

Ragnar Arnason\*

## Commercial Allocation Issues

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\* University of Iceland & JRC

[Ragnara@hi.is](mailto:Ragnara@hi.is)

Ragnar.Arnason@jrc.it

## ABSTRACT

It is now widely recognized that property rights are conducive to economic efficiency in fisheries and, moreover, the higher the quality of property rights the more efficient the associated economic activity. Economic efficiency in fisheries generally implies a high degree of sustainability in the sense that the risk of a stock collapse is small. Note, however, that maximizing the efficiency of commercial fisheries may involve the decimation of non-commercial stocks or stocks of little commercial value. This may or may not be socially optimal.

Property rights suggest the need for (an initial) allocation of these rights. In this paper it is shown that if either the markets are not perfect or the property rights not perfectly tradable, the allocation of rights can make a difference for the outcome in terms of efficiency and sustainability. So, at least in these terms, allocation matters. This suggests two questions: How much does allocation matter and what would constitute a good allocation? The paper considers these questions and attempts to provide partial answers. The paper goes on to examine the income distributional implications of the allocation of fishing rights. It is shown that contrary to common beliefs, it is not generally true that the initial recipients of fishing rights receive all or even most of the benefits associated with using these rights. It is shown, moreover that attempts to effect a more equitable distribution of income by imposing constraints on the trade in fishing rights may easily be counterproductive.

## 0. Introduction

The purpose of commercial fisheries as that of any other economic activity is to contribute to human wellbeing. To maximize this contribution, commercial fisheries must be as economically efficient as possible. Efficiency is synonymous with the maximum flow of economic benefits over time. Due to the nature of fish renewal processes, this generally implies fairly large stocks of the valuable species.<sup>1</sup> Thus, economic efficiency in fisheries generally implies a high degree of sustainability in the sense that the risk of a stock collapse is small. Note, however, that maximizing the efficiency of commercial fisheries may involve the decimation of non-commercial stocks or stocks of little commercial value. This, depending on conservation sentiments, may or may not be socially optimal.

It has been known for a long time that high quality property rights promote economic efficiency (Smith, 1776, Furubotn and Richter 2005). Later research indicates that high quality property rights may be sufficient for efficiency and economic growth (Demsetz, 1967 Arnason 2006a). Fisheries are no exception to this rule. It has been found both theoretically and empirically that property rights are conducive to economic efficiency in fisheries and that the higher the quality of fishery property rights the more efficient the fishery operations (Arnason 2006b). Moreover, it has also been found, that attempts at fisheries management that are not based on private property rights are generally failures, often abject ones (OECD 1997). It follows that if we want efficiency in fisheries, we must look to property rights-based regimes.

Property rights do not exist in nature. They are a human creation, a social institution. To apply this social institution, that is to say create property rights, requires the (initial) allocation of these rights. This, obviously, raises the question of how. Clearly the allocation of property rights has implications for the distribution of wealth and income. Whether it also has implications for economic efficiency and, in the case of natural resources, sustainability, is much less clear.

In this paper we explore the implication of allocation of fisheries rights to commercial fishermen. First and foremost we will be interested in the effects of allocation on economic efficiency. The basic result is that if markets are perfect and trading costless, the allocation of fisheries property rights has no impact on the economic efficiency of the fishing activity. So, in that special case allocation doesn't matter. If, on the other hand, markets are not perfect or the property rights not perfectly tradable, the allocation of rights will generally make a difference for the outcome in terms of efficiency and sustainability. Therefore, under these circumstances, allocation matters. We will also look briefly on the distributional implications of the allocation of fisheries property rights. The general assertion here,

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<sup>1</sup> There have several theoretical studies of optimal extinction of animal species (see e.g. Clark). From this literature and other more advanced considerations (e.g. the option value of keeping a species alive), it appears that for valuable species, extinction can only be optimal when either the stock is so small that it is not worth preserving, or the rate of discount is so high that the future is worth very little. The first situation happens only by accident — it basically violates the fundamental optimality of sustainability. The second situation is where society has no interest in the future in which case extinction, and, in fact, general liquidation of assets would be optimal.

much branded about, is that the initial recipients of the property will receive all the benefits it can offer. It is shown that as a general theorem, this is not true, although as an empirical matter, the initial recipients may well receive the bulk of the benefits.

