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# Spatial Fishery Rights and Marine Zoning: A Discussion with Reference to Management of Marine Resources in New England

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**Abstract** *The absence of property rights leads to dissipation of resource rents in fisheries. Economists have long recommended the assignment of property rights to the fishery as a means to internalize the stock externalities that lead to rent dissipation. However, there is less agreement and little research on the optimal nature of property rights for fisheries. Sole ownership of the fishery, while potentially efficient, is generally not politically acceptable. Individual transferable quota (ITQ) systems may fail to achieve an efficient outcome for a variety of reasons, many of which are related to spatial phenomena. Territorial user rights in fisheries (TURFs), also will generally fail to achieve efficient outcomes. This paper illustrates a number of cases where inefficiency may persist in a rights-based fishery management system. Some of the potential benefits and costs of territorial stock use rights in fisheries (T-SURFs) are discussed along with the role of marine zoning.*

**Key words** Property rights, marine zoning, ITQ, TURF.

JEL Classification Code Q22.

## Introduction

The absence of property rights leads to the dissipation of resource rents in fisheries and, quite often, to depletion of fishery stocks below levels that can support maximum production. Even when catches are strictly limited to maintain the biological productivity of the fishery, rent dissipation can be expected to persist as a result of overcapitalization. Economists have long recommended the assignment of property rights[1] to the fishery as a means to internalize the stock externality[2] that leads to rent dissipation (Gordon 1954; Scott 1955). However, there is less agreement and little research on the optimal nature of property rights for fisheries. There has been little attention paid to the spatial dimension of these rights.

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[1] Here and throughout this paper I refer to an economic concept of property rights rather than a legal one. In this context, property rights can be defined as an enforceable right to undertake specific actions (*e.g.*, land a specific quantity of fish from a designated area).

[2] The cost imposed on other fishers by reducing the fish stock that may include both increased unit harvest costs and decreased resource productivity.

Where rights-based systems have been implemented for fisheries, the property rights have been restricted in a variety of ways. For example, the property right granted is typically limited to a share of a total quota, the absolute size of which is ultimately determined by a government agency (though perhaps not without influence by the rights holders). Limits are often put on the type and scale of eligible quota holders, the harvest methods they can use, and even to whom catch can be sold. Although spatial regulations, such as closed areas and spatial gear restrictions, are quite common in fisheries, there has been relatively little attention paid to whether and when spatial attenuations of property rights for fisheries are likely to be desirable.

Spatial delineation of fishery rights (TURFs) has also been proposed as a means to internalize stock externalities (Christy 1982). TURFs grant exclusive fishing rights for a specific area to an individual or group. In some parts of the world, TURFs have been used extensively (*e.g.*, customary marine tenure for reefs and lagoons in the Pacific Basin [Ruddle, Hviding, and Johannes 1992] and community-owned fishing rights to inshore fisheries in Japan [Yamamoto 1995]). However, except in the case of some sedentary species, TURFs fail to fully internalize the stock externality unless they are extensive enough to cover the full geographic range of the fishery or fisheries concerned. A TURF owner will have incentives to catch fish before they move out of the areas he or she controls or risk them being captured by others. TURFS become even more problematic if they grant use rights to the full suite of fish stocks in an area. While this may resolve cross-fishery externalities, it is likely to make enclosure of the entire suite of fisheries impossible since different species will have different ranges.

In this paper, I propose that optimal property rights systems for some fisheries must, like terrestrial property rights, pay explicit attention to space. Combining stock use rights in fisheries (SURFs) and territorial use rights in fisheries (TURFs) to create territorial stock use rights (T-SURFs) may be necessary to achieve efficient management of the marine commons. Along with spatial delineation of harvest rights, zoning regulations may be required to minimize conflicting uses and coordinate activities across fisheries and user groups to achieve system-wide objectives.

Developments and limitations of property rights theory for fisheries are discussed in the next section. The following section discusses a variety of spatial processes that may lead to inefficient outcomes in ITQ fisheries, and explains how they might be mitigated with T-SURFs. Examples from fisheries in New England (figure 1) are used as a backdrop to illustrate a variety of problems that reduce the benefits derived from marine resources and that may not be resolved by conventional individual quota systems. Some of the limitations of T-SURFs and motivations for marine zoning are discussed next. Finally, conclusions are presented.

## An Unfinished History of Property Rights Theory for Fisheries

In his seminal article, H. Scott Gordon (1954) illustrates the inefficiencies that result from a lack of property rights to a fish stock and argues that a monopolist would choose an intensity of effort coincident with the social optimum. Anthony Scott (1955) develops this argument further with a somewhat more sophisticated, dynamic argument allowing for declining resource productivity with increasing effort and opportunities for intertemporal arbitrage. He, too, suggests that the sole owner of a fishery would, under certain conditions, pursue a socially optimal harvest policy both in the short and long run.

Notably, Scott suggests that socially optimal exploitation of the fishery might be achieved by allocation of the resource to an association, cooperative, or government, as well as a sole owner. It has become obvious that government ownership is not a

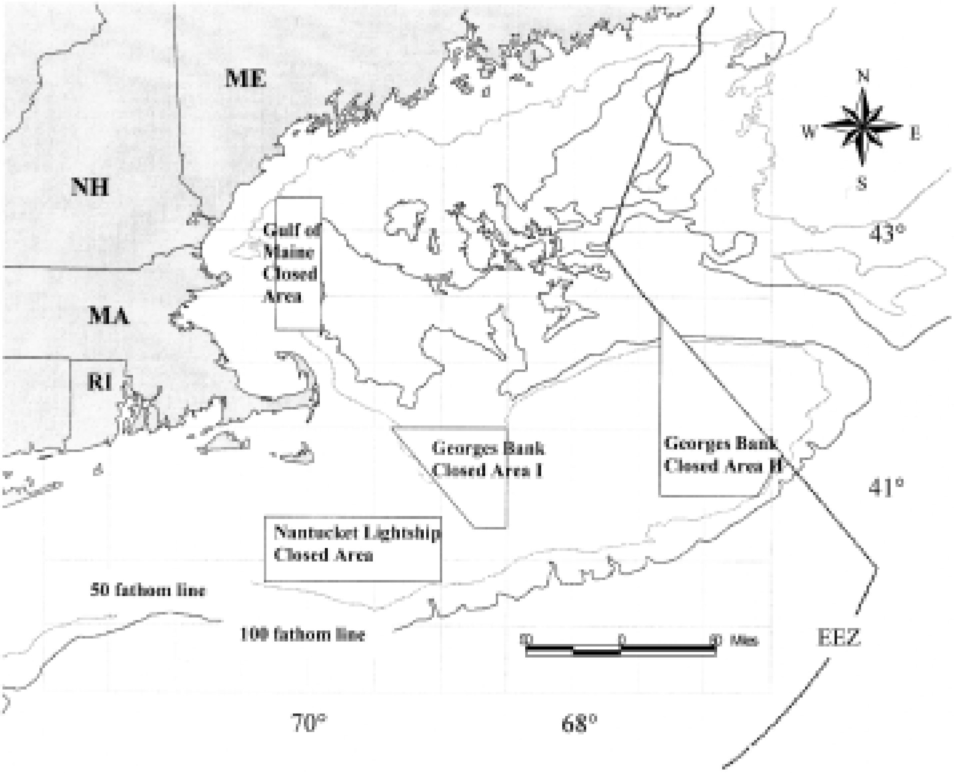


**Figure 1.** Fishing Grounds off the Northeast Coast of the United States in the Gulf of Maine, on Georges Bank, and in Southern New England

sufficient condition for achieving optimal use. Overexploitation and excess capitalization have continued in many, if not most, fisheries that were effectively nationalized by declaration of extended economic zones (EEZs). The competitive equilibrium based on international competition is simply replaced with another based on domestic competition.

