Evolution of a Fishery Management Plan: A Case of the Atlantic Herring Fishery

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Abstract : This paper describes the evolution of a management plan for the Northwest Atlantic Herring fishery in US waters. It is relatively small fishery in value of landings. Also the fishery is a highly volatile one. However herring is an important species in the food web of the Northwest Atlantic. Sea surface temperature(SST) has been demonstrated to be a key parameter in determining the production of pelagic fisheries in a changing environment. So, Juvenile and larval stage herring are hypothesized to be very sensitive to low temperature. We focus only on sea surface temperature effects on Atlantic herring stock by estimating the correlation coefficient between the SST and the change of stock using the two year old stock. The correlation is 0.69. The Atlantic Herring fishery has currently an unusually large offshore stock and inshore stock component is close to or already fully exploited. Permits designed to elicit the appropriate response in conservation of a fully exploited stock, we refer to as "Fishery Conservation Permits(FCP)". Development of available resource would be achieved through "Fishery Development Permits(FDP)". FCPs would control access to and exploitation of the coastal resource of Area 1. Also, there are three kinds of FDPs and they differ by their priority. This permit plan did appear to be approved at a New Bedford meeting of the Council. However herring was not on the list of Council priorities and would not receive the benefit

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of their attention. In response to the refusal of the Council to take a more pro-active stance, a group of commercial herring harvesters has expressed theier interests in a "sole owner" approach. The structure of this fishery's industry, and its robust condition make it a good candidate for a painless transition to a right-based system.

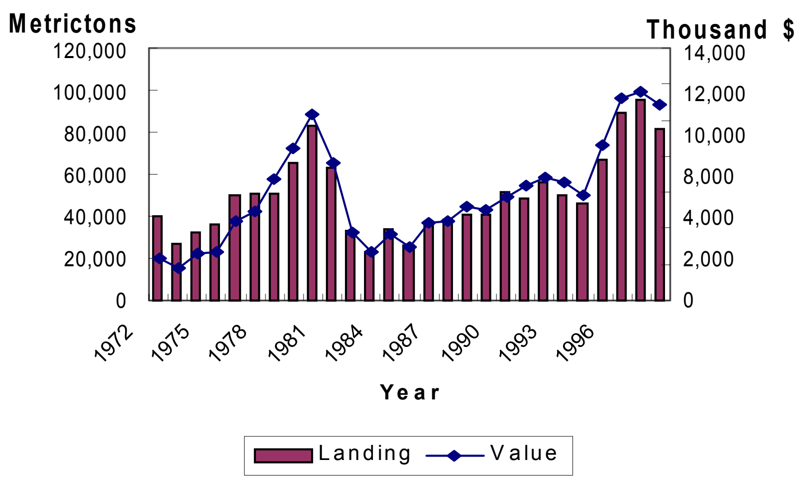
Key words : Herring, Fisheries Management Plan, Fishery Conservation Permit, Fishery Development Permit, Right-based System

Ⅰ. Introduction

This paper describes the evolution of a management plan for the Northwest Atlantic Herring fishery, *Clupea herengus*, in US waters. It is a relatively small fishery in value of landings ranging from $1.8 million in 1973 to $12 million in 1997. The landed weights have ranged from 23 Kilotons in 1983 to 96 Kilotons in 1997 (Figure 1). Thus, the fishery is a highly volatile one.

The sources of this volatility lie in both the resource and in markets. Excessive fishing (especially by foreign vessels) is believed to have caused the collapse of the Georges Bank Stock in the late 1960s and early 1970s. In the early 1980s, there was large demand for export of herring to Europe because a depressed herring stock off Iceland and Norway opened a niche for US fillet product. As a result, landings during that era soared from 50 Kilotons in 1978 to 83 kilotons in 1980. Presumably as a result, at least in part, of this intense fishing pressure, the resource collapsed.