The paper is organized broadly as follows: In the next section we will talk about allocation of fisheries rights and the resulting efficiency of the fishery. In the following section we will consider allocation and distribution. Finally, in the last section of the paper we will attempt to draw practical conclusions from our investigation.

## 1. Allocation and efficiency

To rigorously study the impact of allocation of property rights in the full dynamic setting of the fishery is a complicated undertaking. Fortunately, it so happens that the key results of the theory can be deduced and explained in a reasonably simple manner and without having to resort to any higher level mathematics.

Consider a fishery subject to some overall rights to be allocated to individual fishers or fishing firms. These rights can theoretically be any fishing rights defined by the fisheries authorities including fishing licences, allowable fishing days, catch quotas, rights to apply certain fishing gear, enter certain areas and so on. However, it is probably easiest to think of them as just harvesting rights. In that case the overall rights would be the total TAC and the allocated rights individual harvesting quotas or quota shares. For simplicity, we assume that the rights, whatever they are, can be allocated in any quantity to any number of potential receivers.

In most fisheries, the number of potential receivers of fishing rights is very high. To derive our basic results in an easy manner, it is sufficient, however to consider just two potential receivers. The reason is that the allocation to any number can be analysed as first an allocation between one individual and all the rest, and then the allocation between the first individual in the rest and the then remaining group and so on.

The fishers or fishing firms in question may derive some benefits from using the rights they receive. If they derive no benefits from the right, the right is worthless and there is no problem of allocation.<sup>2</sup> These benefits would often be profits but could be anything of value to the fishers. In what follows, we will measure these benefits, irrespective of their nature, in monetary units. It is important to realize that this is totally unrestrictive.<sup>3</sup>

Formally express the benefits to the fishers as the benefit functions:

$$(1) \quad B(q(i);i), i=1,2,$$

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<sup>2</sup> Under a poor fisheries management regime, equilibrium profits in the fishery are zero and, consequently, rights to such a fishery are approximately worthless.

<sup>3</sup> As is well known utility can in general be expressed in monetary units (money metric utility function, see e.g. Varian 1992).

where  $q(i)$  denotes the quantity of the right allocated to fisher  $i$ . As already mentioned, we only consider two fishers, fisher 1 and fisher 2. The two benefit functions will generally be different, hence the index  $i$  in the functions, but could be the same. We take it that for both functions, the benefits increase in the quantity of rights received, at least up to a point.

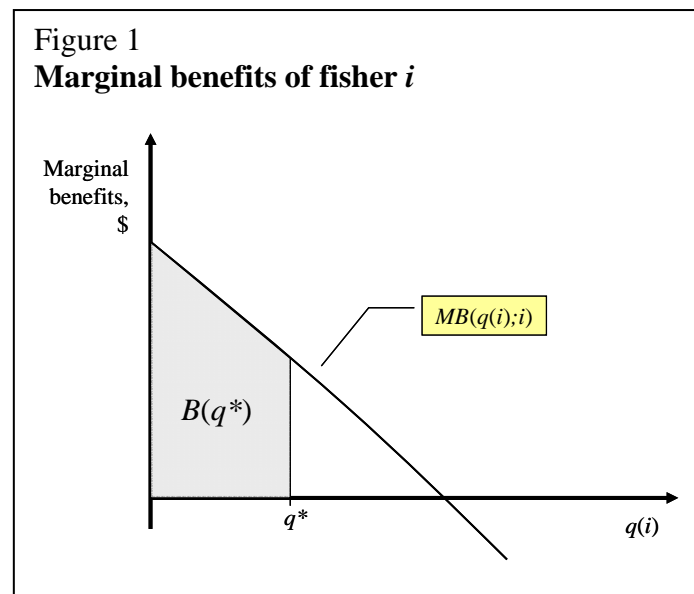
Since we are considering the allocation of more or less rights to the fishers it is helpful to consider the marginal benefit function, i.e. a function describing the additional benefits they get from additional units of rights. This function is formally defined as:

