Discussion and Conclusions

The section on fishery management in national fishing zones described the actions of regulatory authorities to control fishing activities within the zones created by jurisdictional extensions to 200 miles, their philosophical underpinnings in terms of objectives and strategies, and the changes in stocks and catches which occurred as a result, or in spite of, these actions. The same was then done for the international commissions in regard to high seas fisheries in the post-200 mile era. In the present section, these post-200 mile regimes are compared to each other. The comparisons are organized in a similar way to the accounts of individual management regimes. Firstly, the institutional frameworks for managing fisheries are compared, followed by comparisons of management objectives and of harvesting strategies and tactics. Enforcement and compliance are then discussed, although information is scant and comparison of compliance levels is not possible. Finally, the differences in exploitation level brought about for the stocks of the primary species under the new jurisdictional regimes, compared to the previous international commission era, are summarized.

Institutions

There are substantial variations among management regimes in their institutional framework for devising and implementing fishery regulation programs. These differences could influence the prospect for management efforts to have a satisfactory result. The most common North Atlantic institutional model is that where authority for marine fishery management rests with a ministry of the national government, which then supports a scientific research agency to generate the biological information necessary for decision making, an enforcement agency to ensure implementation of, and compliance with, decisions, and an advisory body of clients which provides domestic fishermen and other interested parties with the opportunity to participate in the decision making process.

When international commissions had authority to propose regulations for coastal fisheries, these commissions made provision for the review and synthesis of scientific results from national laboratories so that all commission members had the benefit of the same advice arrived at by scientific consensus. In the Northeast Atlantic ICES served that purpose and in the Northwest Atlantic ICNAF had its own Standing Committee on Research and Statistics as well as committees of Scientific Advisors to each of its Panels. It is difficult to envision how these commissions could have functioned if each delegation had a separate view of the status of the resources. The commissions were dependent on member governments to implement proposed regulations through domestic laws and to enforce them on their own fleets, although the commissions also achieved some success in implementing joint inspection schemes to improve regulatory compliance. The implementation of 200 mile limits required new international commissions but these retained the same institutional model as their predecessors (although in the case of the new NEAFC no international inspection scheme has yet been required as it has generated almost no regulations). Scientific advice is provided to the new NEAFC by ICES, as it was to its predecessor. In NAFO, a Scientific Council is supported to provide the Fisheries Commission with the advice required.

In the post-200 mile regime the institutional arrangements for management of domestic fisheries were close to the standard model in Canada, Faroe Islands, Iceland, Norway and, from 1985, also Greenland. Centralized decision making resides in the hands of the government Minister responsible for fisheries who maintains consultative mechanisms to gather the views of clients. The EU and USA systems were quite different.

The power to adopt new fishery conservation measures has lain with the EU, rather than its members, from 1979. Thus, it is the EU that has the authority to function as a coastal state with regard to fisheries (Churchill, 1987b). Decision making authority lies with the EU Council which is composed of member governments represented at ministerial level. Thus, fisheries policies and regulations are compromises between the sometimes disparate interests of EU member governments, as determined by a voting procedure. The EU administrative arm, the Commission, is responsible for initiating legislation whereas the input of the fishing industry is largely channelled through member governments and then through ministers to the Council.

The USA management system is formalized in federal law which gives power to regional councils to develop regulatory plans. The bulk of the council members are individuals who are knowledgeable or experienced in fishery management or fishing, while the remainder are state and federal officials. The councils are required to conduct public hearings to ensure that all interested persons have an opportunity to be heard. The role of the federal government, through the Secretary of Commerce, is to review council plans against the national standards for conservation and management and other legal provisions and either approve them or return them to the council for amendment. The Secretary of Commerce also has various emergency powers to directly implement plans. Prior to implementation, the Secretary is also required to receive comments on the proposed plans and also has the authority to call hearings on them. The USA system thus gives actual participants in the fishing industry a strong, even predominant, influence on management planning.

The EU and USA decision making systems thus differ from those regimes which conform to the "standard model" both in the distribution of decision making power and in the complexity of the mechanisms used for arriving at a decision. Therefore, not only is the nature of decisions affected, so too is the ability to make decisions and the timeframes within which they can be made.

The distribution of enforcement and scientific authorities are also pertinent to regulatory effectiveness. In the countries conforming to the standard model the central agency responsible for fisheries supports an enforcement force, although in all cases these receive some degree of logistical or other support from the armed forces or coast guard. In the EU case, enforcement authority resides with member states and the agency responsible for fishery management, the EU Commission, can only influence enforcement indirectly by evaluating member state enforcement and encouraging improvements. Enforcement responsibility in the USA lies with federal authorities and is shared by the Secretary of Commerce and the Secretary of Transportation, who is responsible for the Coast Guard which does essentially all at sea enforcement. There is no *a priori* reason why any of these arrangements cannot result in effective enforcement of fishery regulations. Nonetheless, there is a greater scope for imbalance between the regulatory aspirations of a management agency and its ability to ensure that its regulations are respected if there is a weak connection between regulators and enforcers. The USA system would appear weakest in this regard. Not only do those determining management plans, i.e. the Regional Councils, have little or no influence over the capabilities of the agencies responsible for enforcement, much of the enforcement authority resides in a government department other than that responsible for fisheries management. The connections in the EU system are also tenuous and enforcement efforts are viewed as unsatisfactory by the EU Commission. According to Holden (1994) many member states, while guarding their authority for enforcement, demonstrate a lack of political commitment to effective control of fishing. In the other (standard model) cases there is also variation in the degree to which enforcement capability resides under the control of the fishery management agency. At one end of the scale, the Canadian Department of Fisheries and Oceans maintains a substantial fleet of dedicated enforcement vessels and contracts commercially for overflight and observer services. Thus armed forces support is not central to enforcement efforts although utilized on occasion. In contrast, Norwegian at-sea surveillance is the responsibility of the Coastal Surveillance Service which is part of the Military High Command. There is greater opportunity to tailor management aspirations to enforcement capabilities or, conversely, to expand enforcement activities to meet management needs, when regulators and enforcers are part of the same management agency. It is, nonetheless, only an opportunity, not necessarily a consequence.

The national scientific laboratories which conducted the research on fish stock dynamics and the effects of fishing continued after the extensions of jurisdiction much as before. The EU did not set-up its own research capability, depending on the already well established national laboratories of member states. The primary changes came in the way scientific results were evaluated and how advice on management options was developed and delivered to regulatory authorities. Years of experience in providing scientific advice to the international commissions convinced scientists of the importance of a committee structure for peer review of research results and the development of a consensus on stock status and yield prospects. This provided a sound mechanism for quality control, a way to develop and use consistent methods in the application of scientific theory and biological knowledge to practical fisheries problems, and a vehicle for documentation of the scientific basis for management which made results available for public scrutiny.

In the Northeast Atlantic, ICES, which functions under its own international convention, was not affected directly by jurisdictional changes. All regional management agencies saw virtue in continuing to use ICES as the vehicle for generating scientific advice for stock management after jurisdictional extensions. Management responsibility for many Northeast Atlantic stocks continued to be shared, of course, and ICES advice provided a common scientific footing on which regulatory agreements between the interested parties could be based. However, ICES advice continued to be sought even for resources entirely within the jurisdiction of each management authority. Indeed, Iceland, which had withdrawn their cod and haddock stocks from ICES consideration at the time of the cod wars, returned there for advice on cod in the early-1990s. The EU maintains its own Scientific, Technical and Economic Committee for Fisheries but this builds on advice received from ICES and does not serve as an alternative to it.

In the Northwest Atlantic, scientific advice was provided by a standing committee of the ICNAF Commission, and this disappeared along with ICNAF as a whole to be replaced by the Scientific Council of NAFO. In addition to its obligation to provide the NAFO Fisheries Commission with all necesary scientific advice, the Scientific Council was given the authority to provide scientific advisory services to coastal states on their request. However, as the USA chose not to join NAFO (until 1995) these services were not available to it, whether it wanted them or not. They were available to Canada and were used quite extensively in the initial years when there was a strong foreign presence in a variety of domestic fisheries. Over time however, usage was reduced to advice for straddling stocks and a very few domestic stocks which were still fished almost exclusively by foreign fleets.

On extension of jurisdiction many stocks in the new Canadian zone were reserved for exploitation by domestic fishermen only and it was decided to establish a domestic science advisory committee, CAFSAC, to assess these stocks and also to provide an advisory vehicle for all other aquatic resources along Canada's Atlantic coast. It was thought that CAFSAC, which was allowed to function with a great deal of autonomy, provided a more effective vehicle for scientific review of these resources than did the NAFO Scientific Council which could not attract the broad scientific participation previously enjoyed by STACRES of ICNAF. However, the decline in groundfish resources in the late-1980s and early-1990s brought CAFSAC under severe criticism, and it was disbanded by the Minister of Fisheries in 1992, and subsequently replaced by stock assessment reviews within regional laboratories organized by science managers, an approach which leaves some doubt about the ability of Canadian scientists to provide the same standard of advisory services as previously.

Each of the USA regional councils is required by law to maintain a scientific and statistical committee to provide scientific information for management plan development. However, that of the New England Regional Council did not function effectively and scientists of the Northeast Fisheries Science Center of the National Marine Fisheries Service felt it necessary to establish their own scientific review (Stock Assessment Workshop) system, starting in 1985, which became more broadly sponsored and developed into a Stock Assessment Review Committee which embodies many of the features of the now defunct Canadian CAFSAC. Despite the use of domestic, rather than international, scientific advisory mechanisms by Canada and the USA, both countries are members of ICES and participate fully in the functions of that organization. Thus, there is a continuous flow of information among the fishery scientists in the North Atlantic and a conformity of standards and procedures.

Domestic and international science advisory agencies have their own strengths and weaknesses, but both can function effectively if they retain their freedom to conduct an open system of peer review and to document publicly the results of their work. Fortunately, these safeguards for collective scientific objectivity are generally (if not universally) appreciated within fisheries bureaucracies.

