish were not producing as much biomass as they would have in the 1970's, while the high rates of fishing removed more biomass from the stocks than was being produced in total.

Fishing mortality and fishing effort are related. While the standard theory of fishing states that there is a proportional relationship between these two variables, there is rarely sufficient variation in one or the other in real fisheries to clearly demonstrate the relationship. However, the situation has changed recently in Atlantic Canadian groundfish fisheries where fishing effort increased significantly in the late 1980's and early 1990's, then fell dramatically with the reductions in catch quotas and eventual closures of directed fisheries. As an example, the relationship between fishing mortality and nominal fishing effort (days fished) by mobile gear vessels directing for southern

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Gulf of St. Lawrence cod is presented in Figure 1 (data from Sinclair et al. 1995). Fishing effort increased in the late 1980's and early 1990's, as did fishing mortality. In 1993, the total allowable catch (TAC) for the stock was decreased substantially and the fishery was closed in September. In 1994 there was a very small amount of directed fishing effort associated with sentinel fisheries. There is a highly significant correlation between fishing effort and fishing mortality during this time period ($R^2 = 0.91$) which supports the basic theory that the two are proportional.

If we take the period preceding the closure of the southern Gulf cod fishery (1986-1992) as a baseline in terms of fishing effort, there would have to be a substantial reduction in fishing effort to meet current fisheries management objectives. Canada has followed a fixed fishing mortality management strategy since the extension of fisheries jurisdiction in 1977. The target fishing mortality has been $F_{0.1}$, and for cod stocks this has meant fishing mortalities of around 0.2. More recent studies which base fishing mortality targets on considerations of replacement recruitment have indicated that fishing mortalities in the range of 0.2 to 0.3 may be sustainable for cod (Maguire and Mace 1993). Fishing effort reductions of 65% - 75%, relative to the 1986-92 period, are needed to meet either of these targets. While the example presented here is for southern Gulf of St. Lawrence cod, most other cod stocks in Atlantic Canada have experienced similar high levels of fishing mortality and fishing effort (Angel et al. 1994; Hutchings and Myers 1994; Sinclair 1994). Thus, similar reductions in fishing effort are also implied for these stocks.

The relationship between F and effort is not perfect and may be influenced by several factors. It will be important to take some of these into consideration if measures are taken to reduce F by reducing nominal effort (e.g. days fished). These factors may be divided into two broad categories, those related to the behaviour and distribution of the fish, and those related to the act of fishing. We refer to the former as catchability, or the fraction of a fish population caught by a standard unit of fishing effort. Catchability has a strong seasonal component for many species. Fish become more aggregated and thus vulnerable to fishing during spawning and migratory periods. They are less vulnerable to fishing during feeding periods when they are more dispersed. This effect is illustrated for southern Gulf of St. Lawrence cod in where the amount of fish caught, and therefore the fishing mortality, with a days fishing varies considerably by season (Figure 2). In the spring (April - May), and fall (November), when the fish migrate into and out of the Gulf respectively, the catch per day fished was 3 - 4 times higher than in July and August when the fish feed and are more widely dispersed.

The fishing power of different types and sizes of vessels also affects the relationship between fishing effort and F. Larger, more powerful vessels, generally catch more fish per unit effort than smaller vessels. An example for southern Gulf cod is presented in Figure 3. Trawlers in the 50-65' range catch about three times as much cod per day fished, on average, than trawlers in the < 45' range. The average catch per day for trawlers > 65' was less than for vessels in the 50-65' range. This is probably because the larger vessel class consists mainly of older side trawlers which have lower horsepower than the newer, predominantly stern trawlers in the 50-65' range. For seines, the catch per day for the largest vessel class (>65') was more than four time greater than that in the <45' range. Consideration must also be given to the effect of technological improvements on fishing power. There is a general tendency to move toward larger engines, more efficient fishing and fish finding equipment, with the expressed intent of increasing catch rates.

Fishing Effort Targets

Fishing effort targets would be a useful addition to fisheries management. The limited entry policies established in the late 1970's did not have quantitative effort targets as a basis. Consequently, they were largely ineffective in controlling both fleet capacity and fishing effort. Empirically based targets could form the basis of a renewed policy.

Little attention was paid to trends in fishing effort in the late 1980s. As a result, fishing effort by key fleet sectors increased substantially when many stocks had already begun to decline (Angel et al. 1994; Hutchings and Myers 1994; Sinclair et al. 1994). Heavy reliance was placed on TAC regulation to control fishing mortality, however, their effectiveness was reduced by the ability of the industry to misreport total catches. On the other hand, fishing effort targets would be less variable since fishing effort would remain relatively stable from year to year.

It is possible to determine fishing effort targets on a stock-by-stock and even sector-by-sector basis, bearing in mind the importance of catchability and fishing power on the relationship between F and fishing effort. The first step is to investigate the basic F / effort relationship for the stock (Figure 1). One then needs a fishing mortality target, in this case we have assumed it to be the $F_{0.1}$ target of 0.2. For the fleet of interest, what is it's share of the total catch? These shares have already been established in the traditional TAC allocations. For southern Gulf cod, the mobile gear sector has traditionally received 75% of the TAC. This loosely translates into 75% of the total fishing mortality, or a target F of 0.15. Referring to Figure 1, this indicates that the mobile sector fishing effort target would be of the order of 2000 fishing days annually. This assumes the same seasonal and vessel-size allocation of fishing effort as occurred during the baseline period. If more effort is exerted in the spring and fall, then the total number of fishing days would have to decline. Conversely, if effort shifted to the summer months or to smaller vessels, more fishing days could be used.

Fishing effort targets are less variable from year to year than TACs. As long as the stock size warrants a commercial fishery, the management strategy is to keep F constant. Therefore, fishing effort would also be constant, except for minor reductions to account for increases in fishing power due to technological improvements. TAC's, on the other hand, would vary as stock size varies. When stocks are high, TACs would also be high, when stocks are low, TACs would be low. Effective TAC management also requires precise annual stock assessments of stocks size which is often difficult given the variability of abundance indices from research vessel surveys and commercial fisheries.

It is doubtful that area closures, technology limitations, and/or catch controls alone can be used to meet the fishing effort targets. If and when groundfish fisheries reopen, there will be room for only one quarter the fishing effort that was exerted in the late 1980s and early 1990s. Many of the stocks are highly migratory. Closing a portion of the stock area to fishing would only protect the stock from exploitation for the period of time it occupies that area. There would be no protection when the stock migrates out of the closed area. Technological limitations may provide some fine tuning of the relationship between fishing effort and F, however it is unlikely that any limitations could achieve a 75% reduction in fishing efficiency. Changing gear selectivity to avoid catching small fish will not affect fishing mortality on the larger fish. Changing selectivity and keeping the same TAC will increase fishing mortality on larger fish because more effort will be required to catch the same tonnage. There are also considerable difficulties enforcing at-sea regulations, in particular gear restrictions and catches. It is unlikely that fishing mortality targets can be achieved while having the same number of fishing days or having the same number of boats on the water. Direct measures to reduce fishing effort are needed.

A Two-Level Control System Using both Catch and Effort

Effort monitoring would be a useful addition to stock assessment. Traditional assessments used research survey and commercial fishery data to track stock size and catch projections were highly sensitive to the most recent abundance index. Management information comprised mainly projections of catch at various levels of fishing mortality and little attention was paid to trends in fishing effort. However, once the relationship between F and effort is quantified, the amount of fishing effort expended annually could be used as an index of fishing mortality. The assessment could then provide both a TAC projection and a fishing effort projection. The F/ effort relationship could become an integral part of the assessment just as the TAC is now. Where the catch projections are highly sensitive to the most recent abundance index, the effort target would more stable. If the catch and effort projections did not match, this could indicate a problem with the stock assessment and trigger further investigation. Possible causes for mismatches include errors in estimates of stock size or changes in the F/effort relationship (catchability or fishing power). Another advantage of an effort target is that an estimate would be available even if there was no abundance index for the most recent year.

It might be possible to take effort monitoring one step further and use it as an upper limit, similar to a TAC. In a conservation oriented and risk averse management system, if either the catch or effort limit was reached this could trigger a fishery closure. Given that a mismatch between the projected catch and effort indicates an error in the stock assessment or the monitoring system, a risk averse strategy would tend to err on the side of conservation, i.e. stop fishing. Fishing could at least be halted until the cause of the mismatch could be investigated. It may not always be possible to isolate a specific cause, and again a conservation oriented management strategy would favor closing the fishery. Such an approach implies additional control rules and the associated bureaucracy, and the costs and benefits warrant evaluation.

The multi-species nature of some groundfish fisheries may require more careful definition of fishery units. Fish stocks generally follow consistent seasonal migrations. As a consequence, the degree of spatial overlap between species, and therefore the multi-species fisheries they support, would follow predictable seasonal patterns. Multi-species groundfish fisheries have been defined and characterized by analysis of the species composition of catches on the appropriate spatial and temporal scale (Murawski et al. 1983; Sinclair 1985a). The question then becomes, how are the single species fishing mortalities distributed among the multi-species fisheries. Linear and non-linear programming techniques may be used to investigate optimal fishing effort distribution among fisheries (Sinclair 1985b). The amount of effort allocated to each fishery could be constrained by the single species conservation targets in such a way that no species is overfished relative to it's target. Fishing effort by multi-species fishery could be monitored as part of regular stock assessments in order to identify inconsistencies between predicted and actual values. Fishing effort by fishery could also be regulated if warranted.

Now is the time to determine quantitative fishing effort targets for Atlantic Canadian groundfish fisheries. There has been considerable variation in fishing effort in recent years with substantial increases in the late 1980's followed by large declines imposed by fishery closures. This provides the necessary range of fishing effort to determine the relationship between fishing mortality and fishing effort for many important fisheries. Now may also be the time to implement policies that will ensure fishing effort does not exceed these targets if and when the groundfish fisheries reopen. Fishing effort is at an historic low level because of numerous closures.

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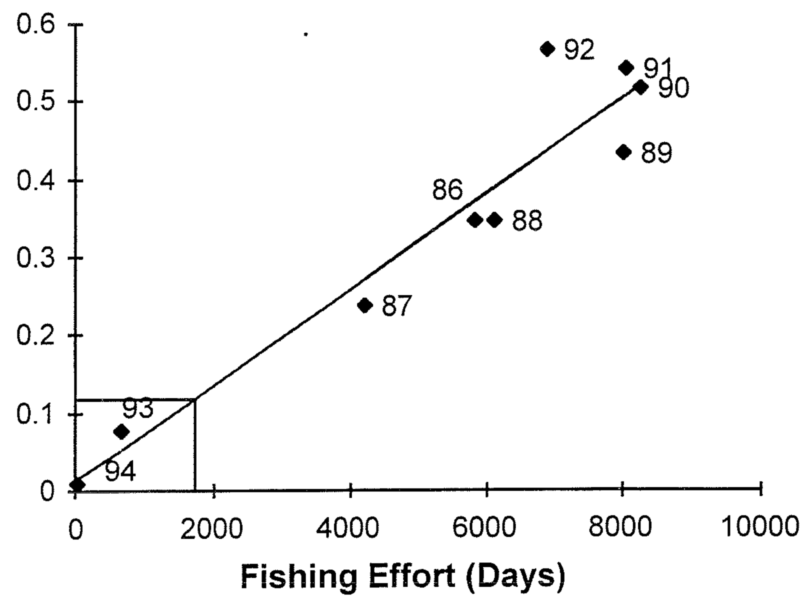

Figure 1: The relationship between fishing effort and fishing mortality for mobile gear vessels directing for cod in the southern Gulf of St. Lawrence. The straight line is from linear regression ($R^2 = 0.91$).

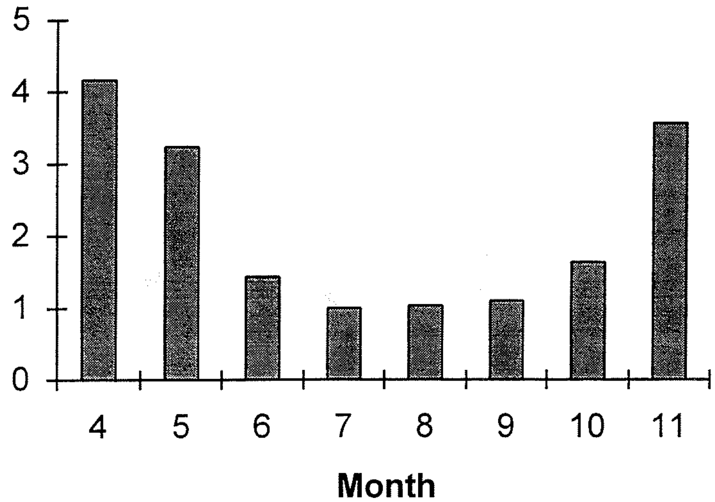

Figure 2: Seasonal variation in catchability of southern Gulf of St. Lawrence cod. The relative catchability is based on average monthly catch rates (t/day) of cod over the period 1986-92. Catch rates in April, May, and November were from 3 - 4 times higher than in July and August.

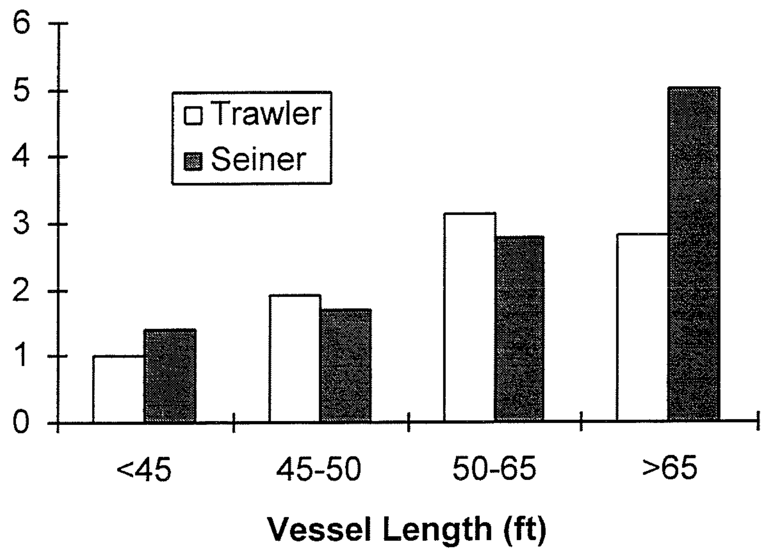

Figure 3: Relative fishing power of otter trawlers and seines fishing southern Gulf of St. Lawrence cod in relation to vessel length overall.

Alternative Approaches to Management of the Fixed Gear Sector

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Introduction - The Beginnings of Co-Management in the Scotia-Fundy Fixed Gear Sector

In the fall of 1994, the Department of Fisheries and Oceans informed the Scotia-Fundy Fixed Gear Groundfish Committee that they would have to play a larger role in the management of the fishery in 1995. As probably the largest and most complex sector of all Scotia-Fundy fisheries, this was not an easy task. During the previous year, the Committee had in fact taken more responsibility for management in terms of its involvement in the formulation of a conservation harvesting plan and in making adaptations in that plan as the season progressed due to the very low quotas available for haddock.

The major new elements of industry responsibility in the fall of 1994 included:

i) the need to establish a Committee Terms of Reference that would enhance the accountability and operations of the Committee;
ii) the establishment of a monitoring system that would apply to all vessels;
iii) the requirement to prepare a conservation harvesting plan without the management tool of DFO enforced trip limits; and
iv) the de facto responsibility to determine the quota allocations among the various components of the fleet due to the very low quotas for cod, haddock, and halibut.

The 1995 Fixed Gear Groundfish Management Plan

By October of 1994, the Committee had adopted a new terms of reference of which the most important new element was membership criteria. To quality for membership, an organization had to have:

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i) papers of incorporation;
ii) a constitution or bylaws;
iii) at least 50 members who held a groundfish licence. Exceptions were made for this last criteria when an organization could show that they represented all the licence holders in a particular gear sector or distinct geographical area, but the total number of licence holders was less than 50.

In the end, 17 organizations qualified for committee membership. Nevertheless, there was still a sizable number of licence holders unrepresented by any organization.

The development of a conservation harvesting plan for 1995 was an extremely difficult task. Given the very low quotas in 4X and 5Z, and the cod moratorium in 4VsW, much time was spent in determining the allocation of fish among the different fleet sectors. At times, the complexity of the fishery seemed overwhelming as different sectors had different requirements as to the arrival of fish in their area, the overlap with other fisheries such as lobster, and the basic economic needs of different classes of vessels and gear types.

A breakthrough in negotiations took place when Committee members signed an agreement recognizing that all decisions made for 1995 would have no bearing on future years, that the Committee conduct a workshop in the fall of 1995 to look at alternative approaches to fixed gear management, and that they ask the FRCC for advice on the conservation aspects of TAC management versus effort controls. The FRCC subsequently accepted this request. In the end, a plan was only finalized in late March for a fishery beginning in early April. The management plan actually consisted of 18 separate plans (or 18 quota groups) with 12 in 4X, three in 5Z, and three in 4VsW. As well, the plan did include trip limits, but industry enforced trip limits through a system of contractual arrangements with the catch monitoring companies and an industry sanctions committee. (The full legal dimensions of this system are still under review and further elaboration.)

Despite the fact that some monthly or seasonal quotas were fished up very rapidly, the plan worked amazingly well given the small quotas. Most quota groups had a fishery that lasted well into September and at least one will continue even later into the fall. The main problem encountered was with the large number of unorganized fishermen who were poorly or totally not informed about the management plan and only realized that some drastic changes had taken place in groundfish management when their summer fishery was closed in mid-summer and was not scheduled to open again until September.

The Scotia-Fundy Fixed Gear Groundfish Workshop

The purpose of the workshop held on September 20-21, 1995, in Truro, N.S., was to explore innovative and alternative approaches to groundfish management. In order to expand the exposure of a wider number of fishermen to the process of groundfish management and Committee functioning, each organization was invited to send up to five delegates to the workshop. In all, over 50 fishermen representing 14 different organizations attended the workshop.

Invited guests and speakers included fisheries scientists, ecologists, social scientists, the FRCC, private consultants, and fisheries managers from DFO and the provinces. The workshop was structured to provide fishermen with substantial presentations in the plenary sessions, and large amounts of time allocated to participate in four smaller discussions groups. Discussions focused on two goals:

i) to determine the conservation, social, and economic objectives of groundfish management; and
ii) to determine the major management tools that can be used to realize these objectives.

The objectives of groundfish management as determined at the workshop were:

i) Sustainability of the Resource: This included such dimensions as the use of non-destructive gear, a code of conduct, the consideration of ecological features, the reduction of waste, and an improvement in yield.
ii) Sound science incorporating an ecosystem approach and greater involvement by fish harvesters.
iii) Sustainable coastal communities oriented toward economic viability, stability of incomes, and an equitable sharing of the benefits of resource exploitation. The sustainability of communities also included such values as independence, inclusivity, commitment, and flexibility.
iv) Improved communication and educational programs for fishermen and the general public.

The discussion of management tools was particularly dynamic and resulted in a whole host of possibilities. In a plenary session, consensus was reached that the primary tools of groundfish management should be:

i) Community-based Management: This tool was largely one of local groups having greater control over the management of the fisheries in their area. It does not refer to fishing grounds but to a unit of land-based management authority. The community could be a geographic area or a community of interest. Besides control, community-based management would lead to enhanced simplicity, flexibility, and communication. Inter-community management would be coordinated through the Scotia-Fundy Fixed Gear Groundfish Committee.

ii) Time Area Closures: There was broad support for increased protection for fish in spawning and nursery areas. This was also seen as an area where fishermen's ecological knowledge in providing an inventory of sensitive areas could play a key role. At the same time, community-based management would be an opportune method of identifying and implementing such closures based on real-time knowledge and flexibility.

iii) Effort Control/TAC Controls: A considerable segment of fixed gear representatives would like to develop a greater reliance on a combination of biological and effort controls to control fishing mortality rather than a strict dependence on TAC management. Again, community-based management would provide a new and effective vehicle for determining local effort control requirements and enforcement. Effort controls could include gear selectivity, limits on gear, trip limits, timed openings and closures, shorter seasons and other limits on time on water, owner-operator, and the promotion of multi-species licensing. With the exception of a few dissenting voices, most representatives believed that a greater use of effort controls must, over the shorter term, be done in conjunction with TAC management.

iv) Capacity Control/Multi-Species Fishery: The problem of latent capacity was identified as a major concern. Fishermen recognized the ineffectiveness of measures used to reduce capacity up to the present time, including HABS. Still again community-based management, together with the promotion of a true multi-species fishery, was seen as an opportunity to take a fresh, local approach to this problem.

In addition to the above, a major accomplishment of the workshop was to bring a large number of fishermen together for two days to discuss their industry in a relaxed and reflective context. The increased mutual understanding resulting from this exercise should be extremely valuable once the difficult task of developing a 1996 management plan begins later this month.

Managing the Atlantic Groundfish Fishery
Formula for Change

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When Canada extended its jurisdiction to 200 nautical miles in 1977, the prospects for the Atlantic fishery looked bright. Groundfish stocks, which had been ravaged since the late-1950s by large international fleets of factory trawlers, were predicted to rebound under a new fisheries management regime.

Unfortunately, the optimism was short-lived. Within a decade, groundfish stocks began to show signs of overfishing (i.e., declines in mean size, age-at-maturity, abundance in inshore areas, etc.). By 1991, reported catches of cod and haddock (the two most important groundfish species) had fallen to historic lows. The closure of the Northern cod fishery off Newfoundland in 1992 signaled the latest crisis in the Atlantic fishery.

Why has Canada been unable to effectively manage its own groundfish stocks? Foreign fleets, which continue to fish on the nose and tail of the Grand Banks, are partly to blame for the decline in stocks which migrate outside the 200-mile limit. Within the Canadian zone, foreign fishing effort was quickly replaced by newly-built Canadian vessels, mostly small (less than 65') otter trawlers. By the time fisheries managers had limited the entry of vessels in all gear sectors (mid-1980s), fishing (and processing) capacity in the groundfish fishery was estimated to be many times the optimal level (Haché 1989). Despite developing a sophisticated and costly fisheries management system (Hurley and Gray, 1988), the Department of Fisheries and Oceans (DFO) was unable to adequately monitor the groundfish fishery and enforce a myriad of new regulations. Total Allowable Catches (TACs) were commonly exceeded and the quality of fisheries data was jeopardized by extensive discarding at sea and catch misreporting.

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Virtual Population Analysis (VPA), the most commonly used model to assess groundfish stocks, has many shortcomings. It relies on catch/effort data which is at least two years out of date. VPA does not take into account multi-species interactions or the effect of oceanic variables (e.g., temperature, salinity, currents, etc.) on fish production. Retrospective analyses have revealed biases in the model which have led to consistent underestimates of fishing mortality and overly optimistic predictions of future catches. Poor data quality was determined to have reduced the accuracy of the model predictions, but was unable to explain the biases found in the retrospective analyses (ICES 1991).

In contrast to the groundfish fishery, the inshore lobster fishery has exhibited long-term stability without a limitation on total catch. Although DFO has the ultimate authority, the inshore lobster fishery is largely managed by the fishers themselves through local advisory committees.

In this essay, we propose a community-based system to manage the Atlantic groundfish fishery. Our model, which can be applied to other fisheries besides the groundfish fishery, is not unlike the committee structure used to manage the inshore lobster fishery.

We also outline a formula for a new fisheries management system which is consistent with the essential characteristics of an "ideal" fishery:

- sustainable biologically and economically;
- easily monitored, controlled and enforced; and
- uses fishing gear which is selective and does not destroy bottom habitat.

The proposed system, which is based on control of fishing effort, is predicted to be more effective and less costly than the current system which relies primarily on catch controls (TACs).

The first step in a community-based management system is to define a "community". Community boundaries would follow natural socio-economic divisions onshore and historic fishing areas and stock boundaries offshore. For example, the fishing community in southwestern Nova Scotia would probably be assigned fishing rights to adjacent coastal waters and traditional offshore fishing areas such as Browns Bank and Georges Bank. Communities would be kept as small as possible to increase the degree of involvement and the sense of ownership of the individual fisher. The final decision on community boundaries would require considerable negotiations.

A Community Management Committee (CMC) would be responsible for developing a fishing plan for each community. Besides fisheries, membership on the CMC could also include other major stakeholders in the fishery (i.e., fish processors, seafood distributors, etc.) and citizens' groups.

Representatives of the CMCs would also serve on a Regional Community Management Committee (RCMC). The RCMC would be responsible for formulating regional policies and priorities, for developing fishing plans involving transboundary stocks, and integrating the various fishing plans into a coastal zone management scheme.

The RCMC would work closely with the newly-formed Fisheries Resource Conservation Council (FRCC). In fact, the FRCC would be the appropriate body to review fishing plans and liaise with government agencies such as DFO. DFO would continue to assess the biological condition of fish stocks and enforce fisheries regulations.

The proposed effort control system is based on the method used to handicap ocean yachts for racing events. Like yachts, fishing vessels come in a variety of shapes and sizes. Depending on the species fished, these vessels use a variety of gear types.

Each fishing vessel would be assigned a "Fishing Effort Value" (FEV). The formula for determining the FEV would factor in all items affecting the fishing power of a vessel (i.e., length, width, horsepower, hold capacity, gear type(s), gear size(s), fish-finding and navigation equipment, communications technology, crew size, etc.). Weightings would be determined by reviewing the results of vessel/gear comparison studies, comparing catch/effort data from fisheries observer reports, etc. Factors which support conservation objectives such as non-destructive fishing methods (e.g., hook and line, traps, etc.), vessel safety, and environmental practices would be given a preferential weighting.

A vessel which received an unfavorable rating would be retired from the fishery or could be modified to improve its rating. A licence buy-back system would encourage the removal of excess fishing capacity. Spot checks by DFO or other regulatory agency would be required to ensure compliance. Every vessel would be required to display a measurement certificate.

A Community Total FEV (CTFEV) would be derived from the long-term sustainable effort level corresponding to the optimal fishing mortality for the fisheries resources within each community. The community could choose any mix of vessels and gear types which did not exceed the CTFEV. For example, a CTFEV of 1000 would allow ten 100-unit vessels or twenty 50-unit vessels to fish throughout the year.

Monitoring and enforcement requirements would be much less under the proposed fisheries management system. Fishers would have less incentive to cheat since there would be no limitation on total catch. Social pressure would force fishers to respect community marine boundaries.

In conclusion, the proposed fisheries management system recognizes the inherent rights of coastal communities to adjacent stocks while offering fishers a sense of ownership in their fishery. We echo the appeal of Troadec (1983) who recommended that fishery management systems involving catch quotas "... should be replaced by other more complete methods (limitation of total catch capacities through issue of fishing licences and control over gains of efficiency) ...".

*Note: The main text published originally in *Fisheries*, Vol. 19. No. 3, pp. 22-23.

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Biological Concepts of Importance in Considering Closed Areas as a Tactic

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Closed areas can be a tool to help prevent both recruitment overfishing and growth overfishing. One interpretation of the decline in recruitment levels for groundfish species in the northwest Atlantic is that individual spawning components have not been protected under quota management.

The manner by which spawning components could be lost under quota management is illustrated using the 4VsW cod management unit. Areas where spawning aggregations have been observed in past years are shown in Figure 1. One theory of population biology of marine fish would lead to the working hypothesis that these several spawning areas in 4VsW support self-sustaining populations of different average abundance levels. For example, the Sable Island spring spawning aggregation could be considered a potentially large population, in contrast to a smaller Middle Bank or Chedabucto Bay population. During much of the year, under this working hypothesis, the juvenile and adult fish from the several different populations move around 4VsW as a mixture following feeding and overwintering migrations. However, at the characteristic spawning time for the respective populations, the mature adult members "home" to their location of birth for reproduction. Instead of "homing" back to rivers, as is the case for Atlantic salmon, the cod are interpreted to be returning to a particular bank or coastal embayment. If this interpretation of population structure is correct, the individual spawning components are vulnerable to overfishing under present practices of quota management.

Even though the annual quota may be accurate for 4VsW cod spawning complex as a whole, unrestricted fishing on Middle Bank or the Chedabucto Bay spawning aggregations in the early part of the year when the uncaught portion of the TAC is high could result in loss of the smaller spawning populations due to recruitment overfishing.

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The mobile gear with modern fish finding technology has the capability to harvest a high proportion of a spawning aggregation while staying within their allocation. Unfortunately, for most marine species we do not know with certainty what the spawning populations are. Furthermore, it is unrealistic to be able to monitor the relative abundance of the several spawning populations of the many species/area groundfish management units in the region. The core research vessel survey for assessments is conducted during the summer, when the fish are less aggregated. This is good for evaluating overall abundance within an area, but not good for estimating relative abundance of spawning components.

In sum, we do not know with certainty the geographic scales of birth-site fidelity for the groundfish species of commercial importance, nor the relative abundances of spawning components within the diverse management units. Under the precautionary approach, it is prudent to assume that the various spawning aggregations are self-sustaining, and thus that they require individual protection. Spawning closures are one approach to achieve that protection under the working hypothesis described above. During the non-spawning seasons of the year, the members of smaller populations are inter-mixed with other populations, and thus it is less likely that these components could be eliminated. The costs to industry of this precautionary method is lower aggregate catch rates over the year. There is also the costs of enforcement which may have to be covered by industry in the future. The benefits are better protection of the spawning potential of the commercial species in question.

Closed areas to reduce fishing on juvenile fish may be used as a tool to prevent growth overfishing. Given recent changes in mesh size for trawling and hook size/bait characteristics for the longline fishing, we need input from industry on the degree to which dumping of small fish and/or highgrading is still a significant problem. Is there a small fish problem in Scotia-Fundy? If so, closures of areas characterized by juveniles can change the overall selectivity pattern of the fishery and generate high stock biomass levels for a given level of fishing effort (and thus higher catch rates). Using 4VsW as an example, the loss of yield that occurs if there is significant discarding of age 2 and 3 fish is shown in Figure 2. In practical terms, the juvenile nursery area closures are more acceptable when such areas contain relatively low levels of older fish. G. Black will evaluate the degree to which juvenile cod, haddock, and pollock co-occur with older fish.

The presentations in this session should allow us to come to some practical conclusions on the role of closed areas to help protect spawning components and increase growth potential.

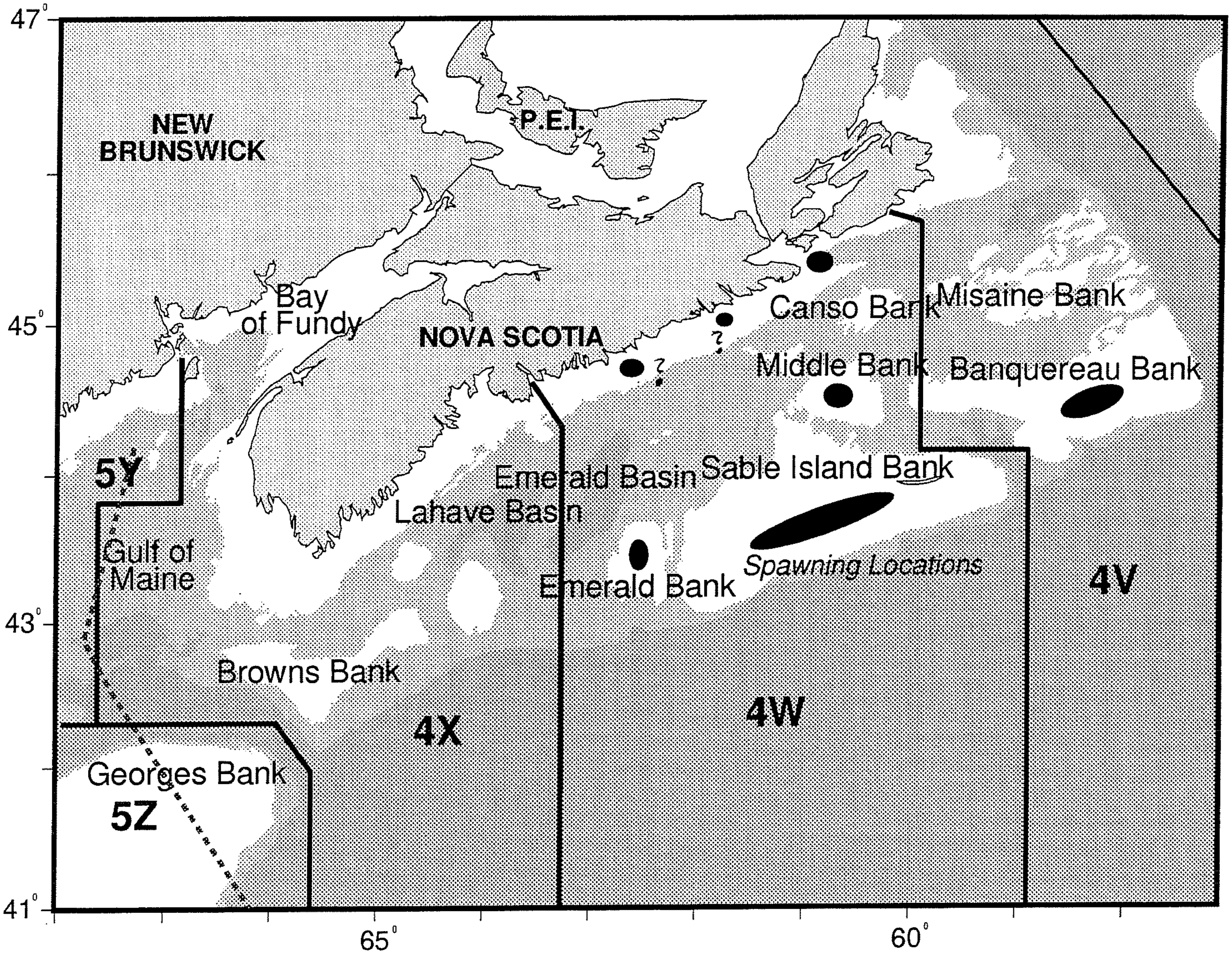

Figure 1. Schematic representation of cod spawning areas within 4VsW based on interviews with fishermen.

