An Elemental Basis of Property Rights to Marine Fishery Resources

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Abstract. Among the questions that ecosystem-based management raises for economists is how to partition uses of the many biological, chemical and physical attributes of marine ecosystems into sets of property rights that undergird total ocean wealth. An elemental basis of property rights for fisheries involves the interplay between ecological and technological interactions, including side-effects (externalities), and transaction costs. Fisheries management typically divides ownership by species. Divided ownership is efficient where production requires specialized skills and technologies and/or where interactions are negligible. When damages caused by side-effects are substantial, divided ownership might be used either by attenuating (e.g., gear restrictions) or excluding (e.g., zoning) a subset of attribute rights, provided that the opportunity (reduced output) and transaction costs of restrictions/exclusions are less than damages in their absence. However, uncertainty about resource dynamics, the recurrent nature of interactions, the complexity of numerous contractual stipulations owing to multi-attribute resources, and practical enforcement problems make it likely that the transaction costs of divided ownership are great at this time. Alternatively, property rights could be bundled into sets wherein tradeoffs across margins which promote the total wealth of a multi-attribute, common pool asset would be decided internally by a governance organization. Bundled sets of property rights influence the choice of organizational structures (government agency, commons, unitization of firms) and contracts (fishery management plans, rules, private contracts). The discussion is illustrated with examples from U.S. fisheries in the Northeast Region.

Keywords: Property rights, contracts, ecosystem-based management

1. INTRODUCTION

Failures of traditional single-species approaches (Larkin 1996) and a growing awareness of environmental impacts (Auster and Langton 1999) are advancing interest in ecosystem-based management of fishery resources.[1] Scientists have identified general principles and recommended policies to maintain ecosystem health and sustainability (NMFS 1999). Sherman and Duda (1999) go further by recommending that science-based assessments be linked to the socio-economic benefits and governance of large marine ecosystems (LMEs).[2] What's missing from these preliminary discussions is a clear understanding of how property rights assignments affect the ways people manage and use the environment and, therefore, the total value of fishery assets and production; property rights, incentives, and economic behavior are closely interconnected (Furubotn and Pejovich 1972).

Among the questions that ecosystem-based management raises for economists is how to partition uses of the many biological, chemical, and physical attributes of LMEs into sets of property rights that undergird total ocean wealth. In contrast to related work on institutional design issues germane to ecosystem-based management (Hanna 1998) and to considerable research on *single*-species or *single*-fishery use rights such as ITQs (Neher et al. 1989), I attempt to explore an elemental basis of property rights to marine fishery resources. An elemental basis of property rights concerns how *mingled* resource characteristics, production technologies, and transaction costs influence wealth-maximizing combinations of property rights and choices of contractual arrangements. This line of inquiry traces back to Gordon (1954) who advanced a theory of rent dissipation from non-exclusive fishing grounds which are differentiated by productivity and location. Later, Cheung (1970) examined how transaction costs can preclude including all attributes of a heterogeneous fishery resource into contracts, leading to rent dissipation along unspecified, incompletely specified, or unenforced margins. With few exceptions (e.g., Eggertsson 1993; Lueck

[1]For example, an entire issue of the journal, Ecological Applications, was recently devoted to “sustainable marine fisheries” (volume 8(1), Supplement, 1998).

[2]See Sherman and Duda (1999) for a discussion of LMEs - i.e., areas of the ocean differentiated by bathymetry, hydrography, productivity, and trophic structure - and references to this literature.

1995), though, the economics literature on natural resources has not kept pace with the body of property rights theory which pertains to partitioned uses of resources and to the so-called "externalities", or side-effects, caused when uses interact.[3]

My paper is organized as follows. Section 2 briefly characterizes the multi-attribute nature of marine fishery resources, including ecological and economic interactions that can cause side-effects. Section 3 reports on the theory of property rights as it relates to side-effects and wealth from uses of multi-attribute resources. In Section 4, the contractual arrangements used to manage uses of fishery resources in the Northeast Shelf Ecosystem of the United States are described. Section 5 concludes the paper.