The fact that it is only natural scientists who maintain such elaborate mechanisms to monitor fisheries and fish stocks and to deliver their end product, scientific advice, to management agencies is a reflection of the predominance of fish stock conservation considerations in fishery management. There appear to be no comparable institutions, maintained by social scientists, directed to promoting the economic and social well-being of the fishing industry. Nor do the scientific institutions described above generally include economic and social research within their mandate, although the USA regional council scientific and statistical committees do have scope to provide economic and social as well as biological information. Also, in 1992, new EU legislation broadened the scope of its advisory committee to include economics, and yet more recently, ICES began to invite economists and sociologists to its annual meetings. The general lack of research coordination and advisory mechanisms in the economic and social fields does not mean of course, that data collection and analysis are not going on within government and other institutions and that the results are not entering into the decision making process. It does indicate, however, that this is not happening in any systematic, organized and consistent way.

Objectives

Other than the statements of purpose of international commissions which are contained in their respective conventions, official statements concerning the objectives of fisheries policy were found for the Canadian, EU, Norwegian and USA management regimes (Table 1). For Faroe Islands, Greenland and Iceland it was necessary to depend on personal communications from government sources and on the conclusions of previous authors, who imputed objectives based on government actions, to reach conclusions about governmental aspirations.

TABLE 1. Objectives of the fisheries management policies of each management regime as stated in international conventions or policy statements of domestic governments when available, or as interpreted in secondary sources (see main text) when official documentation was not available.

Management Regime	Objectives of Fisheries Policy	Notes
old NEAFC	to ensure the conservation of the fish stocks and the rational exploitation of the fisheries	As stated in its convention.
ICNAF	investigation, protection and conservation of the fisheries... in order to make possible the maintenance of a maximum sustained catch (modified December 1971 to: achieve the optimum utilization, defined on the basis of scientific investigations and economic and technical considerations)	As stated in its convention.
Canada	1) best use, as defined by the sum of net social benefits derived from the fisheries and the industries linked to them (also defined in 10 "operational goals" and 20 "precise objectives")	Published statement of Government, 1976.
	2) 1. economic viability of the fishing industry on an ongoing basis 2. maximization of employment at reasonable income levels, and 3. Canadianization of the fishery within the 200 mile zone.	Task Force report accepted by Government, 1982.
European Union	1) to ensure the protection of fishing grounds, the conservation of the biological resources of the sea and their balanced exploitation on a lasting basis and in appropriate economic and social conditions	Preamble to EU Council legislation on conservation policy, 1983.
	2) as concerns the exploitation activities the general objectives of the common fisheries policy shall be to protect and conserve available and accessible living marine aquatic resources, and to provide for rational and responsible exploitation on a sustainable basis, in appropriate economic and social conditions for the sector, taking account of its implications for the marine ecosystem, and in particular taking account of the needs of both producers and consumers	Preamble to EU Council legislation on conservation policy, 1992.
Faroe Islands	satisfactory economic performance of the industry	According to officials of the Directorate for Fisheries.
Greenland	to use fisheries as the primary vehicle for economic development	According to non-government sources.
Iceland	– conservation of the fish stocks – restoration of normal profitability in the industry – maintenance, as far as possible, of the current regional and personal distribution of benefits, and – increase of economic rents	According to non-government sources for the groundfish fishery, but could apply to all fisheries. No formal statements of Government policy have been issued but the present interpretation has been confirmed in general by Government officials.
Norway	1) 1. maintain the main features of coastal settlement 2. protect and maintain the fish stocks 3. ensure safe and profitable employment in the fishery industry	Government policy as report- to Parliament, 1977.
	2) 1. improve the real profitability of the fishery, i.e. profitability after deduction of state subsidies 2–4. Same as 1–3 above	Revised Government policy as reported to Parliament 1983.
USA	conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield from each fishery (National Standard No. 1) – optimum yield is that which provides the greatest overall benefit to the Nation, with particular reference to food production and recreational opportunities, and which is prescribed as such on the basis of the maximum sustainable yield, as modified by any relevant economic, social or ecological factor – six other National Standards are defined which are ancillary to the first	As specified in the Fishery Conservation and Management Act of 1976
New NEAFC	to promote the conservation and optimum utilization of the fishery resources of the Northeast Atlantic area and to encourage international cooperation and consultation with respect to these resources	As stated in its Convention
NAFO	identical to new NEAFC except applicable to the Northwest Atlantic area	As stated in its Convention

Conservation of fish stocks receives a prominent place in most statements of objectives but is, of course, implicit in all, as continued achievement of social and economic objectives requires a successful program of stock conservation. In other words, if the ability of the stocks to maintain a high level of production is undermined by fishing, attaining other long term objectives is compromised. The international commissions saw conservation as a necessary basis for achieving optimum utilization of the stocks. This term adopted by ICNAF, can be considered equivalent to the objective of "rational exploitation" in the old NEAFC convention, to "best use" in Canada's 1976 objectives and "balanced exploitation" in EU, and "optimum yield" in USA, legislation. ICNAF, Canadian, EU and USA objectives make clear that the concept of optimum utilization includes biological, economic and social considerations. Nonetheless, USA legislation uses the biological criterion, maximum sustainable yield, as a foundation for defining optimum yield.

These statements about optimum utilization can, of course, mean anything a management agency wants them to mean. They do convey the idea that the resources are to be fully utilized by the fishing industry to provide economic and social benefits at least to participants in the industry and possibly more broadly to society in general. Canada and Norway, from 1982 and 1983 respectively, adopted more concrete guidance statements about the level of economic performance which the industry was intended to achieve. In Canada's case, economic viability was defined as an ability to survive downturns with only a normal rate of business failure and without government assistance. In Norway, the intention was to improve the real profitability of the industry, i.e. profitability after deduction of state subsidies. Both these countries share broadly similar social objectives, in particular maintaining high employment in the fishery to maintain the viability of settlements in coastal areas, while also ensuring a reasonable level of income. Both jurisdictions recognize that their social and economic objectives are to some extent conflicting and must be balanced.

Although USA regulations provided much the same starting point of optimum yield, the New England Fishery Management Council's thinking evolved in quite a different direction from that of Canadian and Norwegian authorities. This Council's objective became limitation of regulatory interference to the minimum necessary to prevent resources being completely fished out. This could be viewed as a policy with objectives limited strictly to providing minimum resource conservation safeguards.

In the application of EU conservation policy, the economic and social elements translated into preferential catch allocations to support employment and income in coastal regions which were economically disadvantaged or largely dependent on fishing. Other elements of the overall Common Fisheries Policy which related to "structures" and markets clearly also had economic and social motivations. Nonetheless, the preoccupations of the EU during the 1970s and 1980s were the issues of access and of an acceptable system of allocation, at a national level, of catch shares.

These regimes for which official statements of objectives have not been located nonetheless make clear by their actions in most cases that they share, generally, the objectives of Canada and Norway who have documented their intentions more thoroughly. Faroe Islands, Greenland and Iceland, with economies that are heavily dependent on fishing, are obligated to give economic viability of their fisheries a high priority, although Faroe Islands and Greenland have their continuing political association with Denmark as a safeguard in times of adversity, a factor of great importance to the Faroe Islands when its fish stocks declined substantially in the early-1990s. The complete independence of Iceland required particularly rigorous attention to economic efficiency. In Iceland, maintaining the regional distribution of benefits, and hence of community settlement, is also a central element of policy.

As far as can be ascertained then, it appears that a number of post-200 mile management regimes have functioned without benefit of much or anything in the way of "formal" or "official" statements of overall policy objectives. The objectives of those regimes which did make public the intentions underlying their actions on the whole share a generality which allows for wide interpretation. This does not mean that they were necessarily of no value in guiding the actions of the management agencies concerned, but there is no information to suggest that any of these agencies went to the lengths of establishing quantitative targets for other than their stock management objective, and that in itself was not universal. Their economic and social objectives presumably served to give only a general context within which to implement regulatory controls. Thus, it seems fair to say that fisheries in the post-200 mile limit period operated in an impoverished policy environment which was restricted to little more than resource conservation and allocation. The definition of conservation varied greatly among regimes of course, and in some encompassed the concept of obtaining the fullest sustainable advantage from the resource. This meant that social and economic issues were legitimate considerations when imposing regulatory controls on harvesting but nonetheless required that actions be justifiable in terms of protecting or enhancing resource productivity. The focus of attention, therefore, remained on the strategies and tactics of resource harvesting, as it did in the international commissions.

Harvesting Strategies and Tactics

Maintaining the productivity of fish stocks by controlling the level and pattern of exploitation has been a preoccupation of management. However, controlling the level of catch, for example, will serve the purpose of stock conservation only if it results in fishing mortality being reduced to, or maintained at, an appropriate level. A TAC may be established, without reference to a particular fishing mortality, to create a regulatory basis for equitable catch sharing, i.e. a social purpose, or to limit supply to market demand as an economic motivation, or simply to establish adequate control over fishing, i.e. to close regulatory loopholes. Similarly, the pattern of exploitation may be modified, or limits placed on the amount of capital or labour employed in the fishery, to address various combinations of these purposes. In the following text, all regulatory actions that controlled the level of catch, directly or indirectly, are summarized under "control of exploitation level", whatever their purpose(s). Similarly, all measures that controlled the size or age of fish caught are summarized under "control of exploitation pattern". A third category of regulatory action is also recognized; "spawning closures". There is a widely held belief among fishermen that leaving fish undisturbed by not fishing during spawning will result in improved, or sustained, recruitment. That such closures enhance the success of the spawning act has not received general acceptance among scientists and regulators. However, these latter have seen other values to spawning closures, such as reducing fishing effort. Closures, spawning or otherwise, also have allocative significance. The reasons behind spawning closures are usually poorly documented but, as the concept of the intrinsic conservation value of undisturbed spawning is different from those of controlling level and pattern of exploitation, these spawning closures are summarized separately.

Control of exploitation level: Faroese and USA authorities placed few or no controls on domestic resource exploitation levels (Table 2). As domestic fleet demands on home water resources increased the Faroese found these could, for a number of years, be accommodated by displacement of foreign fleets. It was not until the late-1980s that restrictions were placed on domestic fleet size for economic reasons, and 1994 that TACs were used to limit fishing mortality on particular stocks for conservation purposes. The USA New England Council abandoned control of fishing mortality for groundfish and herring at the beginning of the 1980s, but fishing effort limits for groundfish conservation purposes were introduced in 1994. (The Mid-Atlantic Council maintained management at $F_{0.1}$ for mackerel.) The new NEAFC could be grouped with the Faroe Islands and USA, as blue whiting and oceanic redfish stocks lay within NEAFC responsibilities but remained unregulated. However, exploitation of these resources was low during the study period and this inaction can hardly be used to characterize the organization's regulatory "philosophy".