In most cases, allocation of an entire fishery to one person or corporation is not acceptable or practical. However, it has been argued (Christy 1973) and shown formally (Clark 1980) that, under certain conditions, the benefits of sole ownership can be achieved by allocating transferable shares of the total allowable catch (TAC) from a fishery to individual users. To maximize the stream of benefits from the fishery, it remains for a social planner to set the annual harvest at the appropriate level, taking into account the productivity of the resource and harvest costs. Cooperatives and associations might be expected to achieve similar results through internal contracting.

ITQs have been shown to internalize the stock externality in the case of a continuous and spatially homogeneous fishery. However, rents from fisheries and other marine resources affected by fisheries may be dissipated across margins not well defined or controlled by a standard ITQ regime. The stock externality may not be fully internalized by an ITQ system when seasonal depletion occurs (Clark 1980; Boyce 1992). As I discuss below, an analogous problem may result from spatial heterogeneity in unit harvest costs. Vernon Smith (1969) illustrates the potential for rent dissipation from congestion externalities.[3] He suggests that these would be internalized and corrected by a sole owner, but the same is untrue for an individual quota system, which corrects only the stock externality. Congestion externalities occur when fishermen interfere with each other in such a way as to reduce catch rates or increase costs. Although he discounted these as a serious problem, Clark (1980) showed that congestion externalities would lead to rent dissipation in an ITQ fishery. The ambiguity of this concept has led to some disagreement over whether these are likely to be a serious problem (Boyce 1992; Danielsson 2000; Boyce 2000), but the possibility that they may be problematic in some cases cannot be ruled out. If congestion externalities result from a suboptimal allocation of fishing activity over space reacting to spatial heterogeneity in the distribution of fish, it is likely that a remedy may be found in spatial definition of catch rights.

Smith (1969) also noted that rents might be dissipated by suboptimal age selection, which will reduce the potential productivity of the stock both by limiting reproductive potential and by catching fish before their individual rate of growth falls below natural mortality risk. He developed this concept as a mesh externality resulting from a suboptimal choice of mesh size. While mesh size is likely to be regulated in an ITQ fishery, catch or incidental mortality of smaller fish may not be completely avoided. It is well known that ITQs provide incentives for high grading (discarding of less valuable catch), which can tend to reduce the productivity of the fishery. If there is spatial heterogeneity across age classes together with imperfect selectivity, a spatial remedy may again be in order.

The problems described above are internal to the overall ownership of the fishery and might be resolved by a sole owner or an institution capable of achieving cooperative behavior among fishery stakeholders. However, there is a second class of harmful effects that the collective owners of a given fishery will not internalize. These include bycatch, gear conflicts, cross-fishery congestion externalities, habitat destruction, and actions that reduce noncommercial benefits derived from the marine environment (*e.g.*, existence value of marine mammals and amenity value of marine recreational opportunities).

As Cheung (1970) points out, the important question to be raised when considering the implementation of property rights is whether the value of correcting the problem is greater than the cost of doing so. This is an empirical question and a dynamic one, since both the perceived value and the cost of internalizing externalities change over time as a result of new information, new technology, and changes in markets and the environment (Demsetz 1967). Thus, it may not be possible or profitable to define an optimal structure of property rights for a given fishery and much less so for fisheries in general. The more modest goal of this paper is to identify some common problems that are poorly addressed by standard property rights regimes, such as ITQs, that might be mitigated by more clearly defining and possibly attenuating fishery property rights over space.

## Spatial Considerations for Rights-based Fishery Management

Most fishery models and management frameworks ignore space. Stock assessments and harvest guidelines are typically based on the concept of a fish stock, which may encompass a very large area. The fish stock and harvest activities for a given species

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[3] Smith illustrates that you need an instrument for each type of externality. ITQs are one instrument meant to resolve the stock externality, but when there are other types of externalities, one cannot expect that one instrument leads to an efficient outcome.

are typically assumed to be distributed homogenously, and the consequences of deviations from that assumption are rarely explored. Hilborn and Walters (1992, p. 67) define a fish stock as, "an arbitrary collection of populations of fish that is large enough to be self-reproducing (*i.e.*, abundance changes are not dominated by immigration and emigration), with members of the collection showing similar patters of growth, migration and dispersal." But, in the text that follows, they note that, "any natural stock that is large enough to be of management interest will consist of a highly heterogeneous collection of individuals with different sizes, ages, growth rates, movement patterns, reproductive abilities, behaviors in response to fishing gear, and risks of mortality." The presence and susceptibility to harm of other organisms and the habitat that supports them may also vary widely across these substocks. Both the value of animals harvested and the unit cost of harvesting them may vary over space.

This spatial heterogeneity presents both problems and opportunities for fishery management that may not be resolved by non-spatial, rights-based systems. Although stock assessments and harvest guidelines are not often spatially resolved, there has clearly been a recognition that spatial heterogeneity matters and can be exploited. The use of area closures (year-round or seasonal) and spatial gear restrictions is common. In New England, such closures have been used to reduce catches of certain species and to protect concentrations of juveniles, spawning aggregations, and habitat (Murawski *et al.* 2000). Seasonal gear restrictions are used in certain areas to prevent entanglement of marine mammals. Due to a lack of information and models of spatial processes in fisheries, these spatial management measures have often been *ad hoc* and of dubious benefit (Holland 2000). Although they are highly popular with biologists and ecologists (NCEAS 2001), economists have questioned whether closed areas are a useful fishery management tool in an optimally managed fishery (Hannesson 1998). A number of papers have explored whether area closures of various designs might lead to higher catches in a spatially heterogeneous fishery under open- or limited-access conditions (*e.g.*, Holland and Brazee 1996; Hannesson 1998; Sanchirico and Wilen 2001; Smith and Wilen 2003), but the question of optimal management given spatial heterogeneity is only now beginning to receive attention (*e.g.*, Sanchirico and Wilen 2002).

There may, in fact, be few cases where complete closures will benefit "well managed" fisheries,[4] but there are likely to be reasons to control the spatial distribution of fishing effort, harvest, and gear used, even in a first-best world. Our level of understanding of spatial processes in fisheries is increasing rapidly, and technological advances have made implementation and enforcement of spatial rights and regulations feasible and more cost effective. Using examples from fisheries in New England, I discuss a variety of motivations to consider spatial management and perhaps spatially defined fishery property rights as part of an optimal management strategy. Some of the problems discussed below have been explored previously in the literature, though without explicit consideration of whether and how they might be mitigated with spatially defined catch rights.