〈Figure-1〉 **Trend in Commercial Landings and Values**

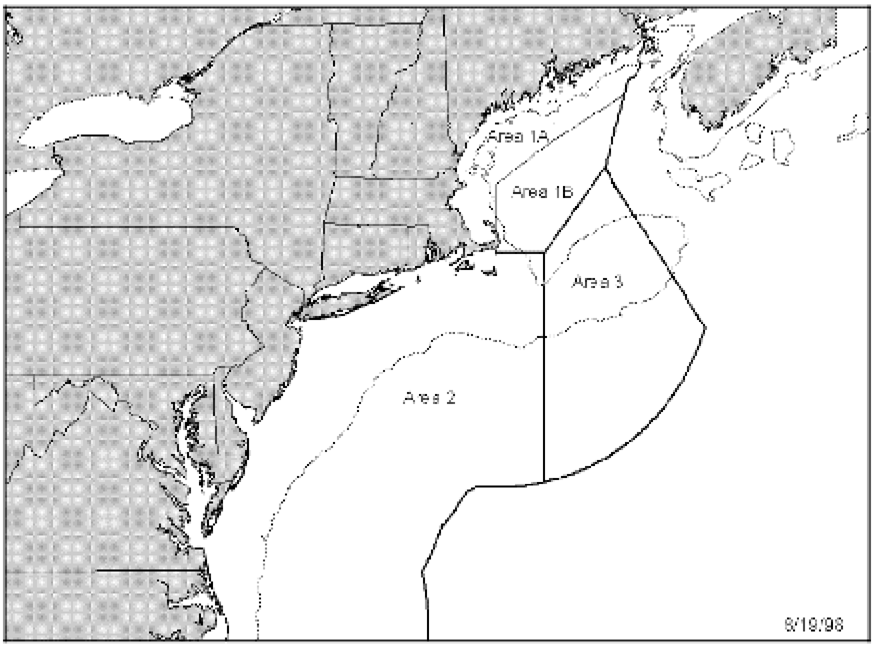


After the collapse of the export market and of the resource, the primary use of herring landings has been as a popular bait for lobster. The lobster fishery, which is the largest New England fishery in employment terms, relies on herring as bait. Herring is also an important species in the food web of the Northwest Atlantic (the Northeast Large Marine Ecosystem, NELME) because herring eggs or spawn are subject to predation by a variety of bottom creatures, marine mammal, and marine birds.

Thus, the fraction of the marine community which is concerned with the status of the herring fishery is much larger than one would expect from the number of herring fishers (fewer than two dozen harvesters account for more than 95 percent of the herring landings).

With reduced harvests the resource has rebounded in recent years.

〈Figure-2〉 **Geographic Range of the Atlantic Herring Fishery**



The estimate of spawning stock biomass was 1.8 million MT in 1997 and there is evidence of older herring dying of senescence. The Atlantic Herring is widely distributed in U.S. waters from Maine to Cape Hatteras. Figure 2 shows the geographic range of the species and the current Management Areas, designated as Areas 1A, 1B, 2 and 3. The first two areas are in the Gulf of Maine. Area 3 overlaps George″s bank.

Ⅱ. The Structure of Committees

There are two Management institutions or Agencies involved in developing a Fisheries Management Plan (FMP) for the Atlantic Herring Fishery, viz., Atlantic States Marine Fisheries Commission (ASMFC) and the New England Fisheries Management Council (NEFMC).[1] Their Technical Committees are the Herring Technical Committee (TC) of the ASMFC and the Plan Development Team (PDT) of the NEFMC. As their names suggest, the TC and PDT are basically technical/scientific in nature and have no decision-making power except insofar as their deliberations are adopted by the Council and/or the ASMFC parent body.

The role of the ASMFC eclipsed after the creation, in 1976, of the Council system. However, the Councils and the National marine Fisheries Services(NMFS) are reluctant to be perceived as infringing on States Rights and so a role often emerges for the ASMFC in developing a plan, (Commission FMP), parallel to the Federal Fishery Management Plan (Council FMP), but applicable within State waters.

1) The National Marine Fisheries Service (NMFS) is also involved in furnishing scientific advice (biological, economic and social), and in reviewing the FMP on behalf of the Secretary of Commerce who must approve FMPs.

The membership of Council and ASMFC decision-making Committees is not fully congruent but there is significant overlap. Many motions tend to be in duplicate with members doffing one hat and donning another between votes for a Council motion and votes for a similar ASMFC motion. As one might expect, this parallel structure does not make for short meetings, and reconciling their provisions in an industry which overlaps Federal and two or more State waters, can be extraordinarily complex.