2. A SCIENTIFIC BASIS FOR PROPERTY RIGHTS TO USES OF FISHERY RESOURCES

It is necessary to characterize marine resources because resource attributes determine potential wealth and the transaction costs of property rights arrangements.

LMEs are comprised of many biological (e.g., populations of phytoplankton, fish, and mammal species), chemical (e.g., salinity, oxygen concentration), and physical (e.g., sediment type, oil pool, currents, space) resources which either directly or indirectly yield goods and services valued by humans, including seafood, recreation, petroleum products, sand, transportation corridors, and waste assimilation. Resources which do not limit human demands because they are superabundant in their natural supply or are too costly to extract compared to manufactured or naturally occurring substitutes on land do not need to be allocated over time or among uses. In contrast, scarce resources are potential candidates for government, common, or private ownership rights.

Marine resources are not one-dimensional, homogeneous entities, however; they are differentiated by attributes associated with quantity, quality, location, juxtaposition, and relationships. Cheung (1970: 50) describes fishery resources as combinations of "the ocean bed, the water, [and] the fish." A fish stock is differentiated by species, biomass, population, fecundity, recruitment, age and size structure, sex composition, growth rate, geographic location in space and time, coexistence with other species, and environmental and habitat attributes. Similar lists can be made for individual cohorts or even individual fish.

Key to the partitioning issue are relationship attributes which link fishery resources and the environment over large spatial scales. Two related aspects of relationship are physical coexistence and the geographic range of the populations and habitats. For example, Gabriel (1992) and Overholtz and Tyler (1984) identified assemblages of demersal finfish species that persistently coexisted inside large areas of the Northeast Shelf Ecosystem. Several species, including Atlantic cod *Gadus morhua*, haddock *Melanogrammus aeglefinus*, yellowtail flounder *Limanda ferruginea*, American goosefish *Lophius americanus*, and spiny dogfish *Squalus acanthias*, were members of more than one assemblage. Although not analyzed, demersal shellfish species, such as Atlantic sea scallop *Placopecten magellanicus* and American lobster *Homarus americanus*, inhabit many of the same assemblage areas. In contrast, pelagic species such as Atlantic herring *Clupea harrengus* and Atlantic bluefin tuna *Thunnus thynnus* traverse several LMEs in addition to the Northeast Shelf Ecosystem.

Relationships go beyond juxtaposition and scale, however. Species that coexist are woven by ecological interactions and habitat requirements. For example, Link (1999) notes that finfish, invertebrate, mammal, and bird species that inhabit the Northeast Shelf Ecosystem are part of a highly generalized food web which exhibits extensive dietary overlap. American goosefish and spiny dogfish are top predators in this food web, consuming a wide range of other commercial species that prey on each other (e.g., gadids and flounders). Single-species management does not explicitly account for trophic interactions (Larkin 1996).

Relationships among resource attributes also stem from economic behavior involving technical and price interactions. In multispecies fisheries in particular, harvest of several commercial (or recreational) species in an assemblage is often joint (Kirkley and Strand 1988; Squires et al. 1998). That is, coexisting species are caught together by the same inputs (e.g., crew, gear, etc. on a vessel), although the relative proportions in the catch are affected by a gear's species- and fish size-specific catchability properties and whether fishermen can alter the catch mix in response to input or dockside prices by adjusting fishing techniques (e.g., speed of tow in trawl fisheries, avoid spawning sites). Likewise, many species for which there is no market - so-called "trash" species, but also marine mammals and endangered species - are either caught incidentally and discarded or harmed by contact with fishing gear (Alverson et al. 1994). Finally, mobile bottom gear such as trawls and dredges modify the geological and biogenic habitat on the sea floor (Auster and Langton 1999).

Data collected by the sea sampling program of the Northeast

[3] Side-effects result when an activity by person A causes an incidental impact - either positive or negative - on the property right(s) belonging to person B. The property rights literature uses the term, side-effect, because "externality" implies that the harmful (or beneficial) effect is inherently outside the decision-maker's consideration.