$$(2) \quad MB(q(i);i) \equiv \frac{dB(q(i);i)}{dq(i)}, \quad i=1,2,$$

where the notation  $MB$  is supposed to indicate marginal benefits. In accordance with basic economic premises (the law of diminishing marginal returns, see e.g. Varian 1992), we assume that the marginal benefits of additional fishing rights are falling as the rights increase, at least ultimately. On this basis we can illustrate the marginal benefit function as in Figure 1. As indicated in the figure the marginal benefits are initially high positive but as the quantity of rights increases, the marginal benefits decline and, as the figure is drawn, finally become negative. This last part may be unrealistic, but is of no consequence for the analysis that follows. As far as that is concerned, we may just as easily have a marginal benefit curve that is asymptotic to the horizontal axis.

To understand the analysis that follows, it is important to realize that the total benefits to fisher  $i$  from any quantity of rights,  $q(i)$ , he receives are given by the

integral of the marginal benefit curve from zero to that quantity. For instance, in Figure 1, the total benefits fisher  $i$  receives from using rights  $q^*$  are given by the area underneath the marginal benefit curve to  $q^*$  as indicated in the diagram in Figure 1.

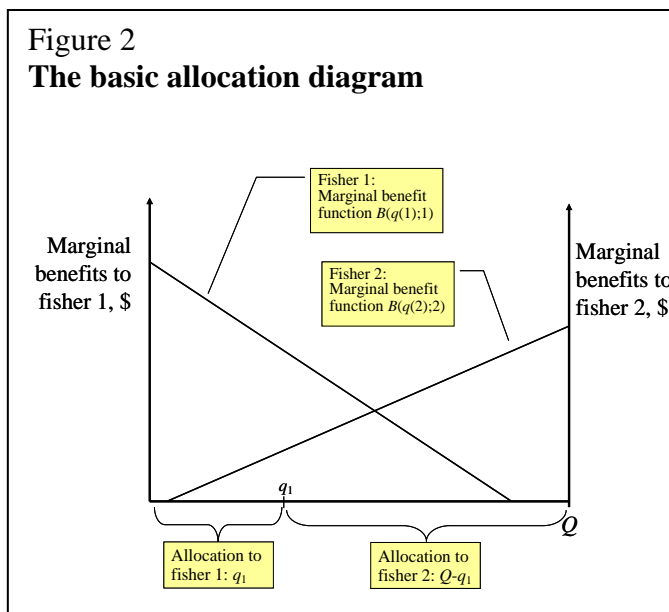


Now, consider the allocation of an aggregate fishing right, e.g. a TAC or some other right, to our two fishing firms. Let us refer to the total right to be allocated as  $Q$ . The essentials of the situation can be expressed as in Figure 2. In this figure, we measure the marginal benefits of rights allocation to fisher 1 on the left-hand vertical axis and the marginal benefits to firm 2 on the right-hand vertical axis. The total right to be allocated (i.e.  $Q$ ) is measured along the horizontal axis between the two vertical axes. Any point on the horizontal axis represents a given allocation to the two fishers. Thus the point  $q_1$  represents the allocation of  $q_1$  units to fisher 1 and the remaining ( $Q - q_1$ ) units to fisher 2.