In general the parallel plans contain similar, often identical provisions, but often, too, there will be differences in the ASMFC plan to reflect concerns and nuances of particular States. For example, the State of Maine is very keen on real time sampling of female herring for the purpose of closing spawning grounds when spawning is imminent. The NMFS is reluctant to endorse such a regulation on grounds of cost-effectiveness and personnel constraints.

Ⅲ. The Characteristics of Herring Fishery

1. Environmental Perturbations

In a paper by Johnson and Sutinen (1996), a bioeconomic model of uncertain biomass shifts, due to an exogenous environmental perturbation, is used to examine optimal harvest policy. They concluded that if there is a biomass shift due to an exogenous environmental change, optimal harvest rate is more rapid than in the no-collapse case. The economic reasoning of this conclusion is that the possibility of a future stock collapse by environmental changes decreases the shadow price of the fishery stock which lowers the economic cost of optimal harvest. The decrease in shadow price occurs because the prospect of a collapse reduces the expected added future value of a unit of the initial stock. As a result, fishermen would accelerate harvests to maximize net profit.

Therefore if we know the correlation between environmental factors such as sea surface temperature (SST) and recruitment, and can forecast the SST, fishery managers may wish to adjust harvest policy to make maximize net benefits. It may be noted that demand uncertainty can have similar effects. Specifically, during a period of unusually high export demand it may be optimal to accelerate harvesting, since future revenues will probably be lower; even without discounting.

SST, one of the environmental factors, has been demonstrated to be a key parameter in determining the production of pelagic fisheries in a changing environment. There is no shortage of studies which suggest a potential role for use of environmental variables in providing conditional forecasts of abundance (Klyashtorin, 1998; Sutcliffe, *et al* ,1988). Such forecasts have error bands that are narrower than those of unconditional forecasts and therefore have potential economic value. Some of the North American studies date to the 1940s. In the recent study by Klyashtorin (1998), the Atmospheric Circulation Index characterizing a dominant direction of air mass transport is closely related with long-term fluctuations of important commercial stocks such as herring, Atlantic cod, sardine, anchovy, Pacific salmon and Alaska pollock. The correlation coefficient is 0.70-0.90 in the period 1900-1994. Also, significant correlations between Atlantic herring landings and water temperature were studied by Sutcliffe et al. (1977). However these studies used only commercial catch data, and even though the changes in catch may reflect real changes in stock size, as in the case of the Atlantic herring, it may not be valid to assume that the change of commercial catch is due solely to either variations in population size or to fluctuations in market demand.

One of the studies on correlation between SST and stock is Cho and Gates (2001). In this paper, juvenile and larval stage herring are hypothesized to be very sensitive to low temperature. So, this study focus only on SST effects on Atlantic herring stock by estimating the correlation coefficient between the SST and the change of stock using the two year-old stock size instead of actual catch. The expected result is that including environmental factors is necessary to understand the cycle of fluctuating stock and is a necessary variable in the production model for a fishery.

For a sensitivity analysis, they took annual data divided it into 5 time period, corresponding annual, winter (September-April), September-December(egg and early larval development), January-April (overwintering- late larval period), and May-August (early juvenile phase). For each period, the mean, maximum, and minimum monthly SST were computed and analyzed to show correlation with recruitment. Table 1 shows the correlation coefficient between SST at t and recruitment at t+1. This table suggests that the January-April period may be important for recruitment. The p-values are in parentheses. At the 5 percent significance level Jan.-April and annual periods are statistically significant

〈Table-1〉 **Correlation between SST and Recruitment Period**

		Period			
SST	Annual	Winter	Sep.- Dec.	Jan.-April	May-Aug.
Mean	0.46	0.39	0.42	0.69(0.02)	-0.14
Max.	0.04	0.38	0.30	0.55	-0.28
Min.	0.64 (0.03)	0.55	0.57	0.58	0.06

Source : Cho, Jung-Hee and John M. Gates (2001).