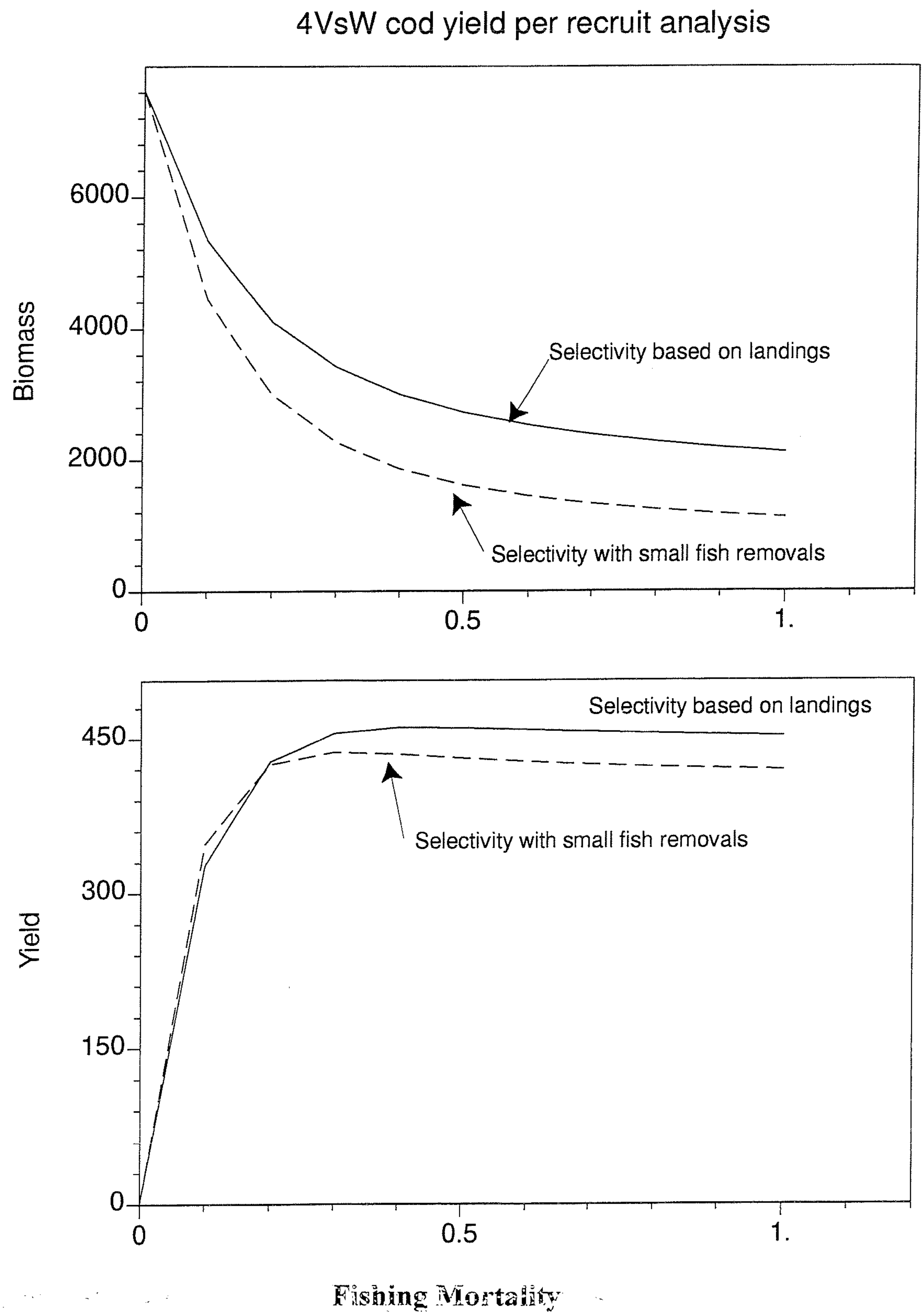

Figure 2. Illustration of changes in biomass and "yield-per-recruit" if small fish are being discarded.

Can Ichthyoplankton Data be Used to Describe Spawning Areas of Marine Fish?

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Introduction

As the fisheries science community strives to develop new approaches for fisheries management, the need for better definition of spawning areas has become topical. Management measures such as closed areas to protect spawners require precise definition of the extent and timing of the distribution of spawners, otherwise fishing opportunities may be unfairly denied. Tools available for the identification of spawning areas include the description of the distribution of spawning adults, either from field surveys or from anecdotal records obtained through interviews, or from examining the distribution of early life history stages.

In this paper, we examine the utility of the latter approach, focusing on the available ichthyoplankton information for cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), and pollock (*Pollachius virens*). In particular, we assess whether available egg distribution data faithfully reflect spawning distributions, and what factors could confound the interpretation of such data. Finally, using an example from the 4X cod stock, we examine some of the implications of establishing a closed area based on protecting spawners for the larger management unit.

Methods

The Department of Fisheries and Oceans is comparatively data-rich with regard to ichthyoplankton information. We examined the results of three recently-completed ichthyoplankton programs, summarized below:

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Survey	Years of Operation	Seasonal Coverage	Geographic Coverage
Scotian Shelf Ichthyoplankton Program (SSIP)	1978 - 1982	All months, except March	Scotian Shelf, but not the Bay of Fundy
Fisheries Ecology Program (FEP)	1983 - 1985	Monthly, February to June	Area off south-west Nova Scotia
Larval Herring Program (LHP)	1981 - present	1981 - 1984 (spring) 1981 - present (fall)	Bay of Fundy, area off south-west Nova Scotia (also included Georges Bank in recent years)

The SSIP offered extensive coverage, both monthly and geographically, but the station density was low compared with the other ichthyoplankton programs. The FEP covered the Browns Bank area intensively, but only during the first half of the year. Groundfish eggs encountered during the LHP have been sorted and identified until 1994. The longest running series of the LHP is the fall series and such data complement the FEP, since the FEP only covered the first half of the year. Thus, each program has particular strengths and weaknesses for the purposes of describing the location of spawning on the Bay of Fundy/Scotian Shelf.

The ichthyoplankton programs often used a variety of gear types and tow patterns. For the purposes of this study, we elected to focus on bongo tows, since that gear type was common to the three programs. The bongo net consisted of two circular fiberglass frames 61 cm in diameter joined together by a central yoke by which the tow wire was attached. Conical monofilament nets, usually of 333 micron mesh size, were attached to each frame and fitted with PVC codends. Flowmeters were attached to centrally-mounted bars across the mouth of each net, and provided estimates of volume of water filtered through each net. The SSIP program employed an oblique tow where the net was hauled back continuously without steps at generally consistent rates resulting in variable tow durations across different depths. Sampling depth was set to a maximum of 200 meters. The sample was usually taken from the port bongo. The SSIP program also employed the surface bongo, which is the same as the oblique bongo except it was towed at the surface without a depressor for 15 minutes. There are other gear types that were employed by the SSIP, but these two gears were used throughout the program and with flowmeter readings an estimate of abundance could be calculated as volume per meter cubed. The FEP followed similar protocols. The LHP, however, employed a bongo net equipped with 505 micron mesh. A "sawtooth" tow profile was used. This method consisted of deploying the net at 50 m/minute to approximately 5 m off bottom and hauled back at a rate of 20 m/minute. The sink time was subtracted from the total time to get retrieval time. If the retrieval time was less than 10 minutes the net was redeployed and hauled back again. This is repeated until the tow duration is greater than 10 minutes. The sample was taken from the port side bongo and the starboard sample was used as a backup in case there were problems with the port side sample.

Eggs were identified to species and stage according to Markle and Frost (1985). Data from the Larval Herring Program were selected for pollock, haddock, and cod for all egg stages, and disaggregated by year and season. The abundance index calculated was number of eggs caught/volume of seawater filtered (m^3). Zero catches were also selected. Although earlier data were available, data prior to 1981 were not used as they were not considered as reliable as the more recent information. Spring data were available from 1981 to 1984, while fall data were available from 1981 to 1993. 1994 data were not used since only a subset of the stations completed were sorted and identified.

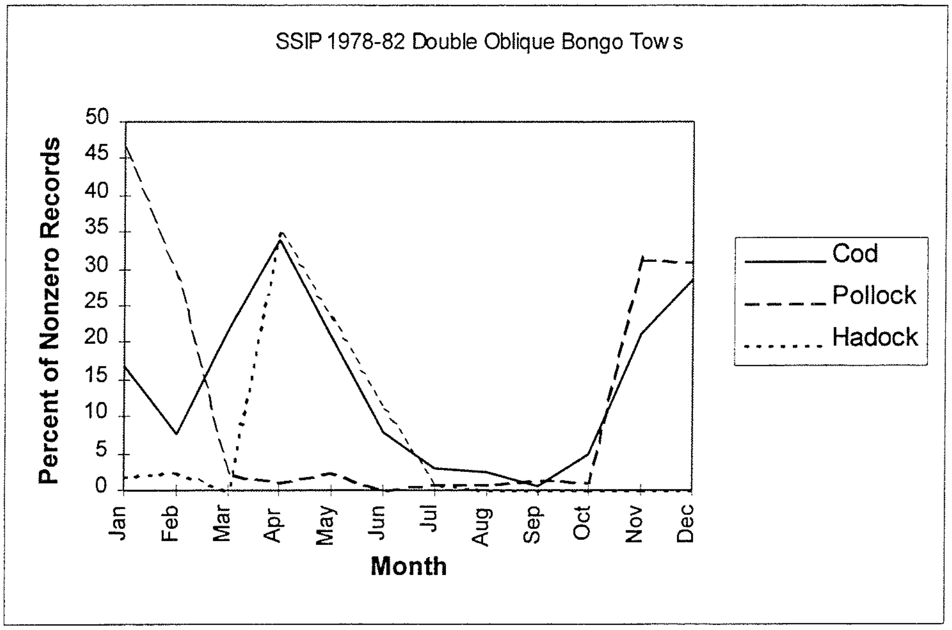
For extracting the SSIP data, a similar procedure was followed to that employed with the LHP data, except that the information was disaggregated on a monthly basis by species by tow type (oblique, or surface). The data were pooled by month over all years of the SSIP program.

In the case of the FEP, two bongo sets were done at each station. All four samples were sorted, but an average of all four catches along with the average volume filtered are presented here.

Results

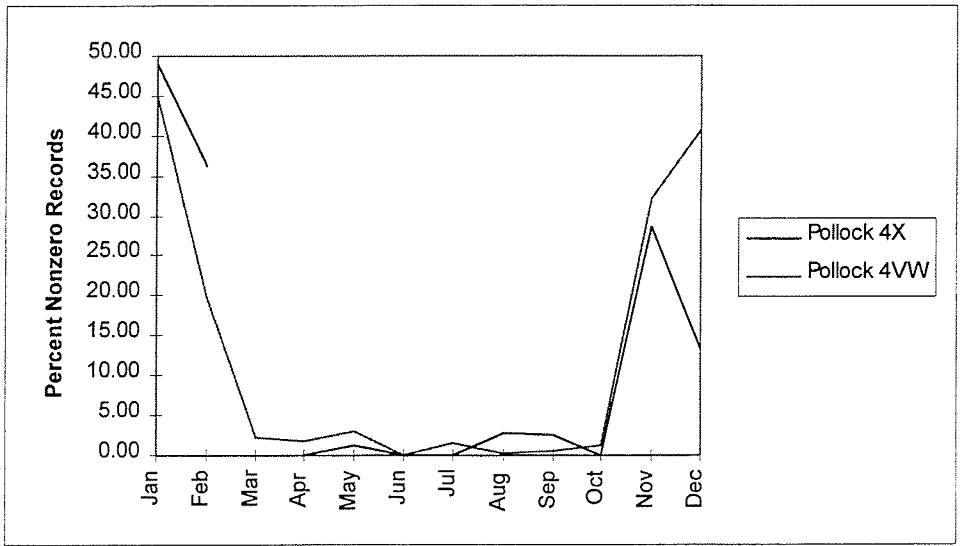
Timing of Spawning

Due to the monthly nature of the SSIP surveys, that program provides the best information on the timing of spawning. The percentage occurrence of cod, haddock, and pollock eggs from all sets made in a given month over the five-year duration of the program is shown below:

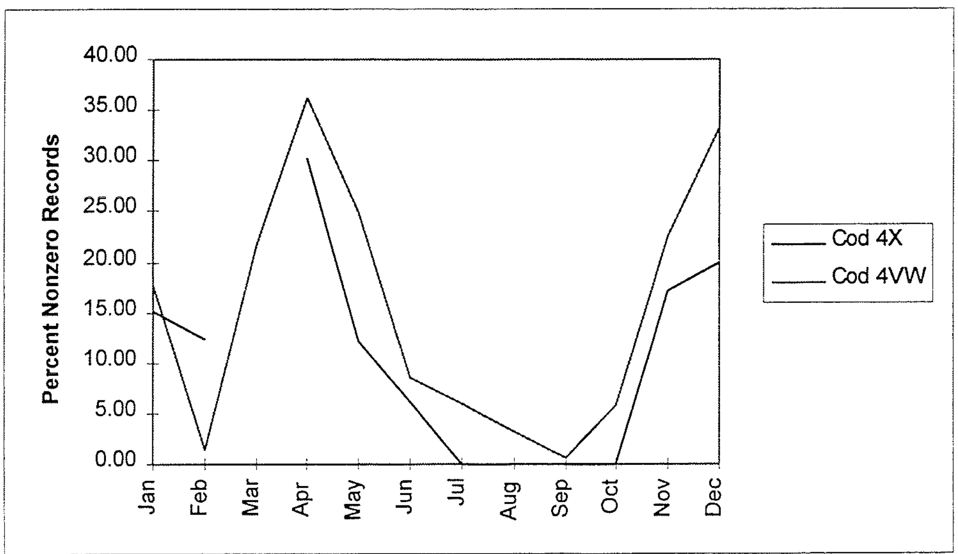


Peak egg abundances occur for pollock in November through February. For haddock, the peak months are April and May. Cod spawning activity occurs in a broader time period than the other two, and there appears to be two peaks in spawning activity, one in the spring and the other in the fall.

Spatially, these data are highly aggregated. Previous studies on the Scotian Shelf have indicated that the timing of peak abundance of groundfish eggs is earlier in the west and later to the east (see, for example, Neilson et al. 1988). Hence, this difference may mask important trends. We therefore split the above data into eastern and western components, using an arbitrary break at 63 degrees 20 minutes longitude, corresponding with the 4X/4VW split. The following plots show the timing of spawning by month for the eastern and western components of the Scotian Shelf:

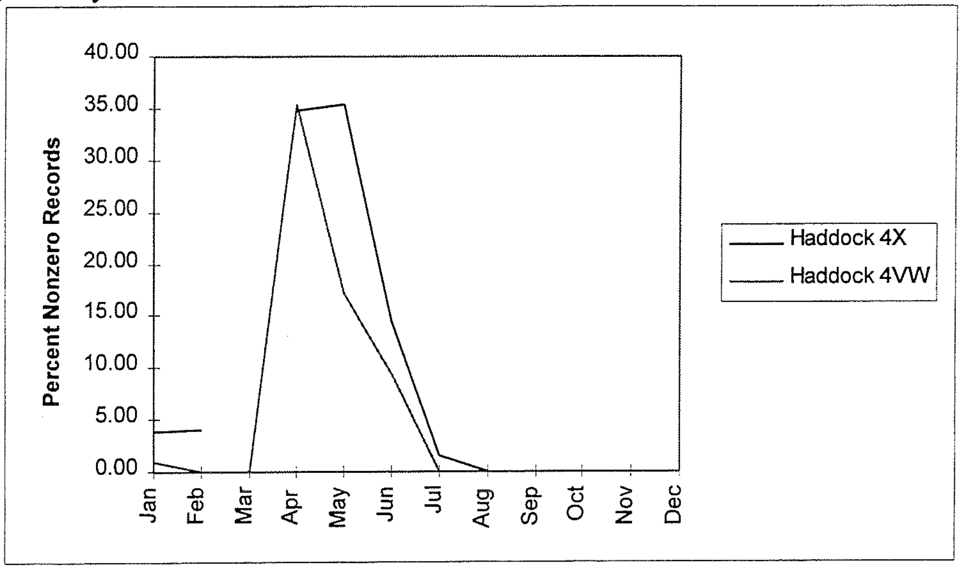


Pollock show only one peak in egg abundance. The peak release of eggs occurs in January in both 4X and 4VW. There are very few occurrences of eggs from March through to October.



Cod have two peaks in the egg production curve, with one peak in April and the other in December. The timing of the peaks does not appear to differ from the eastern shelf to the west. Compared with the other two gadids, cod appear to be less precise in the timing of their spawning activity.

west. Compared with the other two gadids, cod appear to be less precise in the timing of their spawning activity.



Haddock eggs were most frequently encountered in April in 4VW and May in 4X.

Spawning Locations

To obtain the best synopsis of the distribution of eggs throughout the study area, we combined the results of programs in single plots, by species, for the spring and fall periods. In doing so, we assumed that the distribution of eggs will not have changed appreciably over the period for which we have data. Each program is represented by a different symbol type, and the egg densities are presented using the same scale. The results for pollock in the spring are shown in Figure 1. Browns Bank appears to be important for spawning, particularly on the west side. There also appears to be spawning activity in the Trinity-Lurcher area. A large portion of the central Scotian Shelf was not covered during any survey. In the fall (Figure 2), pollock eggs were found again in the Trinity-Lurcher area and Browns Bank. Further east, there were concentrations found on Emerald and Western Banks, and also near Sable Island Gully.

Haddock egg distributions in spring were highly localized compared with pollock (Figure 3) , and occurred only on Browns and Georges Bank. There were very few occurrences of haddock eggs on the eastern shelf. In the fall (Figure 4), virtually no haddock eggs were encountered.

Aggregations of cod eggs were found in the spring on Browns Bank (western side) and Georges Bank. Cod eggs were generally distributed, although at low densities, throughout the Bay of Fundy and in the Trinity-Lurcher area. To the east, eggs were also occasionally present (Figure 5). In the fall (Figure 6), the Trinity-Lurcher aggregation persists, and there are also some eggs found on the western side of the Bay of Fundy. Notable concentrations occurred at the most landward of the stations along the southwest Nova Scotia coast and also in the Sable-Western Bank area.

Some indication of the complexity of cod spawning is obtained by examining the distribution of cod eggs by month frȯm the SSIP (Figure 7). In April, there are eggs taken on Browns, Emerald, and Western. In May, egg distributions have shifted up the shelf to Middle Ground and Banquereau Bank. There are comparatively few eggs collected until October, when comparatively high densities were encountered around Sable Island. A similar pattern was found in November, including evidence of inshore spawning. A similar pattern persisted in December.

Discussion

Mayo et al. (1989) postulated that spawning areas for pollock included The Gully, Middle Ground, Western Bank, Emerald Bank and Emerald Basin, inshore along the southwestern coast of Nova Scotia, LaHave Bank, and Baccaro and Browns Bank. Their conclusions were also based on examination of data from ichthyoplankton surveys, including USA sources. Our interpretation of the available data confirms that Emerald/Western Banks, Lurcher/German Banks are significant. We did not observe notable concentrations of eggs in the vicinity of Bacarro/LaHave, as Mayo et al. (1989) found. We found that pollock are fall/winter spawners, with the peak months for egg production being November through January.

Of the three species we examined, the data are sparsest for haddock. However, as noted by Hurley and Campana (1989) in the their examination of the FEP information, the Browns Bank area is clearly significant for haddock spawning. From the SSIP data for April and May, haddock eggs were generally distributed throughout the area to the west of Sable Island, although in lower concentrations than those on Browns Bank. To the east of Sable Island, there were very few records of haddock eggs. Further south, there were virtually no records of haddock eggs in the Lurcher/German area, which is in contrast to cod and pollock. Haddock egg production occurs mostly through March to June with a peak in April/May.

How reliable are such conclusions regarding spawning site and duration when they are based on ichthyoplankton data? One of the most important limitations of egg survey information is that cod and haddock eggs can usually only be identified by stage 4. Pollock, on the other hand, can be identified at stage 1. Stage duration is related to water temperature, with development taking place quicker in warm water compared with cold. Thus, in cold water, there is potential for a late stage egg to have been in the plankton for a considerable period. Page and Frank (1989) developed a relationship between stage duration and temperature for both cod and haddock. Using that relationship, we show stage durations for a typical range of water temperature:

	Temperature (degrees C)					
	2	**4**	**6**	**8**	**10**	**12**
Stage 1	9.9 d	5.4	3.5	2.5	1.9	1.5
Stage 2	18.2	10.2	6.7	4.9	3.8	3.0
Stage 3	19.0	12.5	9.3	7.4	6.1	5.2
Stage 4	9.5	5.2	3.4	2.4	1.8	1.4
All Egg Stages	56.6	33.3	22.9	17.2	13.7	11.2

Given such stage durations, what are the expectations for advective movement? The table below incorporates egg stage duration information from the previous table with estimates of horizontal movement in kilometers. The first estimate (shown at the top of the table) is from Drinkwater et al. (1979) and is an average value which could be applicable to the Scotian Shelf. The second value for advective movement is more typical of a tidally active environment (F. Page, pers. comm). The shaded values on the left indicate possible displacements in spring at a water temperature of 4 degrees C. The shaded values on the left indicate possible displacements that a fall-spawned fish might experience. These temperatures are indicative of the temperature regime off southwest Nova at 25 m during spring and fall (F. Page, pers. comm.). The implication is that any inferences of locations of spawning areas of fish based on data collected during the fall may be more precise than similar data collected during the spring. Obviously, straight line displacement is assumed in the calculations, and this is unrealistic. For example, the presence of residual gyres over spawning grounds such as Browns Bank (Smith 1983, Greenberg 1983) may result in the retention of ichthyoplankton close to the location of spawning, These inferences should therefore be considered worst case estimates.

			Temperature			
	2	4	6	8	10	12
Advective Movement	*(assumes 2 cm/sec movement)*					
By end of Stage 4	97.8	57.5	39.6	29.8	23.6	19.4
Advective Movement	*(assumes 10 cm/sec movement)*					
By end of Stage 4	489	287	198	149	118	97

In contrast with cod and haddock, there is comparatively little information for pollock. Fridgeirsson (1978) suggested that the time to hatch (end stage 4) was about seven days at 7.2 degrees C. Stage 1 was complete around two days. Given the scenarios for advection presented in the previous table, a pollock egg would move about 16 km by the end of stage 1, and about 56 km by the end of stage 4, at a temperature of 7 degrees. The development rates of pollock appear faster than those of cod at a given temperature, thus pollock egg distributions may give a more precise indication of spawning location than cod and haddock.

The realization (although certainly not novel) that 4X cod is comprised of many spawning populations that are reproductively isolated by either location or time is, we believe, significant in the evaluation of closed areas as a possible management tool. An obvious consequence of this observation would be that any management measure (such as a closed area) which changes the distribution and timing of fishing effort will likely result in certain spawning components absorbing a higher rate of exploitation than would be the case if the fishery was spread throughout the management unit. For example, off southwest Nova Scotia, Halliday (1988) documented that the closed area around Browns Bank was in effect only for March and April when the area was established in 1970. More recently, Hansen and Annand (1995) noted the 1994 closure extended from January to June. In the case of the 4X cod fishery, decreasing access to the Browns Bank spring-spawning aggregations means that a greater proportion of the total removals by the fishery from the 4X management unit will be taken from other spawning components, including the fall aggregations we identified earlier. Clark et al. (1995) have noted changes in the dynamics of the 4X cod fishery, with a greater proportion of recent total landings coming from the Bay of Fundy component of the management unit.

In summary, the available SSIP data are somewhat imprecise for the purpose of describing well-defined spawning areas. The FEP and LHP programs offer greater potential because of greater station density, but have geographic and temporal restrictions in their coverage. In general, the best prospects for precise definition of spawning groups from ichthyoplankton data are for fall spawners because of accelerated egg development at higher water temperatures and for pollock, in general, because of ease of identification at all stages of development.

Acknowledgments

We thank Fred Page, Don Clark, and Stratis Gavaris for helpful discussions as this paper was developed. L. van Guelpen (Atlantic Reference Centre, Huntsman Marine Sciences Centre) gave useful background on egg identification procedures.

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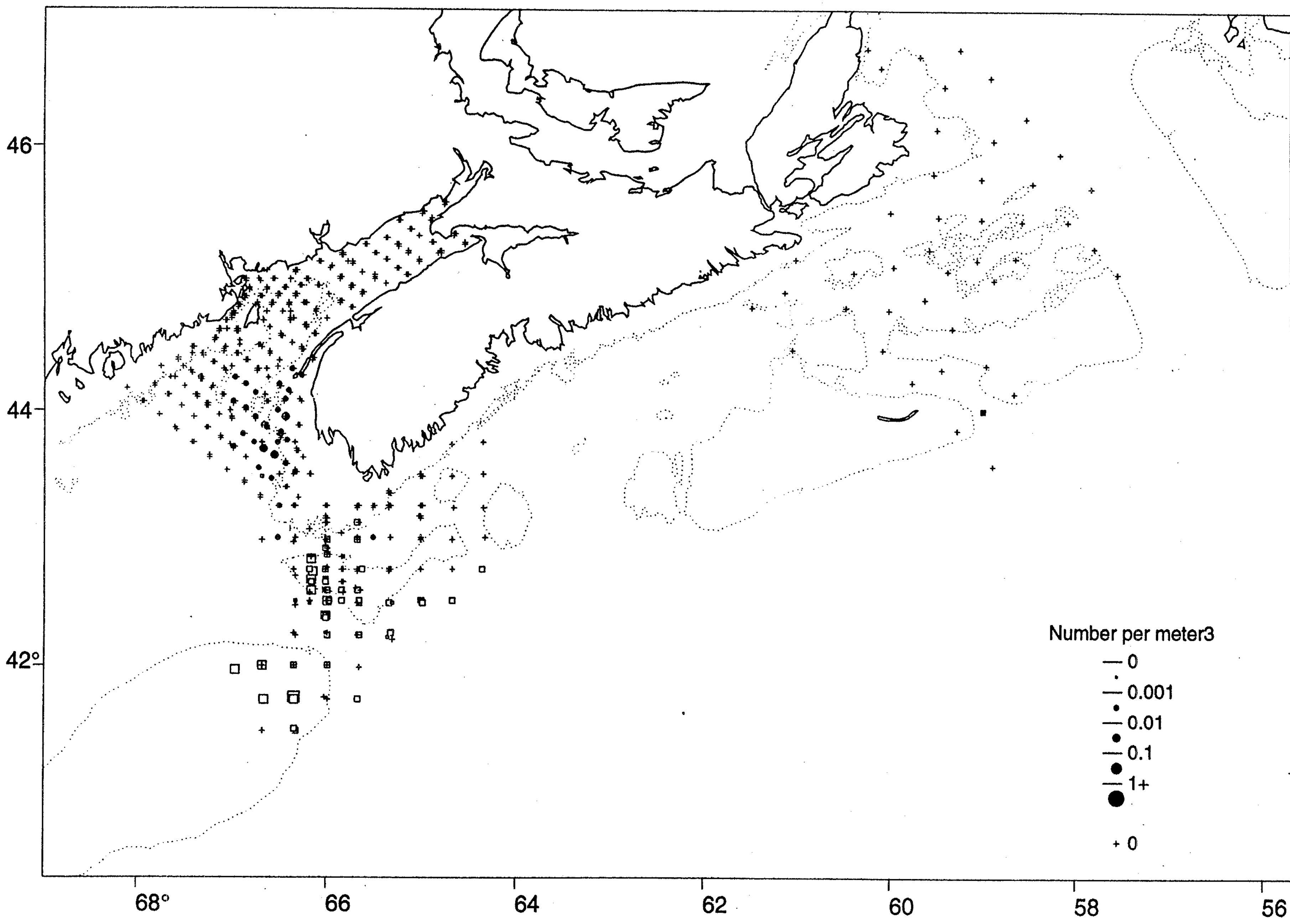

Fig. 1. Distribution of pollock eggs (March) from the SSIP (■), FEP (□) and LHP (●). See text for program and gear description.

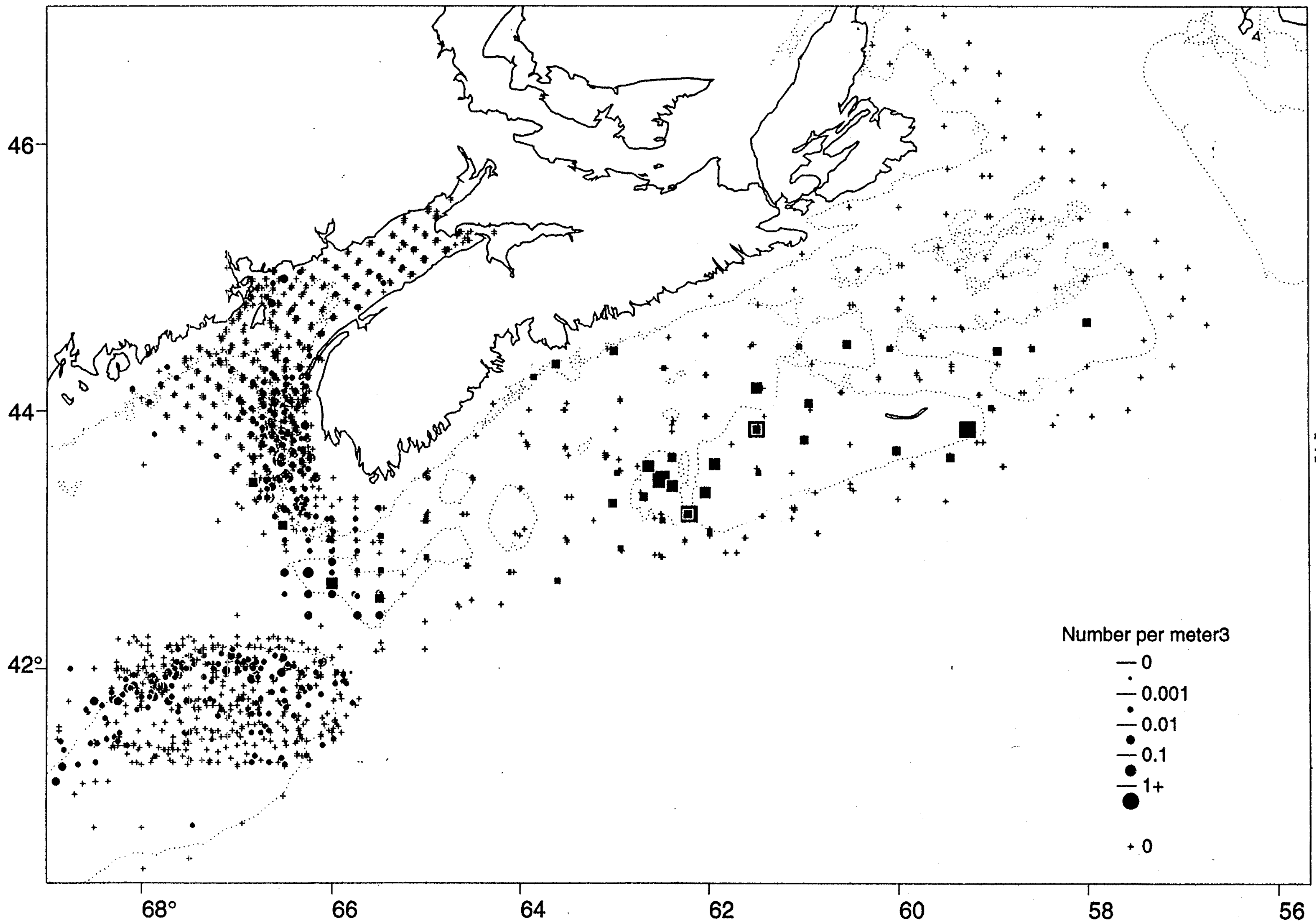

Fig. 2. Distribution of pollock eggs (October/November) from the SSIP (■) and LHP (●).

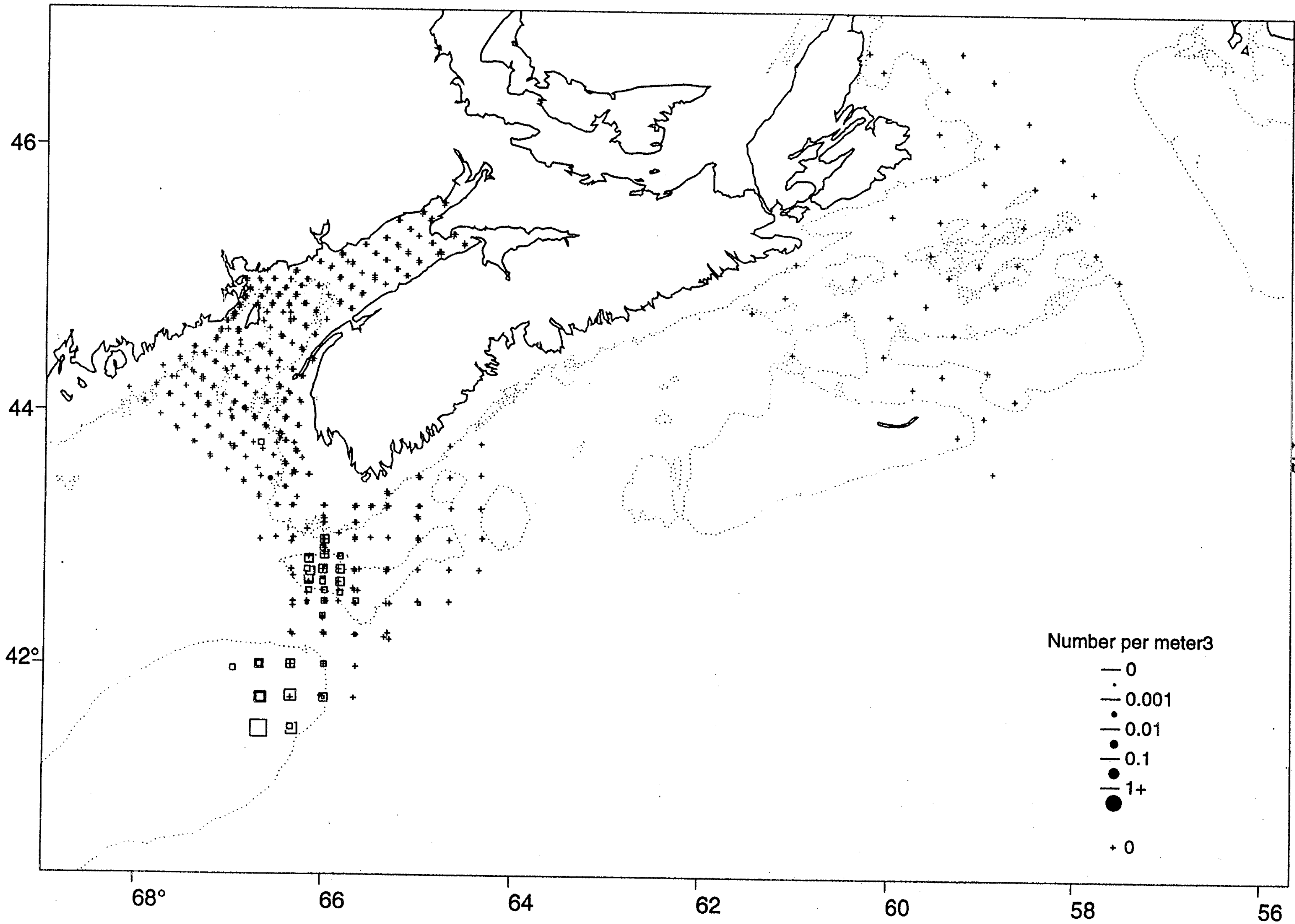

Fig. 3. Distribution of haddock eggs (March) from the SSIP (■), FEP (□) and LHP (●).