Fisheries Science Center of the U.S. federal agency, the National Marine Fisheries Service (NMFS), are suggestive of joint production and incidental catches (Edwards et al. in press). Among the trips sampled, "target" species comprised roughly half of total catches by weight in the groundfish, Atlantic sea scallop, and American lobster fisheries. Species regulated by other fishery management plans in the Northeast Region comprised a small fraction of lobster pot catches to over half of sink gillnet catches by weight. For example, spiny dogfish constituted a substantial catch in groundfish trawl and gillnet fisheries. Similarly, American goosefish was a significant component of the catches in the groundfish and Atlantic sea scallop fisheries, and the flounder catch in the scallop fishery was also considerable. Unregulated marketable species also accounted for a significant share of catches by each gear. For example, lobster pot gear caught large amounts of *Cancer* crabs, while bottom trawl gear caught considerably more quantities of skates *Raja* spp. than Atlantic cod, haddock and yellowtail flounder combined on the sea sampled trips. Finally, catches of uneconomic species provide a glimpse of possible ecological impacts. For example, most discards by bottom trawl vessels were comprised of "trash" fish such as various sea robin and starfish species.

Joint production, incidental bycatch, and habitat impacts often lead to regulations intended to restrict production. For example, regulatory bycatch limits are often used to control the landings of species that are perceived to "belong" to other fisheries. Once a limit is reached, the fishery exhibiting bycatch either discards the species or it is closed. Area closures are also frequently used to exclude fishermen from the juvenile or spawning populations of bycatch species, and from habitat, marine mammals, and endangered species.

3. PROPERTY RIGHTS THEORY

Section 2 briefly discussed attribute heterogeneity and ecological and economic interactions that influence property rights structures and organizational arrangements for fisheries. With this foundation, Section III addresses for marine ecosystems what Lueck (1995: 8) says is "the fundamental question of wildlife ownership: What is the optimal pattern of landownership when the land has numerous valued attributes that require property rights to be defined over different margins?" I draw heavily from the original insights of economists such as Nobel laureate Ronald Coase and others who have synthesized the general theory of property rights and transaction costs (e.g., Barzel 1989; Eggertsson 1990).

At its core, "economics is the study of property rights over scarce resources."[4] Property rights are the socially sanctioned and protected entitlements of individuals or governments to use, to change the form and substance of, to benefit from (e.g., income, utility), and to alienate ownership of these rights to assets, including natural resources (Barzel 1989; De Alessi 1983; Eggertsson 1990; Furubotn and Pejovich 1972). Ownership and exchange apply to property rights, not physical entities:

> "We may speak of a person owning land and using it as a factor of production but what the land-owner in fact possesses is the right to carry out a circumscribed list of actions ... [including] the right to do something which has a harmful effect (such as the creation of smoke, noise, smells, etc.) ... Just as we may use a piece of land in such a way as to prevent someone else from crossing it, or parking his car, or building his house upon it, so we may use it in such a way as to deny him a view or quiet or unpolluted air." (Coase 1960: 44).

Likewise, fishermen do not own vessels per se; they own a title and permits that allow them to use their vessels to catch certain fish, but they may not engage in piracy or smuggling. The exchange of property rights involve contracts that stipulate ownership, the rights being exchanged, and the conditions and rules (e.g., attenuations, duration, responsibilities) of exchange (Cheung 1970). Contracts between individuals often attenuate (e.g., limited warranties and leases) or exclude certain specific property rights from the exchange. Government regulations also exclude or restrict property rights.

Related to property rights is the notion of transaction costs. Transaction costs are the (opportunity) costs of negotiating, monitoring, and enforcing an exchange of exclusive property rights to resources (Barzel 1989; De Alessi 1983; Eggertsson 1990). The cost of gathering information on resources in order to stipulate a contract is included in transaction costs, but production costs are excluded. Transaction costs are key to an understanding of side-effects (Cheung 1970; Coase 1960), organizational arrangements (De Alessi 1983; Williamson 1979), and property rights development (Libecap 1989).