Finally, we assume that total social benefits from the fishing activity are equal to the sum of individual benefits. More formally:

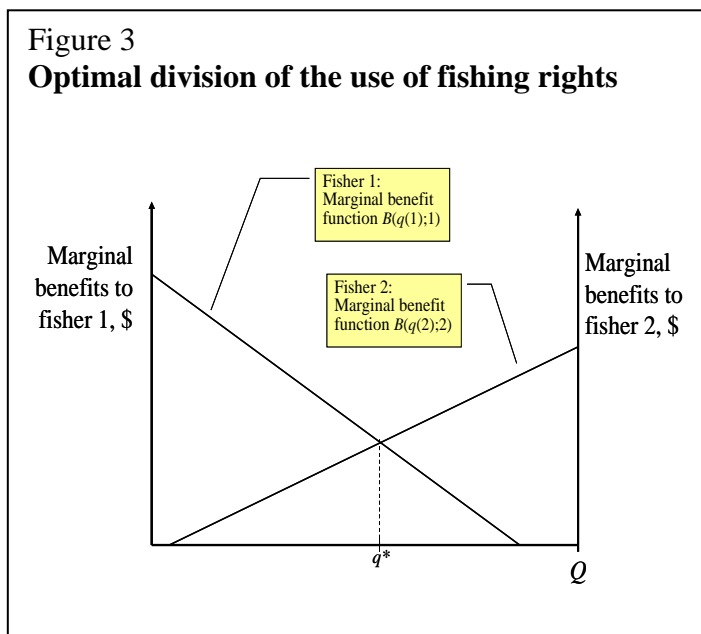
$$(3) \quad W = B(q(1);1) + B(Q - q(1);2),$$

where  $W$  denotes the social benefits (or welfare) generated from a fishery allocating rights  $q(1)$  to fisher 1 and  $Q - q(1)$  to fisher 2. Note that by this adopting this assumption, we are explicitly ignoring the possible impacts the fishing activity might have on other agents and sectors in the economy.



To be able to assess the efficiency impacts of allocation of fishing rights, we obviously need to identify the most efficient, i.e. the socially optimal, division of the use of the fishing rights (as opposed to the mere allocation of these rights). A moment's thought will reveal that provided both fishers harvest, this point occurs where the two marginal benefits are equal, i.e.  $MB(q(1);1) = MB(Q - q(1);2)$ . This point is illustrated in Figure 3. Why this should be the case is easy to see. Let the division of the use of the fishing rights

be at the socially optimal point,  $q^*$  in Figure 3. Now imagine a little increase in the use by firm 1 and a corresponding reduction in the use by firm 2 — remember the overall right,  $Q$ , is constant. Then, a quick look glance at the two marginal benefit curves in Figure 1 reveals that the increased benefits to fisher 1 are not sufficient to compensate for the reduced benefits to fisher 2. Therefore, this change in use reduces the overall or social benefits. A corresponding argument holds for an increase in the use by fisher 2 (and a reduction in the use of fisher 1) from  $q^*$ . Thus,  $q^*$  must be the optimal division of the use of rights (i.e. resource use) by the two firms.



The preliminaries are now over and we are in a position to examine the efficiency impact of different allocations of fishing rights. Allocation of rights

corresponds to a point on the horizontal axis in Figure 3. For many technical and administrative reasons this allocation would almost certainly not be the optimal division of rights use. To move from this point of allocation to the most efficient usage point,  $q^*$ , requires trading of the allocated rights. Therefore, obviously, the efficiency of the allocation depends on how smoothly these trades can occur. In this study we consider two types of trading barriers; (i) formal restrictions on trades<sup>4</sup> and (ii) transaction costs which basically cover all sorts of market imperfections such as the cost of finding trading partners and effecting trades, the payment of commissions, registration fees and so on. On this basis, we consider three special cases as follows: (1) Perfect tradability of rights and no transaction costs, (2) perfect tradability of rights and transaction costs and (3) non-tradability of rights and no transaction costs.

### **(1) *Perfect tradability, zero transaction costs***

This case is straight forward. Irrespective of the initial allocation, both parties will benefit from trading toward the optimal usage point,  $q^*$ . The arguments are the same as for the optimality of  $q^*$  itself. At any point outside  $q^*$ , say slightly below  $q^*$ , the marginal benefits of fisher 1 from an increase in his use of fishing rights is greater than the cost to fisher 2 of reducing his right. As a result both will benefit from trade in the direction of  $q^*$  and since there are no obstacles to trade, this trade will occur. This shows that the optimal division of the use of rights, i.e.  $q^*$ , is the only equilibrium in the market.<sup>5</sup> So, in the absence of any trade barriers, the point  $q^*$  will be reached. We conclude that in this case allocation does not matter for efficiency. More formally, we have the basic result:

#### *Result 1*

If there is perfect tradability and no transaction costs, then allocation of rights has no effect on efficiency — the division of resource use will be optimal irrespective of the allocation.