2. The Economic Problem

It is common in many industries to have ups and downs in either (or both) demand for product and/or input supplies to which it must adapt. Herring fisheries are notorious for the volatility of their stocks. This volatility also induces volatility in trade flows as traders attempt to compensate for local shortages by importing from other regions. If there were no such stock and market uncertainties, firms could build just the right numbers the most efficient scale of plant (vessels and processing plants), consistent with the stable output demanded. However, given these uncertainties, several strategies can be used to address them:

- build a plant that is adaptable, though more costly
- subcontract for production
- rent resources (capital, labor), etc.

What industries don"t do is build productive capacity to satisfy the greatest output ever seen, or build to satisfy the greatest input supply ever seen. Such a strategy will cause unemployed resources and economic hardship when demand or input supplies diminish.

The Atlantic Herring fishery has currently, an unusually large offshore stock whose harvest and processing can be developed in an efficient and sustainable way or in an eventually wasteful and unsustainable way. However the approach to taking advantage of this opportunity is complicated because an inshore stock component is close to or already fully exploited. The challenge is to encourage development in such a way that when the stocks return to more typical levels, industry has not invested in huge amounts of excess harvesting or processing capacity and, to guide this development without seriously damaging the long term potential of any of the components of the resource. In situations like this in other industries, such peaks are regularly met by short term subcontracting, leasing and renting of productive capacity. This has not happened in local fisheries because, with a very few exceptions, there are no formalized use rights. The matching of appropriate amounts of capital and effort with sustainable resource levels has to be arranged by regulations rather than having the market guides the match.

3. Herring Resources

The Atlantic Herring Resource tends to be concentrated seasonally and geographically with the Gulf of Maine being the area of principal spawning (in late summer months), and also the area of principal harvests. The fish do migrate seasonally; for example, the Rhode Island harvest in Area 2 tends to be in January while in Area 1, the harvest is mainly in July-October. This seasonal migration is reflected in area specific Total Allowable Catches (TAC) which attempt to take into account the seasonal migrations and such premises: An uncertain (i.e., ill-defined) fraction of the Rhode Island Catch in January are really Maine″s September herring. Many biologists regard the stock as one, but for the purposes of staking postures on TAC allocations, it is perceived important that such area specific distinctions be seen as based on science.

Behind this broad picture there are some other structural aspects which are important. Under more “normal” or average conditions, most of the harvests are near shore, using low-cost purse seine vessels and the product is used primarily for lobster bait (Gates, 2000). During periods of stock expansion, the high quality of export market demands and the distance from shore require on-board refrigeration which traditional seiners do not have. Seiners are relatively unadaptable, however, and the export demands are met primarily by mid-water trawlers, which, although higher cost than purse seiners, have the flexibility to switch to other fisheries.

The coastal stock of fish in area 1A is considered fully exploited. Expansion of the fishery can occur only in offshore areas e.g. Area 1B (where there are said to be few herring) and in Areas 2 and 3. Estimates of sustainable yield for the entire herring stock are somewhat in excess of twice what is landed currently. Therefore, the three components of harvestable biomass are:

A. a fully exploited inshore (coastal Gulf of Maine) stock,
B. an amount offshore above the current catch or TAC of the coastal component up to some conservative estimate of long term potential yield or MSY, and
C. a temporarily available biomass extending from a generously defined MSY up to a conservative estimate of an overall TAC.

Ⅳ. A Structured Permit Approach to Managing the Herring Resource

1. Fishery Management Plans

As mentioned section 3, we tried to take into account the following characteristics and principles to improved management of the Atlantic Herring Resource:

A. The fishery is particularly volatile both in terms of market demand and resource fluctuations.
B. These fluctuations in biomass coincide with fluctuations in the

geographic range of the biomass. To a first approximation, the fishery persists even in low periods in the Gulf of Maine where there is a more than century old fishery based on Atlantic Herring.

C. As with other fisheries in New England, the behavior of interest groups in fishery management is highly consistent with the findings of Public Choice Theory.
D. Given the fluctuations in resource and in market demands, it is of interest to know the costs and benefits of alternative ways of coping with uncertainty. It is possible, for example that resource "mining" during periods of high export market demand may be economically desirable.
E. As a forage fish for other species in the NELME, adaptation to fluctuating markets may impose external costs on other components of the ecosystem. It may be useful to estimate the opportunity costs of deliberately constraining harvests to accommodate such non-market goals.
F. The broad category of tools entitled Rights Based Fishing may have some potential for helping to achieve some of the goals of fishery management.