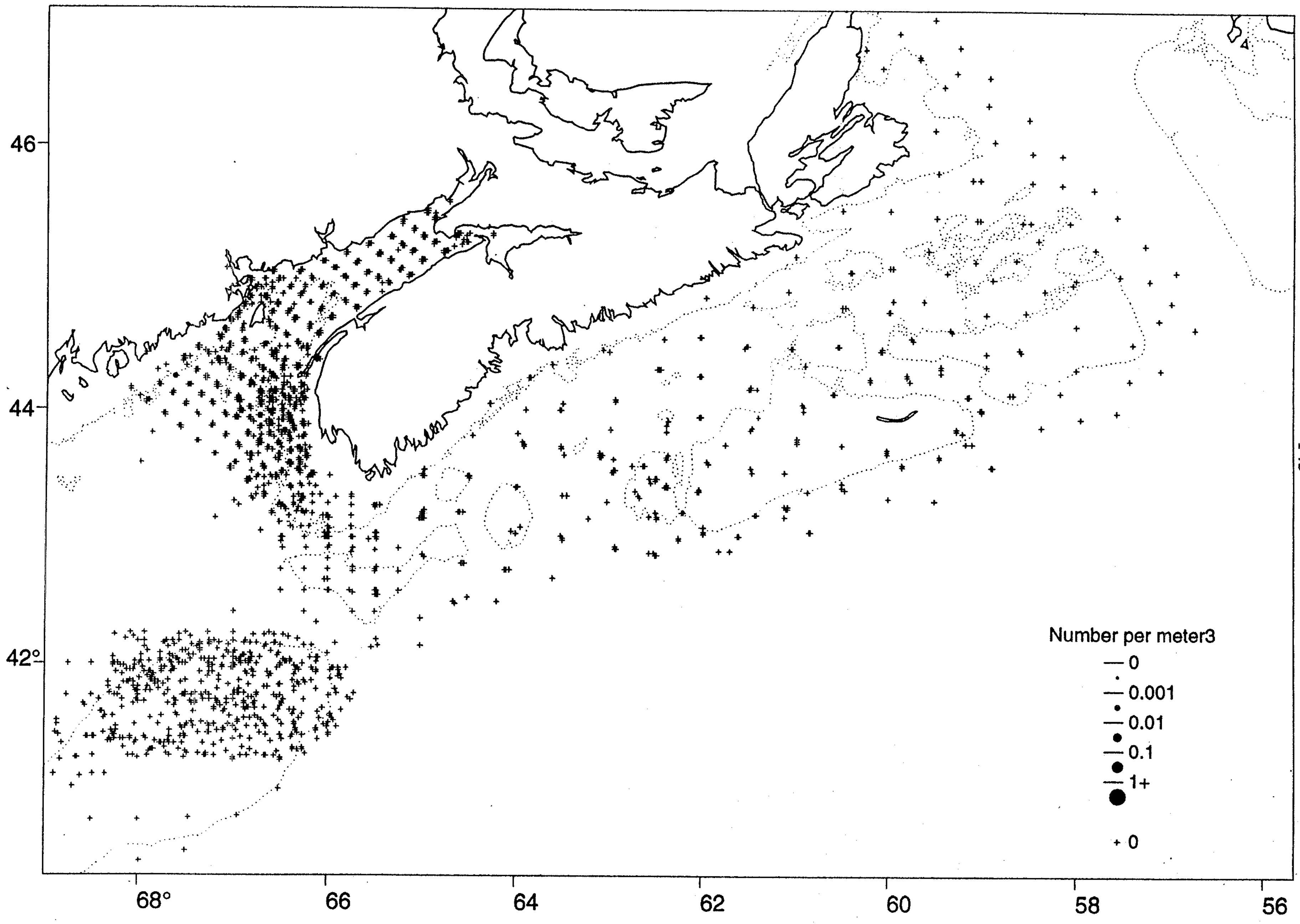

Fig. 4. Distribution of haddock eggs (October/November) from the SSIP (■) and LHP (●).

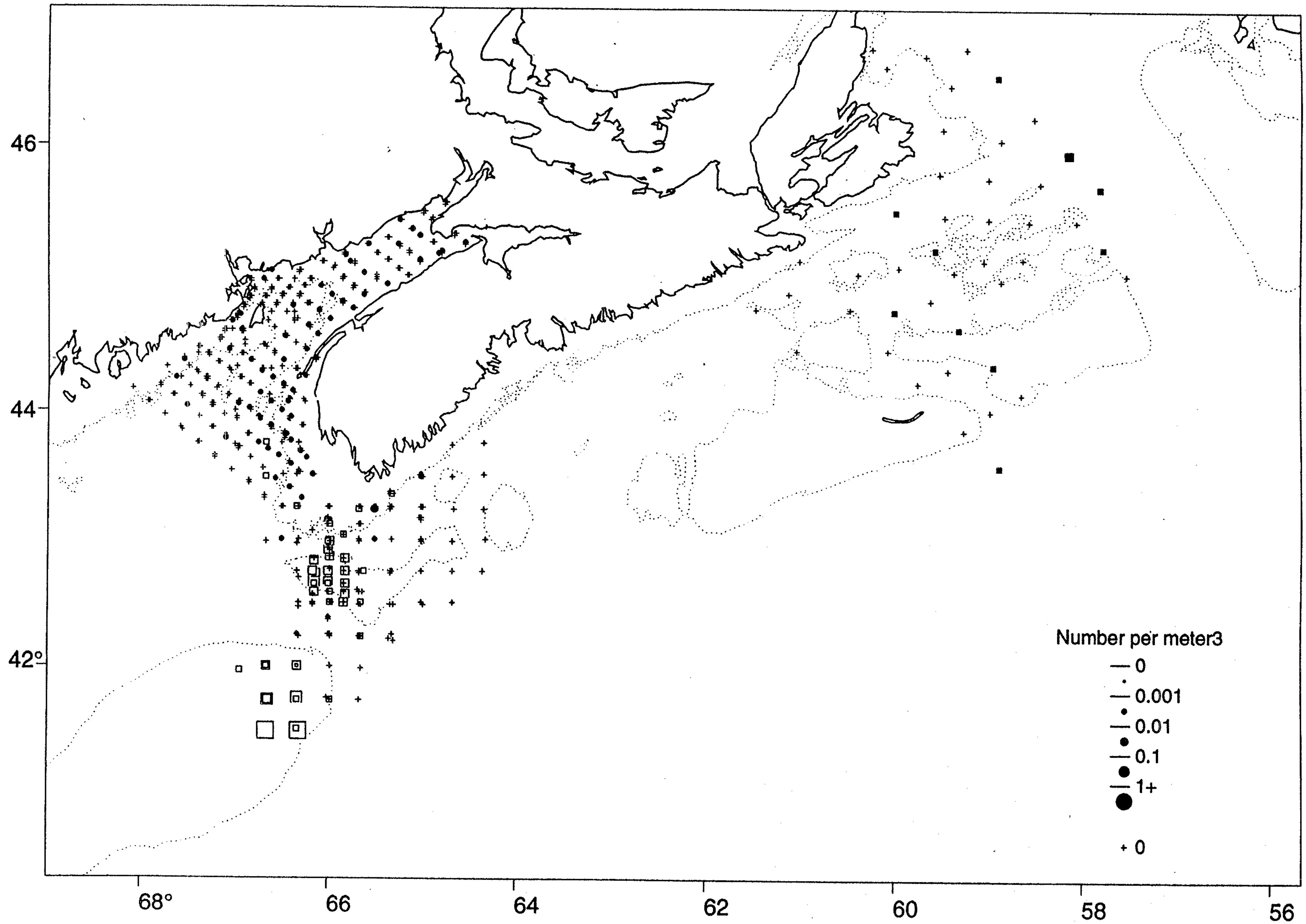

Fig. 5. Distribution of cod eggs (March) from the SSIP (■), FEP (□) and LHP (●).

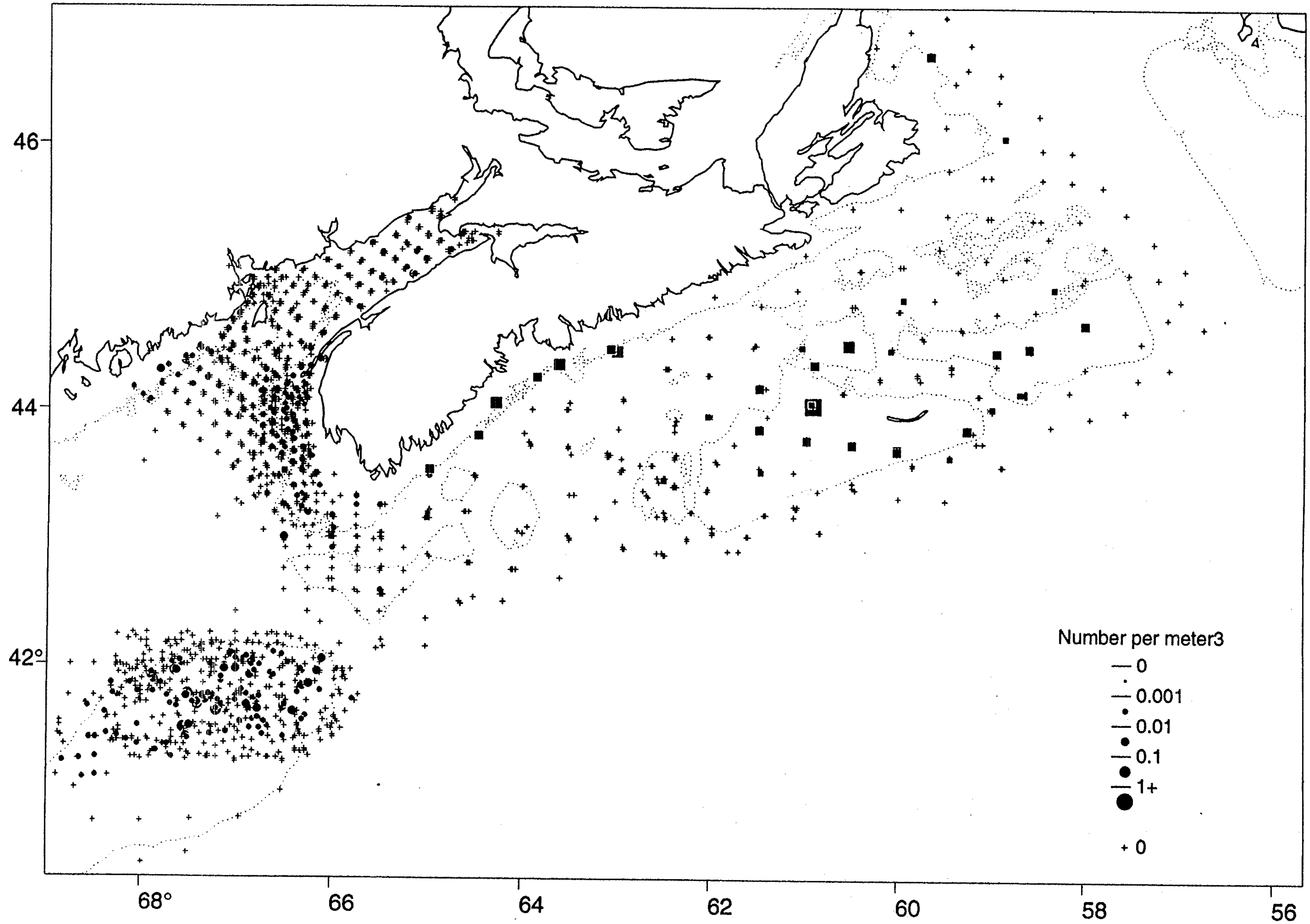

Fig. 6. Distribution of cod eggs (October/November) from the SSIP (■) and LHP (●).

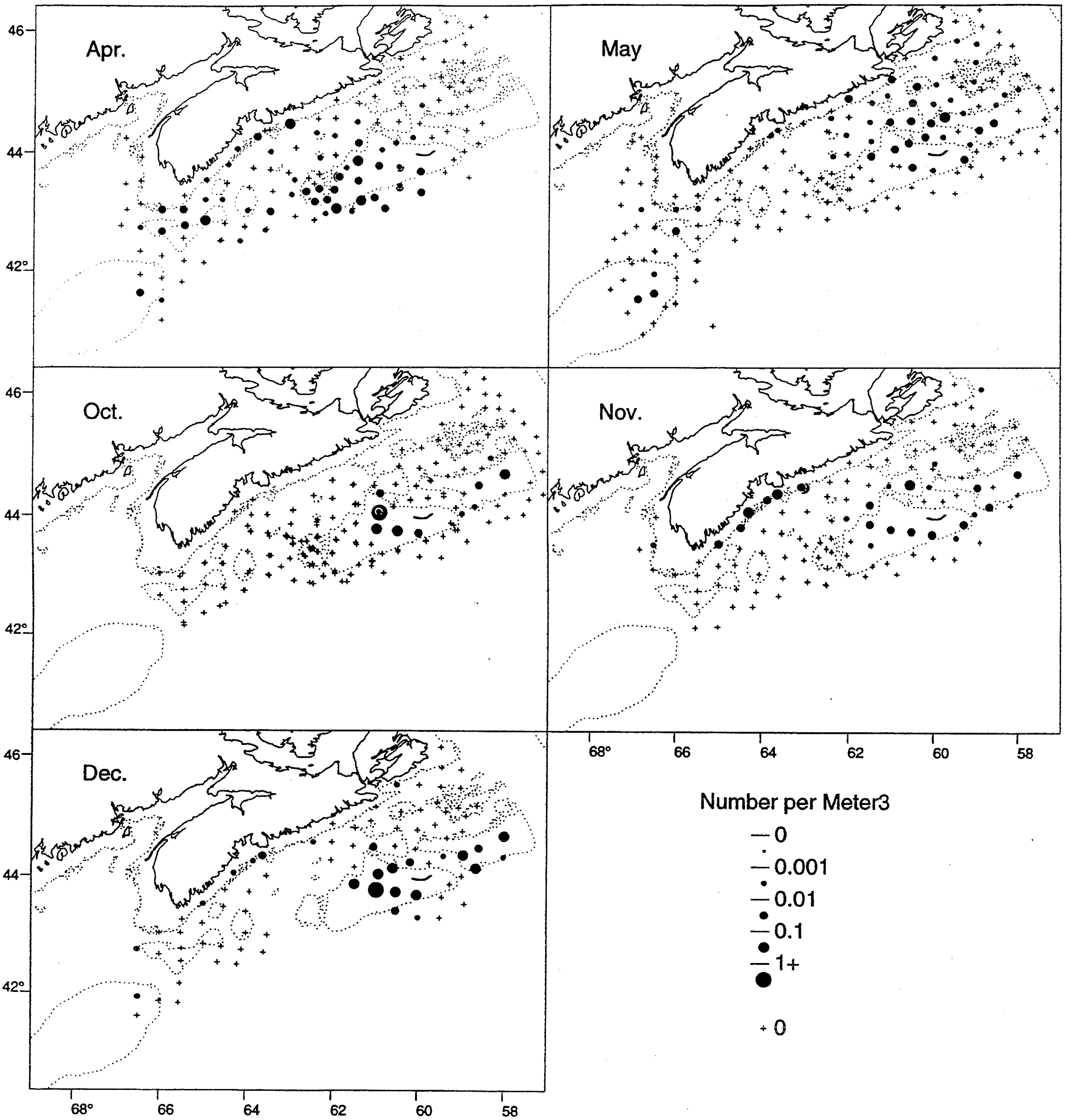

Fig. 7. Distributions of cod eggs by month from the SSIP. Scotian Shelf, 1978-82, oblique bongo tows.

Fisheries Knowledge of Spawning Locations on the Scotian Shelf

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Introduction

As part of a larger study on the use of closed areas as a fisheries management tool, a questionnaire survey of active and recently retired Scotia-Fundy fishers was initiated in July and August 1995. The preliminary results, as well as the methodology, are summarized in this paper. It is anticipated that the study will be continued in order to gain more confidence in conclusions on the location of past and present spawning areas on the Scotian Shelf.

Methods

It was originally felt that a stratified-random design would be the best way to choose fishers for interviews on spawning locations. In order to proceed with this, the licensing division of Fisheries and Oceans in Halifax provided a list of all current and recently inactive groundfish licence holders in the Nova Scotia portion of the Scotia-Fundy Region. This list totalled approximately 4000 names and addresses. A further list was received which contained a listing of fishermen of the same region who actually had landings in the 1994 calendar year, the last full year prior to project commencement. This list included approximately 300 names.

In order to determine the sample size, a number of factors were taken into consideration. Most importantly was time. A period of only six weeks was allowed for the interviews by two interviewers following project set-up. This time had to include

Burke, D.L., R.N. O'Boyle, P. Partington, and M. Sinclair. 1996. Report of the Second Workshop on Scotia-Fundy Groundfish Management. Can. Tech. Rep. Fish. Aquat. Sci. 2100: vii + 247 p.

travel and interview time. A further consideration was the legitimacy of the sample. It was felt that the project needed to include 150 to 200 fishermen based on statistics from licensing as mentioned above, and on reviewing reports of similar interviews by both Ralph Halliday and Kees Zwanenburg. It was further felt that an average of two or three interviews could be done per day by each interviewer on days in which travel time was not a consideration

A random list of 200 fishers was generated from the licensing list through the use of random number tables. However, as the process of phoning to set up interviews began, it was quickly determined that a stratified-random design would be inappropriate for this situation because it excluded retired fishers and crew members from the selection process. When phoning began, it was found that many fishers were either unavailable during the summer months (one of the few remaining fishing times for some) or were simply unwilling to cooperate. Further, it was desirable to interview those who would most likely be informed about groundfish spawning components. Thus, a different method of selection was adopted. Each interviewer set up one or two interviews in a community and then planned to travel to said community for a couple of days. While there, the interviewer set up additional interviews by systematically working through licence holders on the list as mentioned previously. This method proved much more fruitful, as interviewed fishers often supplied the names of others in the community who might be good sources of information. While this method was by no means completely random, it was found to be acceptable given that the goals of the project indicated a need to seek out those with information. To this end, as much as possible, preference was given to interviews of fishers with at least 10 to 15 years of experience in the groundfish industry, and who had fished for at least part of the 1980s.

Results

The method of selection resulted in 150 interviews distributed as shown in Figure 1, which can be compared with the distribution of all fishers with groundfish landings in 1994 (discussed earlier) shown in Figure 2. Further interviews will permit a more even distribution to be obtained over time.

The average number of months fished by those interviews is shown in Figure 3. Over a third fished throughout the year. Most of the other fishers interviewed fished between six and ten months per year. Most of the fishers interviewed had many years experience in the groundfish industry (Figure 4), and could potentially be aware of changes in spawning location over time if this had indeed occurred. In general, in recent years fishers seem to be directing their attention to species other than groundfish, with about 30% indicating recent experience in these areas (one to five years).

In an attempt to relate seasonal catch rate trends to times of spawning, the fishers were questioned about the months of the year for highest catch rates of cod, haddock, pollock, and various other species. For cod, peaks in catch rate occurred during the spring (May) and autumn (November for 4VsW), Figure 6. For haddock and pollock, preliminary responses on seasonal catch rates do not seem to reflect the timing of spawning as indicated in research studies. It would appear that cod fishers are targeting on spawning aggregations, but this may not be the case for haddock and pollock.

Essentially all of the fishers were familiar with spawning behavior (Figure 5). The number of pair trawl fishers interviewed was too small (two) to reflect on the knowledge of fishes in this gear type.

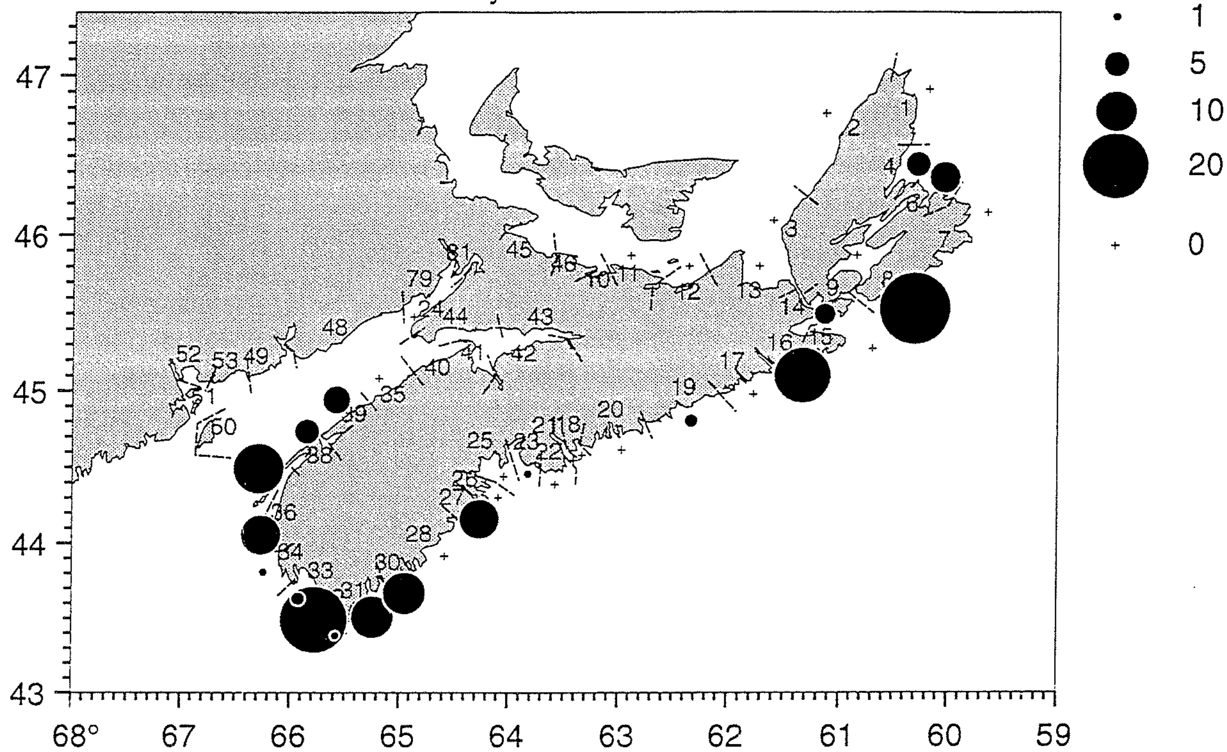
Fishers describe spawning of cod on most of the offshore banks (Browns, LaHave, Sable, Misaine, Banquereau), as well as in near coastal areas (Sydney Bight, Gabarous Bay, Chedabucto Bay, Mahone Bay). For Mahone Bay, a detailed description is shown in order to illustrate the scale of observations of fishers in this study (Figure 7). These preliminary observations from fishers are consistent with research studies on offshore banks. It is of particular interest to have reports on near coastal spawning areas as less research has been conducted on reproduction along the coast. Several fishers reported the loss over time of a spawning aggregation in the Chedabucto Bay off Canso coincident with heavy fishing activity in the mid-1980s. The loss over time of spring spawning in 4VsW was also reported.

Concluding Remarks

The results of the questionnaire survey indicate that fishers have, in some cases, detailed knowledge of spawning locations and their changes over time. Some fishers have kept logs of their experiences, while other fishers were not as interested in such information in past years when the groundfish resources were more abundant. It could be profitable to search out more systematically those fishers with an interest in biology in order to synthesize their collective observations during the past several decades. It is clear that fishers have, in general, a diverse knowledge base useful in the assessment of groundfish spawning locations.

Figure 1

# of Fishermen Interviewed by Statistical Area.



Nova Scotia Fishermen With Groundfish Landings in 1994

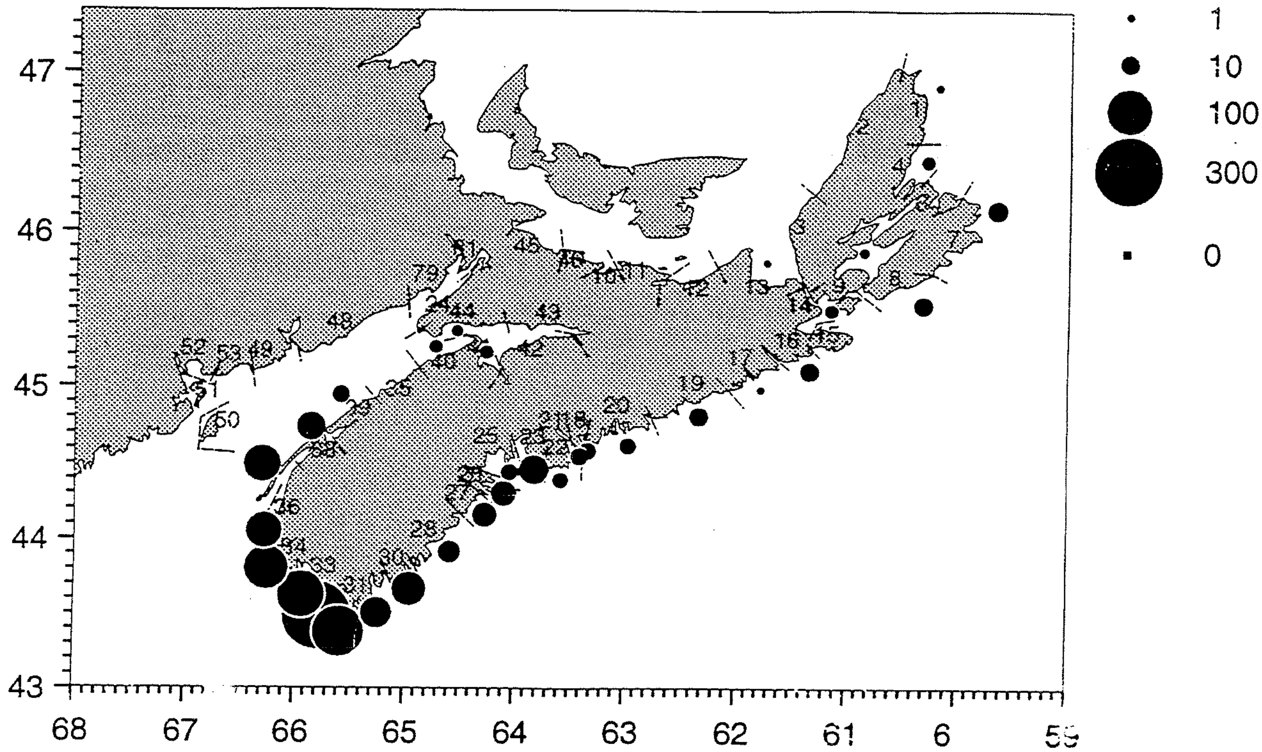


Figure 2

Figure 3

Average Number of Months Fished
1980 - 1990

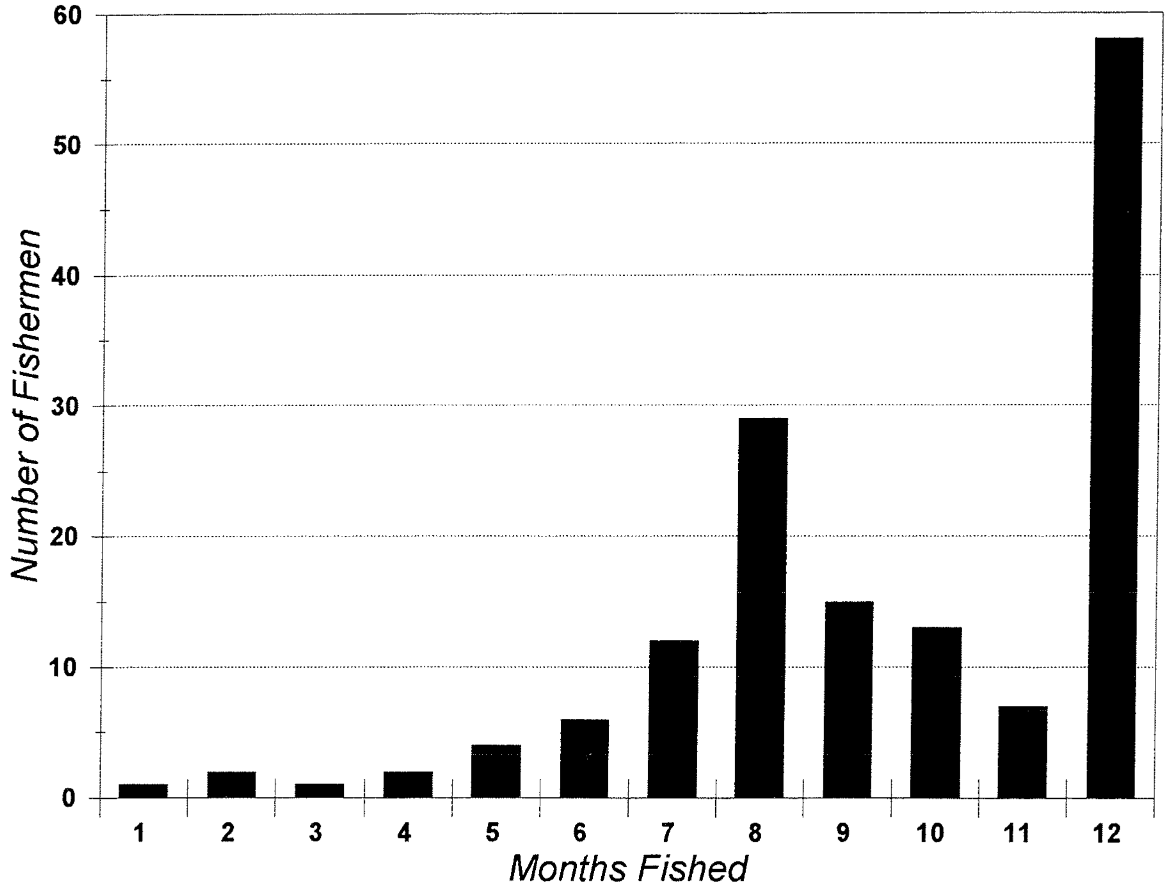


Figure 4

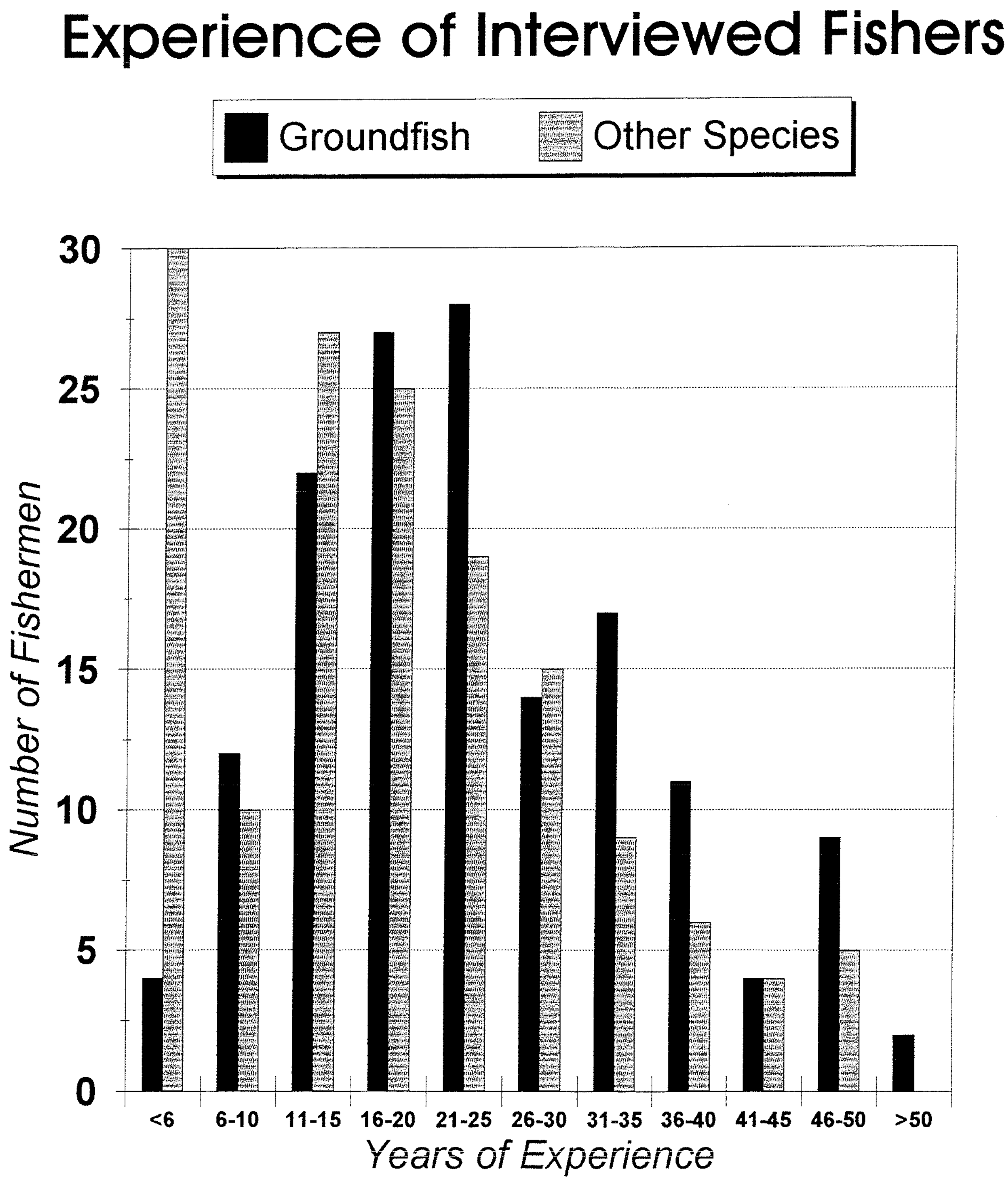

Experience of Interviewed Fishers
Groundfish
Other Species
30
25
20
15
10
5
0
Number of Fishermen
<6
6-10
11-15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
>50
Years of Experience