### **(2) *Perfect tradability, positive transaction costs.***

Let us now consider the case of transaction costs. To simplify matters, let the transaction costs be constant per unit of trade. So they are like fixed commission fees, trading taxes or simply the cost of finding a suitable trading partner that increases proportionately with the amount of trade. Without any loss in generality (but considerable gain in concreteness) let us assume the buyer bears this cost. So, for someone who has to purchase all his use rights, his benefits are simply reduced by the amount of transaction costs. This, in effect, shifts his marginal benefit curve of resource use downward by the amount of the transaction.<sup>6</sup>

So for the sake of illustration, consider the case where fisher 1 is allocated a smallish amount  $q_1$ , as in Figure 4, and buys additional fishing rights from fisher 2.

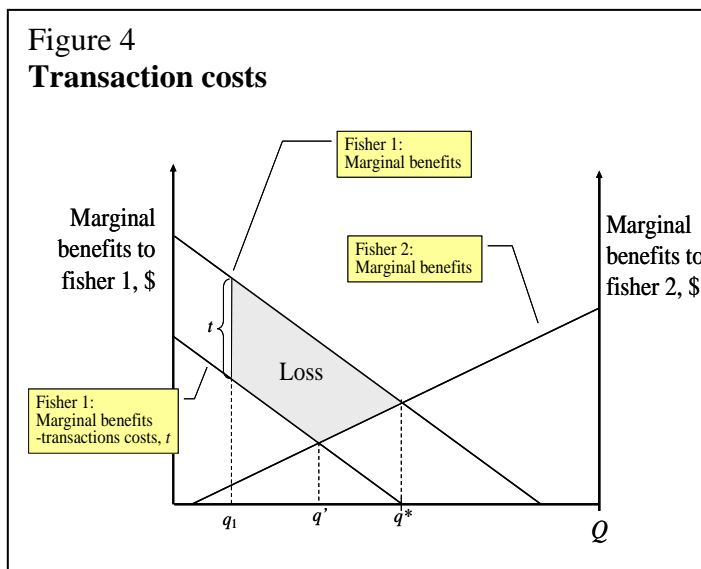
<sup>4</sup> Which is basically the same as reducing the quality of the property right (Arnason 2000).

<sup>5</sup> For a formal proof see Appendix 2.

<sup>6</sup> For the formal derivation of this consult Appendix 3.

Then, his marginal benefit curve is reduced by the amount of the transaction costs as illustrated in Figure 4. The trading equilibrium is now at  $q'$ , not  $q^*$ . Therefore, the division of resource use will be sub-optimal compared to optimal allocation of rights. Remember that if the allocation had been at  $q^*$ , there would have been no trading and therefore no transaction costs incurred. The loss in benefits is measured by the shaded area in Figure 4.

These arguments show that in the presence of transaction costs, the division of resource use is no longer independent of the allocation of use rights. The wrong allocation — and there is only one correct one — will lead to a loss in economic efficiency. This establishes our second basic result:

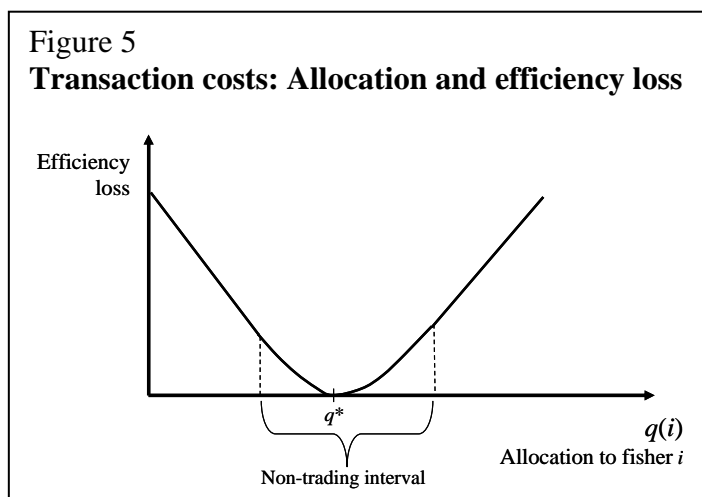


### Result 2

If there are transaction costs, the allocation of rights has implications for efficiency — only an allocation identical to optimal division of resource use will be fully efficient.

Note that with any allocation of rights falling in the interval  $[q', q^*]$  and a corresponding interval on the other side of  $q^*$ , there will be no trades. The benefits from trade will simply be too little to the fishermen to justify the associated transaction costs. Refer to this interval around  $q^*$  as the *non-trading interval*.

From the diagram in Figure 4, it is easy to see that the efficiency loss depends on the amount of transaction costs,  $t$ , as well as the slopes of the two marginal benefit curves. Moreover, as we have already seen, it depends on the allocation of rights itself. If the allocation of rights is correct, there will be no losses. If the allocation of rights is within the non-trading interval the efficiency loss will be less than the one indicated in Figure 4. If the allocation is outside the non-trading interval the loss equals the one indicated in Figure 4. As a function of allocation, the efficiency loss of sub-optimal allocation under this type of transaction costs will be similar to the



curve drawn in Figure 5.

### (3) *No tradability, zero transaction costs*

Resource use rights may not be legally tradable. This, for instance, is the case with non-tradable quotas, IQs. Obviously, non-tradability for legal reasons constitutes a substantial weakening of the property rights quality of the use right in question. Irrespective of its source, non-tradability may be represented as very high transaction costs, i.e. transaction costs so high that no trade can occur. So, basically, we can apply the analysis of the previous section with the modification that the non-trading interval now covers the whole allocation. So, in the case of non-tradability, the allocation of rights is also the division of resource use. Thus we have established our third basic result as follows:

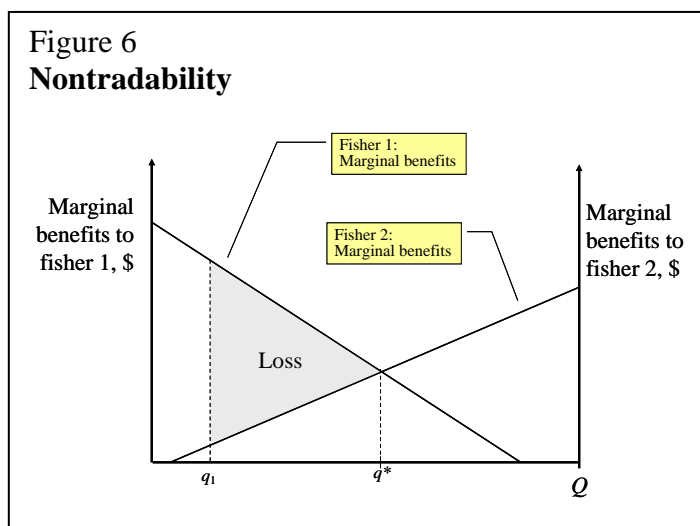
#### *Result 3*

If there is no (or limited) tradability, then allocation of rights has implications for efficiency — only an allocation identical to optimal division of resource will be fully efficient.

The impact of non-tradability is illustrated in Figure 6. In this figure we have the same allocation as in the transactions costs case, namely at  $q_1$ . Since trades cannot occur this is also the division of resource use and the loss, compared to full tradability and no transactions costs is as indicated in Figure 6.

Comparing Figures 4 and 6 immediately shows that provided the allocation is outside the non-trading interval, non-tradability can lead to much greater losses than in the case of mere transaction costs.