In the following section the use of a variety of permits is an example of such an arrangement which mimics some of the virtues of market based approaches. Permits designed to elicit the appropriate response in conservation of a fully exploited stock, we refer to as "Fishery Conservation Permits". Development of the second and third of these quantities of available resource would be achieved through "Fishery Development Permits". We did not propose Individual Transferable Quotas (ITQs) for the simple reason that, at the time, the US Congress had imposed a moratorium on such measures. Nor did we consider a sole owner approach although, the measures proposed could be converted to ITQs or to sole ownership at some point in the future.

2. Fishery Conservation Permits

Fishery Conservation (FC) Permits would control access to and exploitation of the coastal resource of Area 1. The allocation of FC Permits would cap the eligible vessels appropriate for the TAC of that area. A variety of criteria and procedures could be used to determine those eligible for FC permits. Some would qualify more vessels than others. The harvesting capacity of those qualified, expressed in allowable days at sea (DAS) by gear, tonnage, etc., would provide the mechanism for equitable decreases in effort that should be warranted by stock conditions. The point would be to match effort to resource in that area. Catch and DAS would be monitored during the season. If it appears that cumulative catch is about to exceed 80 percent (for example) of the coastal TAC several mechanisms could be activated to prevent exceeding the limit in a given year. Adjustments to the allowable DAS could be made part of a framework mechanism for the following year, for example. Another feature of FC permits is that they could be defined for other areas, such as coastal areas of Area 2. This would be useful if the criteria chosen for determining who is qualified for an FC in coastal Area 1 or 1A resulted in too many claims arising. Secondly, not all currently active vessels target the coastal Maine stock. Other areas may be preferable. In other words, more than one limited access FC area might exist with a separate fleet and TAC defined for each.

Fishery Conservation Permits could have the following attributes:

- Stock area specific (limited to inshore areas). Limited access.
- Defined on DAS limit by ton class, etc.
- DAS subject to rescaling in event of unexpected stock changes with TAC provisions.
- Defined on TAC for the area defined.
- Leasable DAS among permitted vessels using relative DAS conversion rates.
- Lease transfers of DAS between areas may be subject to restrictions.
- Permits may be purchased or rented by a NMFS approved public agency or non-governmental agency for the purpose of temporarily or permanently retiring the associated DAS.
- Tenure provisions: FC permits could be permanent or long term temporary, i.e. would be for a "rolling" 10 year period, renewable via a process to be determined.
- In the event of reductions in DAS, FC permits would have priority over FD permits.

3. Fishery Development Permits

There are three kinds of Fishery Development (FD) Permits and they differ by their priority. The first and second (FD1, FD2) are designed to match effort to sustainable biomass: that quantity of available resource above the Coastal TAC for FC permits, but below a conservative estimate of the overall MSY. FD1 permits would be durable and would encourage long-term commitment to the herring fishery. FD2 would provide for temporary participation (e.g. 1-5 years duration) in the herring fishery by distressed Northeast fleets from other fisheries.

FD2 and FD3 permits would be issued only for Areas 2 and 3. The goal would be to guide development of a conservative level of effort capacity to take up to a cautiously defined long-term potential yield while providing some measure of temporary relief for regional fleets.

The division of sustainable resource available for FD1 versus FD2 exploitation should be relatively permanent to discourage undesirable expansion of permanent capacity. The FD2 resource should provide an additional buffer for sustained resource availability. When the FD2 resource component is not utilized, some form of very temporary access (such as described for FD3) might apply. Conversely, where FD1 participants are insufficient to predictably take the FD1 Resource, FD2 capacity could be allowed to spillover temporarily.

FD1 Permits would be allocated on some unspecified basis for fishing exclusively in areas offshore of the limited access coastal area(s). The number of these permits would be gauged using a conservative projection of the amount of effort expressed as DAS required to harvest the MSY quantity of fish as defined above.