In the remaining management regimes, regulation of exploitation level was an important element of control measures, and all used TACs as the primary mechanism (Table 2). The EU system of national catch quotas (not fully established until 1984) was essentially for allocative purposes and TAC levels set by the EU Council bore no relation to a particular mortality rate strategy, although the Commission, through its proposals to Council, attempted to stabilize mortality at prevailing levels (Holden, 1994). For most stocks, these levels were above F_{max}. Norwegian and Icelandic approaches were quite similar in that regulatory authorities had a general intention of fishing at about F_{max}, but the importance given to stability of catches and, in the case of Norway to reaching agreement on management of shared stocks, caused mortality to be higher than F_{max} on the most important stocks. Both these countries adopted lower exploitation levels for herring, and for the special case of capelin, most of which die after spawning, target spawning stock size was used as a conservation reference point.

The Canadian management approach was unique both in the extent to which TAC regulations were hinged to a particular biological reference point, and in the fact that this was a low exploitation rate strategy, fishing at $F_{0.1}$. This was seen as addressing economic, as well as conservation, objectives (but ran counter to other measures which promoted high employment in the fishery). This same $F_{0.1}$ strategy had been adopted by ICNAF, albeit under coercion from coastal states, particularly Canada, and was inherited by NAFO. However, unrestricted fishing by non-members of NAFO and unilateral actions by one of its most influential members, the EU, made NAFO adoption of an $F_{0.1}$ strategy nominal, at least from the mid-1980s. Greenland, although not adopting a fixed-F strategy, consistently favoured low exploitation in its management of cod and hence was closest to Canada and NAFO in its strategy. The low exploitation approach of Canada, Greenland and NAFO extended to the capelin fisheries, although in the case of Greenland the fishery has yet to be industrialized and is under a "controlled-development" strategy. Canada and NAFO adopted an arbitrary

TABLE 2. Exploitation level strategies by jurisdictional regime for primary species. General strategy is listed first, then strategies by species when exceptions apply. (SSB – spawning stock biomass target level.)

Jurisdictional Regime	Biological Reference Point	Exploitation Level Strategy	Methods Used to Control Exploitation Level
Pre-1977			
NEAFC	–	Regulated F in 1975–76 only. Intention was to restore stocks to levels giving MSY by first stabilizing F at prevailing high level then reducing F towards F_{max}.	TACs and national allocations from 1975
ICNAF	F_{max}	Regulated F from 1970, comprehensively from 1974. Objectives of maximum sustained catch and, after 1971, optimum utilization were equated with fishing at F_{max}	TACs from 1970 and national allocation from 1972. Second tier TAC in southern area from 1974 to reduce mixed fishery and by-catch problems. Effort regulation in northern area in 1976.
Post-1976			
Canada	$F_{0.1}$	Optimum F for "best use" equated with $F_{0.1}$. For marginal reduction in total catch, reduced required fishing effort significantly, increased catch rates and size of fish in catch for improved economic performance; maintained larger stock size for increased inter-annual catch stability and as a buffer against stock assessment error or enforcement deficiencies; provided for an adequate spawning stock.	Licensing and capacity constraints on replacement vessels-herring purse seiners form 1968, large groundfish vessels from 1973, groundfish vessels less than 65 feet from 1976.
	–	**Capelin**: from 1979, exploitation rate of 10% used for regulation to reflect difficulties in estimating spawning stock size and in recognition of its importance in the food chain.	TACs and allocations by fleet size category and gear type from 1972 for herring and 1977 for groundfish, boat quotas for herring purse seiners from 1976 – transferability of TAC – shares from 1983 conditional on leaving the fishery, enterprise allocations for large groundfish vessels from 1982 and boat quotas for some groups of under 65 feet groundfish vessels from 1984 - intra-annual quota transferability.
EU	–	Regulated catches from 1984. Intention to obtain highest possible catches, while maintaining inter-annual catch stability, pursued by stabilizing F at current level. Recognized possible benefits of reducing F towards F_{max} but reductions in F not implemented.	Fleet capacity controls from 1983, vessel registry form 1989. Fishing effort controls (fleet tie-ups) for cod and haddock fisheries in the North Sea and West of Scotland in 1991–92. General licensing and special permit for effort limitation, from 1995.
			TACs and national allocations from 1984.
Faroe	–	None until 1989. Then established exploitation rate target, using economic criteria, as the fishing pressure which allows a vessel which is operating normally to obtain an adequate economic return without subsidies	Limited entry licensing and capacity constraints on replacement vessels from 1987. Vessel decommissioning incentives in effect for 1988–91.
			Closed areas.
	SSB	Targets set for cod and haddock in 1994; to be reached by 1988.	TACs from 1994.
Greenland	–	**Cod**: maintain catches as stable as possible given unstable stock conditions and allow stock rebuilding when opportunities arise. Some TACs set at $F_{0.1}$ or lower but a fixed-F strategy not adopted.	TACS from 1977.
	–	**Capelin**: exploratory development only	
Iceland	–	**Groundfish**: regulated F from 1984. Strategy for cod was to reduce F towards F_{max} and increase spawning biomass towards a target level while maintaining catch stability. For other species, when F did not exceed F_{max}, F kept at F_{max} or below. From 1995/96 season,catch of cod limited to 25% of age 4+ biomass with constraint that TAC is not less than 155 000 tons.	**Groundfish**: Fishing effort controls for cod from 1977. TACs and transferable boat quotas for major species from 1984. TAC-shares transferable conditional on selling vessel leaving the fishery
	$F_{0.1}$	**Herring (summer spawners)**: regulation of F from 1968, at $F_{0.1}$ from 1975.	**Herring (summer spawners)**: TACs from 1968, boat quotas and limited entry from 1975. Boat quotas made transferable in 1979.
	SSB	**Capelin**: from 1983/84 season used target minimum spawning biomass.	**Capelin**. TACs from 1978/79, boat quotas and limited entry from 1981 Boat quotas made partially transferable from 1986.
			All Species. General system of transferable boat quotas from 1988. General system of permanent transferability of TAC shares from 1991.
Norway	F_{max}	**Groundfish**: target exploitation rate of F_{max} provided guidance but phased approach taken and compromises required for shared stocks.	Limited entry licensing from 1972, except traditional gears (small coastal vessels). Vessel decommissioning incentives – for purse seine fleet from 1979, for entire fleet from 1984.
	–	**Herring (spring spawners),and Mackerel (North Sea)**: increase spawning stock.	TACs from 1977 and (non-transferable) boat quotas from 1974.
	SSB	**Capelin**: target minimum spawning biomass.	

TABLE 2. (Continued). Exploitation level strategies by jurisdictional regime for primary species. General strategy is listed first, then strategies by species when exceptions apply. (SSB – spawning stock biomass target level.)

Jurisdictional Regime	Biological Reference Point	Exploitation Level Strategy	Methods Used to Control Exploitation Level
USA	–	Magnuson Act: optimum yield defined as MSY modified by any relevant factor.	
	–	**Groundfish**: for cod about F_{max} and for haddock about $F_{0.1}$ until 1981, thereafter direct controls on F abandoned From 1986, spawning stock size constraints adopted expressed as percentages of maximum spawning potential.	**Groundfish**. TACs from 1977 and allocations by vessel size category, gear type and season form 1978, abandoned after 1981.
			Moratorium on vessel entry and 5 year effort reduction plan introduced in 1994.
	–	**Herring**: increase spawning stock size until 1982, thereafter all regulation abandoned.	**Herring**: TACs in effect for 1979–82, no controls thereafter
	$F_{0.1}$ & SSB	**Mackerel**: increase spawning stock size until 1982, thereafter $F_{0.1}$ if spawning stock remains above a defined minimum level.	**Mackerel**: TACs from 1977
NEAFC	–	None of the primary species except, recently, Norwegian spring spawning herring, occur in regulatory area.	–
ICNAF/ NAFO	$F_{0.1}$	**Groundfish**: $F_{0.1}$ strategy largely adhered to in formal commission regulatory decisions but, after 1985, combined domestic regulatory actions of members resulted in a higher F strategy *de facto*.	TACs and allocations to Contracting Parties from 1977.
	–	**Capelin**: from 1979, exploitation rate of 10% used for regulation to reflect difficulties in estimating spawning stock size and in recognition of its importance in the food chain.	

10% exploitation level for capelin, combined with fishery closures when stock size was low, in contrast to the Norwegian and Icelandic minimum spawning biomass targets.

The general use of TAC regulation reflects its value as a straightforward, readily understood, way to allocate shares of the resource to interested parties, internationally to countries and nationally among vessel size and gear type categories and, increasingly, to individual enterprises or boats. Sometimes boat quotas were not made tradeable, e.g. in Norway, but in most cases some element of tradeability was allowed to provide a necessary flexibility in vessel operation. Tradeability of TAC-shares, i.e. entitlements, as distinct from annual quotas, was less common. Transferability of shares was allowed in the Canadian herring purse seine fleet from 1983 and in the Icelandic groundfish fleet from 1984, but in both cases only upon withdrawal of the selling vessel from the fishery. A full-fledged quasi-property rights system, with relatively unfettered trading of shares, was established only in Iceland and not until 1991. The subdivision of TACs allowed management agencies to pursue a variety of social and economic goals but equity in sharing arrangements among participants was a primary motivation, and the principal criterion for sharing was invariably their historical performance in the fishery. Quota allocation, to the extent that it promoted an orderly approach to harvesting, was also important to maintaining control over the fishery and hence to ensuring that catch limits were respected. The increasing interest in quasi-property rights schemes was by no means entirely motivated by a desire for economic rationalization of fleets. The anticipated economic rationalization was expected to contain the solution to the excess fishing capacity which drives overexploitation. The overexploitation results both from pressures to set too high catch targets and from the difficulty in controlling catches to the levels set, when fleet sizes are much in excess of those required to exploit the available resource.