## Externalities Unresolved by ITQs

The first example to consider is a familiar one that has already been addressed in the literature, but the focus has been on understanding the problem rather than suggesting a solution. It has been shown by Clark (1980) and Boyce (1992) that ITQs may not eliminate congestion externalities that can reduce economic efficiency. Whether

[4] However, non-fishery benefits may justify complete area closures in some cases.

this is likely to be a problem is an empirical question. Boyce illustrates the potential for this problem with the example of a salmon fishery taking place over a discrete period of time at the mouth of a river. In offshore fisheries, such as the Northeast groundfish fishery that is prosecuted over extensive spaces, one might expect congestion externalities would be less problematic. However, as figure 2 shows, the significant overlap in areas fished by fixed and mobile gears in the groundfish fishery suggests at least the possibility of congestion externalities in the form of gear conflicts. Anecdotal evidence suggests that gear conflicts do occur in the Northeast groundfish fishery (Lane 2002). Competition between mobile groundfish gear and lobster gear also takes place. Interestingly, a proposal was made in 1915 (Alexander, Moore, and Kendall 1915) to segregate otter trawl and fixed gear fishing for groundfish in the Gulf of Maine in part to avoid gear conflicts and in part to avoid habitat damage in sensitive areas. Spatially defined quotas might facilitate the process of eliminating conflicts that do exist. Quota holders could resolve these issues through contracting or spatial trades of quota that would segregate incompatible uses. Alternatively, property rights might be attenuated with zoning regulations that segregate gear use.

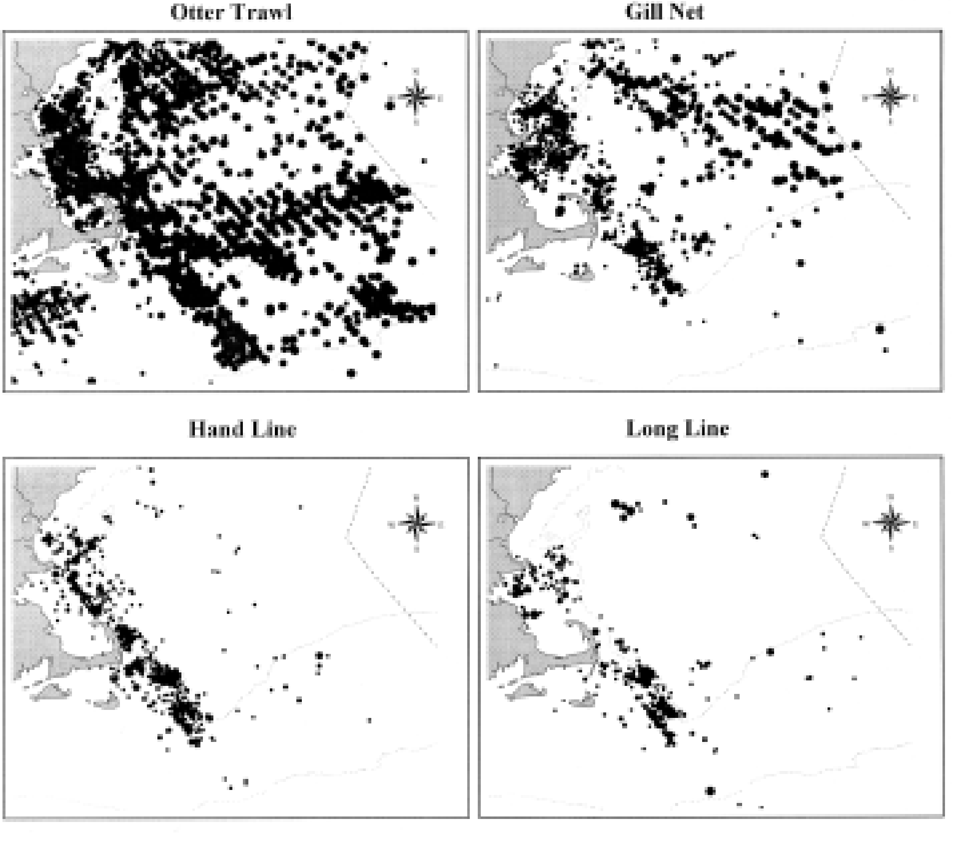


**Figure 2.** Distribution of Groundfish Trips Taken in 2001 Segregated by Gear

Notes: Locations are as recorded in logbooks. The smallest dots are trips of 1 day or less in duration. Intermediate dots represent trips from 1-3 and 3-6 days. The largest dots are trips greater than 6 days in duration. Source data provided by the Northeast Fisheries Science Center of the National Marine Fisheries Service (NEFSC 2001).

A more fundamental concern than congestion externalities is how spatial patterns of exploitation affect the productivity of the fishery resource. Although some fish species are highly mobile and their distributions dynamic, many species, particularly of shellfish, are relatively sedentary or move over a limited range. The concentration of effort in certain areas may reduce the potential productivity of the overall stock by overexploiting part of the population and underexploiting another part. For an organism such as the sea scallop, which aggregates on relatively discrete beds and exhibits limited movement, it is quite obvious that the spatial distribution of effort will affect the productivity of the overall resource. The extreme case of completely prohibiting fishing on a significant part of the stock is likely to drastically reduce yield per recruit. Murawski *et al.* (2000) show that year-round closed areas resulted in a large increase in stock biomass concentration in the closed areas. While these unfished scallop beds might contribute to recruitment[5] in other areas, it is clear that they will reduce the equilibrium yield per recruit for the overall Georges Bank stock unless they are periodically opened to fishing.

Like scallops, groundfish substocks may also experience heterogeneous exploitation rates over space that can reduce overall resource productivity under spatially heterogeneous harvesting. Mixing of the stock through fish movement mitigates this problem, but the degree of mixing may be low for some species. Yellowtail flounder on Georges Bank is an excellent example. Large closed areas on Georges Bank have resulted in high population densities within the closed areas relative to fished areas. A simple visual analysis is compelling. The relative concentration of yellowtail inside the closed areas compared to years prior to the closure is obvious (figure 3).[6] This strongly suggests that movement between areas is limited, which is consistent with scientific knowledge about the spatial dynamics of this species (Murawski *et al.* 2000). Haddock also seem to be aggregated inside closed areas to a much greater degree than they were prior to closures. The situation appears to be quite different with cod. A relatively higher concentration of cod inside the area closures is not obvious. This is not surprising, as cod are believed to be significantly more mobile than yellowtail flounder and have a tendency to move from shallow to deeper water seasonally.

These examples with groundfish illustrate two important points. The first is that spatial heterogeneity in exploitation, particularly area closures, may for some finfish species reduce the overall productivity of the stock in a similar manner as can occur with scallops. A second point is that effects of spatially heterogeneous exploitation rates differ significantly across species. Spatial concentration of catches of species that mix well may have little impact on yields, while for other species it will significantly reduce yields. There is no reason to expect that the spatial exploitation patterns that emerge under a standard ITQ regime will coincide with those that will maximize yields for one species, let alone several harvested jointly in a multispecies fishery.

While heterogeneous exploitation over space may reduce potential yields, there may be other reasons, such as heterogeneity in harvest costs or resource quality (*e.g.*, size or coloration differences, consistency of flesh, occurrence of parasites, *etc.*) that more than compensate for this lost production. Again, ITQs cannot be expected to lead to an optimal spatial distribution of effort, and catch and will tend to motivate overexploitation of the preferred areas. For simplicity, assume that the total

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[5] Technically, recruitment refers to the addition of new fish to the fishable population by growth from smaller age classes, but more generally it refers to additions to the fish population resulting from reproduction.

[6] The groundfish survey undertaken by the National Marine Fisheries Service twice a year is not designed to allow for comparisons of population sizes inside and outside the closed areas, so a formal analysis of relative abundance inside and outside closed areas and the degree of immigration/emigration between them is problematic and beyond the scope of this paper.