Qualification for FD1 Permits could be constrained to participants in the herring fishery as defined by some more liberal qualification criteria which defined the limited access fleet(s) for the coastal areas. FD2 permits could be available on an as yet undefined basis to those with permits in fisheries under stress. This would require an annual determination by the Regional Administrator.

In other words, the fleet to take herring between the TAC of the inshore area (s) and the sustainable conservative MSY would be identified in some priority fashion as coming from current herring fishery participants and from permit holders in other distressed fisheries. The objective would be not only to develop and match capacity with available long-term resource availability but also to temporarily alleviate the problems caused by overcapitalization in other fisheries.

FD1 and FD2 permits would also be defined in terms of DAS specific to the vessel"s configuration. This would provide for equitable reductions in effort. FD1 permits would be superior to FD2 permits in such a resource retraction. FC permits would be superior to both.

FD3 Permits would allow for exploitation of a quantity of resource over and above a cautiously defined MSY up to a conservatively defined overall TAC. These would be very temporary in nature and would expire annually. They would allow the holder to decide how to use his existing vessel and/or some other existing harvesting capacity to exploit the short-term excess resource.

FD3 Permits might be restricted to holders of FC and FD1 permits. They would be defined in terms of DAS so that they could be equitably reduced as the "bloom" was dissipated. They would clarify the decision between building capacity, which may very well prove excessive in a very few years, and leasing the desired capacity (defined as DAS) from another vessel owner. Because the FD3 Permits have a limited life, and because the DAS feature provides some flexibility, they encourage development in a manner which is cost effective and which does not reward permanent capacity development beyond sustainable harvest levels. Capacity of any form develop for the temporary excess fishery would not be permitted to wash back into the capacity pool exploiting the sustainable levels of the resource without a concomitant reduction in that capacity pool. Responsibility would lie with the permit holder.

FD permits would have the following attributes:

- Stock area: only offshore of defined limited access coastal fisheries.
- Ton class specific and based on DAS.

- FD1 Permit: Limited to DAS equivalent capacity to division of remainder of sustainable harvest. FD2 allocated to DAS effort equivalent of remainder of sustainable resource harvest as estimated.
- Distinguished in tenure between longer term (possibly permanent) FD1 permits and temporary permits to other fishing fleets FD2 Permit.
- FD1 permits are superior in right to FD2 permits in periods of stock contraction. Owner may opt to exercise his or her permitted DAS on own or another permitted (or non-permitted) vessel using relative DAS conversion rates.
- While permitted DAS may be used as described above, the permit remains attached to the person and (possible) stock area for which it was issued.
- Permits and/or the associated DAS may be purchased or rented by a NMFS- approved public agency, industry association or non - governmental agency for the purpose of prematurely (DAS expire automatically with the FD permit) retiring the associated DAS.
- In the event of fishery downturns, DAS reductions would affect FD permits before FC permits
- To mitigate the social and economic impacts caused by reduced DAS, by means of a bilateral agreement, the holder of DAS on either an FD or FC permit may swap DAS with another. However, such transfers would be subject to rescaling regulations if DAS are not equally efficient and would require approval by the Regional Administrator of NMFS.

V. Conclusions

The plan did appear to be approved at a New Bedford meeting of the Council, but later it emerged that it had not. The PDT and TC were instructed to continue fleshing out the details of a limited entry proposal but were informed that herring was not on the list of Council priorities and would not receive the benefit of their attention. The remark of a Council member epitomizes the reactive nature of the Council system: "The resource is in great shape, there is no conservation problem, why do anything?". The implication seems to be that action is warranted only after the resource has been destroyed.

However, a recent informal survey of processing capacity indicated significant expansion and a planned capacity for 2003 about equal to the MSY. It appears that in five years we have made the transition from abundance to overcapacity with no significant progress on an economically rational management plan for the Atlantic Herring fishery. In response to the refusal of the Council or ASMFC to take a more pro-active stance, a group of commercial herring harvesters has expressed interest in a "sole owner" approach, by-passing the Council system if necessary. Industry has subsequently hired a professional to represent their interests in promoting a rights based approach. The structure of this fishery"s industry, and its robust condition make it a good candidate for a painless transition to a rights based system - if it is not already too late.

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