In his path-breaking article on maximizing wealth where side-effects exist, Coase (1960) explained that, aside from the wealth effect of income distribution, the initial partitioning of property rights does not affect the total value of an economy's production *if* information and transaction costs are zero. In such a hypothetical world, property rights to all resources are privately owned and costlessly exchanged in markets (at a price) until combinations that maximize the total value of production are realized. In reality, however, transaction and information costs can preclude an optimal rearrangement of rights. The mere existence of a side-effect is not sufficient

[4]Furubotn and Pejevich (1972: 1139) quote an unpublished paper by a early property rights theorist, Armen Alchian.

evidence of inefficiency.

Transaction costs vary according to the size of a resource and its complexity (Cheung 1970). In fact, each attribute can require a number of stipulations in a contract that affect its use, benefits, and exchange. For example, being costly, ownership is rarely complete, and the rights to individual attributes are not equally defined (Barzel 1989). The benefits of resources and resource attributes that are not covered by enforceable contracts are vulnerable to capture and dissipation in the public domain.

Side-effects reveal either the absence of a contract, a contract with incomplete stipulations to attributes, or stipulations that are somehow inconsistent with marginal equalities (Cheung 1970). These conditions result because of social or legal constraints, ambiguity in rights assignments, or transaction costs being greater than expected benefits. Where rights assignments or transaction costs are the impediment, different arrangements of property rights could account for side-effect losses. Coase (1960) explored options that can be loosely classified as ***divided*** or ***bundled*** forms of ownership.

Divided ownership was illustrated by Alchian (1977: 132), a early and frequent contributor to the property rights literature:

> "What are the effects of various partitionings of use rights? By this I refer to the fact that at the same time several people may each possess some portion of the rights to use the land. A may possess the right to grow wheat on it. B may possess the right to walk across it. C may possess the right to dump ashes and smoke on it. D may posses the right to fly an airplane over it. E may have the right to subject it to vibrations consequent to the use of some neighboring equipment."

Dividing property rights to resources or resource-attributes among different owners with specialized production skills promotes total wealth provided that the transaction costs of negotiating and enforcing contracts to side-effects are less than damages without a contract (Barzel 1989). Thus, the people in Alchian's illustration might negotiate mutually beneficial contracts that "internalize" tradeoffs. Likewise, using standard examples from economics and law, farmers and railroads might contract ways to reduce or compensate for damage caused by engine sparks, a factory or airport might resolve nuisance levels of smoke or noise, and, as an example of positive side-effects, beekeepers and apple orchard farmers might agree on the supply of apple blossoms. Often, though, transaction costs preclude contracts because property rights to the land, air, and sea are ill-defined, the side-effects are complex and poorly understood quantitatively, and/or stakeholders are too numerous or heterogenous stakeholders. In such cases, a government might insert regulations that either attenuate or exclude ownership rights that interact. Pollution control and zoning are classic examples of divided ownership assisted by government.

However, Coase (1960) and others (Alchian 1977; Demsetz 1967) caution against the automatic application of divided ownership and government regulations to redress side-effects unless the opportunity costs of foregone production are considered. Ownership rights to different resources or resource-attributes might instead be combined, or bundled, to reduce transaction costs through administrative decision-making (versus market exchange or bi- or multi-lateral contracts) and to maximize ***joint*** wealth. The property rights structure that results expands the outputs of the owner(s). Referring again to a standard example:

> "After the railroad purchases title to enough land to make it worthwhile, it could take into account the effect of its output of sparks on land values and profitably bring about an adjustment of this output to the socially optimal amount - that which maximizes the joint value of railroading and landowning" (Demsetz 1964: 23).

The comparative efficiency advantage of bundled versus divided ownership favors bundling as resource complexity complicates contracts and raises transaction costs (Alchian 1977; Demsetz 1967).

The choice among contractual arrangements includes deciding which arrangement minimizes the sum of transaction and production costs in the system (De Alessi 1983). In addition to resource complexity as discussed in Section 2, contractual arrangements are influenced by uncertainty, the frequency of transactions, and the degree of transaction-specific investment (Williamson 1979). Williamson's (1979) essay on transaction costs and the governance of contractual relations specifically focuses on the exchange of property rights to intermediate products, but his results can be extended to other economic systems.