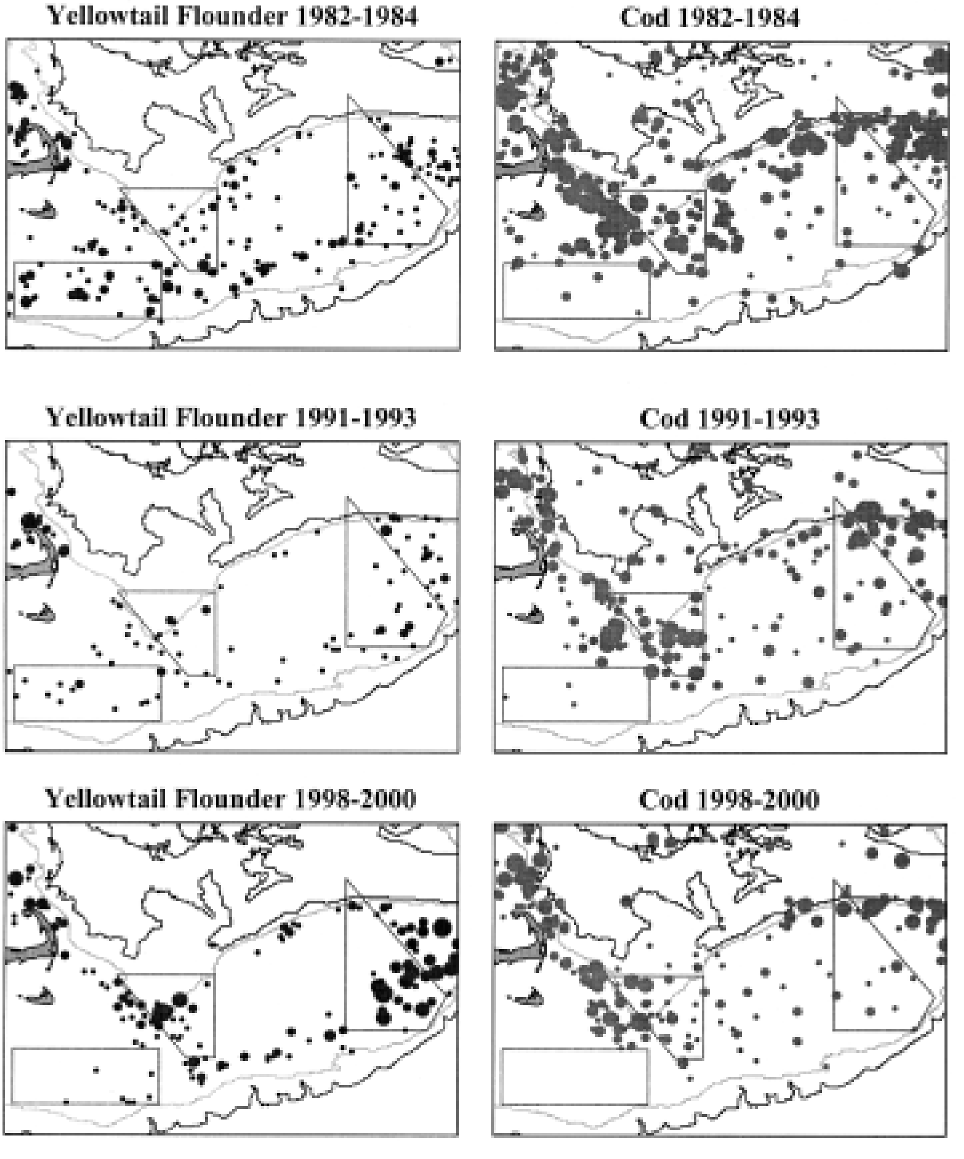


**Figure 3.** Catch per Tow for Summer Flounder and Cod from NMFS Bottom Trawl Surveys (NEFSC 1982–2000)

Notes: Each figure shows all tows with positive catch during spring and fall surveys over three-year intervals. The smallest dots represent tows with CPUE of 1–5 kg per 30-minute tow. Largest dots represent tows over 75 kg per tow. Intermediate size dots represent 5–15 kg/tow, 15–35 kg/tow, and 35–75 kg/tow, respectively. The figures suggest that year-round area closures on Georges Bank (the outlined rectangular and triangular areas) have been effective at protecting resident populations of yellowtail flounder, but there is no clear indication that they have led to a greater buildup of cod populations within the closed areas relative to outside them.

productivity of the stock is not affected by the spatial distribution of the stock. Consider whether an ITQ system will lead to an efficient spatial distribution of effort and catch (relative to sole ownership) when spatial heterogeneity in the productivity of fishing effort exists either as a result of distance from port or physical or biological fishing conditions. Following the logic of Gordon (1954), we would expect effort to be distributed so as to equilibrate the average product across grounds, if the individuals are free to choose where to fish. If we assume that catch is limited, this does not lead to the total dissipation of rents as in Gordon's open-access example, but it does lead to an inefficient distribution of effort. In equilibrium, average net revenue will be equated across grounds, which will be different from the optimal allocation that would equate net marginal product for the two grounds. Relative to the equilibrium solution, total harvest costs would be reduced by the sole owner by moving some effort away from the low-cost grounds to the higher-cost grounds.

The effect of spatial heterogeneity in the productivity of effort is similar to a seasonal depletion model. As Clark (1980) shows, the optimal solution in that case is to apply a constant effort level over the season, but individual vessels have the incentive to apply a decreasing level of effort over time. This will lead to dissipation in rent as a result of increased costs (vessels will not be operating at minimum average cost throughout the season). The same effect would be likely to occur with spatial heterogeneity in the productivity of effort creating a race to fish the best areas with the same effects on cost as the seasonal depletion case. Thus, in the case of spatially heterogeneous harvest costs, a non-spatial ITQ system may allow resource rents to be dissipated both by increasing costs and by decreasing the overall productivity of the resource. Using a simple fishery model with a connected two-patch system, Sanchirico and Wilen (2002) demonstrate, analytically and with simulations, the potential divergence of harvest levels, effort, and overall rent that might occur when an individual quota or optimal tax is applied to the overall resource versus optimal controls on each patch.

The discussion above suggests that spatially heterogeneous exploitation rates may be desirable in the sense that they equate the value of marginal product of effort over space. However, if heterogeneity in exploitation rates reduces the productivity of the resource, rent maximization may require balancing cost increases from effort distributions that don't equate marginal product with gains from effort distributions that maximize resource productivity. An adjustment must be made in determining the correct overall quota, and the size of the adjustment is dependent on knowing the distribution of fishing effort. Thus, the optimal sizes of the total quota and the correct spatial distribution of effort are interdependent and must be solved for simultaneously.

There are additional problems that may be caused by spatial concentration of catches. It has been suggested that the ability of substocks to regenerate may, in some cases, be dependent on their own adult populations rather than the overall stock. Given limited movement of adults, spatial concentration of effort might lead to serial depletions in this case. If we consider the usual fishery production function, $Y = qEX$, where catch, $Y$, is a function of nominal effort, $E$, biomass, $X$, and a catchability coefficient, $q$, serial depletion would be likely to occur only if the catchability coefficient rose as biomass fell (*i.e.*, $q'(X) < 0$). This has been hypothesized to occur for schooling pelagic fish such as tuna, but is also likely for sedentary species, which may remain in dense aggregation even as increasing proportions of the physical area the substock occupies are fished out (Hutchings 1996). Individual fishermen, even ITQ holders, would not have the incentive to move to another area if catch rates remained high, since they do not incur the full cost of their actions. In theory, U.S. law would require that these substocks be managed independently if they were indeed reproductively isolated, but in practice it may not be possible to identify such substocks. It has been suggested that serial depletion may have occurred in Canada's northern cod stock and may be the reason that stock has not regenerated despite an almost complete cessation of fishing (Hutchings 1996). Such serial depletions could likely be avoided if the total catch from the stock was limited to the level providing the maximum economic yield, but the possibility is not eliminated. In the absence of information about the connectivity and range of individual substocks, it might not be feasible to specify an appropriate catch for each, but a management system that tended to smooth out exploitation rates over space could be expected to decrease the risk of serial depletions.