Figure 5

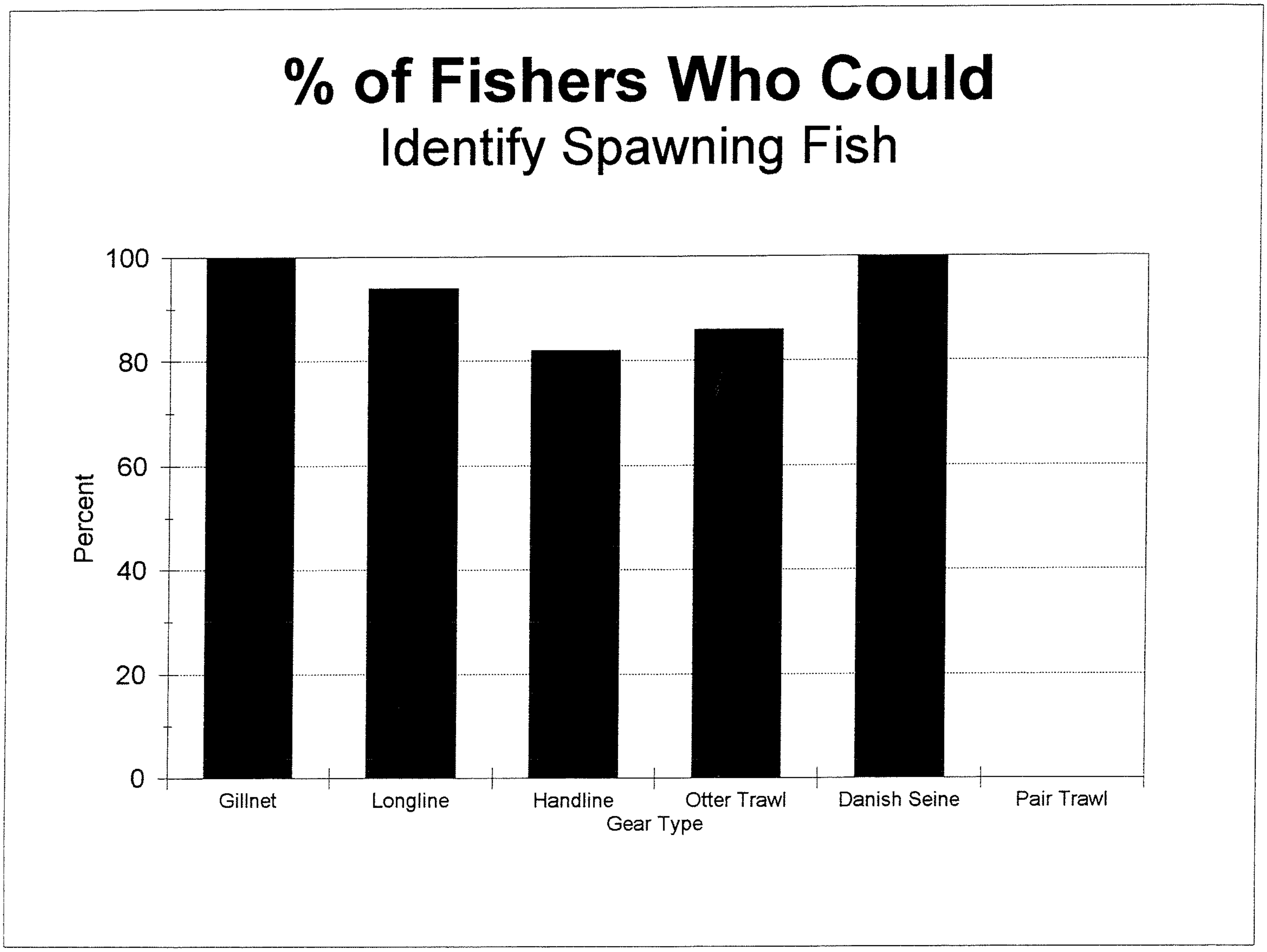
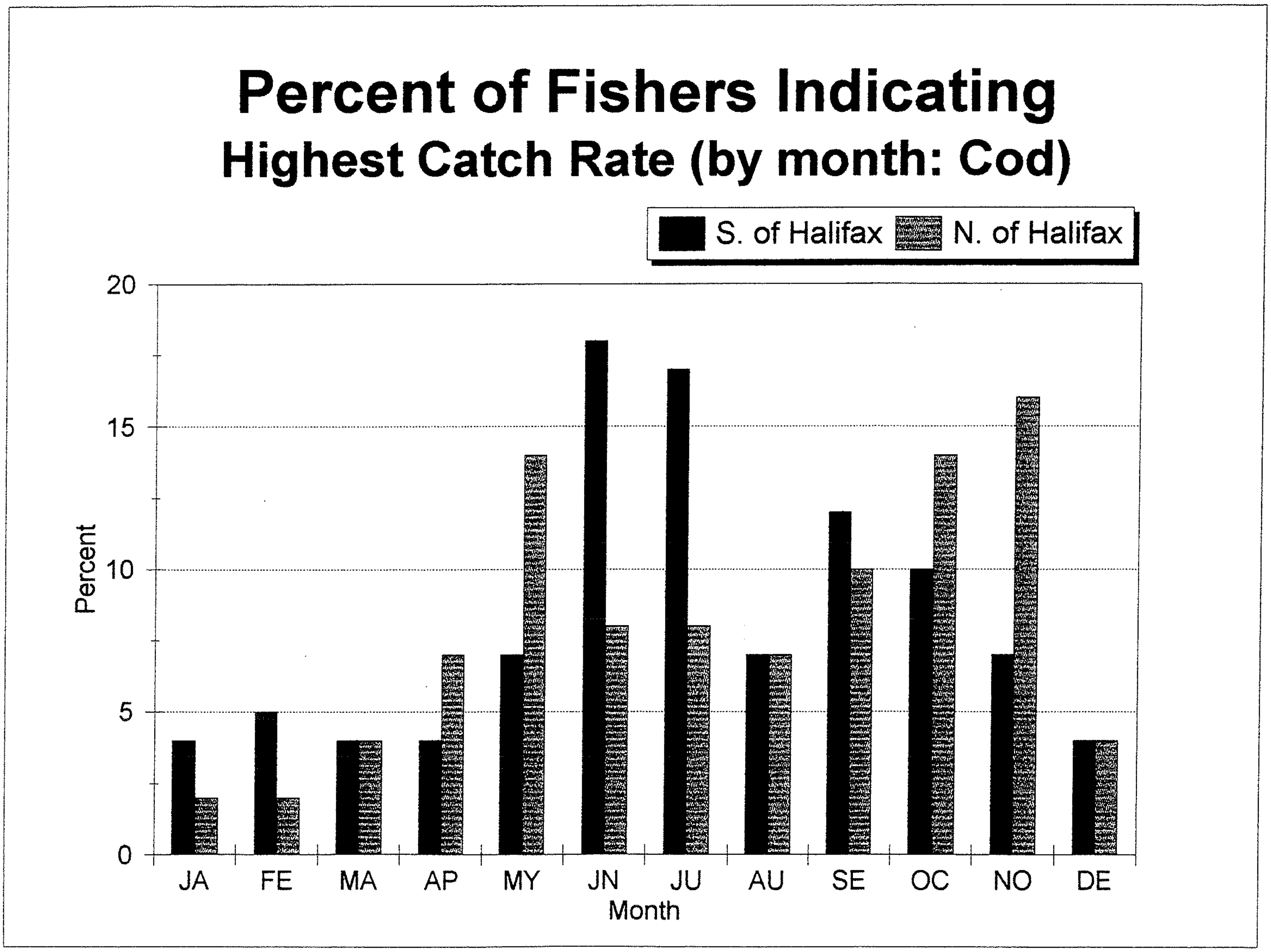

% of Fishers Who Could
Identify Spawning Fish
100
80
60
40
20
0
Percent
Gillnet
Longline
Handline
Otter Trawl
Danish Seine
Pair Trawl
Gear Type

Figure 6

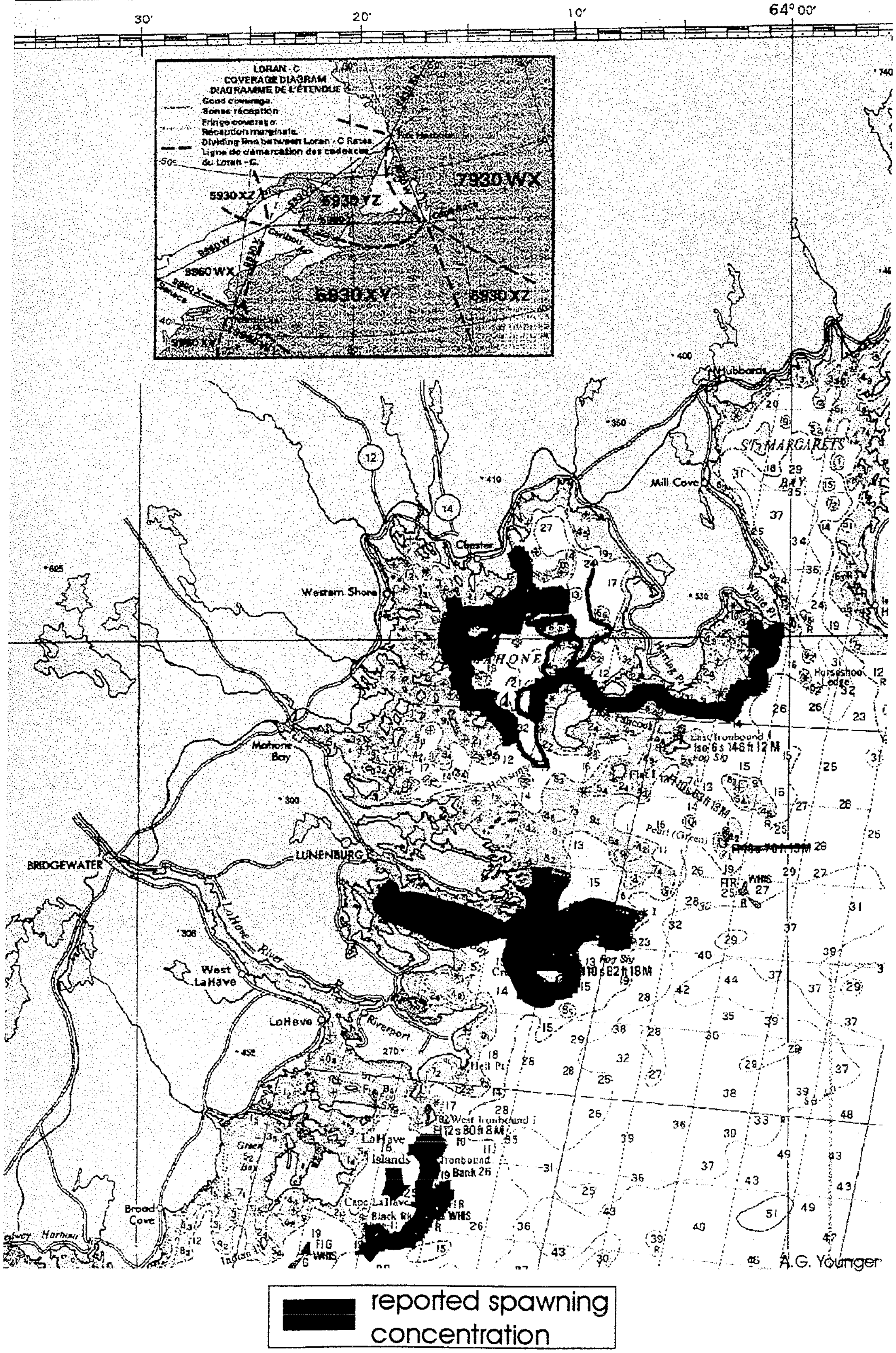


Percent of Fishers Indicating
Highest Catch Rate (by month: Cod)
S. of Halifax
N. of Halifax
Percent
20
15
10
5
0
JA
FE
MA
AP
MY
JN
JU
AU
SE
OC
NO
DE
Month

Preliminary Spawning Chart

Figure 7

Mahone Bay, Lunenburg, W. Ironbound



Assessing Closed Areas with a Fisheries Model Having Several Spawning Components

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Because of the difficulty in obtaining the necessary data, traditional fisheries models tend to be overly simple. For example, $F_{0.1}$ is based on a model which includes only fish growth and the partial recruitment of the gear; no environment, no recruitment variability, no migration, etc. It is impossible with such models to assess the contribution of distinct areas and hence the effects of a closed area.

The following model is largely exploratory; most of the underlying data needed to validate the model are not available. In fact, in most cases there is not even enough data to estimate the uncertainty via bootstrapping. Therefore, working assumptions are made and their sensitivity is explored by varying them over logical ranges; simulation experiments.

Methods

A computer simulation is used to model a resource comprised of three spawning components which are exploited by two fleets within a year which has two seasons, spawning and feeding. The model is comprised of a standard aged-structured population model, plus a number of modules that describe reproduction, stock fidelity, and dynamic removals by fishing.

The base population model has seven ages, weight at age ranges from .05 to 1.67 kilograms, and it is assumed that the fish are 50% mature at age 4. A schematic of a single stock model is shown in Figure 1. This formulation is similar to the stock projections currently used in the annual assessment process. The population is comprised of three spawning stocks each with a carrying capacity. The carrying capacity, the related

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density, were defined in terms of the biomass of fully mature fish. The carrying capacity of the larger stock is twice the size of either of the two others. One of the two smaller spawning stocks is protected by a three-month closure during spawning season. A schematic of the three spawning stock model is shown in Figure 2. When not spawning, the fish are assumed to be mixed and removals are proportional to the relative abundance of each stock. Each spawning stock has a percentage loss of the fish spawned there that typically ranged from 0 to 10%. The stocks are fished by two fleets both of which use gear of the same selectivity. The partial recruit for these fleets was plateau shaped, with 10% of two-year olds recruited, and full recruitment at age 5. The distinction between the two fleets is that one of them is more efficient when fish are congregated in spawning aggregations and hence exerts proportionally more effort during the spawning season. The efficiency for gear 1 doubles while the efficiency of gear 2 is halved during the spawning season. The fishing sub-model also allows a Paloheimo-Dickie effect to be activated, which increases the efficiency of the gear as the population contracts. Figure 3 shows the impact of the Paloheimo-Dickie effect. That is, the same effort generates more fishing mortality during the spawning season as the stock gets smaller. As modeled, the effect is not a factor until the stock is less than 15% of its maximum size.

The model is typically run for 30 to 50 years under a given fishing regime so that the populations can stabilize. Yield calculations for each fleet were performed over a range of fishing moralities. The "other" fleet was not fishing while the effort ranged for the fleet under consideration. The model does not currently include the switching of effort between seasons or spawning stocks in response to changes in abundance or catch rate. For this reason, it also does not include a colonization module.

Results

The first set of results concerns the performance of the single stocks which are the model's building blocks. Figure 4 shows the equilibrium yield estimates over a range of fishing mortalities. These plots are similar to those used in yield-per-recruit calculations. Fleet 1, which is more efficient during spawning aggregations, has a maximum at an F of 0.6. If the Paloheimo-Dickie effect is operant the fishery collapses at about an F of 1.1. Fleet 2 has a maximum at an F of 0.9 at a slightly lower yield than Fleet 1 and is essentially unaffected by Paloheimo-Dickie.

A sample trajectory from the model is shown in Figure 5. Recruitment success has 30% random noise added and the three stocks are independent, i.e. no mixing. Fleet 1 is fishing at an F of 0.9, while fleet 2 is fishing at 0.2. During the first few years, a transient response is seen as the model moves from the initial population estimates. Thereafter, the biomass of stock 3 (protected during spawning) slowly increases until it plateaus at about year 15. Stock 2 slowly declines and is almost collapsed by year 30.

The lower plot of Figure 5 shows the catches from each of the stocks. After the transients, the catch from the small, but closed, stock slowly grows and approaches the productivity of the large stock.

Figure 6 is analogous to Figure 5 except that now there is a 5% loss to the other stocks from each component. This small amount of mixing greatly stabilizes stock 2 and allows it to better sustain the high exploitation.

Figure 7 is yield isopleth which portrays the yield as a function of the effort in each fleet. Fleet 1 is varied along the y-axis and Fleet 2 along the horizontal axis. The darker the shading the higher the yield. The optimum region runs from about 0.6 on the Fleet 1 axis to about one on the Fleet 2 axis. The steepness in the vertical direction reflects the greater danger in overshooting by Fleet 1.

Discussion

Because of the difficulty in obtaining the necessary data, traditional fisheries models tend to be overly simple. We have developed a more sophisticated model than data could support as a tool to investigate the potential effects of a closed stock. We have assumed two Fleets which may not correspond well to actual fishing practices. A brief investigation of the distribution of trawler catches in 1992 (Figure 8) showed some correlation with known spawning location. See for example Figure 8c, the area west of Sable Island which is a known area of fall spawning.

Almost all aspects of this model need to be linked to data. Much of this information can only be supplied by the industry. For example, the Paloheimo-Dickie effect depends on how various fishes aggregate as the population size changes, as well as how various fleets respond to the fish concentrations.

We have not investigated any of the economic aspects of this question. Although Fleet 1 is more likely to cause damage to a weakened stock, it also may be much more efficient economically if its effort can be controlled.

Figure 1. Single Stock Model

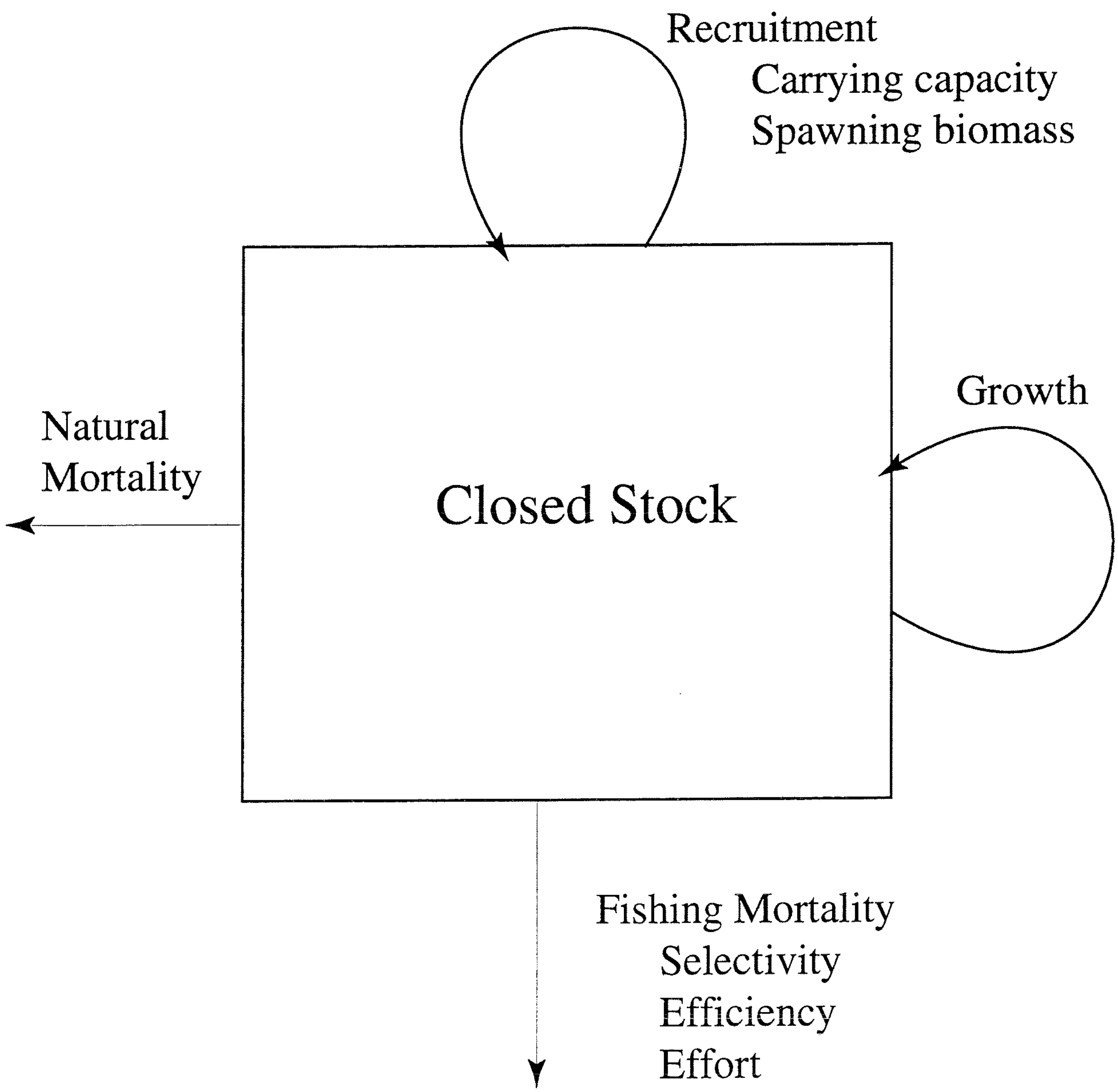


Figure 2. Schematic of multiple spawning stock model

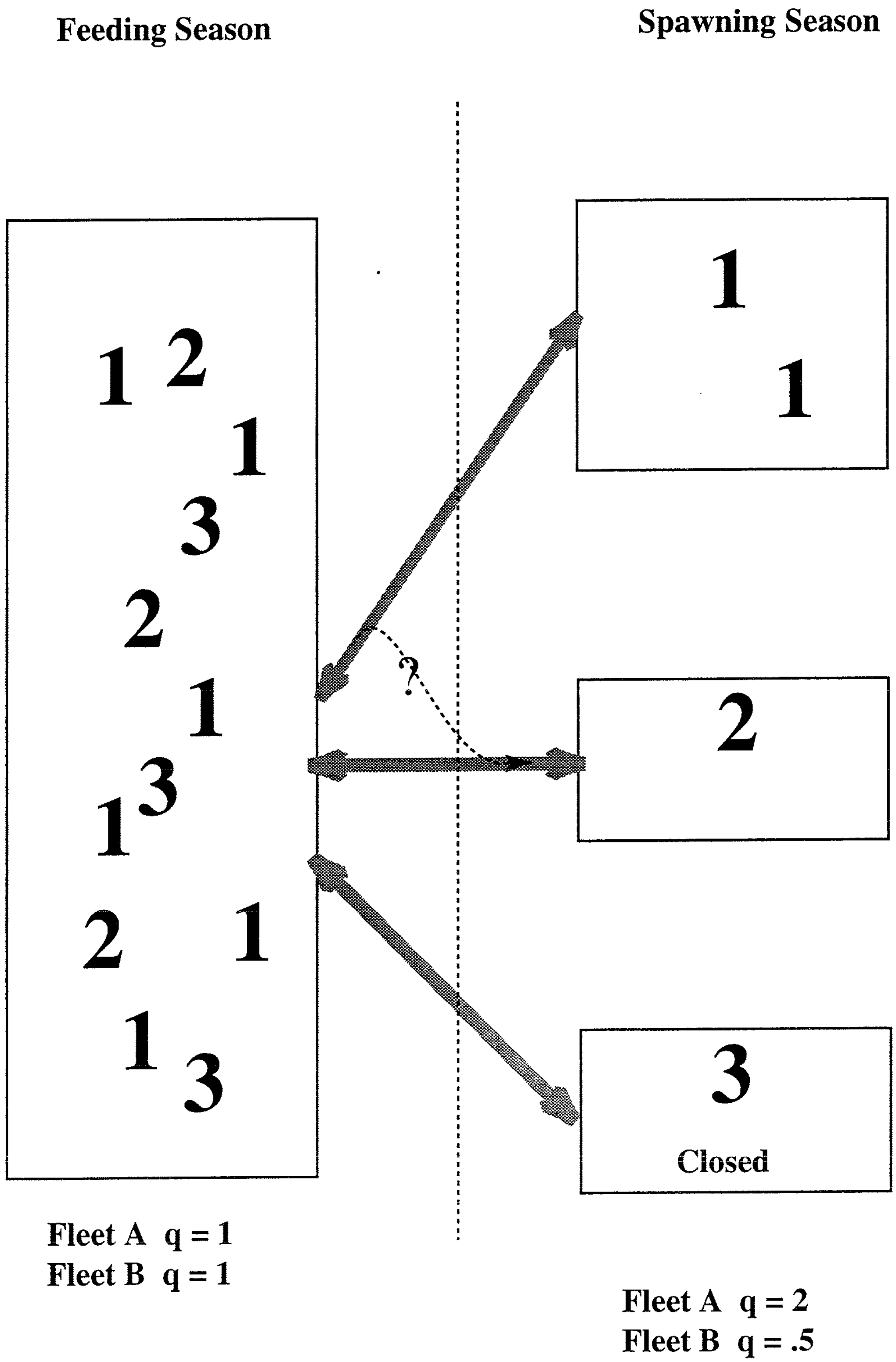


Figure 3. Paloheimo - Dickie Effect

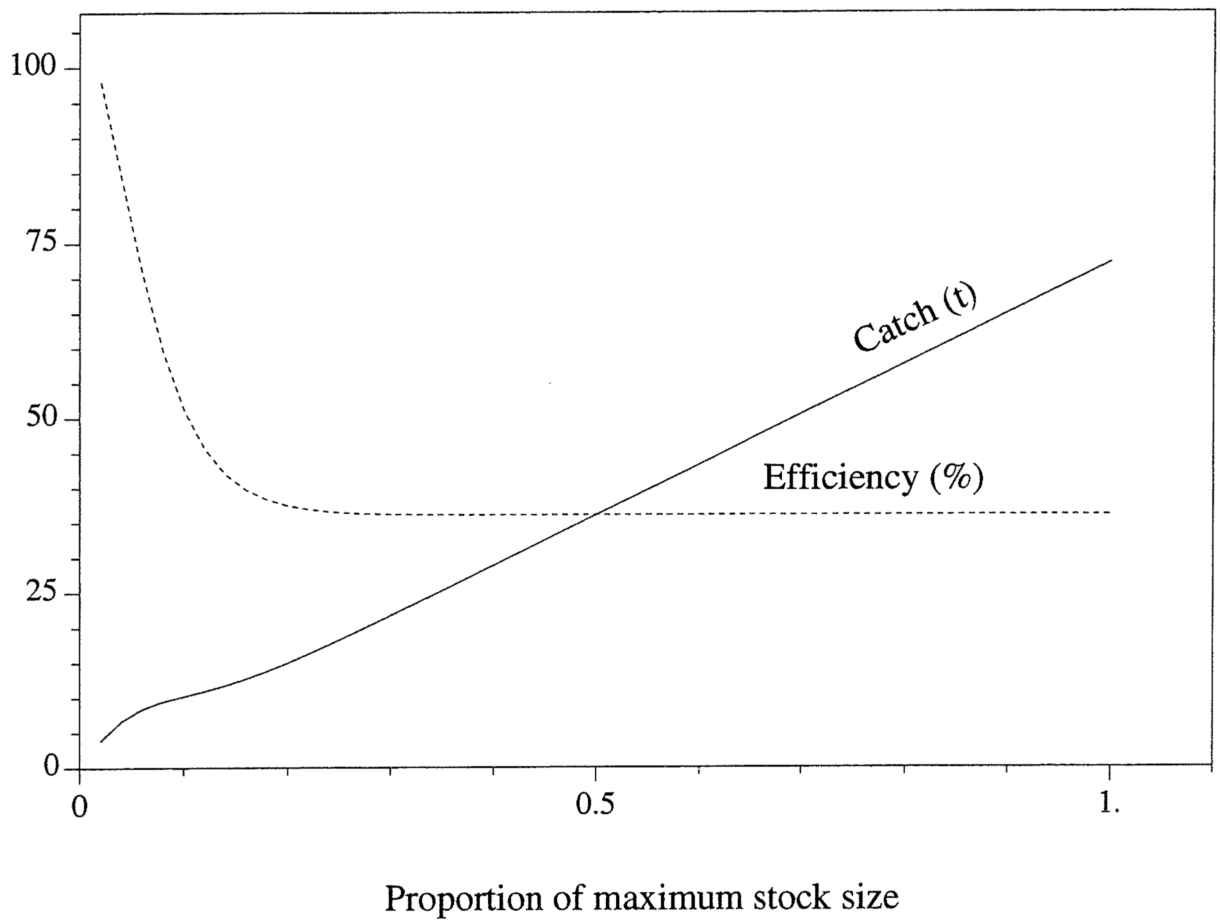
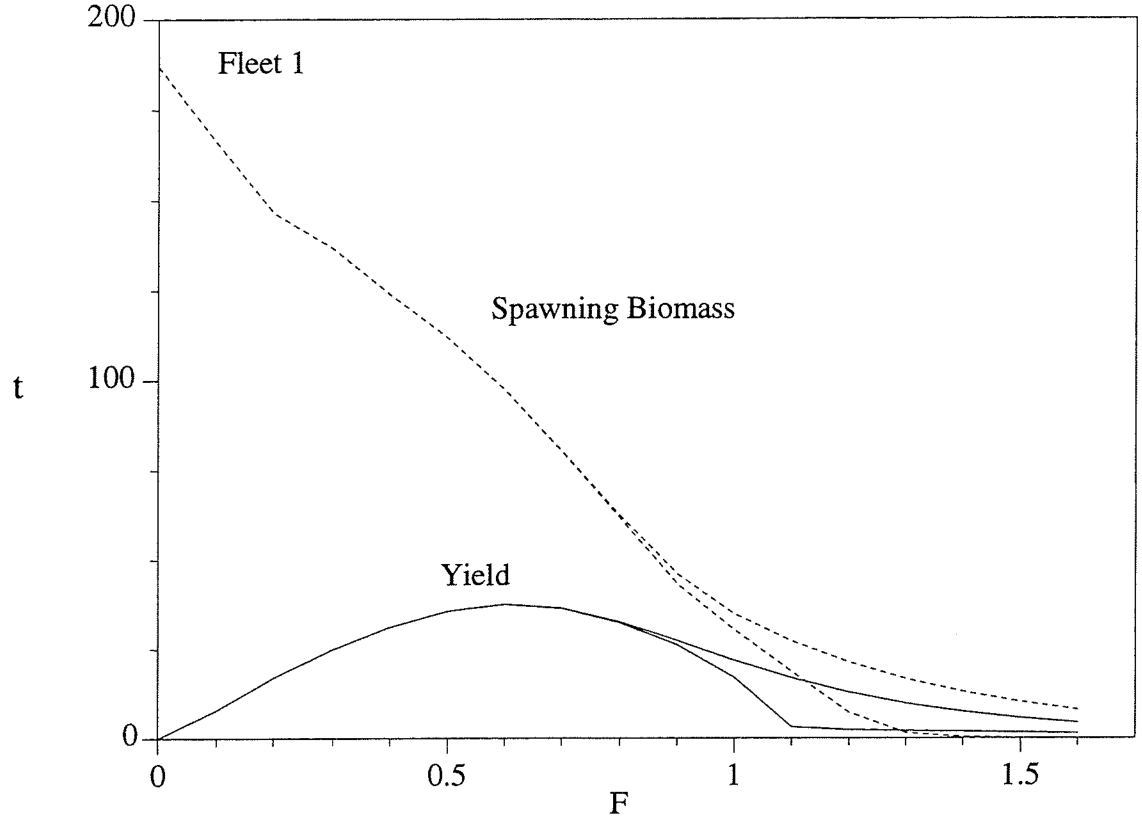


Figure 4. Equilibrium yield projections.