Standardized commodities which are familiar to all parties and relatively inexpensive lend themselves to divided ownership, classical contracts (e.g., warranties, simple return policies), and market exchange. Seafood products are examples of this case. In contrast, multi-attribute resources require detailed contracts that are expensive to gather information on and to negotiate and enforce. Complexity is compounded by uncertainty about attribute quantity and quality. Frequent transactions further increase transaction costs over time, as do exogenous changes in technology and markets. These conditions favor either accepting losses associated with non-exclusive ownership or combining resources and resource-attributes in a unified governance structure such as a government administrative agency, a commons, or firms. Unified governance can give way to divided ownership, however, once uncertainty is reduced and resource dynamics are better understood.

4. U.S. Management of Fisheries Resources in the Northeast Shelf Ecosystem

This section characterizes ownership of marine fishery resources and contractual arrangements in the Northeast Region (Maine to North Carolina) of the United States.

The U.S. Magnuson-Stevens Fishery Conservation and Management Act of 1976 (Act) codified federal ownership of property rights to marine fishery resources within 3-200 miles of the shoreline. The Act transferred the right to determine harvest policies to eight Regional Fishery Management Councils (Councils) around the United States whose voting members from commercial fisheries, state and federal governments, and other stakeholder groups (e.g., recreation and conservation) serve as agents appointed by the Secretary of the U.S. Department of Commerce.[5] The Act transferred long-standing de facto rights to harvest and sell fishery resources to U.S. fishermen; in relatively few cases, foreign fishermen are allocated TALFF (total allowable level of foreign fishing) at a fee.

The Fishery Management Plans (Plans) and related rules (i.e., amendments, frameworks, emergency and interim actions) prepared by Councils and NMFS act as contracts between the federal government and the fishing industry which stipulate producers (e.g., permits), outputs (e.g., total allowable catch in fishery, trip limits, individual annual quotas, minimum fish size, bycatch limits), inputs (e.g., number of crew, days-at-sea quotas, vessel size), and technologies (e.g., gear type and specifications, vessel monitoring electronics). Plans follow the Act's "National Standards", other applicable federal law (e.g., National Environmental Protection Act, Regulatory Flexibility Act, Paperwork Reduction Act, Marine Mammal Protection Act, Coastal Zone Management Act, Executive Order 12866 on Regulatory Planning and Review), and guidelines on overfishing and habitat protection established by NMFS. NMFS and the U.S. Coast Guard monitor and enforce compliance with regulations. NMFS also conducts and funds fisheries research, including surveys of fish populations which form part of the basis of stock assessments and management advice to the Councils.

To date, the New England and Mid-Atlantic Councils in the Northeast Region have prepared 12 Plans to manage stocks of 30 species of finfish and invertebrates in federal waters. There are also three Secretarial Plans prepared by NMFS to manage sharks, tunas, and billfish that migrate inside several LMEs along the Western Atlantic Ocean and Gulf of Mexico, including the Northeast Shelf Ecosystem. In addition, the Atlantic States Marine Fisheries Commission has prepared 21 Plans to manage 22 species of finfish and invertebrates inside state waters (generally 3 miles from shore), including several stocks that overlap with federal jurisdiction (e.g., American lobster and winter flounder *Pseudopleuronectes americanus*).

Although four Plans incorporate more than one species,[6] and the U.S. federal government is the ultimate owner of resource rights, fisheries management in the Northeast Region has evolved into a system of divided use rights with scores of restrictions that constrain production and limit "regulatory bycatch".[7] Divided use rights stem, in part, from requirements to attain maximim sustainable yields of individual species (stocks) and a political economy which allocates "target" species to separate fisheries (typically based on gear). Recently conservation organizations have advocated the use of mutually exclusive ocean zoning, especially marine protected areas.