Source-sink processes may also contribute to suboptimal outcomes in ITQ fisheries. Consider the example of the scallop fishery on Georges Bank and in Southern New England. It has been hypothesized that recruitment to the scallop grounds to the south and west of Georges Bank is supplemented by reproductive output of scallop substocks on Northeast Georges Bank (Tremblay *et al.* 1994). Beds on Northeast Georges may be somewhat reliant on western substocks for recruitment. This is the result of a relatively stable gyre that transports the eggs and larvae in a clockwise direction around Georges Bank and in an east-to-west flow off the western end of the bank (figure 4). It may be beneficial to forgo harvests in source areas in order to increase recruitment in others. Higher exploitation rates might be justified in areas that are sinks for recruits but do not appear to be sources for other areas. In the absence of good information about the spatial and temporal dynamics of recruitment, this problem may be difficult to solve. However, that lack of information suggests a management strategy that would prevent local depletion of any area that might be a reproductive source. This would require controlling catches on a finer spatial scale than is currently done and might be facilitated by spatially defined catch rights.

Examples of source-sink relationships between fish substocks are not uncommon. Although they do not explore the optimal spatial distribution of effort, Smith and Wilen (2003) show that the benefits of area closures in the Northern California urchin fishery would differ greatly by location due to oceanographic processes that effect larval dispersal as well as the resultant distribution of fishing effort. Non-sedentary finfish species may also be subject to these phenomena due to migratory patterns (Jones and Wells 2001) or spatial recruitment processes (Roberts 1998).

## *Multispecies Fisheries*

Multispecies fisheries can present particular difficulties for ITQ management systems if species are subject to jointness in production. Where fishermen have limited ability to determine the species composition of catch, both overfishing and reduction of quotas below optimal levels (due to bycatch constraints) can occur (Holland and Maguire 2003). In most multispecies fisheries, fishermen will probably have some ability to alter the species composition of their catch either by location choices or alteration of fishing gear or methods. Quota prices for individual species should adjust to provide incentives for the fleet to bring their catch composition in line with species quotas. However, in some cases it may be more profitable for an individual fisherman to simply discard certain species rather than land them and pay for quota. Eliminating these incentives may require a high degree of observer coverage, which can be very expensive, particularly for small fishing vessels.

The problem is analogous to high grading in a single-species fishery. Regulations may prohibit discarding, but without observers on board at all times, such regulations may be unenforceable. Although information requirements to do so may

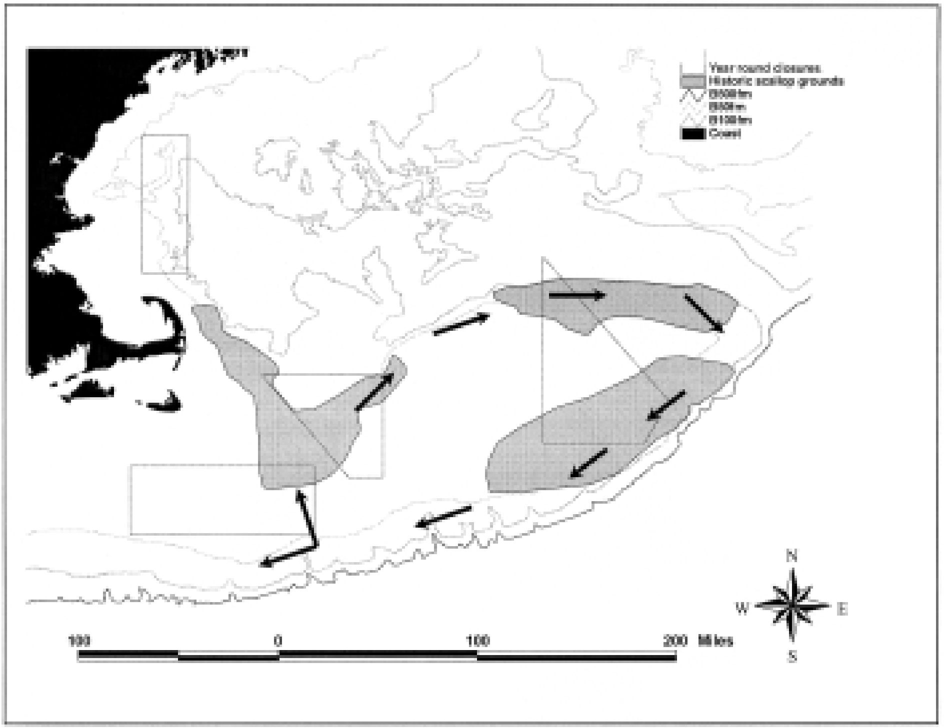


**Figure 4.** Scallops Have Historically Been Concentrated in the Gray Areas Indicated

Notes: These probably do not represent independent, self-sustaining populations. The prevailing currents form a clockwise gyre that tends to advect scallop larvae around the bank and off it to the southwest. As a result, recruitment to various locations on Georges Bank may be at least partly dependent upon current stocks. Some scallop beds in Southern New England may be dependent on recruitment from Georges Bank.

be high, there may be cases when spatially defined catch rights will mitigate this problem. For example, a larger share of the overall quota for a relatively abundant species with a high TAC might be allocated to an area where another less abundant species with a low and constraining TAC is less prevalent, thereby decreasing the probability of discarding. As figure 5 shows, different groundfish species taken on and around Georges Bank are distributed heterogeneously in space offering opportunities for fishermen to alter species composition through location choice. Individual quotas might provide the proper incentives for the fleet to adjust its species composition in line with quotas. However, if discarding is still problematic, the incentives to do so might be eliminated by allocating catch rights by area. The same argument may hold for juvenile bycatch. ITQs will provide little, if any, incentive to avoid bycatch of juveniles. Thus, unless fishing gear is perfectly selective, it may be useful to concentrate quota in areas with relatively few juveniles or use zoning regulations to restrict use of non-selective gear in those areas.