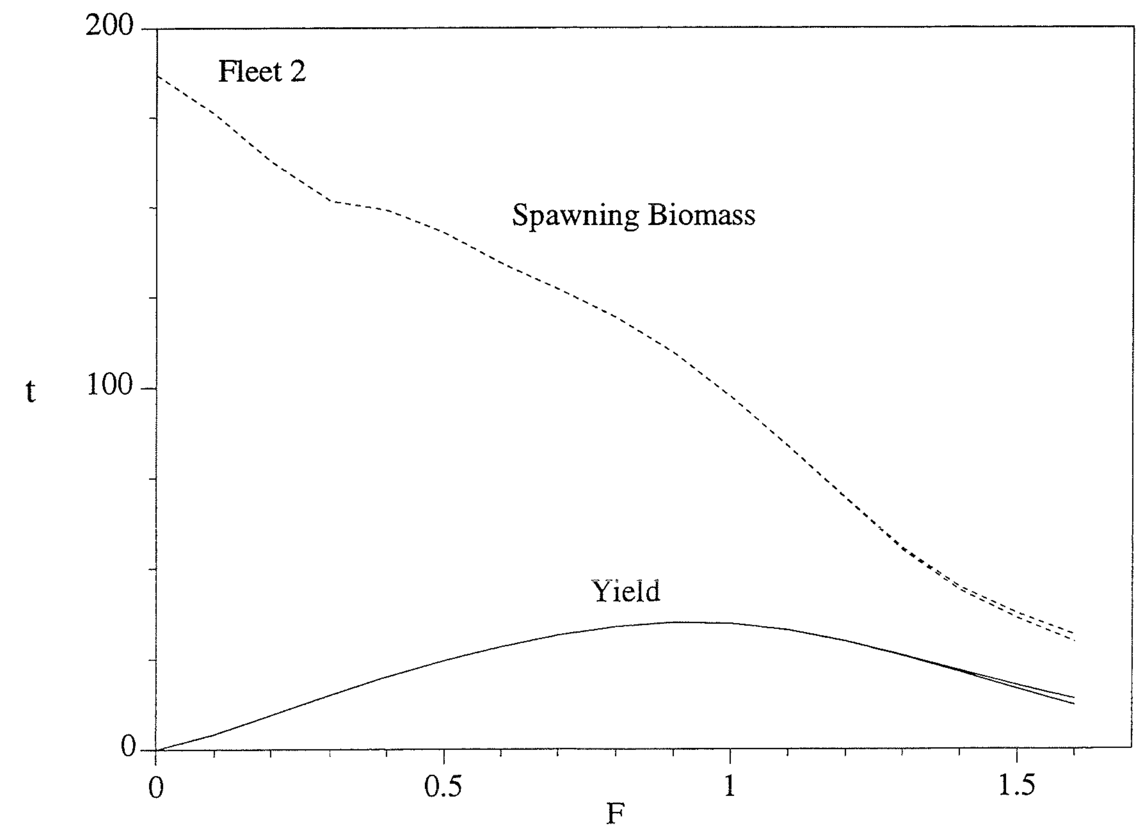
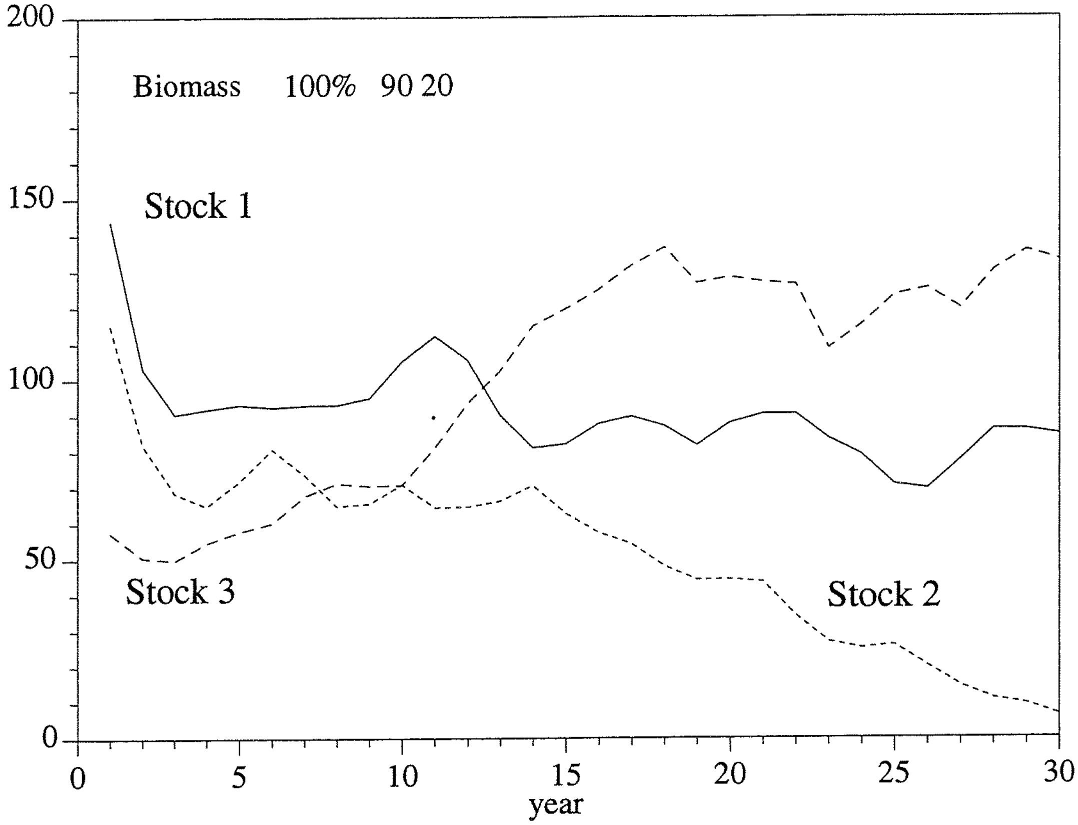


Figure 5. Sample biomass and catch output from 3 stock model independent stocks



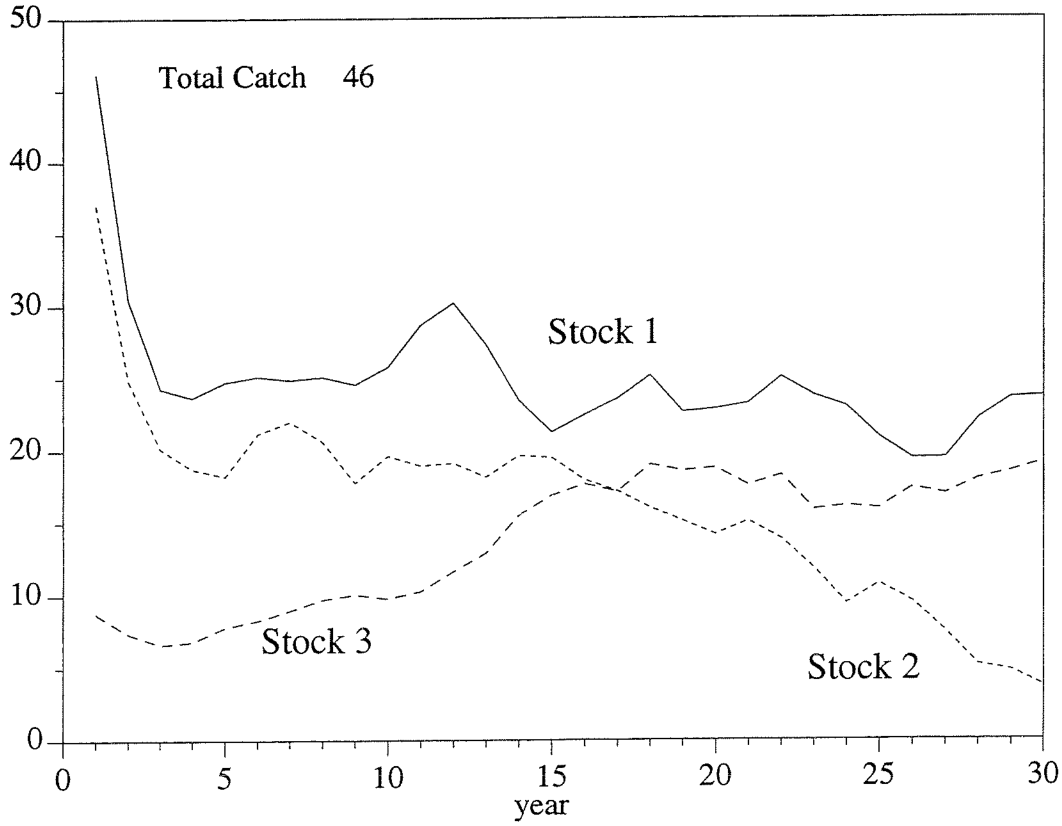


Figure 6. Sample biomass and catch output from 3 stock model
5% mixing

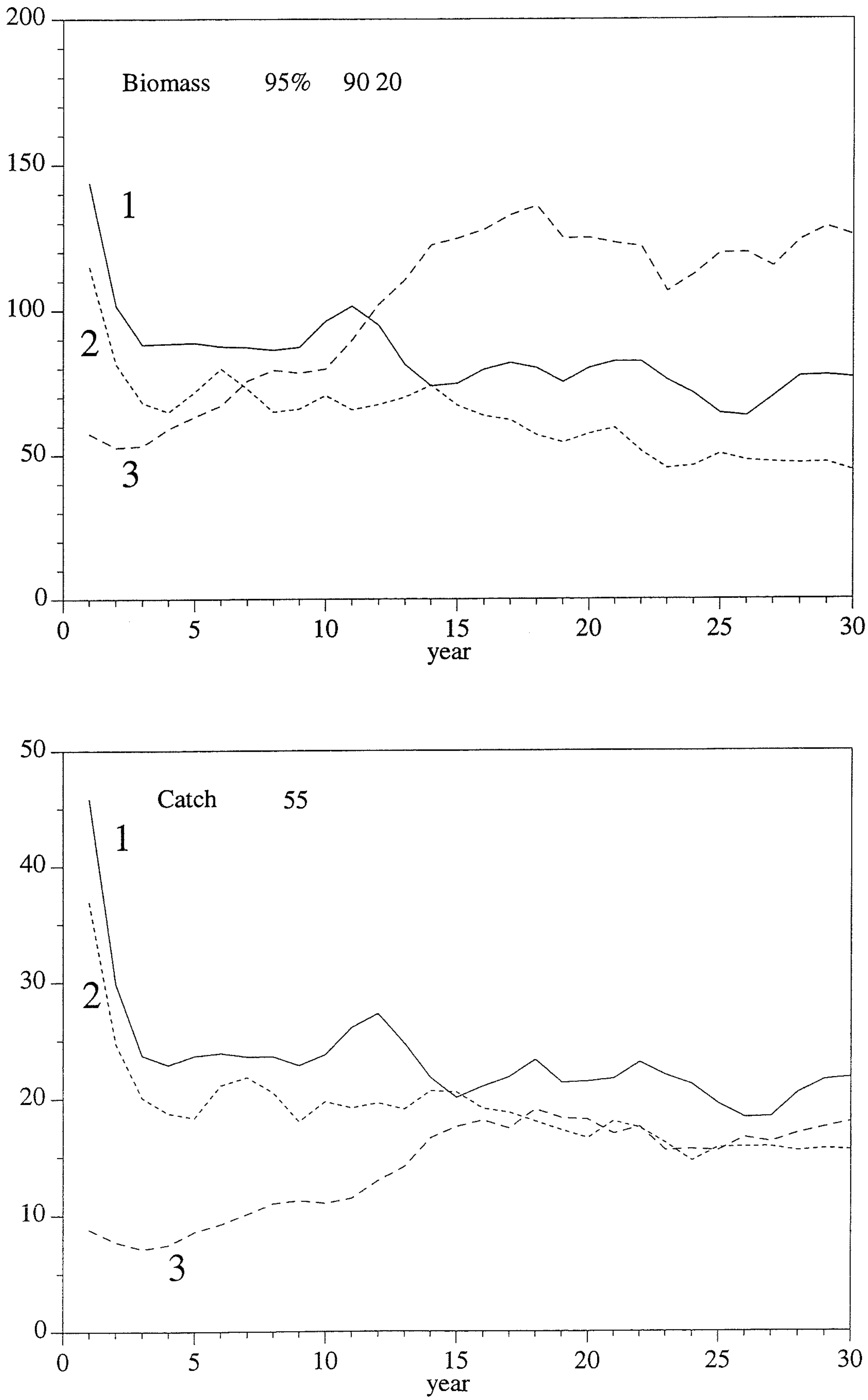


Figure 7. Yield Isopleth. Yield in tons as function of fleet Fs

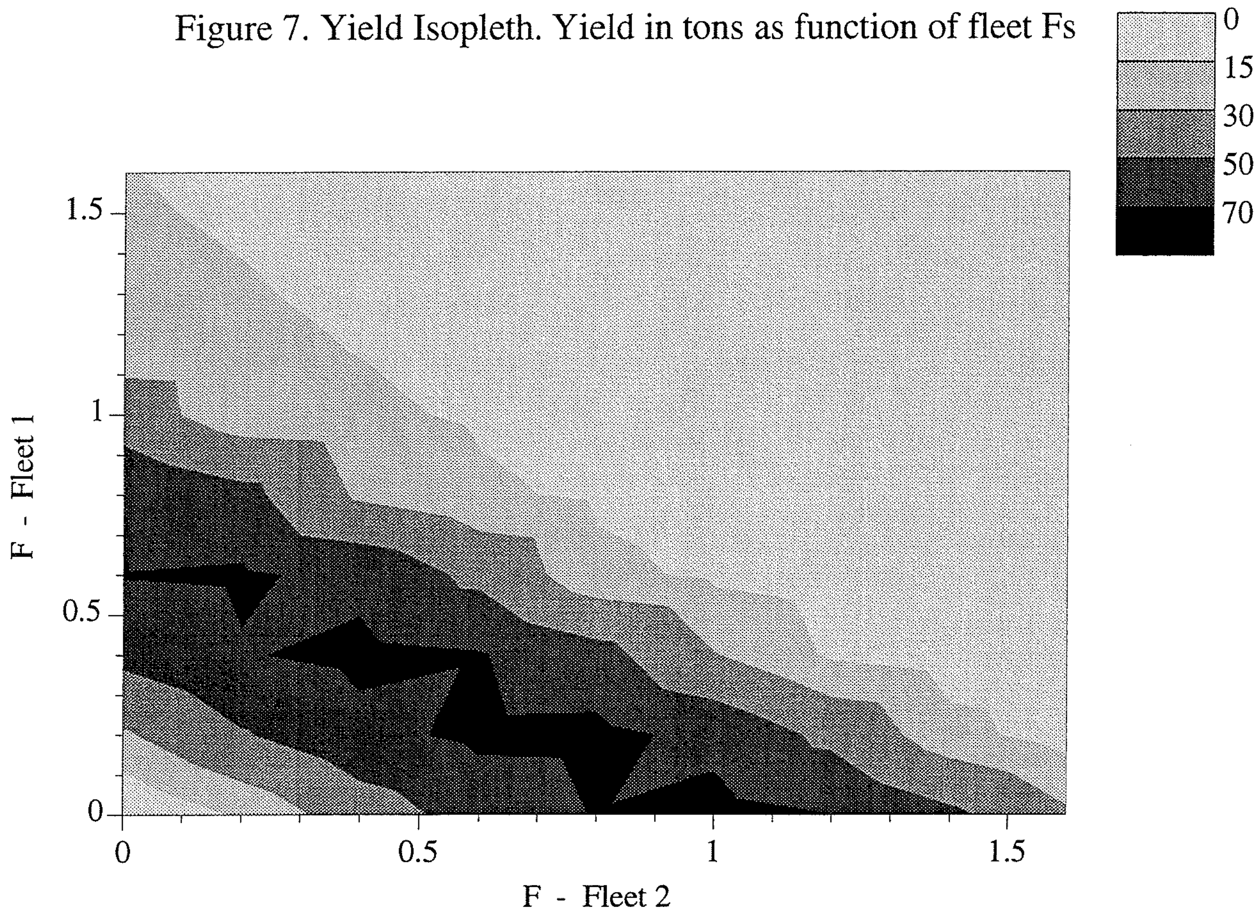
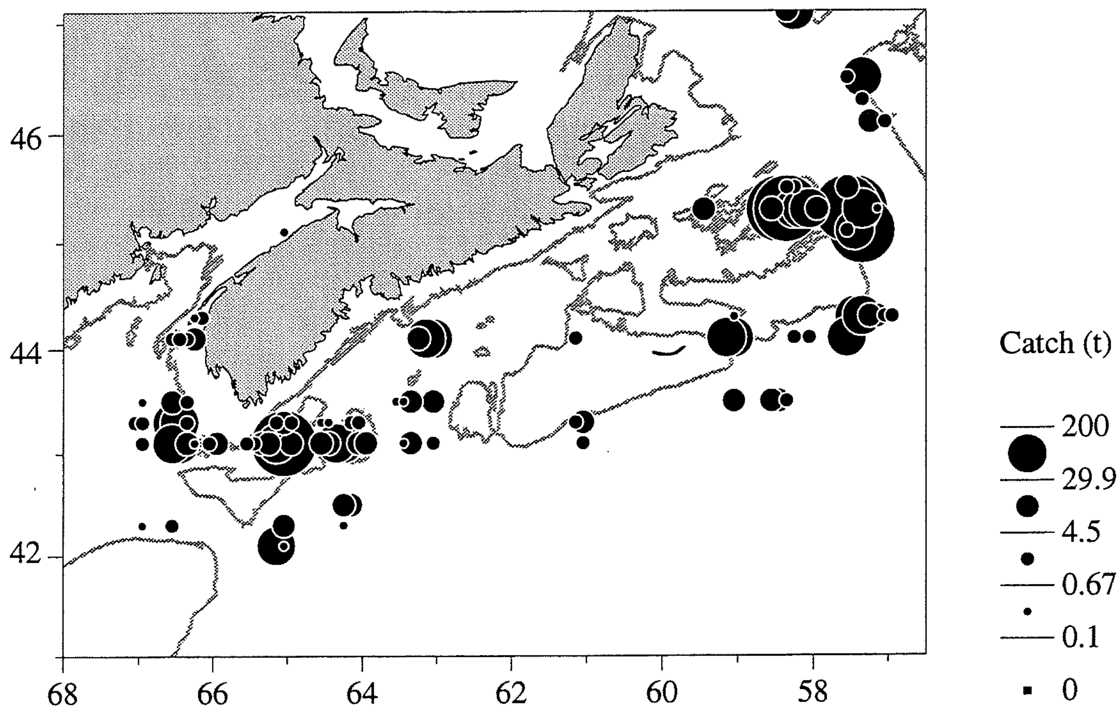


Figure 8a.

Aggregated monthly catch from logbooks (trawlers)

March Cod



Haddock

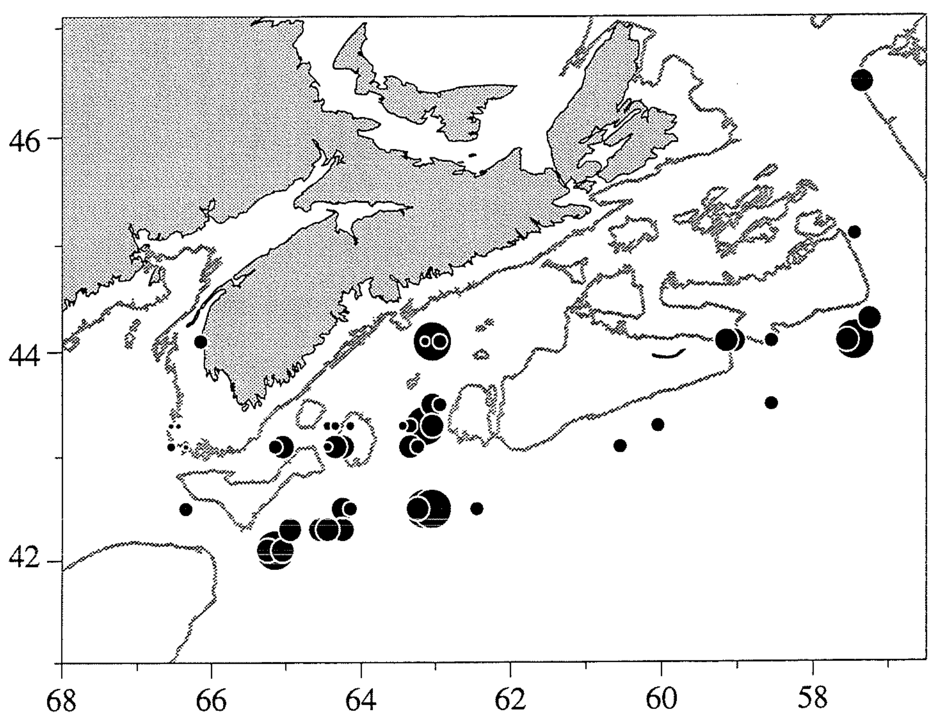
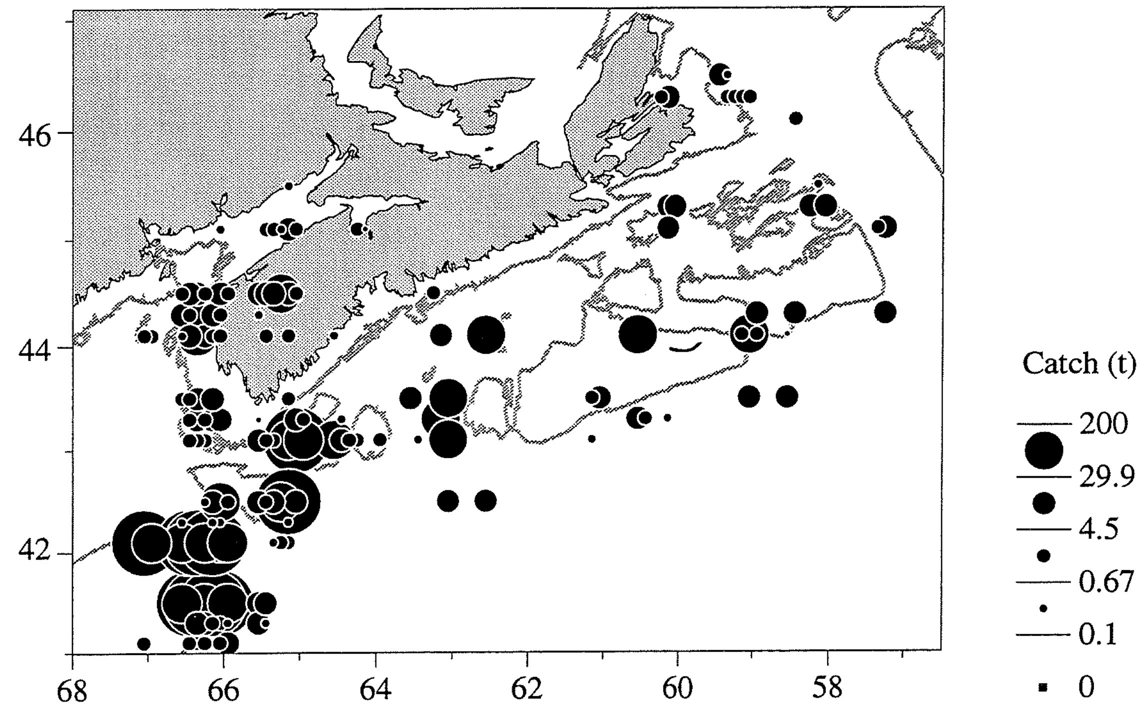


Figure 8b.

Aggregated monthly catch from logbooks (trawlers)

June Cod



Haddock

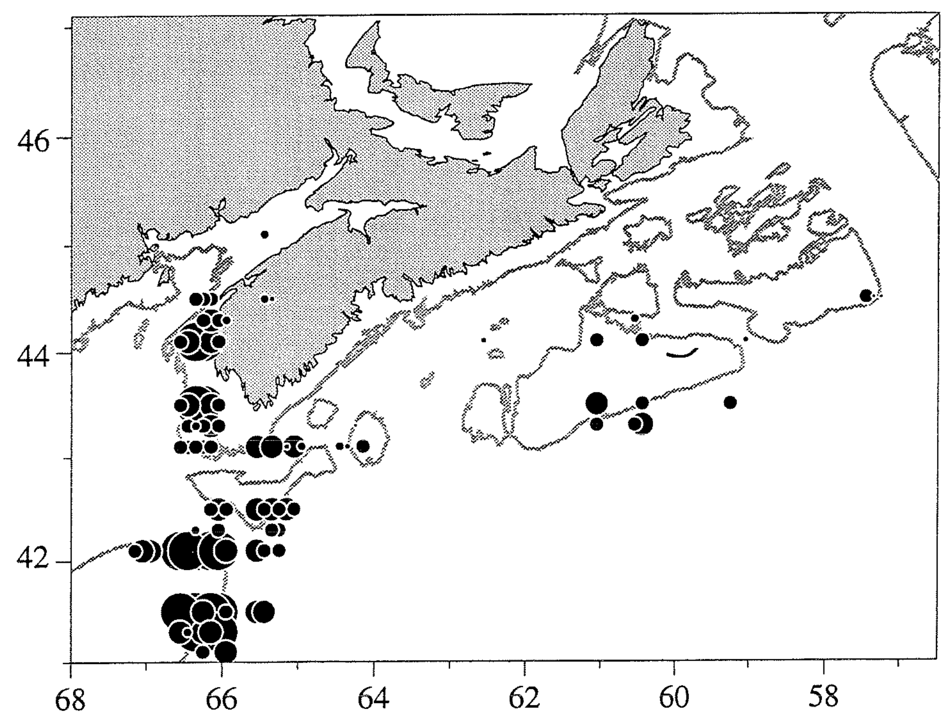
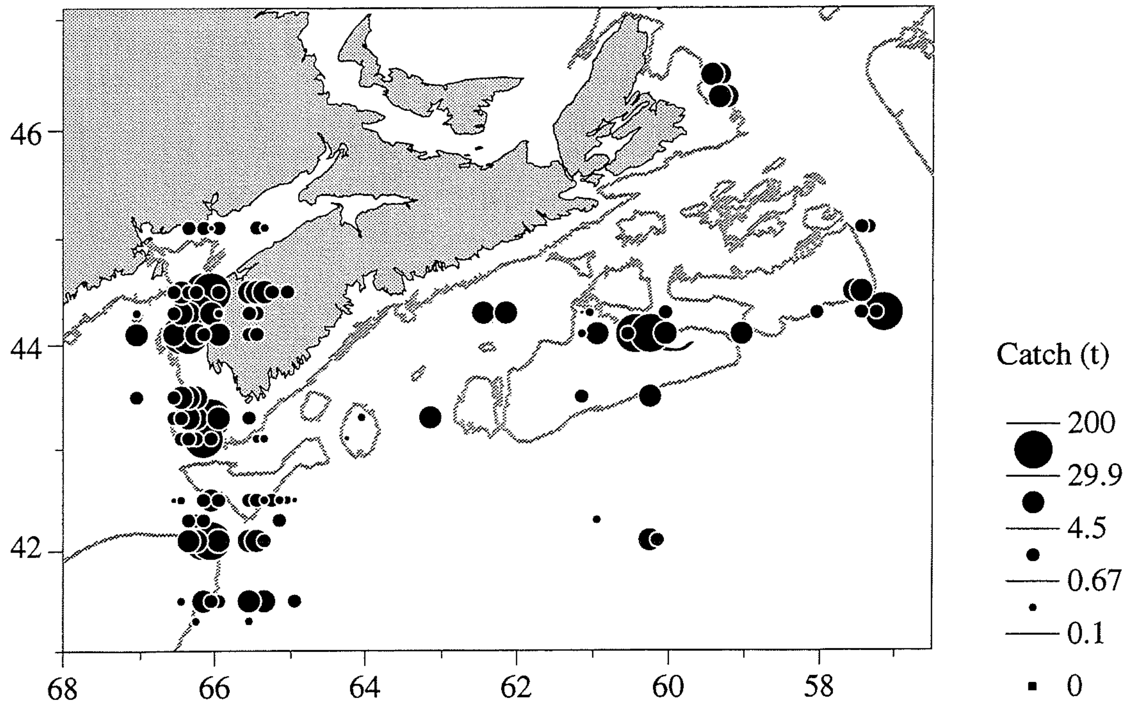
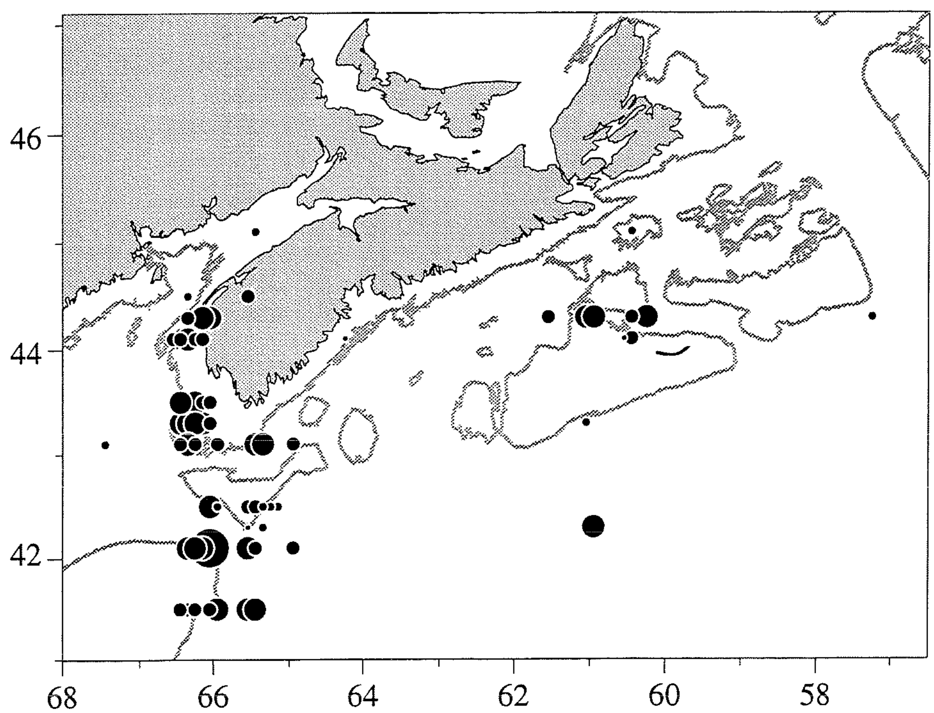


Figure 8c.
Aggregated monthly catch from logbooks (trawlers)

September Cod



Haddock



Costs to Patrol Groundfish Closures

H. Parker

Department of Fisheries and Oceans, P.O. Box 550, Halifax, N.S., B3J 2S7

Introduction

In 1994 the total cost for the patrol vessels, aircraft, and fishery officers to enforce the groundfish juvenile closures on Western Bank and the groundfish spawning closure on Browns Bank was $1.6 million.

Since the late 1980s, enforcement effectiveness of the two closures has improved dramatically as fewer fishers now take the chance to illegally fish. Due to significant improvements in offshore surveillance (discussed below), fishers now perceive a greater risk of being caught and receiving administrative license sanctions. However, enforcement effectiveness on these closures cannot be fully evaluated without a thorough deterrence study, i.e., interviewing fishers and fishery officers to determine their view on the level of compliance. The number of detected closure violations cannot be used exclusively to evaluate enforcement effectiveness.

Costs to Patrol Groundfish Closures

The 1994 surveillance costs (see Table 1) to enforce the two groundfish closures were determined by multiplying the patrol time spent by the three platforms (ships, aircraft, and fishery officer) in each closure by the cost of each platform. Patrol vessel hours were derived from patrol vessel trip packages, aircraft hours were derived from the aerial surveillance information system (ASIS), and the fishery officer hours were derived from the fishery officer weekly report (FOWRS).

Effectiveness of Enforcement on the Closed Areas

During most of the 1980s there was heavy groundfishing throughout the Scotia-Fundy Region. Illegal fishing inside groundfish closed areas was a common occurrence. For example, it was not uncommon to see small groups of groundfish draggers fishing inside the northeast and northwest corners of the Browns Bank Closure as illustrated in the attached Aerial Surveillance Composite - Browns Bank Closed, 1994 (Figure 1).

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As the fisheries patrol vessel (FPV) approached one group, these boats would fish their way out of the closure by the time the FPV arrived. Meanwhile, the group at the other end would move inside the closure. The FPV would turn around and steam towards this group allowing the previous group to move back in again. This "Cat and Mouse Game" was a common occurrence well documented in DFO observer trip reports. Added to this dilemma was the all too frequent Rescue Coordination Centre (RCC) tasking of the FPV to aid fishing boats that had run out of gas or had engine problems, often resulting in the FPV towing the boats to port. The result was lost closure patrol time and a "free for all" for the draggers. Each year DFO's efforts would be rewarded with a few closure violations with a net enforcement result of no real closure compliance. The low fines, usually between $1,000 to $5,000, given to guilty fishers were considered by many as a cost of doing business. DFO was unable to keep the habitual violators off the water. At the time, DFO used the DND Tracker for air patrols, but this platform was of little use for boundary closure patrols as it was equipped with the Omega Navigation System (two to four mile error). A fishing vessel would have to be plotted well inside a closure before charges could be laid as a result of a Tracker navigation fix.

In 1989, significant offshore enforcement improvements occurred with the arrival of the DFO helicopter (S-76) in Yarmouth. With its fast speed, accurate Loran C navigation (to less than a quarter mile), DFO now had an effective platform to quickly identify a fishing boat, its activity, and to accurately determine its position.

In 1990, the Tracker was replaced by a Beechcraft King Air 200 (private sector contract) which was a fast, medium endurance (five to six hours) aircraft, equipped with a computer controlled navigation system (CCNS) - accuracy to less than one quarter mile, a data management system (ADAM), and a sophisticated 360 degree radar capable of detecting (depending upon target size and sea state) fishing boats at a distance of approximately 200 miles. Now fishing boats (completely unaware of detection) were plotted illegally fishing while the aircraft was miles away. Upon arrival, the aircraft could easily identify and photograph the boat illegally fishing before its gear could be retrieved. The computer generated fishing vessel target plot was faxed to the FPVs and the DFO helicopter resulting in less search time (more productive patrol time) for fishing boats.

In 1992, the FPV Louisbourg was removed from service in the Scotia-Fundy Region. Also that year, the DFO helicopter was equipped with nighttime photography. Joint night patrols were flown to the groundfish closures using the sophisticated radar plots of the fixed wing (not equipped for night-time identification), and the excellent night-time identification capability of the helicopter. In 1992, during one such patrol to Georges Bank, the helicopter detected 11 US draggers fishing inside Canadian waters.

In 1994, DFO signed a five-year air surveillance contract with PAL. In 1995, the DFO helicopter contract with Canadian Helicopters Inc. was not renewed. Later that year the fixed wing aircraft was equipped with night-time photography and identification.

Today with the decrease in groundfish quotas (fewer boats on the water), a strong DFO monitoring, control, and surveillance (MCS) program including increased observer coverage, increased air hours (as compared to the Tracker days), better coordination of SAR taskings between DFO and RCC, the use of Black Box Technology (vessels automatically transmitting their positions via satellite to shore), possibly the prohibition of prohibiting certain fleets from transiting through closures, and the continued use of license sanctions, illegal fishing in the groundfish closures should remain under control. From 1994 to 1996, there has been only two recorded groundfish violations in both the Western and Browns Banks Closures.

Table 1

SURVEILLANCE COSTS*, WESTERN BANK JUVENILE CLOSURE, AND BROWNS BANK SPAWNING - 1994 CALENDAR YEAR

	Western Bank Juvenile Closure	Browns Bank Spawning Closure	Total
DIRECT COSTS			
Patrol vessels	$202,243	$304,501	$506,744
Patrol aircraft - rotary & fixed wing	39,752	245,696	285,448
Fishery officers	85,664	139,003	224,667
Other Fisheries Management costs**	53,517	112,567	166,084
TOTAL DIRECT COSTS	$381,176	$801,767	$1,182,943
INDIRECT COSTS			
Regional Indirect support costs***	$71,272	$149,915	$221,188
Headquarter Indirect Costs****	47,647	100,221	147,868
Corporate Overhead*****	28,588	60,133	88,721
TOTAL INDIRECT COSTS	$147,507	$310,269	$457,776
TOTAL COSTS	**$528,683**	**$1,112,036**	**$1,640,719**

* See attached Notice to Reader

** Fisheries Management costs include costs related to Regional Director - FH&M, Program administration, Regional Director - FH&M Enforcement, Director - Conservation and Protection, Resource management, Investigation and legal affairs, and Quota monitoring

*** Regional Indirect costs include Communications, Personnel, Finance, Economics, Management Services, Informatics, etc.

**** Headquarter Indirect Costs refer to indirect Headquarter costs incurred in support of regional activities

***** Corporate Overhead refers to Headquarter costs that support all DFO activities

Notice to Reader

The costing data provided above does not represent the true cost of the program delivery as set out by Generally Accepted Accounting Principles. The costs that are not included in the analysis are as follows:

- Amortization of the cost of fixed assets (Depreciation) in the program delivery, i.e., vessels and facilities;

- Other government department's support to DFO program, i.e.. DND support, PWGSC, Department of Finance (debt cost) etc.;

- Regional support from oceanography, hydrography, habitat, etc.; and

- Science support from other regions, i.e.. vessel survey, stock assessment, etc.

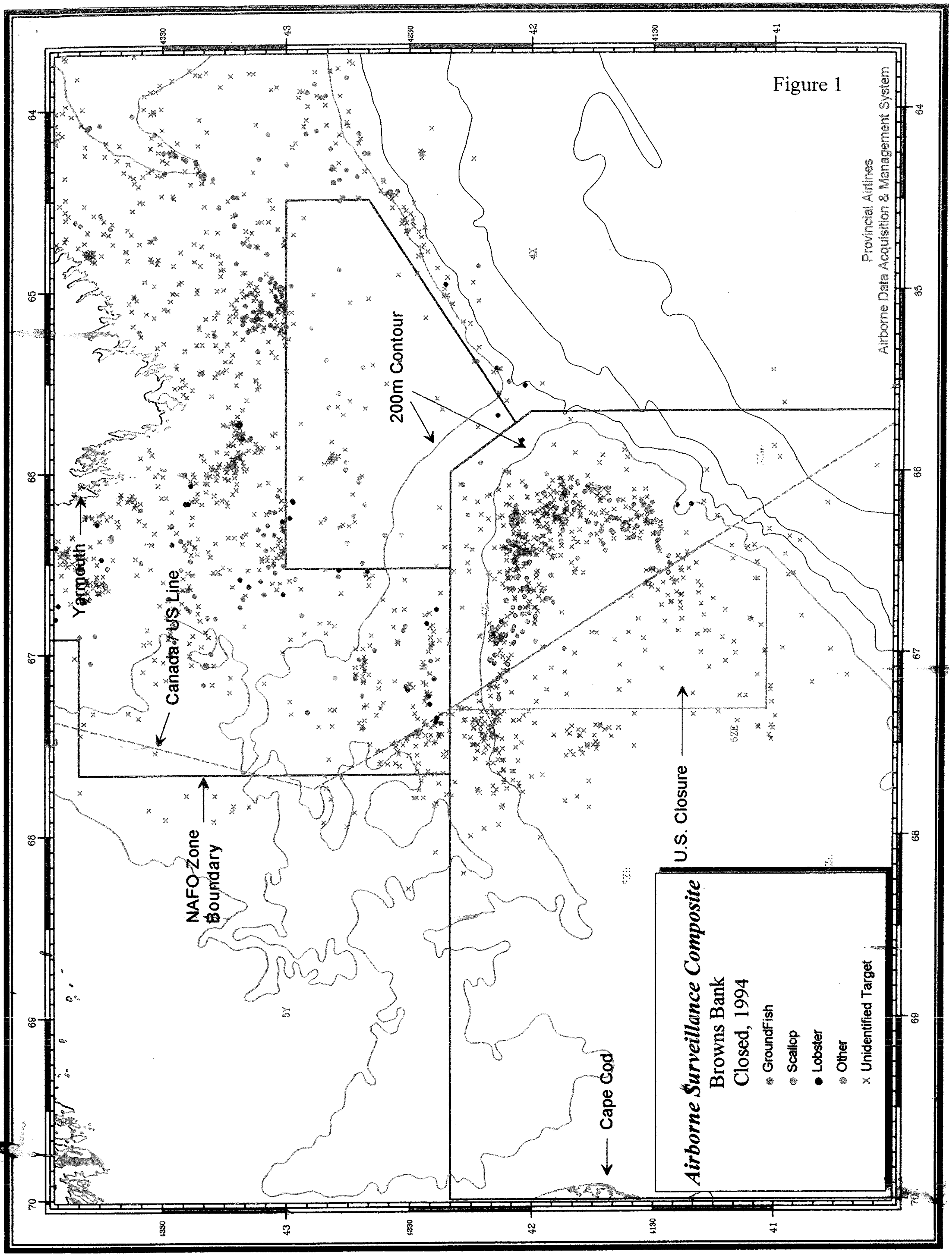
Figure 1
Airborne Surveillance Composite
Browns Bank
Closed, 1994
GroundFish
Scallop
Lobster
Other
x Unidentified Target
Provincial Airlines
Airborne Data Acquisition & Management System
200m Contour
Yarmouth
Canada / US Line
NAFO Zone Boundary
U.S. Closure
Cape Cod
4X
5ZE
5Y
64
65
66
67
68
69
70
43
42
41
4330
4230
4130

A Model of the Costs to Industry of Closed Areas

L. Brander

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Introduction

The following is a simple estimation of the impact of particular stock management tools on harvesting costs. This "model" does not have elements interacting over time to show how the stocks will react to this management, nor how harvesting costs may fall in the long term in response to improving costs. This model provides only the immediate reaction to new management activities.