All domestic management agencies, sooner or later, gave importance to controlling participation in the fishery through licensing, vessel decommissioning, restrictions on vessel size on replacement, fleet size restrictions, direct control of fishing effort, or some combination thereof. These are all methods designed to more directly counter the tendency toward fleet overcapacity inherent in common property fisheries.

Virtually all agencies made exceptions to quota and vessel capacity restrictions for small coastal boats, partly as an element of social policy but also to avoid the practical difficulties of controlling large numbers of small vessels. This typically encouraged expansion of the activities and fishing capabilities of these fleets, and this required that exemptions be largely or completely eliminated, e.g. in Canada, Faroe Islands, Iceland and Norway.

Despite these many efforts to control fleet composition, in terms of both vessel numbers and vessel and overall fleet size, by almost all management agencies, 15 years after acquiring control of their own fisheries destiny, all recognize fleet overcapacity as an important to extremely serious problem constraining their ability to meet their management objectives. In most jurisdictions, licensing and fleet management were not directly linked to exploitation level targets, and increasingly stringent controls were reactive rather than preemptive. This lacklustre performance of input controls, i.e. of restrictions on investment of labour and capital, resulted in the strong emphasis on output controls, i.e. on catch, and made a market solution based on tradeable TAC-shares an attractive alternative in several jurisdictions, e.g. Iceland, Canada. However, in contrast, the USA made input controls a central element of its management plan in 1994 and the EU is greatly strengthening the input control elements of the CFP because output controls are viewed as not having work at all well.

Control of exploitation pattern: Regulatory measures to reduce the catches of small fish in the groundfish trawl fisheries were essentially the sole preoccupation of the international fisheries commissions in the 1950s and 1960s. Although emphasis was shifted in the 1970s to control of exploitation level, protection of small groundfish was still viewed as important and all post-extension regimes strengthened their regulations in this regard. Indeed, in the initial years of national jurisdiction, Iceland and Faroe Islands made protection of small fish the central element of groundfish conservation strategy. Iceland quickly developed a broader regulatory base, placing increased controls on the level of exploitation. However, the USA took the reverse approach by abandoning controls on exploitation level in the early-1980s in favour of almost exclusive dependence on protection of small fish.

Protection of small specimens of pelagic species has a less extensive history than that for groundfish. The fisheries commissions began introducing regulations to restrict catches of small sizes of pelagic fish only in the early- to mid-1970s just prior to extensions of jurisdiction, although Iceland introduced a minimum fish size in its domestic herring fishery as early as 1966. While the yield-per-recruit argument for protection of young fish is as applicable to pelagic as to demersal fish, there are differences in other aspects of the biology and in the fisheries for the two types of species. In the case of herring, one important difference is that there are commercial products based on small herring, e.g. the Canadian and USA Atlantic coast "sardine", and these may be more valuable than products from adult herring such as fish meal. In other words, the economic yield-per-recruit, as distinct from the physical yield-per-recruit, would in these circumstances favour exploitation of young fish. A further difference is the tendency for pelagic species to show a greater spatial segregation by size than do groundfish. This results in regulation of the temporal and spatial distribution of fishing being a more effective management tool to reduce catches of small pelagic fish than it is for groundfish, and also allows fishermen themselves a greater control over the size of fish they catch. Many pelagic fisheries are directed towards pre-spawning or spawning concentrations, either by regulation or because this is when fishermen have the greatest fishing success (or can obtain the desired product, e.g. herring roe); a circumstance under which few if any small fish will be caught. Moreover, it is more difficult to achieve effective size selection by fishing gears for pelagic species than it is for groundfish. Small mesh is required if meshing problems are to be avoided. The Icelandic purse seine fishery for capelin is a special case, where the difference in size between age 1 fish and the older fish is sufficiently large to allow good escapement of age 1 fish without serious meshing problems (Vilhjálmsson, 1994). Trawl selection for pelagic fish, at commercial catch rates, is poor and most fish which do escape are damaged and likely die (Casey *et al.*, 1992; Suuronen, 1995).

The following comparisons of the specific regulations adopted in each regime with regard to minimum mesh and fish sizes is intended as a factual summary only. There is no intention to imply that the regulations should be the same for all regimes. To the contrary, stocks vary in their growth characteristics, the fisheries on them vary in their intensity, and the objectives of management vary among regimes. Thus, "optimum" minimum mesh and fish sizes will vary accordingly, and differences in the regulations among regimes are to be expected. When comparing minimum fish sizes between regimes it is important also to remember that some were in terms of fork length whereas in other cases total length was used. For pelagic species, the conversion between fork and total length is roughly 10%. For groundfish the difference is much less, about 3% for haddock and about the same percentage for pollock, whereas the two length measures are essentially identical for cod.

The primary method of preventing the catch of small groundfish was to specify how fishing gear was to be constructed, with most attention being devoted to controlling the codend mesh size used in mobile gears. Trawl regulations can be complex but essentially all of the technical specifications for construction are intended to ensure that the net is rigged in a proper way so that, when it is used, size selection by the codend meshes is effective. Among fixed gears, gillnet mesh sizes were usually regulated also. During the study periods used in this paper, all netting was constructed of synthetic materials, although regulations continued to be phrased in terms of manila equivalents until extensions of jurisdiction or later. It is a safe assumption that, differentials or not, nets in use had a mesh size no larger than the smallest allowed, as no ready way was available to enforcement officials for determining the different types of synthetic twines. Most post 200-mile regimes dispensed with differentials based on material. Danish seine nets were classified with otter trawls as a mobile, trawl, gear but were allowed to use smaller mesh than otter trawls in international commission regulations. A differential for Danish seine nets was dispensed with by all post 200-mile regimes, as there were insufficient selection data to justify its retention (but was reintroduced in Norway and Iceland).

In the gadid fisheries of the North Atlantic as a whole, the otter trawl is by far the predominant gear used. Thus, a comparison of minimum mesh size allowed in otter trawls, i.e. the minimum allowed for any material, provides the best standard for comparison of gear regulations among regimes. The otter trawl mesh sizes in effect in 1972 and 1984, the mid-years of the study periods used in this paper, and in 1990, to represent recent years, provide one such set of comparisons (Table 3). All regimes increased the mesh size required after obtaining management authority. The range in mesh size was 70–120 mm in 1972 under international commission regulation whereas by 1984 it was 80–155 mm, and three regimes had implemented further increases by 1990. However, excluding the special case of the EU fisheries in the North Sea and west of the British Isles, the range in mesh sizes among regimes was much less pronounced, in 1972 varying from maximum to minimum by 20 mm and in 1984 and 1990 by 25 mm. The regimes which implemented the largest proportional increases between 1972 and 1984 were Iceland, Faroe Islands and USA at 30%, whereas at Greenland and in the northern Canadian zone and NAFO Regulatory Area the increase was less than 10%.

In the Northeast Atlantic fishery commissions, minimum fish size regulations for groundfish were viewed as useful supplements to mesh size regula-

TABLE 3. Minimum trawl mesh sizes and fish sizes for cod, haddock and pollock, in effect in 1972, 1984 and 1990 in each of the North Atlantic regulatory zones. Mesh sizes cited are the minimum size permitted in otter trawls regardless of material. (Canada/NAFO = NAFO Subareas 0, 2 and 3; Canada–south = NAFO Subareas 4 and 5 [Canadian Part].)

Regulatory Zone	Minimum Mesh Size (mm)			Minimum Fish Size (cm)								
				Cod			Haddock			Pollock		
	1972	1984	1990	1972	1984	1990	1972	1984	1990	1972	1984	1990
Norway (N of 64°)	120	135[1]	135[1]	34	42	47[2]	31	39	44[2]	–	32/40[3]	32/40[3]
European Union	70	80	90	30	30	35	27	27	30	–	30	35
Faroe Islands	100	135	145	34	34	40	31	31	37	–	35	45
Iceland	120	155	155	34	50	50	31	45	45	–	50	50
Greenland	120	130	140	34[4]	40	40	31[4]	31	–	–	35	–
Canada/NAFO	120	130[5]	130[5]	–	–	41[5]	–	–	41[5]	–	–	41[5]
Canada–south	105[6]	130	130	–	–	41	–	–	41	–	–	41
USA	105[6]	140[6]	140	–	43	48	–	43	48	–	–	48

[1] USSR 125 mm mesh may be equivalent to Norwegian 135 mm mesh.
[2] Norway only.
[3] Five Zones – 35–40 cm north of 64°N, 32–35 cm south of 64°N. (30 cm in Skagerrak.)
[4] East Greenland only.
[5] Canadian Zone and Canadian vessels only in NAFO Regulatory Area, NAFO Regulation was 120 mm mesh size, no fish size limits.
[6] Not applicable to pollock.

tions. It was recognized that the two regulations should be consistent with each other so that fishing with regulation mesh size should result in few undersized fish being caught. The benefit of the minimum fish size was that it provided a way to regulate fishermen's behaviour through shore-based inspection of landings, whereas mesh size regulation required expensive and logistically difficult observation of fishermen’s practices at sea. Furthermore, fish size regulations provided a control over sizes landed by gears other than trawls. In the Northwest Atlantic, ICNAF depended solely on mesh size regulation to reduce the catch of small groundfish. The post 200-mile regimes in the Northeast Atlantic all retained minimum fish size regulations for groundfish, and increased the regulated sizes from those of NEAFC (Table 3). In the Northwest Atlantic, the USA imposed minimum fish size regulations immediately on extension of jurisdiction. Canada followed suit, but not until 1988, as did NAFO from 1992. Thus, all North Atlantic jurisdictions now have minimum fish size regulations for the primary groundfish. Regulations for pollock lagged those for cod and haddock; NEAFC did not introduce size limits for pollock until 1976 and in the case of the USA it was 1986, reflecting the lesser fishery importance of pollock.

The actual regulated sizes for cod and pollock were quite similar while those for haddock tended to be lower reflecting its lower growth potential (Table 3). By 1990, minimum sizes for cod ranged from 35 cm in EU waters to 50 cm at Iceland. The smallest minimum size for pollock was 30 cm in the Skagerrak (based on tripartite agreement between EU, Norway and Sweden), and the largest was 50 cm at Iceland. For haddock, the smallest size was 30 cm for the North Sea and west of Scotland stocks (EU waters) and the largest was 48 cm in USA waters.