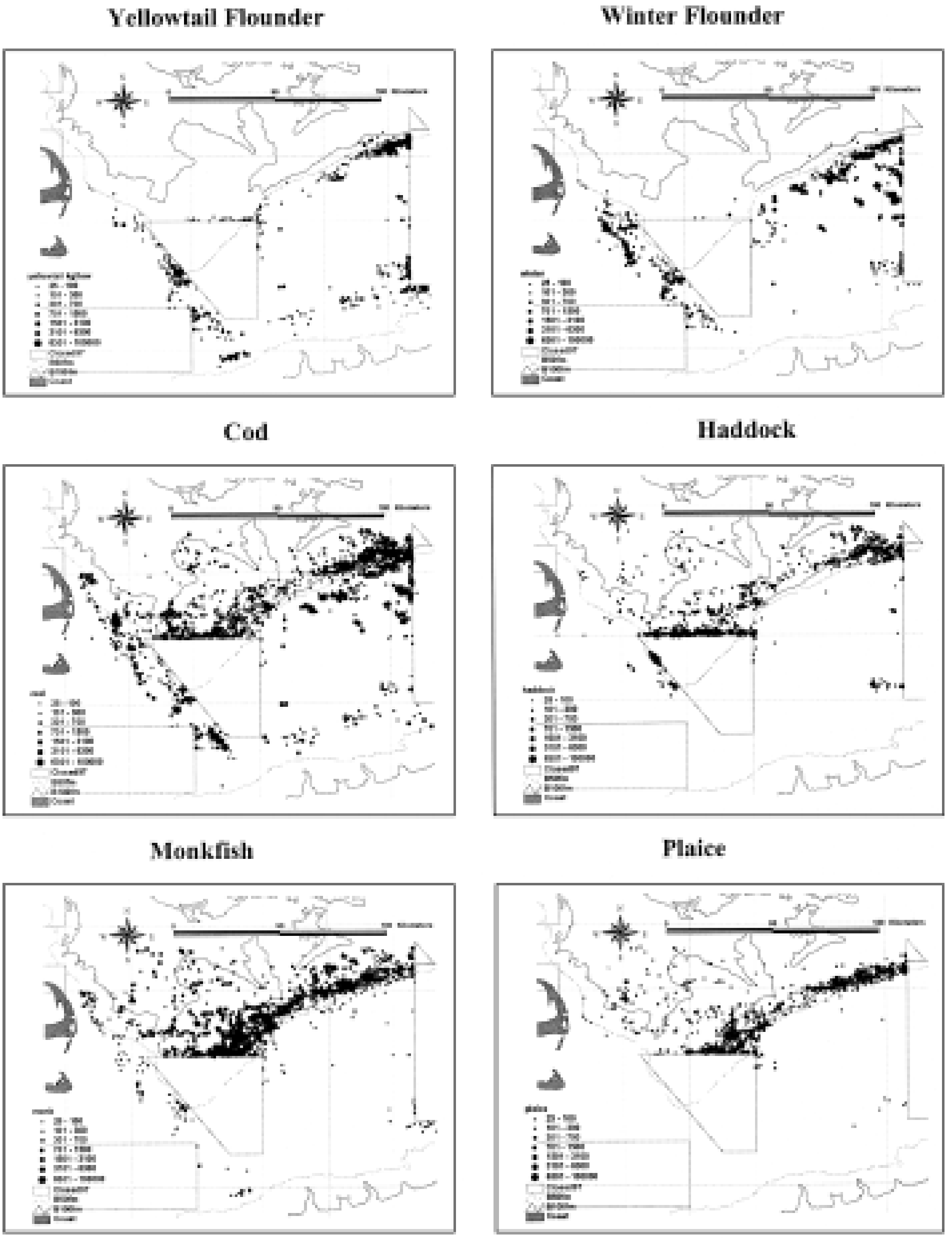


**Figure 5.** Spatial Distribution of Catch per Tow, by Species, for Five Primary Groundfish Species and Monkfish

Notes: Data reflect catches from individual tows recorded by a study fleet of trawlers based in New Bedford, Massachusetts. Source data collected by the RFAC program, School of Marine Science, University of Massachusetts Dartmouth (RFAC, 2001).

### *Considerations Beyond the Objective of the Sole Owner*

The sole owner of a fishery or a group of owners working cooperatively might internalize and mitigate many of the externalities discussed above. Sole ownership of all fisheries in an area large enough to encompass all fish stocks with interactions (*i.e.*, very large TURFs) would internalize cross-fishery externalities, as might cooperation between owners of catch rights. But, large TURFs are unlikely to be politically acceptable, and cooperation becomes increasingly difficult to organize and monitor with multiple stocks over large areas. Incentives to limit adverse impacts on other components of the marine environment not related to rent generation (*e.g.*, amenity and existence values) would still exist. The assignment of catch rights for fish stocks (whether to sole owners or groups of individuals) may facilitate contractual negotiations to limit these external impacts in a welfare maximizing way (Coase 1960). For example, quota holders might voluntarily agree to avoid certain areas or fishing practices in return for compensation. However, high transactions costs may prevent this type of contracting from happening.

Spatially delineated harvest rights may facilitate these contractual solutions. For example, it might be feasible to use instruments similar to easements used to preserve open space. Environmental groups concerned with protecting a particular area from the effects of fishing gear might purchase the quota for that area or simply buy easements from quota holders that would require them to use gears that would not impact the area concerned. This would be considerably more difficult without spatially defined catch rights because contracts with all quota holders would be required instead of only holders of catch rights for the area of interest. The possibility of contractually resolving gear conflicts or interfishery bycatch issues through agreements to change the spatial distribution of fishing effort or alter fishing practices in sensitive areas would also be increased; again, quite simply, because the number of parties involved in a given area is likely to be smaller.

Spatial property rights may also provide useful information to policymakers about the efficiency of regulatory actions, such as area closures or spatial gear restrictions. Spatial variation in quota prices for the same species will make the costs and benefits of these actions transparent. It will also provide information on the costs and benefits of maintaining a given spatial distribution of catches without requiring detailed cost-earnings data from fishermen. For example, the costs of the imposing a gear restriction in a given area would be revealed by the drop in quota prices for that area and can be compared to the estimated benefits.

## Limitations of T-SURFS and the Case for Marine Zoning

If high transactions costs make contractual methods of mitigating gear conflicts and external effects of fishing infeasible even with spatially defined catch rights, zoning may be a preferred alternative. Unlike the contractual route, zoning will involve an uncompensated wealth transfer from those whose property right is restricted (*i.e.*, the quota holder who loses the freedom to use trawl gear). Since quota shares have generally been gifted to prior fishery participants, to date, zoning that coincides with implementation of the ITQ program will simply reduce the original wealth transfer to quota holders. However, implementing zoning regulations after an ITQ system is in place is likely to redistribute or reduce wealth of quota holders and will be contentious. Distributional issues aside, zoning will be welfare improving if it reduces negative externalities by an amount greater than the costs of implementation and enforcement (Pogodzinski and Sass 1990).

Zoning has been known to motivate rent-seeking activities in the terrestrial case. While rent seeking might dissipate the efficiency gains[7] achieved by zoning, it is not clear that it would be worse under a spatial property regime than a non-spatial one. As Edwards (forthcoming) points out, rent seeking is already widespread in fishery management today where most fishery regulations tend to have uneven effects on different groups of stakeholders. Nevertheless, the problem of rent seeking is important, and it is worthwhile to try and design institutions (*e.g.*, the management organizations that create zoning regulations) in such a way as to minimize rent seeking.

It should be noted that outright separation of activities through zoning may not be as efficient as controlling the levels of those activities. Like area closures, zoning is a blunt instrument and is unlikely to equilibrate the marginal costs and benefits of various competing activities. Furthermore, the diseconomies of competing activities must be weighed against the benefits that may be lost by segregating them. Although the spatial processes and interactions involved differ, the literature on multiple-use forestry has addressed this question using standard concepts from production economics relating to joint production. In this case, we are concerned with jointness in production from the viewpoint of the social planner, where production activities may involve multiple actors rather than an individual firm. Sahanjananthan, Haley, and Nelson (1998) explain the basic analytical framework. Activities are complements if an increase in output of one causes the incremental cost of producing additional units of a second good to fall (economies). They are substitutes if they cause incremental costs of the other good to rise (diseconomies). Activities are independent if they do not affect each other's costs at a particular level of production. The concept of economies of jointness can be extended to consider the net benefits of joint activities. An important observation made by Sahanjananthan, Haley, and Nelson is that cost relationships between pairs of goods may be local in the sense that they vary with the level of production. Thus, the activities may exhibit complementarity, substitutability, and independence at different output levels.