There are several cautions to note in the interpretation of the results:

- all four tools are assumed to be equally effective in resolving the problem;
- these are immediate (first-year) impacts only;
- they do not take the stock reactions into account (long-term benefits of the management action).

The four options to resolve a "stock problem" are:

- reduce TAC (in a quota managed system);
- reduce effort (in an effort managed system);
- close specified areas to fishing for all or part of the year;
- add new restriction on harvesting technology to make it less effective.

What would we expect to happen in the short term?

Reduce TAC : (a) In a competitive or derby fishery, the fishery is closed sooner. Effort (days fishing) is reduced. Operating costs are reduced more or less proportionally,

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depending on the time pattern of catch rates. (b) In an ITQ fishery, effort is reduced, but the fisher chooses when to cut fishing time, based on expected catch rates, prices, and other factors. Operating costs are reduced, probably more than proportionally to cuts. Revenues and profits are lower.

Effort reduction: Same as above.

Closed areas: When the closed area is not the preferred fishing area, the closure has no impact; but where closure forces fishing in a suboptimal area, catch rates will be lower. If the TAC is unchanged, fishing revenue is unchanged but fishing time and fishing costs are higher.

Restricted harvesting technology: Similar to closed areas. More time required to catch the same TAC, stable revenues, higher operating costs, lower profits.

There are other factors at play in each of the above cases, mostly because using these tools alters the timing of the fishery over the year, when catch rates and prices and perhaps the costs of effort will differ from day to day.

Data and Methods

The model considers three fleets to be representative of the whole fishery: longliners 35-44 ft. based in 4X; mobile gear vessels 35-44 ft. based in 4X; and the offshore fleet over 100 ft. based in Scotia-Fundy. To extend the results to the entire groundfish fisheries, the longliner results were applied to all Scotia-Fundy fixed gear catch, the small dragger results to all inshore mobile gear, and the offshore results to all offshore catch, for the year 1991. The intent was to see the impact on revenues, costs, profits, of lowering cpue through the closing of preferred fishing areas. This was not an exhaustive study of a particular closure proposal. Data on catches, revenues, costs, and fishing effort were from 1990 and 1991 vessel performance studies.

Catch rate reductions as a result of closures were set hypothetically at 10% and 20% for each fleet for a full year. TAC was held constant as were prices and operating costs per fishing day, except crew shares which were set proportional to revenues. Effort was increased to maintain the catch under reduced catch rates, and the corresponding increase in the cost of effort was calculated.

As a small reality check on the 10% and 20% catch rate reductions, NAFO monthly catch rate data on inshore longliners and draggers was examined for 4X for 1984 and 1987, to see what happened to catch rates during the annual closure of Brown's Bank from March through May. There is no simple test of what would have happened if the Bank had remained open every spring. Catch rates are usually much higher in winter than in summer. If the overall 4X cpue for the nine open months is assumed to apply to the three closed months as well, then the estimated annual rate (with no closure) was +7%, -3%, and +9% in three tests when compared to the actual (with closure) results. In other words, in two of the three tests, without the Brown's closure catch rates would have been 7 to 9% higher over the year. This is not an adequate study of the impact of closing Brown's, but it puts the 10% and 20% cpue reductions in perspective. Actual impact of a closure would vary considerably depending on the size and importance of the closure area, the difference in catch rates inside and outside the area, and the ability of individual vessels to move to other areas.

The Model

vessel profits = revenue - fixed costs - operating costs - crewshare
revenue = price x catch rate x seadays
operating costs = operating costs per seaday x seadays
(maintenance costs were split 50/50 between fixed and operating costs)

Given a 10% reduction in catch rates (1991 data), effort in seadays was increased proportionally, and the equation was solved for costs and profits.

Results

Results of this exercise are displayed in Table 1. If a 10% reduction in catch rates results from either:

a) closure of fishing areas - for short periods or long; or
b) from changed requirements for gear use, which has a similar impact, then fleet costs will rise by approximately $9 million to reach the initial catch levels.

Estimates of revenues and costs in the fishery from surveys should be relatively accurate but subject to certain confidence levels. Estimates of profits, however, are subject to magnified errors as they are simply the narrow differences between large estimated revenues, and large estimated costs. A small error in estimates of either revenues or costs will become a large error in the estimate of profits. Therefore, the calculated change in this exercise from aggregate fleet profits of $15 million to $6 million may not be a very good estimate. *The $9 million change is more reliable*, given a 10% decrease in catch rate.

A second set of calculations was performed using the same model and data, to estimate what quota or TAC reduction would be equivalent (in short-term financial impact) to the 10% and 20% reductions in catch rates. In this case, catch rates and the new lower profit levels were held constant.

It turns out that, overall, a 10% reduction in TAC will put the fleets in the same financial position as a 10% reduction in catch rates; and a 23% TAC cut is equivalent financially to a 20% reduction in catch rate. The quota cuts needed for equivalent effect in fixed gear is 15.8% and 35.5%. Results are shown in Table 2. In the 10% case, the TAC reduction yields 21% fewer seadays than the catch rate reduction.

What does all this mean? It points out that there can be a significant short-term financial loss to all gear sectors from closing fishing banks, when those banks are the preferred fishing areas because of higher catch rates. In the exercise above, the total fish catch was the same with closed areas as without. Whatever biological effect the area closure might have needs to be at least as beneficial to the stock as a 10% TAC cut would be (this advice needs to be scaled to the particular closure). Otherwise, we have needlessly punished the harvesters.

Ultimately, if the game is played well, any good stock conservation moves will result in a more robust stock in the long term, which usually will pay off in economic benefits. Without a healthy resource base, there is no economic long term for the fishery. The key is to wisely select the management tools to achieve the intended result.

Table 1			
Changes Due To Area Closures			
	Fleet total*	Fleet total.	Fleet total.
	1991	-10% cpue	-20% cpue
Inshore fixed gear			
catch (t)	63,113	63,113	63,113
seadays	58,438	64,931	73,047
revenues	80,450,842	80,450,842	80,450,842
total costs	73,969,839	76,943,209	80,659,957
net earnings	6,481,004	3,507,634	- 209,114
difference vs base		- 2,973,370	- 6,690,118
Inshore mobile gear.			
catch (t)	52,702	52,702	52,702
seadays	39,150	43,500	48,938
revenues	63,520,591	63,520,591	63,520,591
total costs	55,928,492	57,600,274	59,690,285
net earnings	7,592,100	5,920,317	3,830,306
difference vs base		- 1,671,783	- 3,761,793
Offshore.			
catch (t)	153,154	153,154	153,154
seadays	10,414	11,571	13,017
revenues	123,442,124	123,442,124	123,442,124
total costs	122,437,927	126,811,239	132,277,894
net earnings	1,004,197	- 3,369,115	- 8,835,770
difference vs base		- 4,373,313	- 9,839,967
TOTAL FISHERY			
revenues	$ 267,413,558	267,413,558	267,413,558
total costs	$ 252,336,257	261,354,723	272,628,136
net earnings	$ 15,077,301	6,058,835	- 5,214,578
difference vs base		- 9,018,466	- 20,291,879

Table 2			
Quota Loss equivalents			
	Fleet total*	Fleet total.	Fleet total.
	1991	Quota loss	Quota loss
		equiv to	equiv to
		cpue -10%	cpue -20%
Inshore fixed gear			
catch (t)	63,113	53,146	40,687
seadays	58,438	49,209	37,671
% change vs 1991		-15.8%	-35.5%
revenues	80,450,842	67,744,559	51,861,813
total costs	73,969,839	64,236,879	52,070,792
net earnings	6,481,004	3,507,680	- 208,979
difference vs base		- 2,973,324	- 6,689,983
Inshore mobile gear.			
catch (t)	52,702	48,715	43,728
seadays	39,150	36,187	32,483
% change vs 1991		-7.6%	-17.0%
revenues	63,520,591	58,714,097	52,705,975
total costs	55,928,492	52,793,856	48,875,556
net earnings	7,592,100	5,920,242	3,830,419
difference vs base		- 1,671,858	- 3,761,681
Offshore.			
catch (t)	153,154	139,199	121,757
seadays	10,414	9,465	8,279
% change vs 1991		-9.1%	-20.5%
revenues	123,442,124	112,194,874	98,135,784
total costs	122,437,927	115,563,989	106,971,554
net earnings	$1,004,197	-$3,369,115	-$8,835,770
difference vs base		- 4,373,313	- 9,839,967
TOTAL FISHERY			
catch	268,969	241,061	206,171
% change vs 1991		-10.4%	-23.3%
revenues	$ 267,413,558	238,653,530	202,703,572
total costs	$ 252,336,257	232,594,724	207,917,901
net earnings	$ 15,077,301	6,058,806	- 5,214,330
difference vs base		- 9,018,494	- 20,291,631

Analysis of the Distribution of Juvenile Cod, Haddock and Pollock on the Scotian Shelf

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The results of initial analyses to show the distribution of juvenile cod, haddock, and pollock on the Scotian Shelf are presented. A comparison with the distribution of mature fish is also considered.

Method

The July summer groundfish research survey database was used in this analysis. This database contains 4,156 sets with length or age data for the 1970 to 1995 time period. The data was recorded into 71 nominal length groups and 17 age classes. The abundance was partitioned by age for the comparison of juvenile and mature cod and pollock. This was calculated as the stratified estimate of the number of fish caught per standard tow as reported by STRAP. For haddock, the abundance was similarly partitioned by length class; as the documented problem with the age estimates of Scotian Shelf haddock has not yet been resolved.

The data was presented in map form showing the distribution in absolute and relative terms using the software package ACON (Black 1993). (This software package emphasizes the interactive browsing of this database and currently allows the partitioning of the data by year, species, length group, age group, strata, and environmental parameters. "Data movies" can be created to distribute the display of partitioned data series to other individuals.)

Results

Concentrations of 0-2 year old juvenile cod were recorded west and northwest of Sable Island and near the Gully. During the July survey period, there appears to be a differentiation between the distribution of juvenile cod and 3+ cod north of the

Burke, D.L., R.N. O'Boyle, P. Partington, and M. Sinclair. 1996. Report of the Second Workshop on Scotia-Fundy Groundfish Management. Can. Tech. Rep. Fish. Aquat. Sci. 2100: vii + 247 p.

Louisbourg basin and along the Laurentian channel. Where haddock generally appear to avoid the eastern shelf (perhaps related to the colder more saline water masses), 3+ cod were caught extensively in this region, in comparison to lower catches of 0-2 juvenile cod. The distribution of juvenile cod in relation to near bottom temperature for the 26 year period is shown in Figure 1. The percentile catches of juveniles for the last five years is shown in Figure 2. The joint distribution of juvenile and mature cod for 1991 to 1995 is shown in Figure 3.

The growth rate of haddock is known to be variable between the inshore and offshore 4X and 4VsW NAFO divisions (Hurley et al. 1995). The cohort slicing length between 2 and 3 year olds has been estimated to vary between 30 to 40 cm. for these data within this time series. The 1994 assessment of 4X haddock used yearly estimates of mean length at age to account for differential growth. For simplicity in this analysis, a single length value of 35 cm was chosen as the division between juveniles and mature fish. The large catches of 0-35 cm juvenile haddock west and northwest of Sable Island, on Browns Bank and south of Brier Island, are variable and when significant are confounded by the presence of larger haddock in a number of years. The distribution of juvenile haddock in relation to near bottom temperature for the 26 year period is shown in Figure 4. The percentile catches of juveniles for the last five years is shown in Figure 5. The joint distribution of juvenile and mature haddock for 1991 to 1995 is shown in Figure 6.

Prognosis

This analysis does not reveal areas where juvenile fish were caught without significant catches of mature fish. There are, conversely, areas where mature fish are caught in the relative absence of juveniles.

A number of factors may bias these results. The partial selectivity of the gear to juveniles was not accounted for. The five-year moving average window tends to show stable distribution areas, where the yearly distribution is more variable. Percentile plots emphasize distribution differences but may in reality represent very small catch levels. The aggregation unit area size affects the perceived granularity of the distribution.

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Hurley, P.C.F., P. Comeau and G.A.P. Black. 1995. Assessment of 4X Haddock in 1994. DFO Atlantic Fisheries Research Document 95/29: 42 p.

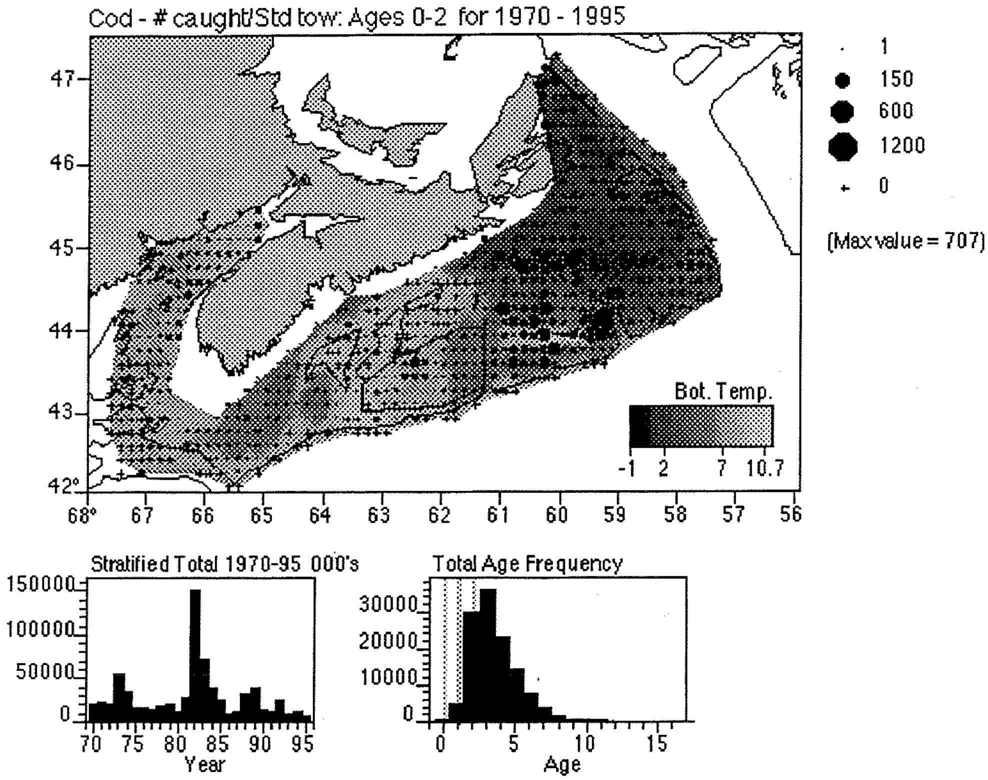

Figure 1. Distribution of Juvenile cod (ages 0-2) from the summer groundfish surveys for the period 1970-95 as scaled symbols and the near bottom temperature shown as a shaded surface.

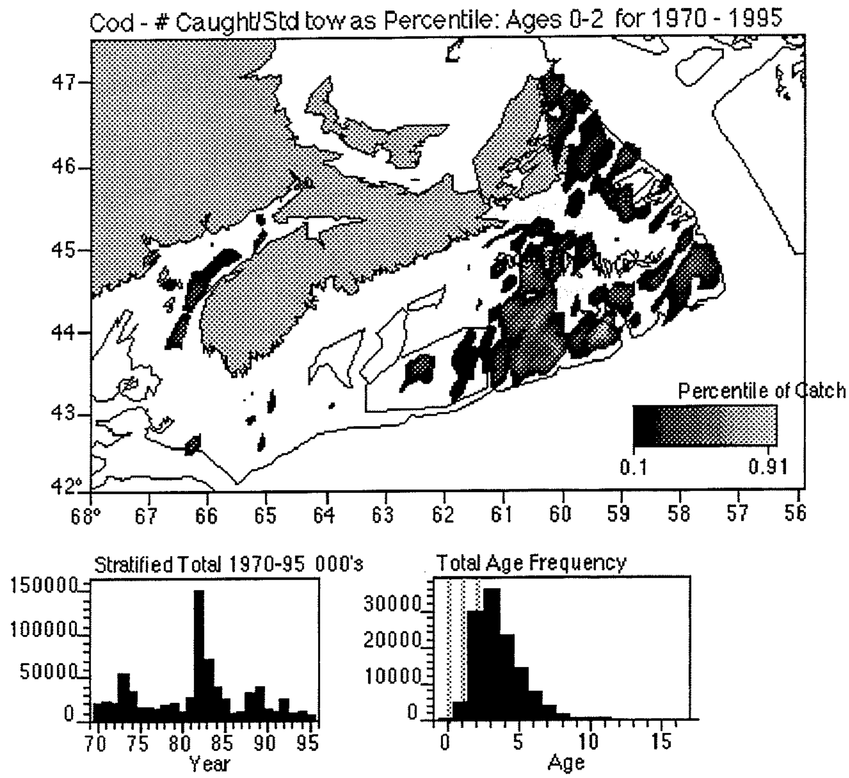

Figure 2. Distribution of Juvenile cod (ages 0-2) from the summer groundfish surveys for the period 1970-95 as percentile of catch.

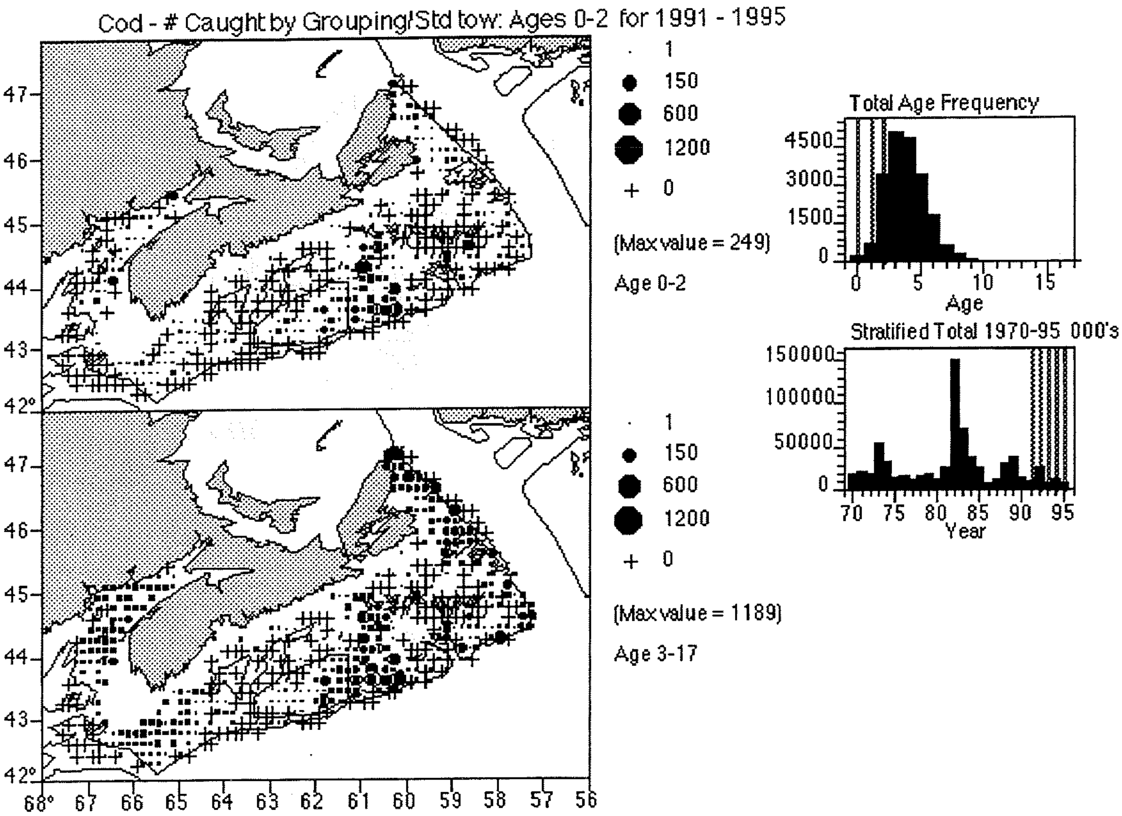

Figure 3. Distribution of Juvenile cod (ages 0-2) and mature cod (3+) from the summer groundfish surveys for the period 1970-95 as scaled symbols.

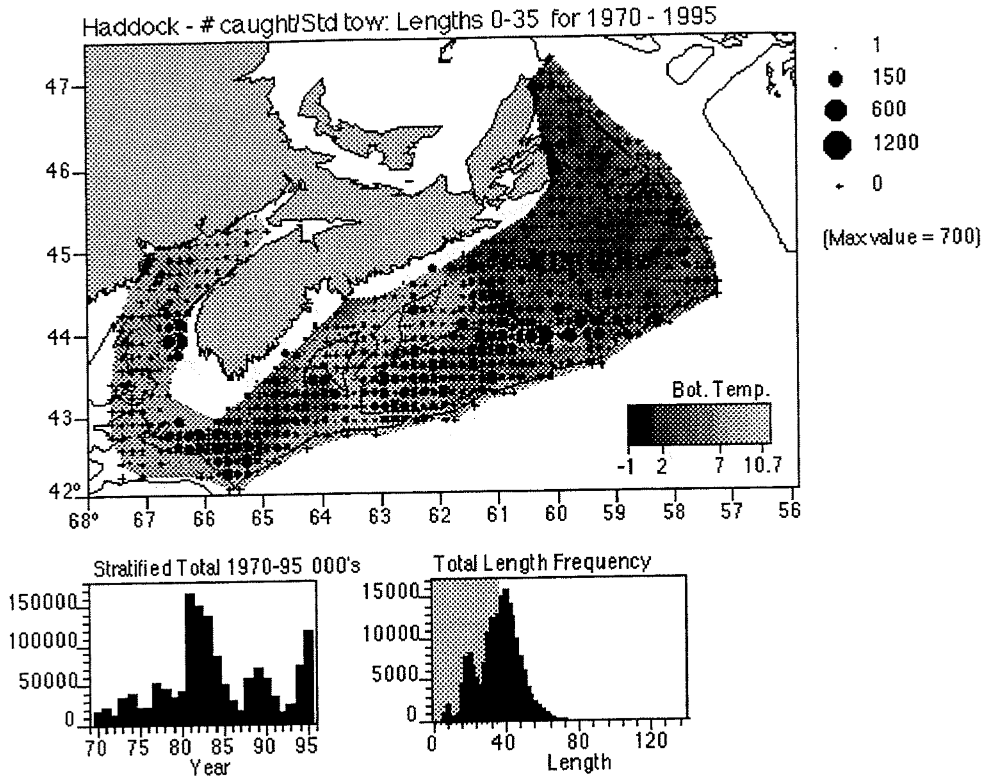

Figure 4. Distribution of Juvenile haddock (length group 1-35 cm) from the summer groundfish surveys for the period 1970-1995 as scaled symbols and the near bottom temperature shown as a shaded surface.

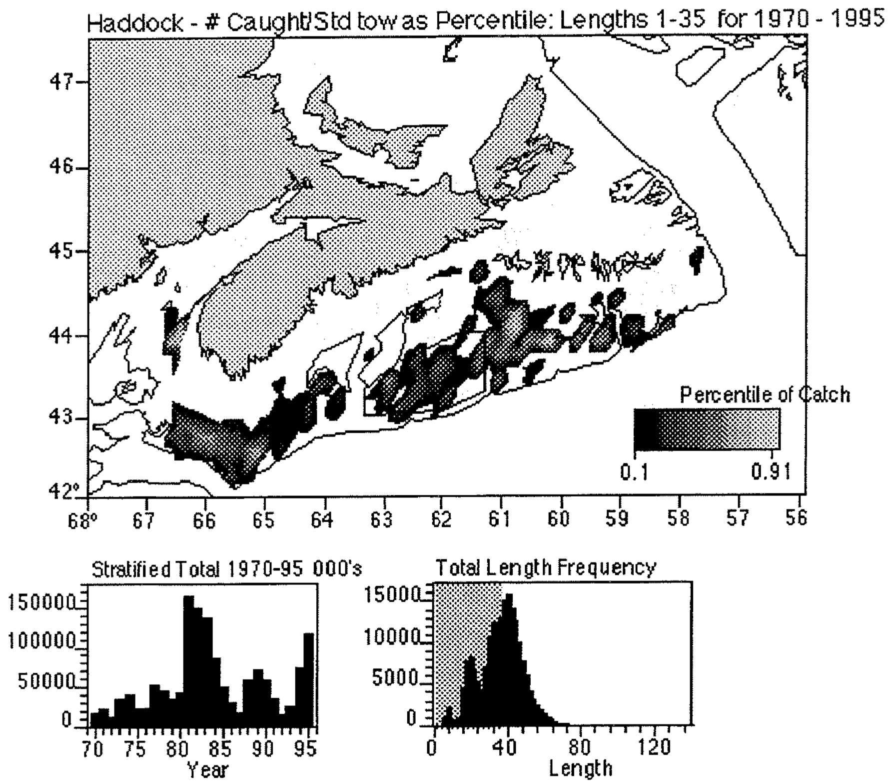

Figure 5. Distribution of Juvenile haddock (length group 1-35 cm) from the summer groundfish surveys for the period 1970-95 as percentile of catch.

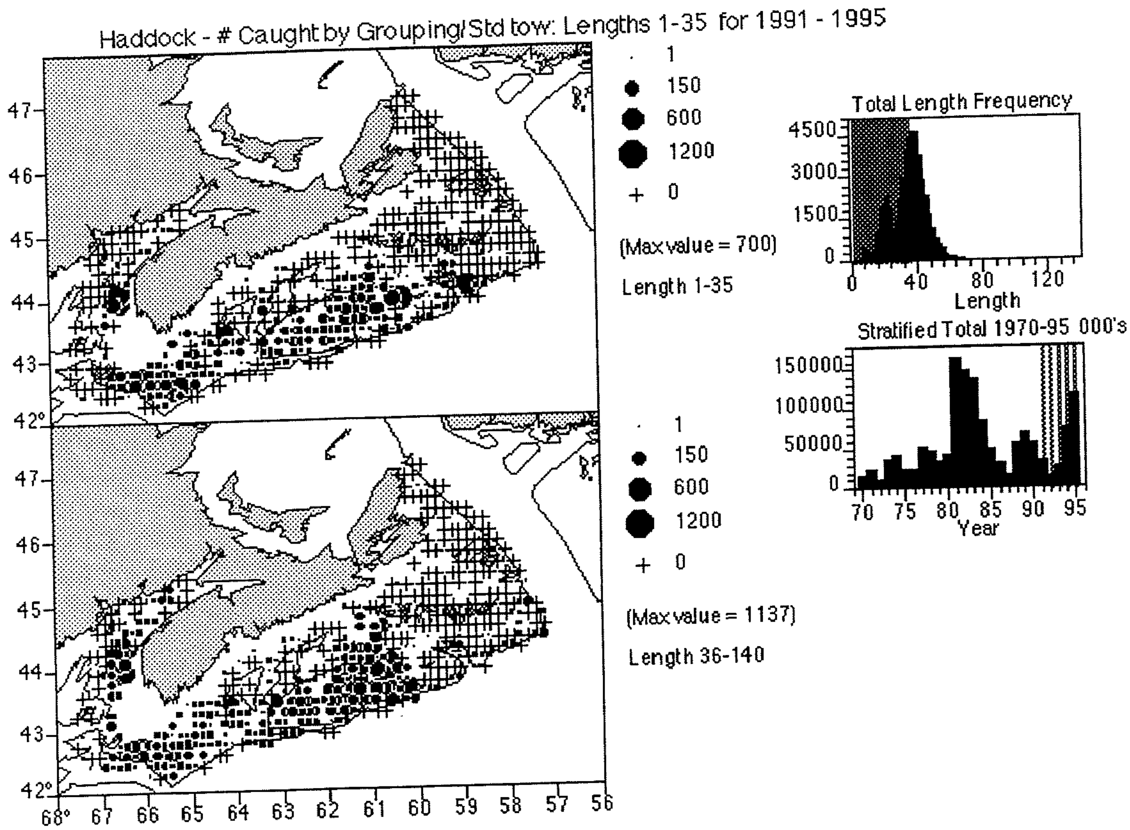

Figure 6. Distribution of Juvenile haddock (lengths 1-35 cm) and mature haddock (35+ cm) from the summer groundfish surveys for the period 1970-95 as scaled symbols.

Are Restrictions on Harvesting Technology Necessary to Achieve the Objectives of Conservation

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PREAMBLE

The topic of appropriate harvesting technology has received a great deal of attention of late. At the international level FAO has been conducting consultations on a Code of Conduct for Responsible Fishing Operations which follow up on declarations from an International Conference on Responsible Fishing held in Cancun, Mexico in 1992. An "expert consultation" was held on this code in Canada in 1994 (DFO 1994) and the code is expected to be formally approved by FAO at its conference in November of 1995.

At the domestic level, the FRCC established a Fishing Gear Technology Subcommittee, the work of which is likely to have a greater and more immediate effect on how Atlantic zone fisheries are conducted than is that of FAO. The purpose of this Subcommittee is:

> "to determine, for each harvesting technology, the conservation implications, optimum manner of usage and relative desirability from a resource conservation perspective. This will be based on an objective analysis of historical experience and current evidence concerning habitat impact, gear selectivity, inherent manageability, the potential for improvement or abuse of the technology, and any other relevant considerations."

The Subcommittee commissioned, and received, "an independent and objective study" of the state of knowledge on conservation implications of fishing gears (Canadian Fishery Consultants Ltd. 1994). Based on this, it published a discussion paper outlining the current state of knowledge on questions of gear technology (FRCC 1994). It is understood that the Subcommittee is soon to issue a "consultation paper" which will be the basis of debate at a number of public meetings to be sponsored by it this autumn. The Subcommittee will then take to the FRCC "appropriate proposals concerning gear technology or gear-oriented regulatory measures required for conservation of the resource". No doubt, the FRCC intends, in due course, to make recommendations on these topics to the Minister.

The present report is entirely independent of these other initiatives. The present Technology Working Group was created solely for the purpose of this Workshop. While extensive overlap with these other reports noted above is unavoidable, it was decided that the present report should focus attention on specific gear issues seen as currently important to Scotia-Fundy groundfish fisheries and to make suggestions as to what, if anything, should be done about them. The aim was to provide a document complementary to, rather than repetitive of, others now available.

INTRODUCTION

Scope of Report

Restrictions on harvesting technology is taken to mean regulation of the way fishing gear is constructed or used to change the species and sizes of fish caught and to reduce incidental mortality and the effects of gear usage on fish habitat.

Excluded, therefore, is the technology associated with fishing vessels themselves and the navigation, fish finding, and other equipment which affects their fishing efficiency. Also excluded are restrictions on gear usage, such as limits on overall gear size or number of units used, when these are intended to limit fishing effort, i.e. the numbers of fish caught. Restrictions on areas and seasons of usage, when these are intended to reduce gear conflicts are also not considered to be relevant, neither are measures taken to improve fish quality/value.

Identification Of Perceived Problems

Issues are referred to as perceived problems because there are many outstanding hypotheses about gear problems which remain to be verified and/or quantified. Issues which are a direct function of gear design and construction or gear usage can be classified into three broad categories:

- catch wastage;
- mortality incidental to the catching process; and,
- effects of gear on habitat.

Catch wastage comes in a variety of forms:

- Capture of fish which are below marketable size or below minimum size limits. These are usually discarded at sea or put into fish meal, although some fish below minimum size limits may nonetheless be marketed. The primary concern is the loss of potential yield projected to be obtainable if the fish are allowed to reach a larger size before capture. Small fish catches may be a problem in fisheries directed for the species in question or in small mesh fisheries for other species such as shrimp, redfish and silver hake/squid.
- Discarding/dumping of catches which exceed vessel quotas, trip limits or bycatch allowances, or which are not marketable. Fish may not be marketable for technical reasons or, due to variability in demand, a market may simply not be available to the vessel owner at the time the catch was made.
- Highgrading to maximize the value of the catch within the constraints imposed by catch limits. This usually involves dumping medium sized, marketable, fish so that more large fish can be caught and retained.

Mortality incidental to the catching process is the killing of fish by the gear other than by retaining them until the gear and its catch are brought aboard the vessel. There are a number of distinct processes which cause this mortality which are more or less characteristic of particular gear types:

- Post-selection mortality results from damage to the fish, through abrasion or stress, from escaping through the meshes of nets. Although likely to be most important in towed nets, otter trawls and Scottish (Danish) seines, it is also applicable to gillnets.
- Ghost fishing is the process whereby lost gear continues to fish for a period resulting in continuing deaths of fish. This problem is associated primarily with gillnets.
- Runover/haulback escapement/predation loss, as sources of mortality, is a grab-bag. The first issue, runover (or roadkill) is associated with the pulling of heavy groundgear on otter trawls over fish trying to escape by passing under the footrope. Scallop dredges may also inflict some runover mortality on groundfish. Haulback escapement is referred to as drop-out with gillnets, drop-off with longlines and float-out with mobile gears. Predation mortality is a fixed gear issue where fish are eaten from the gear prior to haulback.
- Incidental capture of marine mammals and birds is a special case with a high public profile. This is primarily a gillnet issue.

Effects of gear on habitat is an issue involving bottom trawling and dredging and whether passage of these gears across the seabed produces physical, chemical and biological changes which alter the distribution and ultimately the production of groundfish stocks in a detrimental way.