It is doubtful that, in any jurisdiction, the regulated minimum size reflects the actual minimum fish size which can be legally landed because ancillary clauses of the regulations, or enforcement practices, allow for some tolerance. In Norwegian regulation, for example, there are various fisheries for cod, haddock and pollock for which tolerances of 15% by number or 10% by weight of small fish are specified. Tolerances are not specified in Canadian regulation but there are cases where enforcement plans have allowed 15% by weight of small fish in cod fisheries. Small fish caught in excess of these tolerances are required to be discarded at sea by some jurisdictions, e.g. the EU, but in others, e.g. Iceland and Norway and recently Canada, these fish are required to be landed.

Area closures have been used also to protect small groundfish from capture. These fall into two classes, permanent and temporary closures. To provide effective protection, closures must on aggregate encompass most of the area of distribution of small fish for most of the time period that they are available to the fishery. As there is usually a substantial intermixing of small gadids with commercial-sized fish, it is normally difficult to define fixed areas for permanent (seasonal or year-round) closure which do not also cause severe interference with the conduct of normal fishing operations. Furthermore, such geographically-based restrictions usually have greater adverse effects on some fishermen than on others, i.e. they are discriminatory. For these reasons mesh size and fish size regulations are the generally preferred methods of protecting small groundfish.

Permanent closures to protect small fish were prominent features of Icelandic and Faroese groundfish management but the restrictions applied primarily or exclusively to large foreign trawlers, at least initially. Temporary closures more clearly have the singular motivation of protecting small fish. This method was pioneered by Iceland and an almost identical system was adopted by Faroe Islands in the early-1980s, by Norway in 1986 and by Canada in 1993. Based on size composition data from observers aboard commercial vessels, immediate closure was instituted, typically for a week with possibilities for extension, of any area where too many small fish were being caught. The definition of a small fish was not, in the cases of Iceland and the Faroe Islands, the minimum size specified in regulations. It was a size established annually, based on advice from the respective government research laboratories, which depended on the size composition of recruiting year-classes. The percentage of the fish allowed to be under this size was also established by scientists in these two countries. A temporary closure system was also instituted by the USA in 1989 but this did not provide for real-time closure, Regional Council and government consultations being required, and closures were for extended periods of three weeks to six months.

In the Northeast Atlantic, the ban on industrial fishing for herring was of overriding importance in limiting catches of small herring. The EU was the only regime in which trawl mesh size restrictions were adopted for pelagic species and, as noted above, Iceland established mesh size regulation for the capelin purse seine fishery.

Minimum fish size regulations were applied to herring in most jurisdictions and ranged from 20 cm in EU waters to 29 cm off Canada, but there were important exceptions in some cases, such as in Canada where the fishery supplying the sardine industry was exempt. Capelin size limits for the Barents Sea and Icelandic stocks, of 11 cm and 12 cm respectively, were important in protecting age 1 capelin from exploitation, but no size limits were used in management of Northwest Atlantic capelin. Size limits were imposed for all the mackerel stocks, although not for all fisheries, and varied from 20 cm for the western stock to 30 cm for the North Sea in the Northeast Atlantic to about 25 cm in the Northwest Atlantic.

Area closures of various coastal waters established in EU regulation were largely to protect small herring from fishing, and an area was closed off southwest England to safeguard small mackerel. Closure of areas to purse seining by Canada was used to protect small herring when these were particularly vulnerable, e.g. when overwintering in the Bay of Fundy. The real-time closure system in Iceland applied to herring as well as groundfish.

Spawning closures: Seasonal closure of spawning areas has been little used as a regulatory tool. When spawning areas were closed, it was almost invariably as an indirect means of controlling exploitation level rather than to enhance the success of the spawning act *per se*. Spawning area closure was one of the limited arsenal of regulatory measures available to the international commissions and it was used by NEAFC to reduce exploitation of west of Scotland herring in 1974 before the authority to establish TACs was acquired. When TAC control was adopted in 1975, the spawning closure was retained as a supplementary measure, and subsequently became incorporated in EU legislation. In the Northwest Atlantic, ICNAF included closure of spawning areas, along with TACs, in regulation of haddock stocks in 1970, in ICNAF's first venture in control of exploitation level. Proposals for these spawning closures originated from USA fishermen, but were viewed by regulators as supplements to TAC regulation. After extension of jurisdiction, these closures were retained in Canadian and USA regulations.

Norway used spawning ground closures to control spawning escapement of Barents Sea capelin prior to adopting TACs for this purpose, and hence this was intended to control exploitation level, i.e. it was designed to leave enough fish for a successful spawning rather than to allow spawning fish or spawning products to be undisturbed. The purpose of the Icelandic closure of several cod spawning areas is not clear, but the Faroese closure in 1992 of cod spawning grounds was a fishing effort reduction measure to protect the declining cod stock.

Enforcement and Compliance

An enforce-ment program for fishery regulations typically utilizes enforcement officers and data collectors in ports of landing, and aircraft overflights, surveillance vessel patrols and observers aboard commercial fishing vessels, to deter or detect violations on land and at sea respectively. Differences in enforcement methods among North Atlantic regulatory regimes are more in terms of emphasis given to these methods, rather than in the methods themselves. Land-based enforcement is the least expensive but unfortunately, many of the important regulatory controls on fishing require enforcement at sea. Observers are the cheapest at-sea enforcement method, followed by surface craft then aircraft. Each have their strengths and weaknesses.

Observers are unique in their ability to ensure a high level of regulatory compliance but can exert control over the behaviour only of the vessels on which they are aboard and thus a high coverage level is required if compliance at the fleet level is to be reasonably well assured. In special cases, however, such as closure of areas containing undersized fish, conditions on a few vessels can be extrapolated over the whole fleet within a particular area, and thus fleet closures can be effected with a low level of observer coverage. In general, however, a low level of observer coverage, while possibly collecting important scientific information, does little to ensure widespread regulatory compliance. Comprehensive observer coverage of foreign fleets fishing within domestic zones was adopted by both Canada and USA as a primary means of ensuring high regulatory compliance. In Canada the program was extended to give partial coverage of domestic fleets but in special circumstances, when compliance became a contentious, high profile, issue, complete observer coverage of particular domestic fisheries or fleet sectors was instituted. An observer program with only scientific responsibilities was sponsored by NAFO in its initial years, but this came to nothing. In the early-1990s tentative steps were taken by NAFO to establish an enforcement-oriented observer scheme. Thus, observers play a more extensive role in Northwest Atlantic regulatory systems than in those of the Northeast Atlantic, and Canada is unique in its level of utilization of observers for both regulatory and scientific purposes.

Aircraft are most effective in detecting regulatory violations which relate to area of fishing such as patrolling jurisdictional boundaries, closed areas, and detecting unlicensed fishing vessels, because large areas can be covered in short periods. Surface vessels can also perform these tasks but in most cases less effectively. Patrol vessels have the advantage, however, of being able to inspect fishing boats and their gear at sea and have the unique capability to arrest violators (where the legal authority exists of course).

Enforcement which can be done ashore ensures, most importantly, the accurate recording of landed quantities and that sizes of fish in landings conform to regulation. Fishing gear can also be inspected before departure and on return to see that it conforms to regulations. Unfortunately, this does nothing to ensure that gear is not modified at sea to retain small fish, that the catch is not high-graded at sea by dumping undesirable species, undersized fish or catches over quota limits, or that the fish landed were caught in the proper area. Nonetheless, effective shore-based enforcement can put important limits on the extent to which fishermen can profit from illegal behaviour.

The most important question, of course, is not how enforcement was conducted in each management regime, rather how effective was it in ensuring a high level of compliance with the regulations. Unfortunately, measurements of compliance are extremely scarce. The traditional emphasis in enforcement activities is towards detection of illegal actions and apprehension and prosecution of the culprits. Penalties assessed against the perpetrators of illegal acts by the courts hopefully deter them and others in the fishery from committing such offenses in future. Whether or not this works depends on the balance between the financial gains to be had from illegal fishing on the one hand and the probabilities of being caught and convicted, and on the severity of the penalties assessed, on the other. There are trade-offs among these factors, e.g. if penalties are very severe this may deter illegal activity even if the probability of detection is low. This leaves the question of how to measure compliance. If no illegal activities are detected, does this mean that none occurred or that surveillance was ineffective? If there are lots of convictions, does this mean that surveillance is catching culprits very efficiently or that flaunting regulations is so widespread that culprits cannot be missed and, in reality, that penalties are viewed as no more than a business overhead? These are not questions which can be answered using the standard operational statistics usually collected by enforcement agencies such as days at sea by surveillance vessels, number of violations detected, or percentage of successful prosecutions. They require specific data collections and statistical analysis by appropriately qualified analysts, i.e. it is a research activity and as such has not usually been viewed as being part of enforcement agency mandates. While fishery research laboratories typically employ staff with the qualifications to conduct compliance analysis, it has not usually been viewed as their job and this important issue has fallen between stools. Thus, conclusions about the level of compliance with regulations are usually based on anecdotal reports from informal intelligence networks in the industry. This kind of information can have some serious biases and can mislead a management agency as to what might be an appropriate course of action. Nonetheless, if data are collected from fishermen in an objective and systematic way some useful measures of compliance can result. For example, a professionally-conducted questionnaire survey of fishermen illustrated quite convincingly a high level of regulatory non-compliance by the USA fleet fishing Georges Bank groundfish (Sutinen *et al.*, 1990).

A case where a surveillance agency itself designed an observational program to quantify illegal and unauthorized fishing is that of Canadian actions in the NAFO Regulatory Area under the auspices of the Fisheries Commission's Joint International Inspection Scheme. In the NAFO Regulatory Area there was not only the issue of whether contracting parties were observing agreed catch limits but also that of documenting catches of members who refused to be bound by NAFO regulations and catches of non-members. This presented a statistical estimation problem and required the deployment of surface vessel surveillance and boardings, and air surveillance, to provide valid catch estimates. These estimates, whether fully accepted or not, put a quantitative factual perspective on NAFO's conservation problems which drove the organization's agenda from the mid-1980s.