The nature of divided ownership of use rights and government restrictions is illustrated by the December, 1994, Emergency Action by the Secretary of Commerce which closed three large areas of the Northeast Shelf Ecosystem to fishing to protect the Georges Bank stocks of Atlantic cod, haddock, and yellowtail flounder (Closed Areas I and II) and of the stock of southern New England yellowtail flounder (Nantucket Lightship Closed Area) (NEFMC 1996). The action excluded all gear capable of catching these species, including scallop dredge and net gear as well as traditional groundfish gear (trawls, gillnets, lines) because scallop gear "catch significant amounts of yellowtail flounder", "have the ability to catch other groundfish when concentrated for spawning", and "the dredge disturbs the bottom and disrupts the spawning activity."[8] In contrast, the lobster pot fishery continues to

[5] The 1990 amendment of the Act incorporated the highly migratory species of tunas, sharks, and billfishes, and made NMFS the management body.

[6] The New England Council's Multispecies Plan manages the stocks of 13 species of groundfish, including Atlantic cod, haddock, and flounders. The Mid-Atlantic Council has prepared three mixed species Plans: squid, mackerel, butterfish; black sea bass, scup; and surfclam and ocean quahog. The latter two species are managed by ITQs.

[7] Regulatory bycatch is catches of species by one fishery that are considered the principle targets of other fisheries. For example, the Atlantic sea scallop fishery also catches flounders and American goosefish.

[8] The Emergency Action is quoted on page 1 of Framework Adjustment 11 of the Atlantic Sea Scallop Plan which is available from the New England Council (www.nefmc.org).

operate in these areas due to low groundfish bycatch. The northern part of Closed Area II where the sea floor is gravel was also designated a "Habitat Area of Particular Concern" (HAPC) to protect juvenile Atlantic cod.

Whereas groundfish stocks have been slower to recover, the biomass of Atlantic sea scallop in these areas has increased several-fold since 1994. The limited access sector of the Atlantic sea scallop fishery was granted temporary access to Closed Area II in 1999 (NMFS 1998). Access was restricted to the lower third of Closed Area II to prevent gear conflicts with the lobster fishery in the middle area and to preclude disturbing biogenic and hard substrate in the northern HAPC. The summer and fall seasons were chosen to avoid periods when Atlantic cod and haddock aggregate to spawn. Access ended after 5 months when the bycatch quota for the Georges Bank stock of yellowtail flounder was reached; only 64 percent of the scallop quota was caught.

5. Conclusions

Application of property rights theory to fisheries leads to several preliminary conclusions pertaining to ocean wealth. First, single-species (stock) management and its extension to the separate management of habitat divides ownership of use rights to resource attributes closely linked by trophic interactions, habitat dependence, joint harvest technology, and habitat disturbance. Instead of making tradeoffs that maximize combined yields, fishery managers enact numerous rules such as bycatch limits and area closures which constrain or exclude activities that generate side-effects. Probably a better management unit is a persistent species assemblage and its habitat. This actually appears to be what Gordon (1954) had in mind nearly 50 years ago:

> "Demersal, or bottom-dwelling fishes, such as cod, haddock, and similar species and the various flounders, ... live and feed on shallow continental shelves where the continual mixing of cold water maintains the availability of those nutrient salts which form the fundamental basis of marine-food chains. The various feeding grounds are separated by deep-water channels which constitute barriers to the movement of these species; ... The significance of this fact is that each fishing ground can be treated as unique, in the same sense as can a piece of land, possessing, at the very least, one characteristic not shared by any other piece: that is, location. Other species such, such as herring, mackerel, and similar pelagic or surface dwellers, migrate over very large distances, and it is necessary to treat the resource of the entire geographic region as one."

Geographic scale and the cost of enforcement are special considerations. Demersal assemblages might be smaller in geographic area than an LME. In contrast, pelagic assemblages are more likely to encompass more than one LME, but the water mass which constitutes their habitat is most likely too costly to own rights to at this time.

Second, it is prohibitively costly to stipulate and enforce complete contracts for uses of multi-attribute fishery resources owing to their heterogeneity, geographic scale, and interactions. Many attributes probably contribute to the total value of fisheries production in complex ways, especially in the Northeast Continental shelf where omnivory and generalist food habits characterize the food web. Moreover, no LME is completely isolated from its surroundings - e.g., ocean currents and estuaries exchange nutrients, pollutants, and so forth from neighboring marine, fresh water, and land systems.