In cases where diseconomies of jointness, including transactions costs associated with coordination of joint production, exceed related economies of joint production at all levels (*i.e.*, activities that do not exhibit complementarity for any combinations of activity levels), it may be preferable to separate production activities. This may suggest the need for zoning or year-round closed areas. Note, however, that if diseconomies are local, then it may be sufficient and preferable to limit the level of various activities rather than completely separate them. Specifying the levels of various activities that equilibrate costs and benefits at the margin may also require information not available to regulators. However, allowing some limited level of activity will produce information about the value of the activity that will otherwise remain an uncertainty.

Economies of jointness, at least local economies, provide motivation for multispecies fisheries. However, weak separability in outputs (*e.g.*, decreasing one "bad" output requires reducing another "good" output) may lead to diseconomies of jointness when there is an incidental catch that is not commercially valuable or is not saleable for regulatory reasons.[8] Incidental take[9] of marine mammals is an im-

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[7] Rent seeking can dissipate efficiency gains because resources are expended to influence distributional outcomes without increasing total benefits and because they may lead to outcomes that yield lower total benefits but high benefits to a small, but influential, group.

[8] Interestingly, existing ITQ systems have specifically prohibited fishermen from taking advantage of these economies in some cases. Trawlers in Alaska are not allowed to purchase and use halibut quota, but are tightly restricted in the level of bycatch allowed. Since this can restrict their ability to harvest the total quotas of other species, the potential value of halibut quota to this fleet may be considerably higher than market prices (Holland and Ginter 2001).

[9] Take may refer to the killing of the animal, but in the case of marine mammals, even a disturbance of the animals may be considered a take.

portant example, but fishing gear may "take" a wide variety of animals and plants that generate value through the role they play in the ecosystem or simply due to value people place on their existence. Spatial heterogeneity in the distribution of different species may provide opportunities to coordinate resource exploitation spatially to reduce diseconomies and take advantage of economies of jointness. This may not require prohibition of a fishery in an area, but simply place restrictions on gear or timing of the fishing activity. For example, fixed gear is not allowed in certain areas of the Gulf of Maine at certain times of year to avoid incidental catch of marine mammals (figure 6), but mobile gear is still allowed in those areas. Although managers may not have explicitly examined the tradeoffs, presumably fixed gear is not prohibited from these areas year-round, because marine mammal interactions are relatively low at those times and prohibition would be an unnecessary cost.

Habitat damage from fishing gear has become an issue of increasing concern in recent years. The 1996 reauthorization of the Magnuson-Stevens Act (the "law of the land" for federal fishery management in the U.S.), requires fishery managers to identify "essential fish habitat," and most Fishery Management Councils are developing plans to protect certain areas from habitat damage either through outright closures or gear restrictions. The primary motive for protecting habitat is that it contributes to the productivity of fisheries. This may occur as a result of decreased natural mortality of juveniles dependent on complex habitat to avoid predators or by increasing or preserving the carrying capacity of fisheries. An individual quota system, and even sole ownership of a fishery, might not provide sufficient incentives to

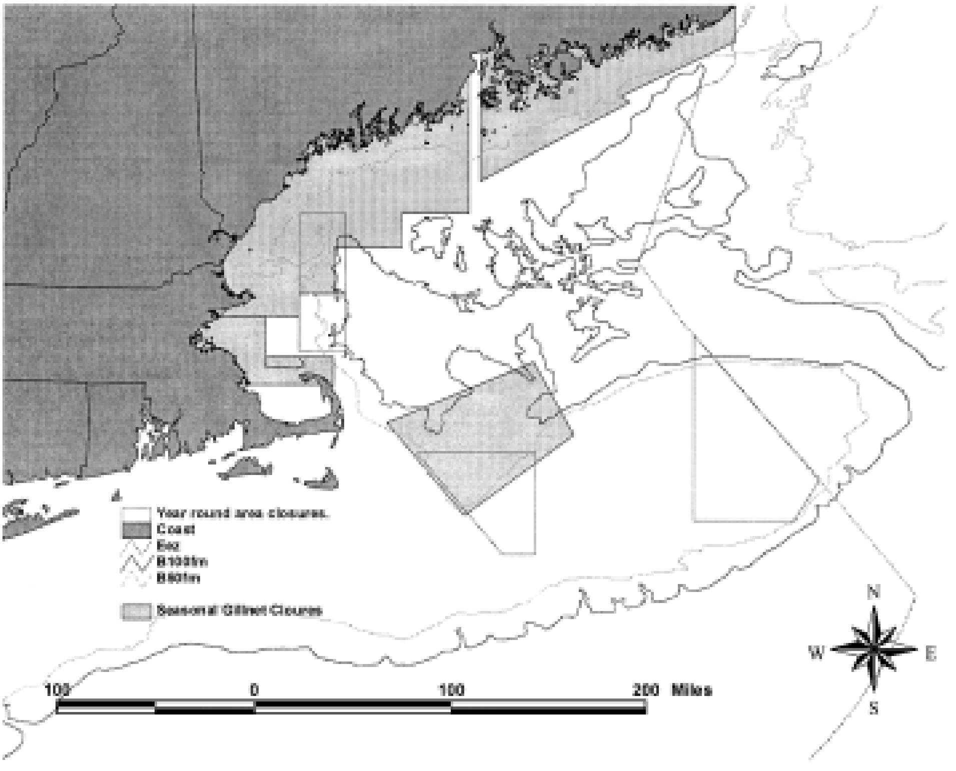


**Figure 6.** Some Areas are Closed to Gillnets at Certain Times of Year to Reduce Entanglements of Harbor Porpoises and Right Whales

forgo fishing activities that would detrimentally affect habitat, particularly where benefits accrue to fisheries other than that for which an individual owns quota.

To optimize the productivity of the fishery, it may be necessary to specify the effort intensity or gear types that can be used in discrete areas. There may well be reasons to completely prohibit all exploitive activities in an area (*e.g.*, particularly sensitive habitat or controls for scientific study), but habitat protection areas and fishery area closures need not be synonymous. Costs and benefits of allowing various levels of competing activities (*i.e.*, habitat conservation and fishing) must be assessed. For example, the New England Fishery Management Council has authorized limited and tightly controlled access to scallops inside two closed areas on Georges Bank (www.nero.nmfs.gov/ro/fso/reports_frame.htm). This special access program has allowed the scallop fleet to harvest tens of millions of dollars worth of scallops that would otherwise have been lost to predation by starfish and natural mortality. The program was limited to less sensitive areas of habitat and may have had a net positive impact on habitat in the larger region. To access the closed area, vessels gave up ten days out of their individual effort quotas and were allowed to take up to 10,000 pounds of scallop meats. On average, they were able to do this in four days. This reduced the fishery's total amount of dredge contact time with the bottom (a net reduction of six days per trip taken in the closed areas), while increasing fishery revenues and decreasing operating costs.