The NAFO and USA situations appear to be exceptions, however, and an overall assessment of compliance in North Atlantic management regimes is largely a matter of accepting the views of the responsible agencies as the best estimates available. On this basis it appears that the geographically more isolated management regimes of Faroe Islands, Iceland and Greenland have experienced quite a high level of regulatory compliance. Faroese regulations, of course, concerned little more than mesh size and area closure regulations in most of the period considered, but the quality of landing statistics deteriorated with introduction of catch controls in 1994. In Iceland too, compliance became an important issue when tighter constraints were placed on the cod fishery in the last few years. Norway, Canada, EU and USA experienced severe enforcement difficulties in some areas. Under-reporting of landings, of sufficient severity to prejudice effective management of some important resources, was documented in Canada and the EU, and to a lesser extent in Norway. In the USA, catch limits were dropped altogether for groundfish and herring as unworkable. Mesh size regulations were frequently violated in Canada, EU and USA. Minimum fish size regulations, when enforced, resulted in discarding at sea, even when this was illegal as in Norway. Highgrading, the dumping at sea of less valuable or unwanted species or sizes, was alleged to be widespread in Canadian enterprise allocation/boat quota managed fleets, although not quantified. In the case of NAFO, the problems were separable into both legal and illegal non-compliance.

Non-member fishing, and fishing by members who had exempted themselves from official conservation measures, was not illegal but nonetheless represented a non-compliance with serious repercussions for the success of the conservation programme. However, members, even when actually bound by NAFO regulations were also recorded through surveillance as exhibiting a high non-compliance.

It is readily apparent that the information which it is possible to gather, is not at all adequate to quantify the level of compliance with conservation programs. It is nonetheless obvious that most regimes experienced a variety of severe non-compliance problems, and it is safe to say that a failure to meet some conservation objectives resulted from an inability to effectively enforce the management measures adopted.

Resource Trends

Biomass estimates for the stocks in each management regime during the 22 years studied, 1967–88, are summarized by species in Fig. 58–63. All cod stock biomass estimates (Fig. 58) varied by at least a factor or two, i.e. the highest biomass was at least twice the lowest biomass in the period,

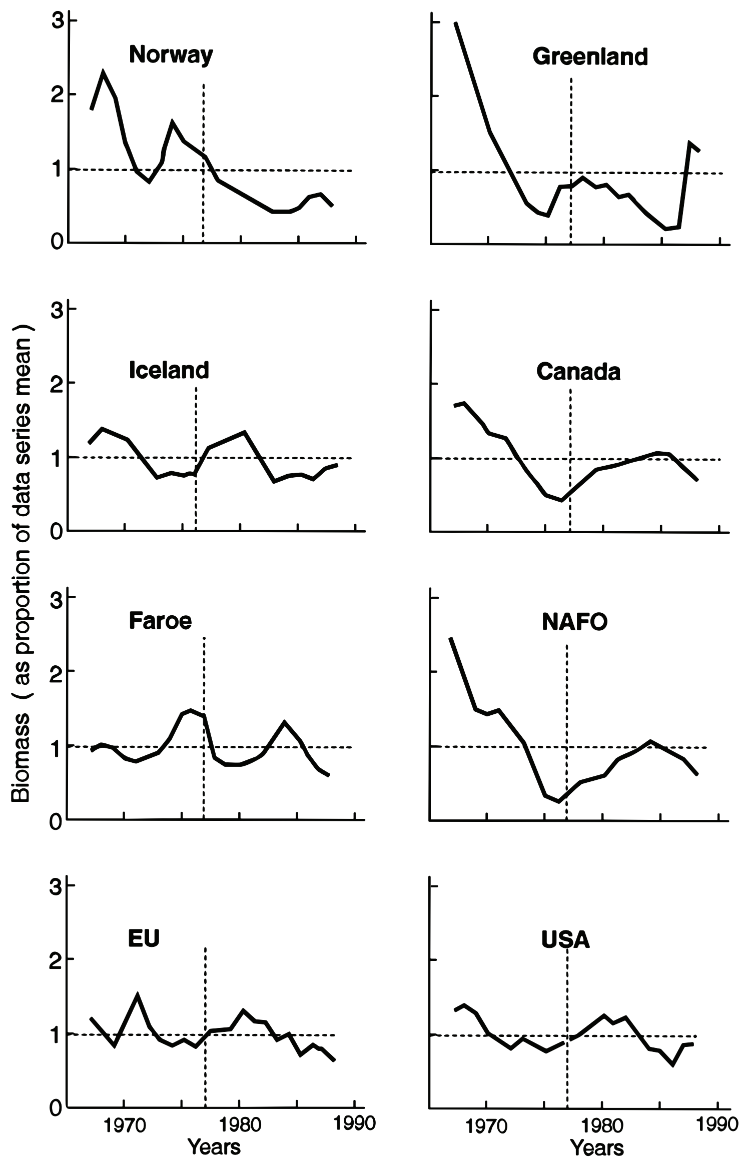

Fig. 58. Cod: biomass trends in North Atlantic stocks, 1967–88. (Break in USA graph indicates a data discontinuity.)

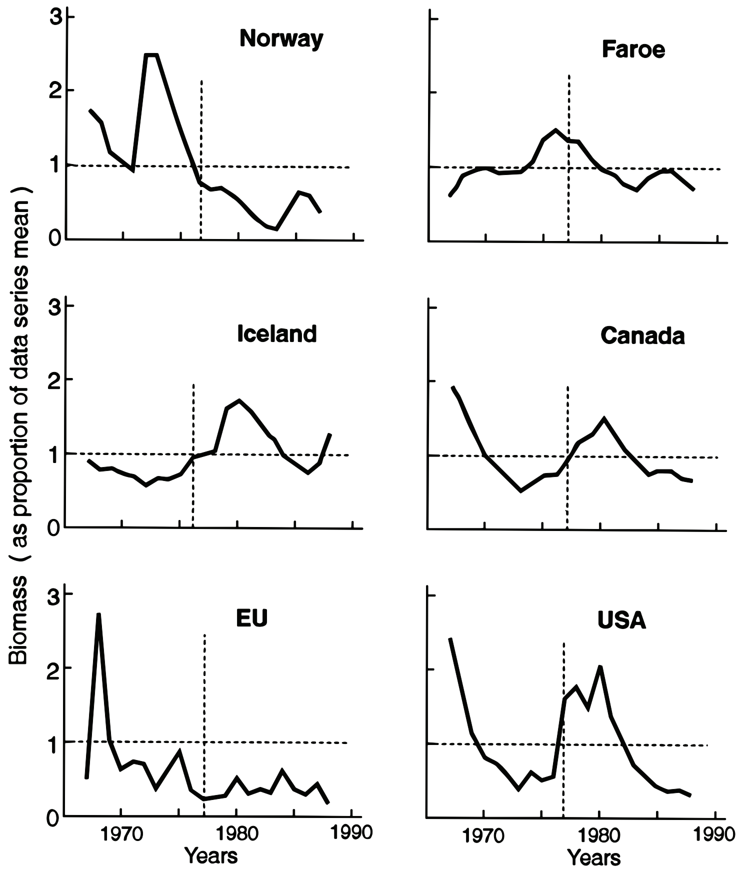

Fig. 59. Haddock: biomass trends in North Atlantic stocks, 1967–88.

and this was true also for haddock (Fig. 59) and pollock (Fig. 60), except for Faroe Islands pollock where the factor was 1.7. The median variation for all groundfish stocks was about 3.5. Biomass of pelagic stocks varied even more, the median factor being about 7.5, and the most extreme values were possibly as great as two orders of magnitude. At the end of the study period, most cod and haddock stock biomass estimates were below the 22 year average, whereas the reverse was true for herring stocks. For the other species, as many stocks were above as below the average by the end of the period. These trends in biomass are largely a function of variation in fishing mortality and in recruitment.

Changes in fishing mortality in each management regime are examined in two ways in Table 4. The change between periods in the fishing mortality of the fished population as a whole is given to indicate whether the population experienced a change in overall mortality. Secondly, the level of fishing mortality in relation to F_{max} is shown. (See section above on Convention and Methodology for explanation of average F calculations.) Capelin is not included in this table because strategic targets were established in terms of spawning stock biomasses and arbitrary exploitation rates rather than standard fishing mortality reference points.

There was a slight overall reduction in the exploitation level of North Atlantic stocks after extension of jurisdiction. Fishing mortality was decreased in almost half of the cases (Table 4). The stocks fished above F_{max} decreased from two-thirds, to less than half, of the total. Mortality decreased in most pelagic stocks, none being fished above F_{max} in the second period. Although fishing mortality decreased in some groundfish stocks, it increased in almost as many, and about 60% continued to be fished above F_{max} in 1979–88, the same percentage as before. Thus, the overall improvement in exploitation level is attributable more or less entirely to more moderate exploitation of herring stocks.

Success in reducing fishing mortality in herring stocks in the Northeast Atlantic in each case required a number of years of more or less complete fishery closure. In the Canadian zone there were fishery closures for some small stock components but the most decisive events were a ban on indus-

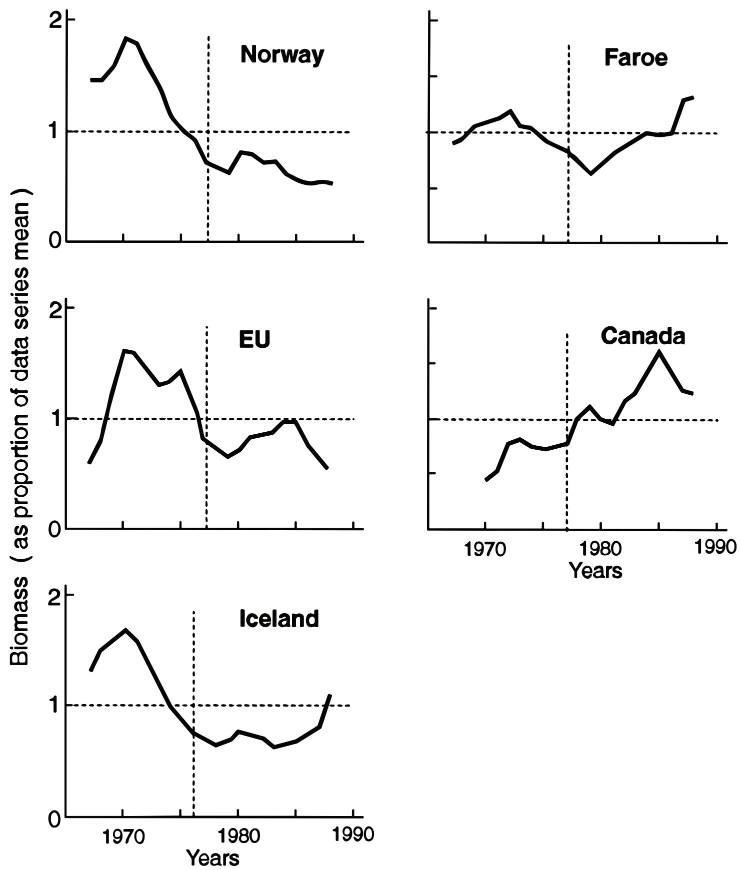

Fig. 60. Pollock: biomass trends in North Atlantic stocks, 1967–88.