Third, scientific uncertainty about resource dynamics (stock sizes, recruitment, natural mortality, habitat, etc.) and the recurrent nature of ecological and economic transactions (including predation and side-effects) argue for a unified form of governance that economizes on the transaction costs of decision-making and enforcement. Although the comparative advantage could shift with experience, knowledge, and technological change, divided ownership of resource attributes would require frequent and costly contracts over side-effects in an uncertain natural environment at this time.

Two related issues will only be highlighted here. One concerns the specific type of governance structure that can contribute most to sustainable total ocean wealth. It is generally felt that enforcement costs alone preclude anything but an administrative government agency to manage uses of wildlife over large geographic ranges (e.g., Lueck 1995). As such, the widespread practice of divided ownership needs to be reconsidered in the context of total ocean wealth. One possible regime - depending on the legal and social environments - is a comprehensive transferable use-rights system whereby ITQs (i.e., individual transferable quotas) are implemented in all fisheries that operate in the common pool assemblage. Although by no means an economic panacea (Squires et al. 1998), a comprehensive ITQ system would facilitate exchange of landings quotas across species and fisheries, conceivably through a centralized market analogous to the New York Stock Exchange. It would also provide a market for anyone - including conservationists - to buy quota or quota rights in order to protect species and habitat, particularly if the ITQs are area-specific.

Government ownership of fishery resource assets is not without its drawbacks, however, including the addition of substantial rent-seeking costs to transaction costs.[9] Furthermore, government can significantly affect the wealth of a society by its assignment of property rights, including the right of transfer (Alchian 1977; Eggertsson 1990; Furubotn and Pejovich 1972). Transaction costs can hinder the reallocation of rights into arrangements that better fit new economic, social, and environmental conditions. Of particular interest are opportunities to unitize communal or private property rights to large common pool fishery resources.[10] Communal ownership can be an efficient adaptation to an uncertain natural environment, particularly in natural resource societies that can not afford or do not have the infrastructure to delineate and enforce private rights (Ostrom 1990; Runge 1986). In such cases, social contracts that stipulate traditional rules for joint-use economize on transaction costs. The comparative economic advantage of a commons over private firms (or over government) hinges on whether the expected value of more complete stipulation of property rights to non-exclusive resource attributes in the commons is greater than the transactions costs required of private firms to develop property rights to the additional attributes. Innovations induced by alternative institutions - including technological change (e.g., switch from wild fisheries to aquaculture) - should be factored into comparisons. It is also possible - even likely given the complexity of natural and social environments (e.g., transboundary stocks) - that a blend of common, private, and/or government organizational arrangements would be needed.

Finally, I have barely mentioned uses of the many other marine resource attributes beside the fishery, but the extension is obvious. It is not clear, however, whether divided ownership of fishery, oil, and other marine resource property rights is inferior to bundled ownership because efficiency gains from specialized production technologies are more pronounced in these cases. Again, it is an empirical question whether ocean wealth would be improved if, for example, oil companies expanded their output mix to include fishery products (or vice versa) and internalized the opportunity costs of pollution on reduced fishery output; or if oil and fishing interests negotiated contracts that stipulated pollution reduction technology or compensation; or if governments imposed regulations or taxes; or if the transaction costs of any of these options exceed pollution damages. In a related example, Coase (1960: 2) sums up the tradeoffs as follows:

> "If we assume that the harmful effect of pollution is that it kills fish, the question to be decided is: is the value of the fish lost greater or less than the value of the product which the contamination of the stream makes possible? It goes almost without saying that this problem has to be looked at in total *and* at the margin."

[9]Rent-seeking - i.e., behavior that uses scarce productive resources to appropriate surplus benefits through the regulatory, legislative, or judicial powers of government - is a net cost to society due to the loss of output from resources devoted to rent-seeking. See Buchanan et al. (1980).

[10]Lueck and Yoder (1997) expect wildlife management to evolve toward unitization. Unitization is collective decision-making by individuals who own property rights to the same common pool resource. For example, oil companies who own leases to the same sub-surface resource might coordinate their production activities in order not to dissipate resource rents in costly overcapitalization (Libecap 1989). A government or members of a commons might also coordinate uses of common pool resources.

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