Potential Problem Solutions

The first step to resolution of a problem is to fully understand its nature, quantify its seriousness and diagnose its root causes, i.e. to marshall relevant knowledge. Alternative solutions can then be evaluated. Solutions may lie in regulation of the way fishing gears are constructed and of when, where and on what species they can be used. However, demonstration, education and persuasion could prove more cost effective. It could also be the case that other elements of the regulatory framework should more appropriately be changed, particularly allocation procedures and fishing plans.

METHODS

This report is organized on the basis of case studies. The first step was to develop a matrix of perceived problem categories and the gears which exhibit a problem falling within that category (Table 1). Some cells in Table 1 are blank indicating that the Working Group did not identify any significant problem within a particular category for a particular gear e.g. longlining is not thought to have an adverse effect on habitat. Other cells have several numbered entries indicating that several problems were identified which fell into a particular category for a particular gear, e.g. otter trawl captures of small fish. The numbers in Table 1 provide a key to a listing of the perceived problems (Table 2), and to a series of appendices to this report which analyze each of these perceived problems and provide potential solutions. The potential solutions arrived at on a case by case basis are then reviewed and conclusions reached on the extent to which regulation of the way fishing gear is constructed and used is likely to prove fruitful.

RESULTS AND DISCUSSION

The answer to the question posed to this working group "are restrictions on harvesting technology necessary to achieve the objectives of conservation?" is surely yes. Restrictions on harvesting technology have, of course, been in place for many years, such as restricting the mesh sizes which can be used in nets of various sorts. The present review of perceived conservation problems associated with the use of harvesting technologies leads to the conclusion that these restrictions could usefully be modified or augmented in some cases. However, the working group's recommended actions in relation to the 16 case studies examined (paraphrased in Table 3) do not provide a list of specific new gear restrictions to be imposed through government regulation.

In a number of case studies, problems remain in the "perceived" category because there are no hard data or research results to establish whether a problem of any real importance exists, and recommendations are to quantify the problem, either by systematically collecting data on its occurrence (e.g. problems 1, 2, 4, 9, 10, 11, 12, 13) or by conducting (possibly large-scale, long-term) research projects (e.g. problems 8, 14, 16). At least in some of these cases it will likely transpire that no remedial action is necessary.

In some of the cases examined, it was concluded that actions already taken had largely resolved these problems (e.g. problems 3, 5), and no further actions except monitoring are necessary at this time.

In other cases it was concluded that apparent gear problems were, in fact, symptoms of other management problems and that their solution did not necessarily lie in further technological restrictions. In the case of the capture of small cod and haddock (problems 1, 6), the definition of a small fish is an arbitrary one in relation to marketability, i.e. smaller fish than the minimum size can readily be utilized. A high small fish size, when translated into an appropriate trawl mesh size (or larger hook size), results in large reductions in catch rates, particularly at the present time when fish are generally small. This increases the incentive for cheating so that returns cover costs. Alternative regulatory approaches could reduce wastage. Dumping of catch overages (problem 7) is entirely a symptom of the catch quota allocation schemes which have been implemented. If a fisherman is allocated cod and no haddock and must dump haddock, is this a gear selection problem or an allocation problem? Allocations need to reflect the reality of fishing operations. Nonetheless, development of more species selective gears would contribute greatly to resolving allocation difficulties and this is recommended as a government/industry initiative, but not as a regulatory approach.

Among those cases where technological innovations are proposed as solutions to what appear to be real problems, some innovations are implementable based on currently available technology, e.g. use of separator grates in redfish trawls (problem 4), or on extensions of current knowledge, e.g. further selection experiments for flatfish (problem 2). Others require development of new concepts, particularly those concerning species selection (problems 7, 15) and design of gears with appropriate size selection characteristics for use in multiple species fisheries, e.g. for gadoids and flatfish (problem 2). These new concepts are most likely to be derived through directed research on the behavior of fish in relation to fishing gear.

Although technological innovations are proposed these proposals are not necessarily for imposition through government regulation. Many current gear regulations are inherently difficult to enforce, trawl mesh size being the most longstanding and notorious case. In the past, inadequate attention has been paid to the enforceability of regulations or to the provision of adequate levels of staff to ensure the necessary level of compliance to make the regulations effective. Indeed, if it had been necessary to conduct analyses of the cost-effectiveness of regulatory proposals, it seems fair to conclude that many would not have been adopted. Although regulation of gear is ultimately a necessity, as there will always be those who are prepared to engage in destructive practices, the restrictions imposed should be minimized, kept simple and framed in a manner which maximizes their enforceability. Severe sanctions for violations are a necessity. Arrangements which include an element of industry self-policing are likely to be more cost-effective.

Of over-riding importance to the successful introduction of technological innovations and to the effectiveness of gear restrictions, however, is a more responsible attitude on the part of industry with regard to fishing practices. More size and species selective gears will be utilized effectively only if fishermen understand not only how to rig them properly but also why their use is necessary and are motivated to resolve the underlying conservation problems. This requires a strong emphasis on education of fishermen but also a transfer of responsibility to them for the success of conservation projects.

In conclusion, this is a time of substantial change in the way fishery management is to be conducted with a predominant theme being transfer of a significant proportion of the responsibility for its success to the industry. There is also a strong thrust developing for the adoption of more "conservation-oriented" gear technology and, as noted above, the increase in industry responsibility is a necessary ingredient for this. There is a need also for another ingredient and that is for a strong organizational focus for delivery of a government/industry gear technology development program. The components of this program would necessarily include research, development, education/demonstration, and field evaluation. All of these components have been parts of previous government programs but these programs, in this Region, have for many years been conducted under temporary funding arrangements and on an ad hoc basis such that a cohesive, directed, research program could not be developed. Although a high proportion of gear issues are inter-regional (and even international) in scope, inter-regional coordination of programs has been slack and, for the research and development components, an Atlantic coast focus has merits.

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FRCC. 1994. Conservation aspects of groundfish gear technologies in Eastern Canada. A FRCC Discussion Paper prepared by the Gear Technology Subcommittee. FRCC94. TD. 4, 37p + appendix.

Table 1. Matrix of perceived conservation problems associated with each groundfish fishing gear and with scallop dredges. Numbers give cross-reference to Table 2 and appendices.

	Gear				
Perceived Problem	Otter Trawl	Scottish (Danish) Seine	Gillnet	Longline (and Handline)	Scallop Dredge
Catch Wastage - capture of small fish	1,2 3,4,5	1,2		6	14
- discard/dumping of catch overages and non-marketable species	7	7	7	7	
- highgrading to maximize catch value	7	7		7	
Incidental Mortality - post-selection mortality	8	8			14
- ghost fishing			9		
- runover/haulback escapement/predation loss	10,11	11	12,13	12,13	14
- capture of marine mammals and birds			15	15	
Effects of Gear on Habitat - physical, chemical and biological change to seabed	16				16

Table 2. Listing of perceived conservation problems associated with groundfish fishing gears and scallop dredges.

Reference No.	Perceived Conservation Problem
1.	Catch of small fish in gadoid (cod, haddock, pollock) mobile gear fisheries
2.	Catch of small fish in flatfish mobile gear fisheries
3.	Catch of small fish in shrimp otter trawl fishery
4.	Catch of small fish in Unit 3 redfish otter trawl fishery
5.	Catch of small fish in silver hake/squid otter trawl fishery
6.	Catch of small fish in longline fishery
7.	Dumping of catch overages and highgrading
8.	Post-selection mortality in the groundfish mobile gear fishery
9.	Ghost fishing by lost gillnets
10.	Runover (roadkill) by groundfish otter trawlers
11.	Float-out losses in the groundfish mobile gear fishery
12.	Dropout/drop-off losses when hauling groundfish fixed gears
13.	Predation losses of fixed gear groundfish catches
14.	Effects of scallop dredging on groundfish
15.	Capture of marine mammals and birds in groundfish fixed gears
16.	Effects of fishing on the sea bottom and its fauna

Table 3. Summary of recommendations regarding the perceived conservation problems listed in Table 2 and discussed in Appendices 1-16.

1. Catch of small fish in gadoid (cod, haddock, pollock) mobile gear fisheries. Return to initial objective of trawl regulations - avoidance of wastage of small fish at sea. Survey construction features of trawls in use, particularly with regard to lengthening pieces, codends and other design features such as lastridge ropes, and discuss with industry ways to ensure proper fish size selection. Modify fishermen's behaviour through education, combined with more severe penalties for violations.
2. Catch of small fish in flatfish mobile gear fisheries. Document whether wastage of small flatfish is an important issue under current regulations. Conduct further selection experiments to establish equivalency between square and diamond mesh codends for flatfish. Study behaviour of flatfish caught by towed nets so that nets can be designed which have selection characteristics appropriate for mixed fisheries.
3. Catch of small fish in shrimp otter trawl fishery. Monitor the quantities, species composition and length frequencies of finfish bycatches to ensure that bycatches remain insignificant during groundfish stock recovery.
4. Catch of small fish in Unit 3 redfish otter trawl fishery. Test the use of separator grates, square mesh, and new netting materials to improve trawl size selectivity for redfish. Document the nature and extent of bycatch problems to provide a basis for problem evaluation and resolution.

5. <u>Catch of small fish in the silver hake/squid otter trawl fishery.</u> Adjust the large boat fishing season within the SMGL to 1 January-30 June on an experimental basis. Monitor closely bycatches in the small boat fishery.
6. <u>Catch of small fish in longline fishery.</u> Address small fish problems through non-technological approaches such as area closures. If there is a consensus within the industry to adopt a yet larger hook size than that required by regulation in 1995 this could be tested, but it would be inappropriate for government to promote or impose this because its effectiveness and practicability have not been established.
7. <u>Dumping of catch overages and highgrading.</u> Adopt a planning process which builds-up from practicable fishing operations while encouraging, and educating fishermen in, the use of more species selective trawls. A directed research program is needed to improve knowledge of fish behaviour in relation to fishing gear and thus move development of more species selective otter trawls beyond a trial and error approach.
8. <u>Post-selection mortality in the groundfish mobile gear fishery.</u> More research is need in measurement of post-selection mortality for large mesh sizes, particularly for haddock. Most cost-effective approach is to cooperate with Europeans with established research programs through shared cost arrangements.

9. <u>Ghost fishing by lost gillnets.</u> Obtain a reliable estimate of the numbers of gillnets lost in this Region. Policy emphasis should be on reduction of net loss rather than retrieval of lost nets or reduction of the effectiveness of lost nets to ghost fish. Impose minimum construction standards for gear and consider permanent closure to gillnet fishing of high net loss areas. Examine the feasibility of incorporating transmitting devices on gillnets so that those which are lost can be easily retrieved.
10. <u>Runover (roadkill) by groundfish otter trawlers.</u> The possibility that escapement of fish under trawl footropes results in a significant mortality of escapees should be investigated by examining videos of the escapement process. If it appears that escapees are being damaged frequently, other footrope designs could be examined.
11. <u>Float-out losses in the groundfish mobile gear fishery.</u> Investigate the level of wastage which occurs as a result of float-out and the mechanisms involved. Test whether taking the strain off the net while on bottom reduces float-out by allowing better escapement prior to haulback.
12. <u>Drop out/drop-off losses when hauling groundfish fixed gear.</u> Investigate the level of wastage which occurs from drop out/drop-off from fixed gears.
13. <u>Predation losses of fixed gear groundfish catches.</u> An attempt should be made to describe and quantify these problems to determine if they are of any general importance.

14. <u>Effect of scallop dredging on groundfish.</u> Determine the behaviour of fish in and around scallop dredges using underwater cameras to determine how and when fish are being captured, possibly in cooperation with US workers who have secured funding for research on fish capture by scallop dredges.
15. <u>Capture of marine mammals and birds in groundfish fixed gear.</u> The only major problem identified, the capture of harbour porpoises in the Bay of Fundy gillnet fishery, could be most simply and effectively solved by banning gillnetting in the identified problem areas during the period of peak local abundance of harbour porpoise. Decision on the value of attaching pingers to gillnets to deter porpoise from approaching them should await results of an ongoing investigation.
16. <u>Effects of fishing on the sea bottom and its fauna.</u> Continue strong support for ongoing research on habitat effects of otter trawling (and extend this research to dredging). As a precautionary measure, develop modified gears which reduce disturbance of the seabed.

Problem No. 1

Perceived Problem

Catch of small fish in gadoid (cod, haddock, pollock) mobile gear fisheries.

Relevant Knowledge

The size selection of towed nets depends on the codend mesh size and how well the codend meshes stay open during fishing operations. There are many elements of net construction which affect how well meshes stay open, the most important of which are the type of mesh, e.g. square or diamond, the "proportionality" of the net, particularly the length of lengthening pieces and the number of meshes in the circumference of the codend, and "additions" to the net such as lastridge ropes, chafers, covers and liners. Square mesh netting stays square when towed allowing fish which are round in shape (roundfish) maximum opportunity to escape through the meshes whereas diamond mesh tends to stay more closed except near the rear of the codend, allowing better escapement of flatfish but poorer escapement of roundfish than does square mesh netting. Too long a lengthening piece and too many meshes in the circumference of the codend both tend to keep codend meshes closed, and chafers, covers and liners obscure mesh openings reducing or preventing escape. Lastridge ropes on the other hand, if properly fitted to take the strain off codend meshes when towing, allow the meshes to stay open better.

The size selection of cod and haddock in relation to codend mesh size and type is well studied for otter trawlers but less so for Scottish (Danish) seiners. The few data available for seiners suggest that they may have a slightly higher selection factor for cod and haddock than do otter trawlers, but for scientific and regulatory purposes selection characteristics of the two gears are taken as identical. The size selection of pollock is poorly described but appears to be very similar to that of cod.

Regulations (for Scotia-Fundy Region), until replaced by similar restrictions in conditions of licence in 1994, required use of a mesh size, when fishing for groundfish, of 145 mm (or 130 mm if square mesh is used) in the codend. Any device which made mesh openings smaller was prohibited but bottom covers and topside chafers of specific design were allowed. No restrictions were placed on other elements of net construction. Enforcement of these restrictions is an intractable problem as nets are easily modified at sea to reduce escapement of small fish. Consequently there is a large body of anecdotal information indicating widespread circumvention of trawl regulations. However, there are no objective estimates of frequency or seriousness of violations.

Although opinions on what constitutes a small fish differ, the minimum landed fish size regulation of 43 cm (17 inches) for cod, haddock and pollock, introduced in 1991 (but replaced in 1993 and subsequent years by small fish protocols - see below), provides a recent reference point which reflects government's view of a compromise position. A mesh size of 145 mm diamond mesh (or equivalent) has a selectivity for 43 cm fish of these species of 15% or less. The usual scientific definition of conformity between mesh and minimum fish size regulations is for the mesh size to have a 25% selectivity for fish of the minimum fish size. Thus, the requirement for 145 mm mesh provides for safeguards against the catch of small gadoids a bit beyond those normally proposed scientifically. (However, flatfish present different issues.)

The catching of small fish is a consequence not only of gear selectivity but also of the size composition of the population being fished. In other words, if there are only small fish in the water, only small fish can be caught regardless of mesh size. Beginning in 1993, landing of all fish, regardless of size, was made mandatory. Minimum landed size regulations were replaced by small fish protocols requiring real-time closure of areas when the proportion of small fish (again defined as less than 43 cm) in landings exceeded the established tolerance level (15% by number). Real-time closures are an appropriate way to deal with a situation such as that prevailing from 1993, where stocks are composed predominantly of small fish, as further modifications to gear selectivity would be ineffective.

There are no estimates available for past years of the extent of illegal trawl gear usage, nor of the quantities of small fish (caught with illegal or legal gear) which have been discarded at sea and hence wasted. Certainly, some proportion of the small fish caught had commercial value and were landed, except when enforcement of minimum fish sizes (which were in effect in 1988-92) required their discard at sea. Under the present rules there is also an incentive to discard small fish at sea to avoid area closures but the present levels of illegal gear usage and of discarding of small fish is not documented.

Potential Solutions

a) **Technological:** The effects of net construction on trawl size selection is quite well understood, so it is possible to establish construction standards. At present there is no regulation of net designs in use other than for mesh sizes and chafing gear. Extra restrictions on lengthening pieces and codend design could be considered, the use of appropriately rigged lastridge ropes could be required, and the continuing need for chafing gear reevaluated.

b) **Other:** Trawl mesh regulations are notoriously difficult to enforce. Minimum landed fish sizes, in contrast, can be readily enforced but encourage the discarding of small fish at sea. Real-time area closures, designed to prevent fishing on concentrations of small fish, present an alternative. However, groundfish are not usually strongly segregated by size which limits the effectiveness of this approach. It also has the disadvantage of requiring continuous government intervention in the day to day operation of the fishery. More extensive education of trawler captains on proper gear design and responsible usage, reinforced by strong social pressures from fishing companies and fishermens' organizations, and accompanied by severe sanctions for any violations of gear regulations which are detected, presents a possible solution.

Recommendations

Trawl regulations were instituted initially to avoid wastage of fish at sea. More recently, arguments for higher mesh sizes have concerned also increasing the value of the catch. However, the implicit costs are often ignored. Another currently popular argument is for augmentation of spawning stocks. Two assumptions underlie this proposal, a) that the small fish not caught will survive and augment the spawning stock and b) that a larger spawning stock will result in larger future year-classes and hence higher yields. There are grounds to question the validity of both assumptions. A pragmatic approach to the issue of small fish capture is recommended; one which optimizes utilization by avoiding wastage rather than putting heavy dependence on hypothetical arguments.

Problems with capture of small fish are not a result of inherent limitations of trawl technology. They are a result of human behavioral responses, primarily to the symptoms of fleet overcapitalization and resource overexploitation. Reduction in participation and in resource exploitation level would create conditions where perceived benefits of exploiting small fish would be reduced. Behavioral modification through education combined with more severe penalties for regulatory violations might then be more effective.

As a first step, a survey could be conducted on the dimensions of lengthening pieces and codends used in trawls at this time, and of other design features such as lastridge ropes, as a basis for discussions with industry on ways to ensure proper codend functioning with regard to size selection.

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Problem No. 2

Perceived Problem

Catch of small fish in flatfish mobile gear fisheries.

Relevant Knowledge

Much less is known about the size selection of flatfish than of gadoids, and there are insufficient data to distinguish whether there are differences in selection of flatfish species between otter trawlers and Scottish (Danish) seiners. This latter point is of greater importance for flatfish than for gadoids because Scottish seine fishing is directed mostly towards flatfish and also a substantial portion of the flatfish catch is taken by seiners.

Mobile gear mesh regulations, until revoked in 1994, required the use of 145 mm diamond, or 130 mm square, codend meshes for flatfish, but actual usage has been evolving by area, vessel size and gear type through development of annual harvesting plans and their implementation through licensing conditions. For example, in 1995 seine netters fishing for flatfish on the eastern Scotian Shelf (Div. 4VW) are required to use 145 mm diamond mesh whereas small otter trawlers (less than 65') fishing for flatfish in that area are required to use 155 mm square mesh. This differential reflects the fact that, for flatfish, square mesh netting has a lower selection factor than diamond mesh netting of the same mesh size, the reverse of the situation for gadoids. A recent experiment in the Gulf Region showed that a seine net equipped with 145 mm diamond mesh had a 50% retention length for American plaice of 35 cm and a selection range of 5.6 cm. Thus, most of the catch with this mesh would be expected to be above the minimum marketable size of 32 cm (12-13 inches). It has yet to be established that 155 mm square mesh is the equivalent of 145 mm diamond for plaice and whether these conclusions for plaice apply to other flatfish species.

Discards at sea by large otter trawlers in the 1980s were estimated through the observer program to be approximately 20% for yellowtail flounder, 10% for plaice and less than 5% for witch flounder in Scotian Shelf fisheries. No estimates are available for Scottish seines at that time. Observer data for both Scottish seiners and otter trawlers in 1993-95 indicate that discarding of these species is now insignificant (at least on observed vessels). However, this is to be expected under the no-discard rules and does not imply that all fish caught are truly of marketable size or that mesh sizes currently in use optimize yields.

Potential Solutions

a) **Technological:** Mesh selection for flatfish has not been investigated at all thoroughly. Thus, there is uncertainty about the absolute values of selection parameters and their relativities between square and diamond mesh and between otter trawlers and seiners. Selection experiments can be conducted but, for seines, proper techniques for this are still in the development stage.

A sizable proportion of the flatfish catch is taken as bycatch or in mixed fisheries and thus with different, possibly smaller, mesh sizes than required when fishing is directed for flatfish. This problem could possibly be solved by developing trawl and netting configurations which utilize the different behaviour of species when in the net, e.g. codends with different sized meshes in different locations, to improve net selection characteristics for flatfish in mixed catches.

b) **Other:** None.

Recommendations

The extent of wastage of small flatfish under current regulations has not been documented and, until it has, no changes in the effective mesh size used for directed flatfish fishing can be proposed. However, equivalency between square and diamond meshes should be ascertained as available data are not supportive of the current differential.

Studies of the behaviour of flatfish caught by towed nets are necessary for design of nets with appropriate selection characteristics for use in mixed species fisheries.

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Problem No. 3

Perceived Problem

Catch of small fish in shrimp otter trawl fishery.

Relevant Knowledge

The Scotian Shelf shrimp fishery was restricted by groundfish bycatches, which were limited to 10%, reducing participation and resulting in shrimp catches far below TAC levels. Although reduced groundfish abundance contributed to reduced bycatch rates in the early 1990s, experimental introduction in 1991 of a separator grate (25 mm bar spacing or less), into the codends of the small mesh (40 mm) trawls used, dramatically reduced bycatch quantities and allowed the shrimp fishery to expand so that, in 1994, the TAC was fully taken for the first time.

Although the bycatch of larger sized groundfish has been essentially eliminated, fish small enough to pass through the grate with the shrimp are still caught and, although bycatch tonnages are low, the numbers of small fish caught could still be high. However, it appears that the numbers of small fish, predominantly redfish and flatfish along with non-commercial species, are also low (P. Koeller, pers. comm.) but species composition and amounts have not been documented. A recovery of groundfish could increase bycatches.

Potential Solutions

a) **Technological:** To the extent that groundfish bycatches are of commercial sized fish, the separator grate solved an allocation problem rather than a conservation problem. The size composition of bycatches was not documented either before or after grate introduction. However, there does not appear to be a small fish bycatch problem at this time.

b) **Other:** As for (a).

Recommendation

The quantities, species composition and length frequencies of finfish bycatches should be monitored to ensure that bycatches remain insignificant during groundfish stock recovery.

References

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Problem No. 4

Perceived Problem

Catch of small fish in Unit 3 redfish otter trawl fishery.

Relevant Knowledge

Increased interest in the Unit 3 (central and western Scotian Shelf) redfish fishery by small (less than 65') otter trawlers from 1993 was accompanied by reports of quantities of very small redfish being landed. These redfish were in large part utilized for lobster bait, and to some extent for food, but concern was expressed about possible deleterious effects on future yields.

Unit 3 redfish catches historically have been composed of smaller fish than these from more eastern stocks. Modal size is typically 25 cm and a high proportion of the catch is in the 20 - 25 cm range. The concern was thus about capture of redfish less than 20 cm. Port and observer sampling indicated that the catch of small redfish (<20 cm) in 1993 and 1994 was 3.5% and 7.0% by number, respectively. The catches of small fish were localized to Statistical Area 4Xo north of Browns Bank and to the early part of the season when the lobster fishery was still in progress.

In addition, in 1994 and again in 1995, the small boat redfish fishery encountered difficulty staying within the 10% bycatch limit for other groundfish. The species composition, quantities, and the size composition of these bycatches has yet to be documented. Thus, it is not known whether this is a small fish conservation problem or solely an allocation issue.

Potential Solutions

a) **Technological:** Use of 90 mm mesh in trawl codends, which was the mesh size traditionally used for redfish fishing, was made mandatory through conditions of licence from 1993. Experimental data and industry experience with larger mesh nets indicate that mesh selection of redfish, at least with traditional diamond mesh nets, is poor (long selection range) and severe meshing problems can occur. Surface floatout could therefore be a serious problem at larger mesh sizes. Nonetheless, the industry is testing again the use of larger mesh nets, and experiments in Newfoundland Region have found that use of lastridge ropes (hung at 88%) narrowed selection range. Use of separator grates to allow small fish to escape while retaining large fish could be feasible. A grate could also be effective in allowing escapement of small specimens of bycatch species and hence alleviate bycatch problems as well.

b) **Other:** The distribution of redfish less than 20 cm is localized and area closures proved useful in 1994 in reducing their capture. Fishermen themselves could voluntarily avoid small redfish areas.

Recommendations

Unit 3 redfish is lightly exploited, only half the TAC being taken in 1993 and 1994. The quantities of redfish under 20 cm caught in these years are a quite low proportion of total removals, and these catches are not likely to significantly affect future catch prospects. In any case, these small fish appear to be making a useful economic contribution to the fishery and allocating some moderate proportion of the yield to the small redfish market could be viewed as appropriate resource utilization. Measures already in place appear capable of controlling the catch of small redfish. However, use of separator grates, if proved effective, would eliminate the need for day to day management of area closures by DFO and might also reduce bycatch concerns, and the utility of grates should be tested. It is possible that use of square mesh, lastridge ropes, or new, more rigid netting materials could improve net selection characteristics for redfish and these are also worth testing. If bycatches are of commercial sizes then problem resolution may require trawl design changes, e.g. use of off bottom trawls, but the scale of the problem should be investigated before embarking on expensive solutions.

References

Branton, R. 1995. Update on the Status of Unit 3 redfish: 1994. DFO Atlantic Fisheries Research Document 95/32, 14 p.

Problem No. 5

Perceived Problem

Catch of small fish in the silver hake/squid otter trawl fishery.

Relevant Knowledge

The silver hake/squid fishery was restricted from 1977 to using a regulated 60 mm mesh seaward of a Small Mesh Gear Line (SMGL) along the shelf edge in Div. 4WX between 15 April and 15 November and low bycatch limits of traditional groundfish species were imposed, e.g. 1% for haddock. Although bycatches were proportionally low, declines in abundance of traditional stocks in the early 1990s caused demand for the virtual elimination of bycatches in the silver hake fishery. There has been very little directed squid fishing since 1982. This fishery has had a high level of observer coverage since 1978 and essentially 100% coverage since 1987. Thus, bycatches are precisely quantified and their location, depth and time of capture is known on a set by set basis.

Government/industry efforts to develop a domestic catching and processing capability for silver hake appear to be coming to fruition. (To date, harvesting has been almost exclusively by large foreign trawlers fishing under national allocations or charter arrangements.) A number of small trawlers (less than 65') are fishing for silver hake on a fully commercial basis in 1995.

It was established through a series of experiments in 1992-93 that a sorting grate in the trawl codend would divert much of the bycatch, which is of fish that are larger-bodied than silver hake, to the escape hole on top of the net while the silver hake passed through the grate into the codend. However, those specimens of bycatch species which were as small as silver hake were still caught. Analysis of historical bycatch data for the large boat fishery indicated that highest bycatch rates occurred in the shallowest water late in the fishing season. It was proposed that the SMGL be moved to exclude water shallower than 190m and to the east of 60°W and that the fishing season, which had been moved experimentally to as early as 15 March, be moved yet earlier and be terminated at the end of June. Use of a sorting grate was made mandatory in August 1993 and the recommended changes to the SMGL were made for the 1994 season, although exemptions to the new SMGL were permitted in 1994 and 1995 and the fishing season was not adjusted. Analysis of bycatches in the 1994 fishery indicated that the combined effect of the measures imposed resulted in large reductions in bycatch rates from earlier levels and bycatch tonnages were negligible.

Experimental fishing using small boats established that there are areas closer to shore than the SMGL in deep basins where good silver hake catches can be made with low bycatches when grates are used. Mesh selection experiments illustrated that 55 mm square mesh codends had a higher and sharper selection for silver hake than regulation 60 mm diamond meshes and eliminated much of the catch of silver hake under 18 cm, which are presently unprocessable. These results likely also have relevance to the offshore, large boat fishery. Grates are required in the 1995 small boat fishery and the use of 55 mm square mesh is an option to the regulation 60 mm diamond. Two additional fishing areas are available to these boats, LaHave and Emerald basins. Bycatches of traditional species are to be covered under IQs (except stocks under moratorium where bycatch limit is 1% per week). However, there are no seasonal restrictions.

Potential Solutions

a) **Technological:** Although there has not been a significant squid fishery on the Scotian Shelf for almost 15 years, high squid abundance years such as those of 1975-81 could recur. Initial trials with separator grates for squid indicate that they do not work well. Off-bottom trawls and automatic squid jiggers may provide better technological solutions to bycatch problems in a squid fishery. (Note also that the squid fishing season is July to November and this emphasizes the need to find a gear solution to bycatch problems in this fishery.)

Domestication of the fishery has generated a requirement for improved data on size selection of silver hake by otter trawls. There are few data currently available for either diamond or square mesh netting and these need to be augmented before the responses, in terms of catch size composition, to changes in mesh size can be projected with reliability.

b) **Other:** Movement of the season for fishing within the SMGL to as early as 1 January could provide additional insurance against bycatches and likely increase catch rates of silver hake. Further experience in fishing more inshore areas will allow improved temporal/spatial definition of the new boxes for fishing silver hake.

Recommendations

The practicality of fishing within the revised SMGL for the large boat fleet has been established and further exemptions are not necessary. An experimental adjustment of the fishing season to 1 January - 30 June should be implemented.

Bycatches in the small boat fishery should be closely monitored.

References

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Cooper, C.G., 1995. Silver hake cod-end selectivity experiment. Industry Services and Native Fisheries, Scotia-Fundy Region, Halifax, Nova Scotia, Project Summary No. 49, March 1995, 4 p.

Problem No. 6

Perceived Problem

Catch of small fish in longline fishery.

Relevant Knowledge

A tendency for longline vessels to land smaller fish in the late 1980s - early 1990s, particularly increased quantities of haddock below the legal size limit, was attributed to a widespread conversion to the use of small circle hooks (Mustad No. 10/0 or equivalent). As a result, use of Mustad No.12/0 circle hooks (or equivalents) or larger was made mandatory from January 1995.

The success of this measure is contingent upon fishermen continuing the practice of using larger baits on larger hooks because experiments show that size selection of longlines is as dependent on bait size as it is on hook size. Secondly, equivalency in size selection characteristics between hook types is presently based on industry consensus, not on experimental data, and thus there is substantial scope for error.

Experience in 1995 to date indicates that longline fishermen continue to catch small fish quite regularly, despite using the large hook. Indeed, the preponderance of area closures in 1995 have been experienced as a result of longliners exceeding the tolerance levels established under the small fish protocols.

Potential Solutions

a) **Technological:** Regulation of bait size is impractical, so it can only be hoped that fishermen continue historical practices. Equivalencies between hook types can be refined through experimentation. An experiment comparing circle and traditional J hooks was conducted in March 1995 and a second comparing circle with semicircle (easybaiter) hooks is currently under way. These three types are the ones presently in greatest use and the results should clarify whether there are serious deficiencies in present equivalency designations. There is some support within the industry for a further increase in hook size to a Mustad No. 14/0 circle hook (or equivalent). However, given that size of fish caught is not very sensitive to hook size and also that the populations being fished at this time are composed predominantly of small fish, this may have relatively little effect on size composition of catches while causing large reductions in catch rates.

b) **<u>Other:</u>** Closure in 1993 of the Div. 4W haddock closed area to all gears, rather than only mobile gear, probably did more to reduce the catch of small haddock by longline than can be expected from hook regulation. Other permanent area closures, such as the tops of LaHave and Baccaro banks, where catches of small haddock are most prevalent, could be considered.

Recommendations

Size selection by longline gear is still poorly understood and thus small fish problems are more readily addressed at this time through non-technological approaches such as area closures. If there is a consensus within the industry to adopt a yet larger hook size this could be done on a test basis but there is sufficient doubt about its effectiveness in reducing the catch of small fish that it would be inappropriate for government to promote or impose this.

References

Halliday, R.G. and K.J. Clark. 1995. The Scotia-Fundy Region groundfish hook and line fisheries: a digest of quantities and sized landed, and comparisons with other gear types. Can. Manuscr. Rep. Fish Aquat. Sci. 2271 178 p.

Halliday, R.G. and T.J. Kenchington. 1993. Size selection of groundfish longline gear. Industry Services and Native Fisheries, Scotia-Fundy Region, Halifax, Nova Scotia, Project Summary No. 40, April 1993, 4 p + insert.

Johannessen, T., A. Fernö and S. Løkkeborg. 1993. Behaviour of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) in relation to various sizes of long-line bait. ICES mar. Sci. Symp. 196: 47-50.

Problem No. 7

Perceived Problem

Dumping of catch overages and highgrading.

Relevant Knowledge

From the initiation of TAC regulation there have been persistent reports of dumping of fish which exceeded bycatch allowances. To these were added similar reports of dumping of fish which exceeded trip limits, or exceeded quotas held under ITQ or EA schemes. In addition to these government imposed limits, fishing companies imposed landing limits on company controlled vessels based on current market demands and this is also reported to have resulted in dumping of fish which was in excess of these limits. Although there has been no objective quantification of fish dumped, there can be little doubt that there has been a substantial wastage of fish through dumping of excess catches, at least in some circumstances.

Highgrading is selective dumping of the less valuable parts of the catch. The reasons for highgrading include the limitations on retention of catch listed above. However, highgrading may also occur when there are no immediate restrictions on the quantity which can be landed, i.e. it is a strategy which maximizes the total value of an overall ITQ or EA or of a catch under a trip limit by landing only that part of any catch which is of highest value. There is probably an element of highgrading in most acts of dumping but whether pure highgrading, i.e. as the sole reason for dumping, has been a widespread practice is unknown.

The reasons fishermen give for dumping is that it is not possible to know what the gear will catch when it is set out and is not possible to catch one species, for which effort is being directed, without catching others which unrealistic and unreasonable regulations require them to discard. It is also the case, however, that many fishermen will fish enough to ensure that all trip and bycatch limits are met, at least for the most valuable species, even if this requires that excess catches of various species must be discarded.

Potential Solutions

a) **Technological:** For otter trawlers, net design innovations offer much which would alleviate dumping problems by improving species selectivity. These utilize knowledge of species behaviour in relation to the gear to separate species through use of horizontal separator panels, grates, off-bottom footropes, different mesh sizes and shapes in different parts of the codend, and other such devices. Other technological improvements include the use of load sensors in the codend to indicate catch size. This would aid fishermen in keeping catches within legal limits.

Modern fish finders are capable of providing indications of species identity. It is likely that, within a few years, fishermen will have little excuse for not having a very good idea about what they are likely to catch when the gear is being set.

b) **Other:** Management policies and procedures are much to blame for dumping problems. The policies of maintaining fleet activity throughout the season, and of full utilization of all allocations, has resulted in large numbers of boats on the water for long seasons which must then be restrained from operating at anything close to full efficiency. A reduction in fleet operation time (through reduction in fleet capacity or otherwise), and freedom to fish more normally when operating would contribute greatly to reducing incentives to dump.