trial fishing from the mid-1970s and stringent controls on the activities of purse seine fleets. In USA waters the removal of foreign fleets, which were responsible for almost all offshore fishing for herring, did little immediately to reduce mortality as most remaining stock components were in coastal waters and vulnerable to expanded domestic fishing. However, the economic decline of the sardine industry from the early-1980s resulted in greatly reduced fishing effort, and thus the consequential reduction in fishing mortality was not brought about by any regulatory action. Thus, with the exception of USA herring, success in reducing fishing mortality required Draconian regulatory actions. The accounts in the above section on Management in National Fishery Zones make clear that these actions were taken only when the stocks were on the verge, or in the process, of complete collapse. Fishery closures for groundfish stocks, however, were unheard of until the Canadian closure of the fishery for Labrador–East Newfoundland cod in 1992, again when faced with strong evidence of collapse. This history would suggest that adoption of measures which were adequate to reduce exploitation level proved possible only when a large scale industrial failure was occurring.

Recruitment varied much more in some stocks than others, over the 22 year study period. The difference in size between the largest and smallest year-classes recruiting to a particular stock was a factor of two in the least variable case, and as high as almost 2 000 times in the most variable. Stock biomass does not vary as much as individual year-classes, of course, because typically there are four to seven or eight year-classes which simultaneously make an important contribution to the biomass of the fished stock. Recruitment was averaged over periods of five consecutive years to provide estimates of how much stock biomass might be expected to vary as a function of varying recruitment. The ratio between the highest five year average recruitment and the lowest, in the time series of data for each stock, varied from 1.5 to almost 60 (Fig. 64). Haddock recruitment was the most variable, followed by that of herring, whereas pollock recruitment was the most stable. The median factor for all stocks was about four. Thus, variation in recruitment

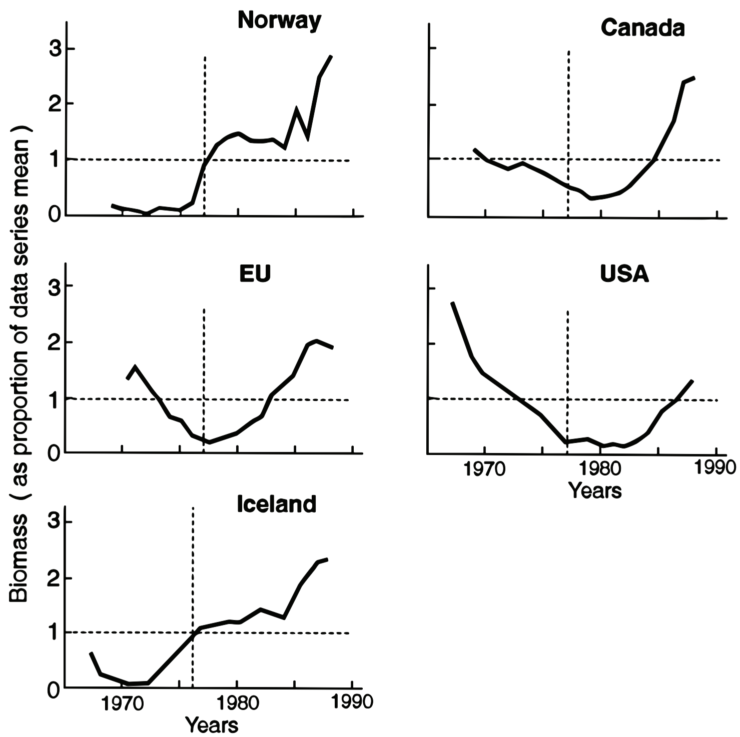

Fig. 61. Herring: biomass trends in North Atlantic stocks, 1967–88.

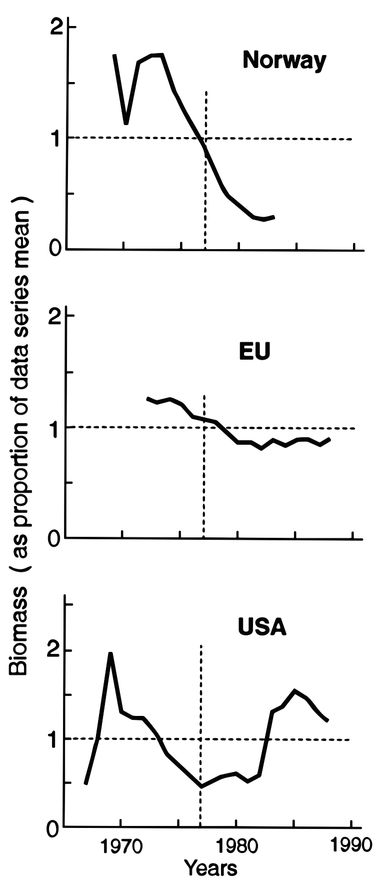

Fig. 62. Mackerel: biomass trends in North Atlantic stocks, 1967–88.

alone was great enough to explain the variation in biomass of most stocks.

In contrast to this large variation in recruitment levels during the study period, it has already been noted that F levels in most stocks did not change greatly after extensions of jurisdiction. Thus, there are relatively few cases where a substantial change in stock biomass could be attributable to a change in fishing mortality. In addition, the changes in F that did occur usually did not result in F being reduced greatly below F_{max} and, as the relationship between fished biomass-per-recruit and F is strongly concave, little response in biomass could be expected. In other words, the greatest changes in biomass-per-recruit in response to changes in F occur when F is relatively low, whereas when F is high, e.g. at F_{max} and above, the change in biomass-per-recruit is relatively small for quite large changes in F (Beverton and Holt, 1957).

This relationship between biomass-per-recruit and F was examined empirically using present data by dividing stocks into three broad categories corresponding to the changes in F experienced between periods. The categories chosen were 1) stocks fished at F_{max} in 1967–76 and at a yet higher level in 1979–88 (eight stocks), 2) stocks fished above F_{max} in both periods but lower in the second (seven stocks), and 3) stocks which, regardless of F in 1967–76, were fished below F_{max} in 1979–88 (eight stocks). Two stocks, pollock at Iceland and

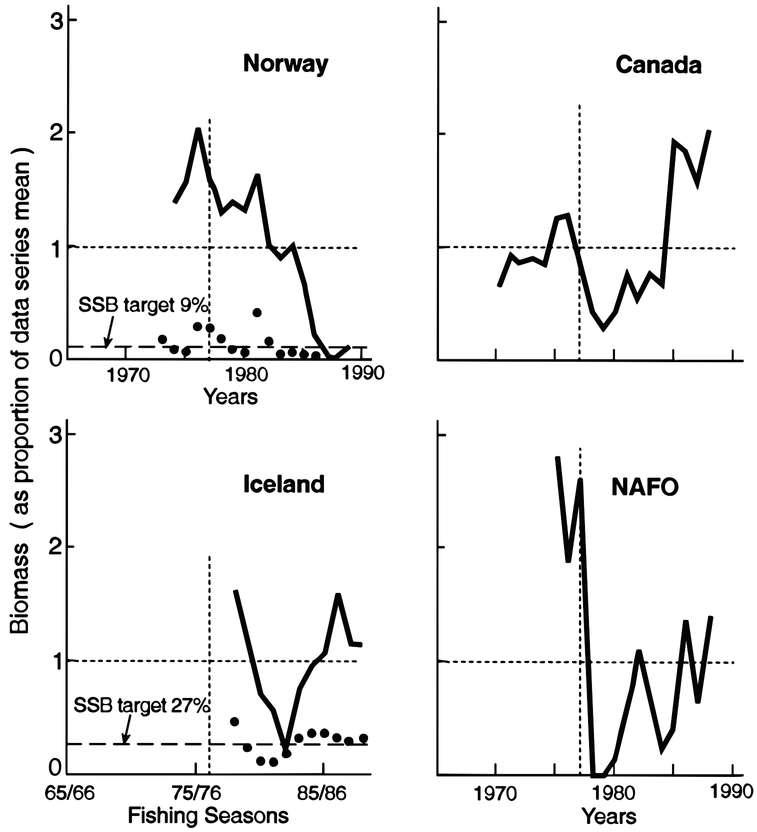

Fig. 63. Capelin: biomass trends in North Atlantic stocks, 1967–88, and spawning stock biomass (circles) in relation to targets for Icelandic and Norwegian stocks (as percentages of mean total stock biomass). (For Iceland, stock biomass is for the beginning, and spawning biomass is for the end, of the fishing season. For Norway, stock biomass calculated for 1 October is assigned to 1 January of following year.)

Faroe Islands, did not experience a change in F which corresponded to one of these categories and were excluded. (Note that, for this comparison, averages of F and recruitment were offset to include 2–4 years earlier and exclude the last 2–4 years of the base periods, as biomass in base periods was more influenced by recruitment and F on these recruits which occurred immediately prior to the base periods than at the end of them.) Changes between periods in F and biomass-per-recruit in the three categories were:

Category	Fishing Morality	Biomass-per-Recruit
1	+45%	-20%
2	-30%	+30%
3	-50%	+100%

As expected, the largest proportional response in biomass-per-recruit occurred when Fs were reduced below F_{max}. It so happens that the stocks in category 3 had an average F close to their average F_{max} value in this first period, and in the second period average F was about their average $F_{0.1}$. This puts a scale on the expected change in biomass-per-recruit if F was reduced from F_{max} to $F_{0.1}$, i.e. an approximate doubling.