Some undesirable outcomes associated with rights-based systems for fisheries may be mitigated by attenuating catch rights, not by where fish are caught, but by where they are landed. Individual quota systems may have adverse effects on fishery-dependent communities as a result of consolidation of landings in fewer ports. This is particularly likely if excess fishing or processing capacity existed before implementation of a rights-based system. U.S. law requires fishery managers to consider the effects of regulations and regulatory systems on fishing communities. To varying degrees, fisheries and spatial subcomponents of them are often tied to communities (figure 7). Requirements to harvest or land fish associated with particular quota shares in specific areas may resolve this problem, albeit at some cost in efficiency from the viewpoint of the industry. However, if preservation of traditional fishing communities provides value to the public, this may be justified.

## Conclusions

Correctly defined property rights offer a means to achieve more optimal use of marine resources with a minimum of top down control. However, ITQ systems may still allow for the dissipation of rents across unpriced and uncontrolled margins. Also, TURFs will generally fail to create complete property rights. Even sole ownership may not prevent many welfare-reducing activities that diminish non-market value streams from public goods. Defining fishery property rights in space, and use of zoning regulations to attenuate those rights in some cases, may provide an effective means to resolve many of these problems. The appropriate spatial resolution of spatial property rights and zoning will differ across fisheries according how much species move and the spatial precision of information. This suggests that terrestrial-style property rights that grant one entity rights to all activities in a particular location are unlikely to be optimal in most cases. Rather, rights to undertake specific activities in specific areas would be given, and the scale and boundaries for different activities would likely differ.

Implementation of spatial fishery quotas or of zoning regulations may be costly for a number of reasons. Although development of vessel tracking systems has reduced these costs significantly, enforcement and monitoring costs may still be

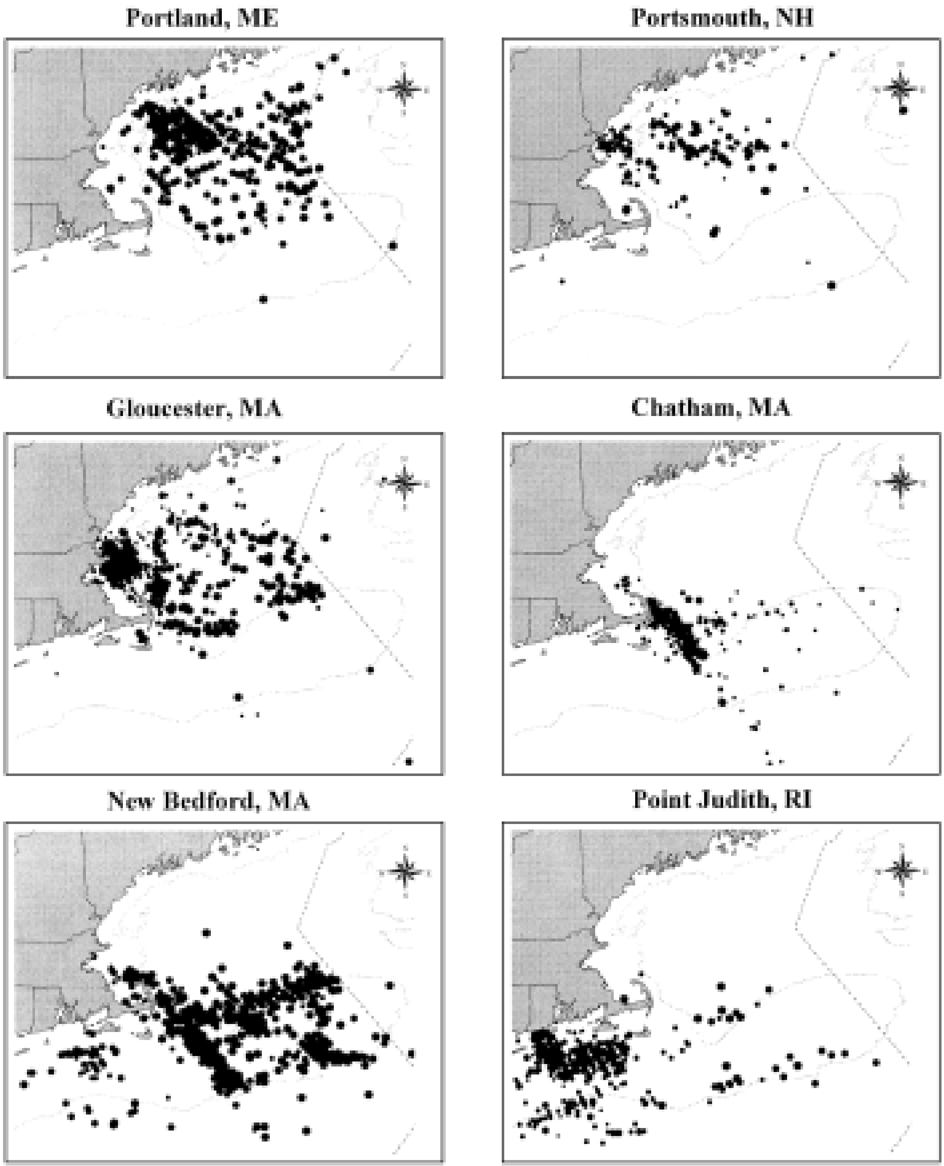


**Figure 7.** Distribution of Groundfish Trips Taken in 2001 Segregated by Port of Landing

Notes: Locations are as recorded in logbooks. The 6 ports shown represent 6 of the most important groundfish ports, and each support important significant fishing communities. The smallest dots are trips of 1 day or less in duration. Intermediate dots represent trips from 1–3 and 3–6 days. The largest dots are trips greater than 6 days in duration. Source data provided by the Northeast Fisheries Science Center of the National Marine Fisheries Service.

higher than for nonspatial management systems. Generating the information needed to set explicitly spatial quotas or determine appropriate zoning regulations may be even more costly. Stock assessments have not traditionally been designed to determine stock distribution. Doing so may require much more intensive surveys and more sophisticated models. The cost and feasibility will, of course, vary across fisheries. While a spatially explicit stock assessment for the sea scallop fishery may be both accurate and cost effective (Stokesbury 2002), spatially explicit stock assessment for groundfish is likely to be much more difficult and probably less precise. Improper spatial assignment of catch quotas that might occur as a result of poor information may be very costly, and might even lead to local fish stock depletions.

The value of explicit spatial policies depends on a variety of factors that will change over time with advances in technology and science and as markets and the environment change. Thus, attempts should be made to build in flexibility to governance regimes that will allow adaptation of property rights over time without eliminating incentives for investment and stewardship that follow from secure, long-term property rights.[10]

This paper used examples from New England fisheries to illustrate some of the benefits and problems associated with use or nonuse of spatial fishery rights to manage fisheries. These fisheries are not currently managed with rights-based systems, although operators do have nontradable individual effort allocations. There is a strong reluctance by many fishery stakeholders to move toward a rights-based system of management (particularly where rights are defined in terms of outputs as opposed to inputs). While a rights-based system might be difficult to implement in these fisheries, it offers substantial benefits over the existing management regime, which has generally failed to control fishing mortality or promote efficiency. A spatially defined rights system may offer greater benefits than a standard ITQ system for these fisheries.

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[10] Institutional innovations such as the "Australian drop through" system (Young 1995) may be useful. This system allows for a gradual change in the set of rights and obligations associated with individual quotas. Individuals have a fixed-term entitlement to a set of rights and obligations, but can exchange them at any time for a new fixed-term set of rights and obligations on offer from regulators. Individuals have the choice of accepting the new entitlement, which may decrease the value of catch rights, or waiting for their entitlement to expire, at which point they would have to accept whatever entitlement was available at that time.

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