Recommendations

The technology solutions suggested are not ones amenable to imposition by regulation. They are aids which could be developed in cooperation with an industry which was truly motivated to improve species selection.

Management planning should invert its focus from making fishing operations conform to the constraints of a top-down planning process to one which builds-up from practicable fishing operations while encouraging, and educating fishermen in, the use of more species selective trawls.

Although progress has been made in this Region and elsewhere, in the development of more species selective otter trawl gear it is slowed by the limited knowledge currently available on the behaviour of the various fish species. A directed research program is needed to improve knowledge of fish behaviour in relation to fishing gear and thus to move gear development beyond a trial and error approach.

References

Angel, J.R. *et al*. 1994. Report of the Workshop on Scotia-Fundy groundfish management from 1977 to 1993. Can. Tech. Rep. Fish. Aquat. Sci. 1979, 181p.

Problem No. 8

Perceived Problem

Post-selection mortality in the groundfish mobile gear fishery.

Relevant Knowledge

It has long been assumed by scientists, based on underwater films of fish escaping readily through the codend meshes of mobile gear, that the mortality subsequent to escapement was negligible. However, in the late 1980s there were experimental and observational reports of high mortalities among escaping haddock. This stimulated further research on post-selection survival, primarily of haddock but also of cod and pollock. The results to date (Problem 8, Table 1) indicate survival of haddock in the range of 43 - 97%. The small amount of data for cod and pollock suggest survival is very high (cod: 91 - 100%, pollock: 96 - 100%). Cod and pollock data are for large mesh codends and there is an indication in the haddock data that survival is higher for larger mesh, about 90% for meshes greater than 100 mm and about 80% for meshes of 100 mm and less. Those estimates of survival are likely minimum estimates as there was probably some mortality due to experimental procedures. Although the results suggest that survival, at least through large mesh nets, is high, the low survival of haddock in some experiments is cause for concern.

Potential Solutions

a) **Technological:** The causative factors for low survival of haddock in some experiments need to be understood before modifications to gear can be devised which will ensure high survival. Nonetheless, one cause of low survival of escapees has been diagnosed as the co-occurrence with haddock in the codend of hard bodied species, particularly crabs and the like but also fish such as sculpins, and of shells and other debris. Horizontally split trawls would separate haddock from the "trash", haddock entering the upper part of the trawl, and improve both escapement and post-selection survival of small haddock. As a bonus, retained haddock would be in better physical condition and thus of higher quality.

b) **Other:** Directed fishing for haddock by otter trawl could be minimized until high survival is ascertained.

Recommendations

More research is required to determine the significance of results to date. Initiation of a domestic research program would be expensive and take several years to develop. Scottish, Danish, Norwegian and Faroese laboratories already have active research programs which may well provide the answers needed within a few years. Maintaining close contacts with the researchers involved, and finding a basis for cooperative work with them, e.g. through shared cost arrangements which ensured that research projects included elements which addressed issues relevant to Canadian problems, would appear to be a satisfactory (and certainly the cheapest) approach.

References

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Soldal, A.V., A. Engås and B. Isaksen. 1993. Survival of gadoids that escape from a demersal trawl. ICES Marine Science Symposium 196: 122 - 127.

Jacobsen, J.A., B. Thomsen and B. Isaksen. 1992. Survival of saithe (*Pollachius virens* L.) escaping through trawl meshes. ICES C.M. 1992/B:29 Fish Capture Committee.

Jacobsen, J.A. 1994. Survival experiments of fish escaping from 145 mm diamond codend trawl meshes at Faroes in 1992 and 1993. ICES Fish Capture Committee, FTFB Working Group Meeting, Montpellier 25 - 26 April 1994.

DeAlteris, J.T. and D.M. Reifstek, 1993. Escapement and survival of fish from the codend of a demersal trawl. ICES Marine Science Symposium 196: 128 - 131.

Problem 8, Table 1 - Summary of survival rates observed for cod, haddock and pollock after escapement through codend meshes of otter trawls. (D - diamond mesh, S - square mesh)

Authors	Mesh	Percentage Survival			Remarks
		Cod	Haddock	Pollock	
Main & Sangster (1990)	90 mm D	-	67-74	-	
	90 mm S	-	92-94	-	
Main & Sangster (1991)	80 mm S	-	86-97	-	codend 108 meshes round
	90 mm D	91-100	43-86	-	codend 120 meshes round
	90 mm D	100	93-97	-	codend 100 meshes round
	90 mm D	100	72-82	-	codend 80 mm S window
	100 mm D	-	83-97	-	codend 120 meshes round
Sangster & Lehmann (1993)	90 mm D	-	73-79	-	
	100 mm D	-	74-86	-	
	110 mm D	-	82-91	-	
Sangster & Lehmann (1994)	70 mm D	-	48-67	-	
	90 mm D	-	79-82	-	
	100 mm D	-	73-83	-	
	110 mm D	-	85-89	-	
Soldal *et al.* (1993)	135 mm D	100	96	-	
	(55 mm)	100	92	-	grid, bar spacing = 55 mm
Jacobsen (1992)	145 mm D	-	-	98	Simulated trawling experiment
Jacobsen (1994)	145 mm D	100	85	96-100	Simulated trawling experiment
DeAlteris & Reifstek (1993)	126 mm D	100	-	-	
	126 mm S	100	-	-	

Problem No. 9

Perceived Problem

Ghost fishing by lost gillnets.

Relevant Knowledge

Ghost fishing has been defined as the ability of fishing gear to continue fishing after all control of that gear is lost to fishermen. Historically, gillnets were made from natural materials (hemp, cotton etc.) and deteriorated quickly when lost at sea. However, in the recent past, almost all fishing gear and especially gillnets are constructed from man-made materials which do not readily degrade. Gillnets in the Scotia-Fundy Region are generally made of monofilament material and because it is not biodegradable, lost nets accumulate on the seabed. There is some evidence to suggest that nets lost in shallow water soon cease to fish because of a buildup of algae which makes the nets visible to fish. However, nets lost in deep water do not develop this algae and may continue to fish for many years. They fish at a declining rate over time but nets lost for 3 -7 years have been documented as continuing to fish. US experiments estimated that lost gillnets fish at about 15% of the capacity of commercially fished nets. The ability of a lost gillnet to fish groundfish has been related to how upright the net remained after it is lost.

Gillnets can be lost for a variety of reasons such as bad weather/seas, snagging on bottom/other gear, and sabotage. It was estimated in 1992 that loss rate was about 2% or about 8000 nets in Atlantic Canada on an annual basis. The loss of nets in the Scotia-Fundy Region was estimated to be 1260 per year.

Potential Solutions

a) **Technological:** Anchors and lines should be used which are suitable for the area being fished. Offshore gillnetters fishing Georges Bank do tend to use heavier lines and anchors than do inshore gillnetters. However, sometimes fishermen use inshore gear in offshore areas where fishing conditions in terms of weather, currents and rough bottom can be more severe. Minimum standards for gillnet gear should be established for each fishing area in consultation with industry.

If the gillnet float line or its attachments were made of biodegradable material lost gillnets would likely become ineffective in catching groundfish quite quickly. However, they could still pose a hazard to other species such as crabs and lobster.

Signal transmitters could be attached to gillnets so that, if lost, nets could readily be retrieved.

b) **Other:** From 1990, gillnetters in Scotia-Fundy have been required to continuously tend their nets when these are set more than 50 nautical miles offshore, as recommended by the Report of the Scotia-Fundy Groundfish Task Force. In addition, areas which continue to have a high loss rate could be closed to gillnetting completely.

A routine search for, and retrieval of, lost gillnets could be initiated. However, its effectiveness would likely be limited due to difficulty in detection. Experimental use of side scan sonar showed gillnets to be easily visible on smooth sandy bottoms but on hard bottoms, with lots of echo scatter, it was difficult, often impossible, to detect nets. Retrieval would also be costly. However, if combined with a requirement to tag all gillnets, and chargeback of recovery costs to net owners, it is likely that greater care on the part of the fishermen would reduce the frequency of loss and increase the incentive for fishermen to recover nets themselves.

Recommendations

Attempts to implement improvements to lessen the loss of gillnets are usually met with protestations from fishermen that they do not lose nets. Earlier estimates of net loss in this Region are highly speculative. Thus, a concerted effort is required to quantify the number of nets lost annually in the Scotia-Fundy Region. If, as expected, gillnet loss is a significant problem, emphasis should be directed at reducing the loss of nets rather than retrieval or reduction of their effectiveness to ghost fish. An Industry/Government committee should be tasked to identify minimum standards for gear and to consider whether areas should be closed to gillnetting to prevent loss, and to examine the feasibility of incorporating transmitting devices on gillnets so that those which are lost can be easily retrieved.

References

Carr, H.A. 1988. Long-term assessment of a derelict gillnet found in the Gulf of Maine. Oceans '88 (Proceedings of the Marine Technology Society): 984-986.

Cooper, C.G. and P. Vass. 1993. Detection of lost gillnets with side scan sonar technology. Industry Services and Native Fisheries, Scotia-Fundy Region, Halifax, N.S., Project Summary No. 43, July 1993, 4 p.

DFO. 1992. Atlantic fisheries - retrieval of lost gillnets and prevention of ghost fishing. Discussion Paper (Draft). Operations - Fishing Industry Services, DFO, October 5, 1992, 38 p + appendices.

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Smolowitz, R.J. 1978. Trap design and ghost fishing: an overview. Maritime Fisheries Review 40 (5-6): 2-8.

Problem No. 10

Perceived Problem

Runover (roadkill) by groundfish otter trawlers.

Relevant Knowledge

Otter trawls used off the Canadian Atlantic coast are commonly equipped with heavy footrope gear incorporating large steel bobbins and rubber rollers. A substantial proportion of the cod, haddock and flatfish herded in front of the net, particularly the smaller specimens (less than 35 cm for cod, less than 24 cm for American plaice and yellowtail flounder), escape capture by passing under the footrope. Whether, and to what extent, these escapees are damaged through collisions with footrope gear or the underside of the net is not known.

Potential Solutions

a) **Technological:** It is not yet established that there is a problem to be solved.

b) **Other:** As above.

Recommendations

The fish which escape under the footrope are the smaller fish and this therefore serves as another selection mechanism for avoiding the capture of small fish. Thus, they should continue to be allowed to escape. However, the possibility that escapement results in a significant mortality should be investigated. Observation of the escapement process using underwater videos might provide an adequate assessment. If it appears that escapees are being damaged frequently, other footrope designs could be examined. However, if survival experiments of escaped fish are required these would be technically difficult and very costly.

References

Walsh, S. J. 1992. Size-dependent selection at the footgear of a groundfish survey trawl. North American Journal of Fisheries Management 12: 625-633.

Problem No. 11

Perceived Problem

Float-out losses in the groundfish mobile gear fishery.

Relevant Knowledge

When mobile gear, both otter trawl and Scottish (Danish) seine, is brought to the surface, and the net is momentarily slack in the water prior to hauling aboard, fish are commonly observed to escape through the net meshes. Many, perhaps most, of these fish die either through damage sustained while in the net or due to swimbladder rupture from pressure change, and thus represent wastage. The extent of this wastage in regional mobile gear fisheries has not been quantified.

Potential Solutions

a) **Technological:** Fish which escape through codend meshes at the surface clearly lie within the selective span of the mesh size in use and ideally these fish should escape while the net is on the bottom and thus survive their encounter with the gear, at least in high proportion. Thus, any devices which allow more effective size selection during towing would be expected to reduce float-out at the surface.

Some float-out may occur during large tows as a result of fish floating forward to the belly section which may be constructed of netting with larger meshes. This loss of commercial sized fish could be reduced by using load sensors to indicate net fullness and haul-back before the smaller mesh part of the net is completely full.

b) **Other:** None.

Recommendations

Investigate the level of wastage which occurs as a result of float-out, and the mechanisms involved.

As float-out at the surface is associated with a temporary slackening of the hauling strain on the net, it is possible that taking the strain off the net at the bottom would enhance escapement prior to haulback. This should be tested but, even if effective, the procedure could be adopted only on a voluntary basis.

References

Isaksen, B. and S. Løkkeborg. 1993. Escape of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) from Danish seine codends during fishing and surface hauling operations. ICES mar. Sci. Symp. 196: 86-91.

Problem No. 12

Perceived Problem

Drop-out/drop-off losses when hauling groundfish fixed gear.

Relevant Knowledge

Fishermen observe some loss of fish at the surface when hauling in gillnets and longlines. Some loss may also occur in subsurface waters. These losses have not been quantified. Some of the fish which drop-out of gillnets or drop-off longline hooks are subsequently retrieved by crew using gaffs or nets. However, most are not. Some of these fish, if they were not in/on the gear long and if the gear was retrieved from shallow depths (say less than 50 fathoms), could survive but many are likely to die.

Potential Solutions

a) **Technological:** The widespread conversion to circle hooks is likely to have improved greatly fish retention by longlines. Swivels between gangions and groundline likely also reduce losses by preventing fish from winding the gangion round the groundline and levering themselves off. There are no suggestions for reducing drop-outs from gillnets.

b) **Other:** None

Recommendations

There is no indication that wastage from these causes is significant but nonetheless this could be investigated fairly readily and thus should be considered.

References

Bjordal, Å. 1987. Swivel connected gangions in mechanized longlining-effect on catch rates and operation. ICES C.M. 1987/B:18.

Problem No. 13

Perceived Problem

Predation losses of fixed gear groundfish catches.

Relevant Knowledge

Fish captured by fixed gear are sometimes partially eaten by seals, other fish, or bottom invertebrates (sea lice), making them unmarketable. The extent of this problem has not been quantified.

Potential Solutions

a) **Technological:** For longlines, adding floats which raise hooks and hence caught fish off the bottom, could reduce sand flea problems (but could affect catch rates).

b) **Other:** Retrieval of gear after only short soak times could reduce predation.

Recommendations

An attempt should be made to describe and quantify these problems to determine if they are of any general importance. Too little is known at the moment to make any novel proposals for solutions.

References

None.

Problem No. 14

Perceived Problem

Effects of scallop dredging on groundfish.

Relevant Knowledge

The scallop fleet has always had a bycatch of groundfish and this has usually constituted about 2% by weight of their (round weight) scallop catch. This has not been viewed as being a conservation problem because the scallopers land the bycatch, although it is not known what proportion, if any, is of small fish. However, with the downturn in the groundfish resource and the closing of major areas of the Scotian Shelf to groundfish fishing, this bycatch is being more closely scrutinized as potentially affecting the recovery of the resource and could precipitate closure of scallop grounds because of the bycatch of groundfish.

In late 1994, the offshore scallop industry approached the Department for assistance in developing methods to reduce or eliminate the bycatch of groundfish in scallop gear. The discussions with the industry revealed that significant changes had been made to scallop vessels in the past 10 years which have contributed to an increase in the capture of groundfish. Towing speed of vessels and haul back speeds have increased significantly.

At an industry/government workshop in 1995 several options which might reduce the capture of groundfish were identified. Five of these were tested by comparing a dredge with modifications to an unmodified dredge. The options tested were:

1) square mesh ropebacks up to 155 mm;
2) opening in the middle of the ropeback;
3) openings at the rear of the ropeback;
4) tickler chains attached to the towing bar; and
5) netting across the mouth of the dredge.

Several of the options appeared to cause a reduction in the catch of cod, namely the square mesh ropebacks and the openings at the rear of the ropeback. However reductions were minor being in the order of 20-30%. One fact that did come out in one of the tests was that the longer a specific area was dragged the greater the catch of groundfish per tow. It was also apparent that the majority of fish are captured during darkness. Whether this is due to a change in location of the fish or a result of reduced visibility of the gear to the fish needs to be determined. There was a strong consensus in the industry that the cod were being captured in the water column rather than on the bottom. It was generally agreed that more video would be required to properly document where they were being captured and their behaviour in the dredges.

Issues which have not yet been considered are those in the category of incidental mortality. This could occur from contacts of fish by the gear, e.g. runover, or as post-selection mortality as a result of escapement through the ropeback or damage within the dredge prior to escapement.

The Northeast Region of the US National Marine Fisheries Service has had a project approved to study scallop dredges and fish capture in 1996. They plan a workshop, to be held in the near future, to identify ways of reducing the by-catch.

Potential Solutions

a) **Technological:** Where and how the fish are captured in scallop dredges, and whether there is a possibility of significant incidental mortalities, needs to be understood before attempting any modifications to the gear. This will necessitate the use of underwater cameras which are portable and do not affect the operations of the dredges, particularly their speed of recovery.

b) **Other:** Fishermen report that the groundfish are usually on the top of the dredges when they break the surface. It is possible that changes to operational procedures such as leaving the dredges resting just off the bottom before hauling back may allow the fish to escape.

Recommendations

More research is required to determine the behaviour of fish in and around scallop dredges and to determine how and when the fish are being captured. Cameras are vital to this work. It may be opportune to tie into the work being undertaken in the US by sharing the data that has already been collected in Canada and making use of their funding. Advantage should be taken of the opportunity (already offered) to participate in their workshop.

References

Stone, H.H. and G.V. Hurley. 1987. Scallop behaviour/fishing gear interactions. Fisheries Development and Fishermen's Services Division, Fisheries and Habitat Management, Scotia-Fundy Region, Halifax, N.S., Project Report No. 123, 85 p.

Problem No. 15

Perceived Problem

Capture of marine mammals and birds in groundfish fixed gear.

Relevant Knowledge

The only major problem that has surfaced in this category in Scotia-Fundy Region has been the capture of harbour porpoises in the Bay of Fundy gillnet fishery. In Eastern Canadian waters large concentrations of harbour porpoises can be found in the summer months in the lower Bay of Fundy around Grand Manan Island. The species is considered by USA authorities to be threatened and is under consideration for inclusion in the USA Endangered Species Act. Thus, continuation of the gillnet fishery around Grand Manan could itself be threatened due to the bycatch of harbour porpoise.

Two studies have been undertaken in the past two years on the harbour porpoise in the Bay of Fundy. One study consisted of monitoring gillnet fishing vessels to quantify the bycatch of harbour porpoise and the other was a study of the diving behaviour of harbour porpoises. The intent of the diving study was to see whether harbour porpoises had a limited diving depth when foraging for food and whether this limit could be exploited to reduce the capture of these animals in gillnets. The study showed that the animals do dive up to 120 meters but the amount of time spent at depths over 40 meters was very small. The monitoring study showed that between 80 to 120 animals were killed in 1994 which was much less than previous estimates and a small quantity compared to the amounts killed in USA waters. This study also showed that: a) the majority (> 95%) of harbour porpoises were caught in two specific areas and most (>70%) at water depths shallower than 51 fathoms; b) the majority (86%) of the porpoises were caught in August and their catch rate was highest in August; and, c) there was no strong correlation between the observed harbour porpoise bycatch and the other species of fish caught in the nets, the duration of the soak time of the nets, the water temperature, the length of the strings of nets and where and how the animals were entangled in the webs. It was noted that only two of the 49 observed entanglements were in the lower third of the nets. The monitoring study is being continued in 1995 to ensure the results of 1994 are representative.

In September 1993, a workshop was held in Falmouth, Mass., to identify modifications to gillnet gear to reduce harbour porpoise bycatch. While a number of areas were identified for examination at this workshop including the use of reflectors, greater spacing between nets, reduced headline height, etc., the most promising concept appeared to be the use of active pingers. The University of Newfoundland subsequently conducted a study of the effect of pingers. Preliminary results indicated that active pingers did appear to have an effect on the number of harbour porpoises captured in gillnets but the reduction was small. The concept is being further investigated under the 1995 monitoring program in the Bay of Fundy.

Potential Solutions

a) **Technological:** There is little that can be identified that has not already been identified at the above-mentioned workshop. The most promising concept appears to be active and passive pingers to deter the animals from approaching gillnets but the effects of these on other species is also an important consideration and merits some research. From the study data it also appeared that longer soak times did not appear to capture more animals. This could suggest that the animals may stay away from gillnets when dead animals are present. Scent in the water may play a role in reducing the bycatch. There is a need to better understand the behaviour of these animals around gillnets and the process of their entanglement.

b) **Other:** The most obvious solution is a management decision to ban gillnetting in specific areas at peak periods of harbour porpoise presence.

Recommendations

Wait for the results of the latest pinger study before expending more resources. The simplest and likely most effective measure is to ban gillnetting in the identified problem areas during the period of peak local abundance of harbour porpoise.

References

Cooper, C.G. 1993. Diving behaviour of harbour porpoises in the lower Bay of Fundy. Industry Services and Native Fisheries, Scotia-Fundy Region, Halifax, N.S., Project Summary No. 42, June 1993, 4 p.

Trippel, E.A. and J. Conway. 1995. Harbour porpoise bycatch in the Bay of Fundy gillnet fishery. Industry Services and Native Fisheries, Scotia-Fundy Region, Halifax, N.S., Project Summary No. 48, February 1995, 4 p.

(Unknown). 1993. Identifying potential modifications to sink gillnet gear to reduce harbor porpoise by-catch. Report of Workshop, Falmouth, Mass., USA, 20-23 September 1993.

Problem No. 16

Perceived Problem

Effects of fishing on the sea bottom and its fauna.

Relevant Knowledge

From the introduction of trawling, fixed gear fishermen have charged that trawling disturbs seabed sediments, destroys the seabed fauna and, as a result, reduces the abundance of commercial fish. There is evidence to support the first two charges. Otter trawls, particularly the doors, disturb sediments. Some of the species living on the seabed, particularly the larger bottom-living fish and invertebrates, are caught in the trawls and thus killed while some species living on or in the seabed are killed by passage of the trawl, either by direct physical injury or indirectly by disturbance from their habitat and subsequent predation by fish and other organisms. Scallop dredging and hydraulic clam dredging cause more severe physical disturbance of seabed sediments than otter trawling but the areas fished by these gears are less extensive. What remains unknown is whether this disturbance has important detrimental effects on the productivity of commercial fish species (or other species of commercial importance).

Determination of the effects of mobile gear fishing on commercial fish production is a complex problem. Several effects could be positive. Disturbance could release more nutrients from the seabed, "fertilizing" the food chain. Damaged or disturbed bottom species in gear tracks increases the availability of prey and it has been observed that fish are attracted to areas fished over; this could enhance the production of these fish species. Longer-term changes brought about by persistent heavy fishing could favour production of the prey species most important in the diet of commercial fish species and enhance or increase their yield potentials. Other effects could be negative. Changes in bottom sediment distribution and, particularly on harder bottoms, the removal of bottom structure created by animals which are sedentary or actually fixed to the bottom, could reduce the amount of habitat suitable for a commercial species at some life-history stage and hence reduce its survival. The production of important prey species could be suppressed to the detriment of a commercial species which feeds heavily on it. Furthermore, these effects, positive or negative, are obscured by concurrent variation in factors other than mobile gear bottom fishing. In many areas a substantial amount of natural disturbance of sediments occurs from wave surges caused by storms and water movements resulting from tidal and other currents. Bottom living invertebrate animals which serve as important prey for groundfish species vary in abundance from natural causes, and commercial fish species themselves vary not only from natural causes but also, of course, from the effects of fishing. It is, therefore, very difficult to separate out the effects of bottom disturbance by fishing on the production of commercial fish stocks.

A study of the effects of otter trawling on bottom communities on the Grand Bank was initiated by DFO in 1991 and is ongoing. This controlled experiment is unique in examining the longer-term effects of trawling on bottom invertebrate species productivity. Studies elsewhere have concerned, almost exclusively, only the immediate effects of mobile gear fishing. There is, as yet, insufficient scientific evidence to reach any conclusion in relation to the hypothesis that bottom mobile gear fishing (otter trawling, scallop or hydraulic clam dredging) is having, as a result of bottom disturbance, a significant negative effect on commercial fish production. It will likely be quite a number of years before this situation changes given the complexity of the problem and the relatively small investment being made, internationally, on research into it.

Potential Solutions

a) **Technological:** Trawl doors, which are the major cause of bottom disturbance by otter trawlers, are now available which skim over the bottom and largely avoid bottom disturbance. However, the effects of those on catch rates need to be considered as it is thought that the sediment plume behind traditional trawl doors may be instrumental in herding fish into the path of the net.

b) **Other:** None

Recommendations

A two-pronged approach is recommended: continue strong support for ongoing research on habitat effects of otter trawling (and extend this research to dredging) and, as a precautionary measure, develop modifications to gears currently used to reduce their effect on the seabed.

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Jenner, K., K.W. Strong and P. Pocklington. 1991. A view of fishery related seabed disturbance in the Scotia-Fundy Region. Industry Services and Native Fisheries, Scotia-Fundy Region, Halifax, Nova Scotia, Project Report No. 166, 54 p.

(See also: Seabed disturbances from fishing activities. Industry Services and Native Fisheries, Scotia-Fundy Region, Halifax, Nova Scotia, Project Summary No. 41, May 1993, 4 p.)

Messieh, S.N., T.W. Rowell, D.L. Peer and P.J. Cranford. 1991. The effects of trawling, dredging and ocean dumping on the eastern Canadian continental shelf seabed. Continental Shelf Research, 11:1237-1263.

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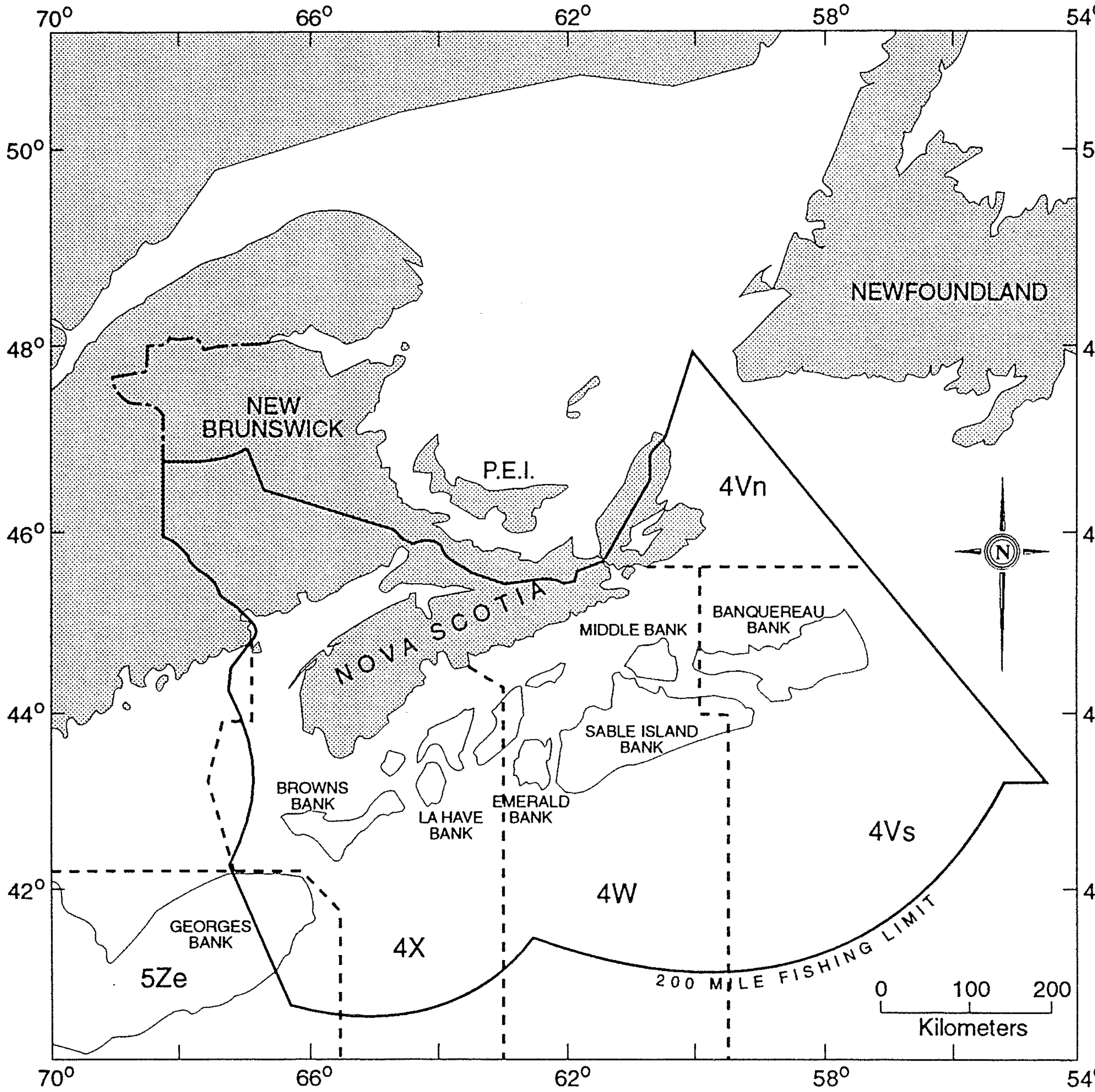
The contribution of Darlene Guilcher in arranging the workshop, and in editing and preparing the report, is very much appreciated. We also thank Cathy Wentzell for her help in arranging Steering Committee meetings and correspondence.

Appendix 1



Map of the Atlantic Provinces showing the boundaries of DFO's Scotia-Fundy Region (solid polygon), and NAFO Statistical Areas for which this Region is responsible (4V, 4W, 4X and 5Ze).

Appendix 2.

List of Participants of the Tactics Working Group

L. Brander
C. Cooper
M.L. Etter
B. Giroux
C. Goodwin
R. Halliday
J. Hansen
R. O'Boyle
G. Peacock
M. Sinclair
E. Walters
K. Zwanenburg

Appendix 3.

SECOND GROUNDFISH MANAGEMENT WORKSHOP

RAMADA RENAISSANCE HOTEL, COMMODORE ROOM
240 BROWNLOW AVENUE, DARTMOUTH
OCTOBER 4 AND 5, 1995

AGENDA

WEDNESDAY, OCTOBER 4 (CHAIR: P. PARTINGTON)

10:00 - 10:10	1.	**Objectives of the Workshop (Neil Bellefontaine)** Rapporteur: Stratis Gavaris
10:10 - 11:00	2.	**Fisheries Management Objectives and Strategies for the next Decade** Rapporteur: Stratis Gavaris
	2.1	DFO's newly redefined role is to assure "Conservation for Sustainable Use". This statement has biological and economic dimensions. What are the implications of this role for the objectives and strategies of groundfish management in the Scotia-Fundy Region? (Pat Chamut and Scott Parsons)
11:00 - 11:30	2.2	What are the expectations of industry from the groundfish resource? (J.-G. D'Entrement, E. Roe, T. Nickerson and E. Walters)
11:30 - 12:00	2.3	Summary of Conclusions of 1st Scotia-Fundy Groundfish Management Workshop (M. Sinclair)
12:00 - 13:00		LUNCH
	3.	**Tactics to Implement the Strategies** Rapporteur: Kees Zwanenburg

13:00 - 17:30 3.1 **Quota and Effort**

3.1.1 An examination of costs and benefits of quota versus effort management systems with comments on potential improvements (R. O'Boyle, K. Zwanenburg, P. Stirling, G. Robert, D. Pezzack)

3.1.2 An industry perspective on potential improvements in quota management system (B. Giroux)

3.1.3 The impact of the ITQ system on the conservation ethic of the small dragger fleet (C. Creed)

3.1.4 A DFO perspective on potential improvements in current groundfish management system (J. Hansen and C. Goodwin)

3.1.5 A DFO perspective on the effectiveness of the dockside monitoring program (M.-A. Etter and D. Murphy)

3.1.6 Phased implementation of local fishery management opportunities under conservation constraints (S. Gavaris and J.-G. D'Entrement)

3.1.7 Days-at-sea as a management tool (A. Sinclair and G. Chouinard)

3.1.8 Alternate approaches to management of fixed gear sector (J. Kearney)

3.1.9 An effort and community based "formula" for fisheries management
(G. Hurley)

THURSDAY, OCTOBER 5 (CHAIR: L. BURKE)

09:00 - 12:00 3.2 **Closed Areas**
Rapporteur: Ed Trippel

3.2.1 Biological concepts of importance in considering closed areas as a tactic (M. Sinclair)

	3.2.2	Distribution of eggs of cod, haddock and pollock on the Scotian Shelf (J. Neilson)
	3.2.3	Fishermen's knowledge of spawning areas on the Scotian Shelf (A. Younger, M. Sinclair and E. Trippel)
	3.2.4	Assessing closed areas with a fisheries model having several spawning components (R. Mohn)
	3.2.5	The costs of enforcement of closed areas and the history of compliance (H. Parker and C. Goodwin)
	3.2.6	A model of the costs to industry of closed areas (L. Brander)
	3.2.7	Juvenile distributions (age 0, 1 and 2) for cod, haddock and pollock on the Scotian Shelf (G. Black)
12:00 - 13:00		LUNCH
13:00 - 14:00	3.3	**Restrictions on Harvesting Technology** (R. Halliday) Rapporteur: Chris Annand
14:00 - 17:00	4.	**Is there a General Consensus on Needs to Modify Present Tactics - General Discussion led by R. O'Boyle** Rapporteur: John Neilson

Appendix 4.

PARTICIPANTS AT 2ND WORKSHOP ON GROUNDFISH MANAGEMENT

William O. Apold, President TAVEL Limited

John Andrews (replacing R. Stirling, SPANS

William A. Apold, TAVEL Limited Dave Bollivar, Seafreez Foods Inc.
Carolyn Creed, Wallace & Assoc.
John Decker, Sou'West Fixed Gear Assoc.
Derek d'Entrement, Fisherman
Jean-Guy d'Entrement, President, Inshore Fisheries Ltd.
Jim Fraelic, South Shore Gillnet Fishermen's Assoc.
Graeme Gawn, Maritime Fisherman's Union
Brian Giroux, N.S. Mobile Gear Fishermen's Assoc.
Willard Grover, Fisherman
Geoff Hurley, Hurley Fisheries Consulting Limited
John Kearney, Fundy North Fisherman's Association
Claude LeBouthillier, N.B. Fisheries and Aquaculture
Tim Nickerson, Sou'West Fixed Gear Assoc.
Mike O'Connor, National Sea Products
Greg Organ, President, North of Smokey Fishermens Association
Eric Roe, Clearwater Fine Foods
Charles Smith, Richmond Fisheries Ltd.
Peter Underwood, N.S. Dept. of Fisheries
Peter Van Buskirk, Shelburne Co. Gillnet Assoc.
Glenn Wadman, D.B. Kenney Fisheries Ltd.
Evan Walters, S-F. Inshore Fisheries Assoc.

DFO Personnel

Chris Annand
Neil A. Bellefontaine
Gerry Black
Leo Brander
Les Burke
Pat Chamut
Ghislain Chouinard
Chris Cooper
Marianne Etter

Ken Frank
Stratis Gavaris
Ralph Halliday
Jon Hansen
Rejean Hebert
Jim Jones
Doreen Liew
John Loch
Robert Mohn
Debbie Murphy
John Neilson
Robert O'Boyle
Hugh Parker
Scott Parsons
Peter Partington
Greg Peacock
Alan Sinclair
Michael Sinclair
Tim Surrette
Ed Trippel
Andrew Younger
Kees Zwanenburg