General Conclusions

The transition to coastal state management of continental shelf resources could be characterized as an evolution from international management, rather than a revolution. The opportunities presented by the greater level of control over domestic resources (most regimes still shared important resources to some extent) to rationalize the social and economic elements of fishery policy, were not firmly grasped. In several regimes, failure to construct a coherent policy framework that reconciled policy elements has been diagnosed as a major

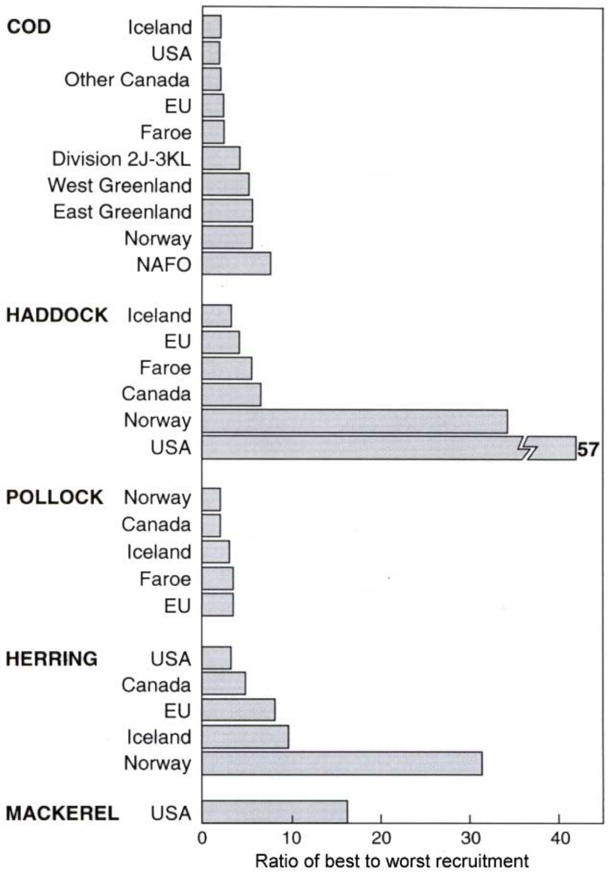

Fig. 64. Variability of recruitment to North Atlantic stocks: the ratio of the number of recruits in the period of five consecutive years when recruitment was highest to that in the five consecutive years when recruitment was lowest, in the 22 years studied.

TABLE 4. Fishing mortality: direction of change between 1967–76 and 1979–88 in fishing mortality for the stocks associated with each management regime (+ indicates an increase, 0 no change and – a reduction) and the relation of fishing mortality to F_{max} in each period (+ indicates F above, 0 at, and - below, reference F). (A stock was classed as 0 if F in the later period was within 15% of that in the earlier period in the first case, and if F was within 15% of the reference F level in the second case.)

Management Regime	Stock	Change between periods in F	F relative to F_{max} in: 1967–76	1979–88
Norway	Cod	0	+	+
	Haddock	0	+	+
	Pollock	0	+	+
	Herring	–	+	–[1]
	Mackerel	...	...	...
Iceland	Cod	0	+	+
	Haddock	–	0	–
	Pollock	0	–	–
	Herring	–	+	–
Faroe Is.	Cod	+	0	+
	Haddock	–	–	–
	Pollock	+	–	0
EU	Cod	+	+	+
	Haddock	–	+	+
	Pollock	+	+	+
	Herring	–	+	0
	Mackerel	+	...	–
Canada	Cod	–	+	+
	Haddock	0	+	+
	Pollock	–	0	0
	Herring	–	–[1]	–[1]
NAFO	Cod	–	+	–[1]
USA	Cod	...	+	+
	Haddock	0	-	-
	Herring	0	+	0
	Mackerel	–	–[1]	–[1]

[1] F at or below $F_{0.1}$.

deficiency in management approach (e.g. Angel *et al.*, 1994; EU, 1991; Hanneson, 1985) and the same criticism can be extended to other regimes. As a consequence, all regimes, 15 years after extensions of jurisdiction, recognize excess capital and labour employed in the fishery as a serious, or critical problem. Fleet overcapacity creates pressures for high exploitation rates, and can make adequate enforcement of regulations prohibitively expensive. Under such circumstances the fishing industry is poorly positioned to withstand adversity, such as a downturn in resource productivity. It is not a situation that is consistent with long-term economic viability of the industry, with stable and adequately renumerated employment for fishermen and other workers in the industry, or with proper protection of the resource base from over-exploitation.

Most regimes are introducing potentially radical reforms to their regulatory systems in the 1990s, subsequent to the study period used here. Iceland has already introduced a comprehensive ITQ system and Canada is moving in that direction. The USA has introduced a fishing effort limitation system for groundfish and the EU has laid the groundwork for effort limitation also. It is too early to judge whether these approaches will put the fisheries on a sounder footing. Much will depend on how well they are implemented and whether adequate control of the behaviour of participants is established. This historical review reveals a tendency to resort to new tools when the results of management are judged unsatisfactory, with relatively little attention being paid as to whether the previous tools were utilized effectively.

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Standard Report Series

International Agencies

Permanent Commission and NEAFC (old and new): Meeting Reports record decisions and provide summaries of discussions – available from the Secretary, North-East Atlantic Fisheries Commission, Nobel House, 17 Smith Square, London, UK.

ICNAF and NAFO: Annual Proceedings/ Reports, published for all years of ICNAF, for 1979 and 1980 and for 1991+ for NAFO, provide summaries of activities; Meeting Proceedings, published for ICNAF Commission meetings of 1963–79, and for NAFO General Council and Fisheries Commission meetings of 1979 and 1991+, record decisions and provide summaries of discussions; scientific activities of ICNAF recorded in reports of STACRES are published in Redbooks for 1958–79, of NAFO Scientific Council in Reports for 1979+; fisheries statistics for the Northwest Atlantic are published in ICNAF/NAFO Statistical Bulletins for 1951+. All these ICNAF and NAFO publications are available from the Executive Secretary, Northwest Atlantic Fisheries Organization, P. O. Box 638, Dartmouth, Nova Scotia, Canada, B2Y 3Y9. (A summary of meetings and discussions of NAFO in 1979–92 was published in 1993, and compensates to some extent for failure to publish General Council and Fisheries Commission reports during the 1980s.)

ICES: Fisheries statistics for the Northeast Atlantic are published in the ICES Bulletin Statistique des Pêches Maritimes, renamed ICES Fisheries Statistics for Vol. 73 *et seq.*, from 1903 (published 1906); advice of ICES to fisheries commissions is published in the Cooperative Research Report series; – available from ICES, Palaegade 2–4, DK-1261 Copenhagen K, Denmark.

FAO: Fisheries statistics for all major areas of the world are published in the Yearbook of Fishery Statistics: Catches and Landings – available from Distribution and Sales Section (Yearbooks) or the Senior Fisheries Statistician, Fisheries Department (data), FAO, Via delle Terme di Caracalla, 00100 Rome, Italy.

Domestic Agencies

***Canada*:** Information on the status of fish stocks in the Canadian zone and advice on their management is available in Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) Research and Advisory documents respectively, for 1977–92. Annual Reports of CAFSAC, which include all Advisory Documents for the year, were also produced. From 1993, the same information is contained in DFO Atlantic Fisheries Research Documents and Stock Status Reports. These documents are available from the Atlantic Stock Assessment Secretariat, Science Branch, DFO, 200 Kent Street, Ottawa, Ontario, Canada K1A 0E6. The Fisheries Resource Conservation Council (FRCC) publishes its advice to the Minister, DFO, and policy discussion papers, which are available from its secretariat, P. O. Box 2001, Station D, Ottawa, Ontario, Canada K1P 5W3. Annual fishery management plans are usually distributed as miscellaneous publications through regional and headquarters Communications Branches and are available as supplies last.

***European Union*:** The Official Journal of the European Union (OJ): produced by the Office for Official Publications of the European Union, L-1985 Luxembourg. The legislation (L) series contains Council and Commission regulations and decisions. (A second C series contains information and notices.) Regulations are referenced in full as, e.g. Council Regulation (EEC) No. 170/83 of 25 January 1983 but the abbreviation R (EEC)170/83 uniquely identifies this regulation. The date is that on which the legislation was signed. The location of this regulation in the Official Journal Legislative Series is OJ No. L24/1, 27-1-83, i.e. it is in volume 24, starts on page 1, and was published on 27 January 1983. The example used here is the legislation "establishing a Community system for the conservation and management of fishery resources", i.e. the Common Fisheries Policy. The legislation containing the permanent technical measures and the first TACs and allocations are contained in R (EEC) 171/83 and 172/83 respectively.

***Faroe Islands*:** A source of general information on Faroese fisheries is the Fisheries Yearbook (Føroyar) published from R.C. Effersøesgøta 25, Postboks 1378, FR-110 Tórshavn, Faroe Islands.

***Iceland*:** Reports on the state of marine stocks in Icelandic waters and prospects for the next fishing season are published annually by the Marine Research Institute, Reykjavik in the series: Hafrannsóknastofnun Fjölrit (in Icelandic but with English summary and figure and table legends). The same information for most of the important stocks is contained in the reports of the ACFM in the ICES Cooperative Research Report series (in English). Annual statistics on fishery performance are published in the series: Útvegur (in Icelandic but with English contents list and glossary).

***Norway*:** The Division for International Fisheries Relations of the Ministry of Fisheries, Oslo, publishes annually a pamphlet in English entitled "Quota Regulations in Norwegian Fisheries Zones for (year)". The Institute of Marine Research, Bergen, publishes stock status and prospects reports (in Norwegian) in the Fisken og Havet series. However, stock status and prospects for the major stocks is provided also through the ACFM of ICES and, for these, the same information can be found in ICES Cooperative Research Reports (in English).

***USA*:** Fishery management plan rules and regulations are published in the U.S. Federal Register. The plans themselves and associated supporting documentation, which can be voluminous, are produced by the regional councils. The New England Fisheries Management Council is located at Suntaug Office Park, Saugus, Mass. The Northeast Fisheries Science Center, Woods Hole, Mass. 02543, produces annually a report on the status of fishery resources off the northeastern United States. The latter organization also issues reports of its Stock Assessment Workshops in its Reference Document series.

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