In terms of the diagram in Figure 5, this implies that the loss function is increasing at an increasing rate with the deviations from the correct allocation. In principle, the wrong allocation, i.e. one to someone who cannot use the resource profitably, can lead to loss of all benefits. In the case of non-tradability, therefore, the correct allocation is even more crucial than in the case of mere transaction costs of a reasonable magnitude.



## 2. Allocation and distribution

We have seen that the allocation of fisheries rights may or may not have an impact on efficiency of resource use. By contrast, the allocation of rights will generally be the

major determinant of the distribution of the benefits associated with the right. As a general rule, provided the rent is transferable, the receivers of the allocation will receive a significant part of the benefits the right can generate irrespective of their own efficiency and how much use they will make of the right. To be more precise, the receiver of the right will normally receive at least the economic rents (Alchian 1987, Arnason 2006) associated with the right. He will, however, not normally receive the full benefits that the right generates. What he typically does not get his hands on in terms of benefits is the surplus, often referred to as intra-marginal rents, the more efficient buyer of the rights obtains.

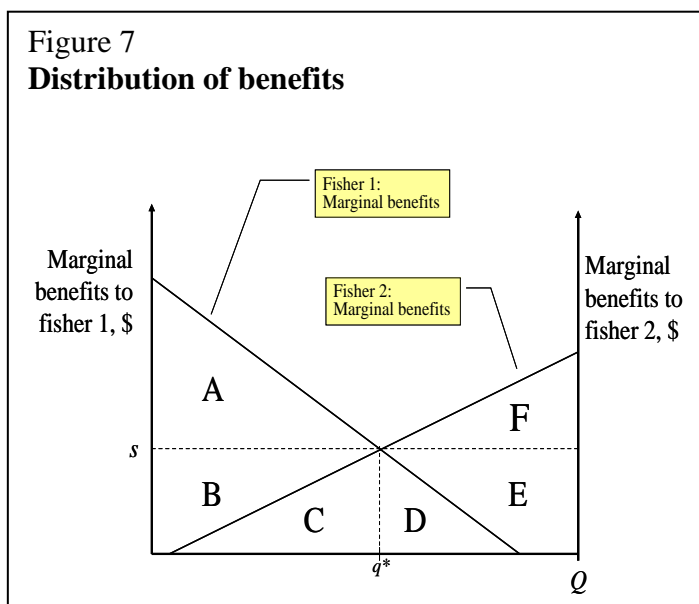
To analyse the general relationship between the allocation of fishing rights and the distribution of the benefits for the fishery is a very complicated task. Fortunately, it turns out that the essentials of the distributional issue can be illustrated with the help of a diagram similar to the ones employed in section 1. A more detailed analysis is given in Appendix 6.

Consider the case of two fishers as in Figure 3 above, where the optimal division of resource use is  $q^*$ . Now, let all the rights be allocated to fisher 1. Then, if there are no barriers to trade, he will sell a part of this right, more precisely  $Q - q^*$ , to fisher 2 at the approximately the market equilibrium price  $s$  (see Figure 7). At this price the two marginal benefits will be equal. More precisely  $s = B_q(q^*;1) = B_q(Q - q^*;2)$  as illustrated in Figure 7.

Now, the total benefits generated by the fishery are represented by the area underneath the two marginal benefit curves. This area may be divided into six segments, labelled A, B, C, D, E and F in Figure 7, whose sum equals total benefits. Note that a part of these total benefits, namely the segments B+C+D+E or more concisely the square  $s \cdot Q$  represents fisheries rents (Alchian 1987, Arnason 2006).

Now, out of these total benefits, fisher 1, the one receiving all the rights, will receive benefits A+B+C from using the resource (fishing) and benefits D+E from selling part of his rights allocation to fisher 2. So, in addition to all the fisheries rents he receives the intra-marginal profits, A. Fisher 2, on the other hand receives benefits amounting to D+E+F from his resource use but has to pay fisher 1 the rent D+E for the privilege. As a result his net benefits amount only to his intra-marginal profits, namely F.

So, in the case illustrated in Figure 7, fisher 1 gets most of the benefits. However, it is important to note, he does not get all the benefits. Fisher 2, who has to



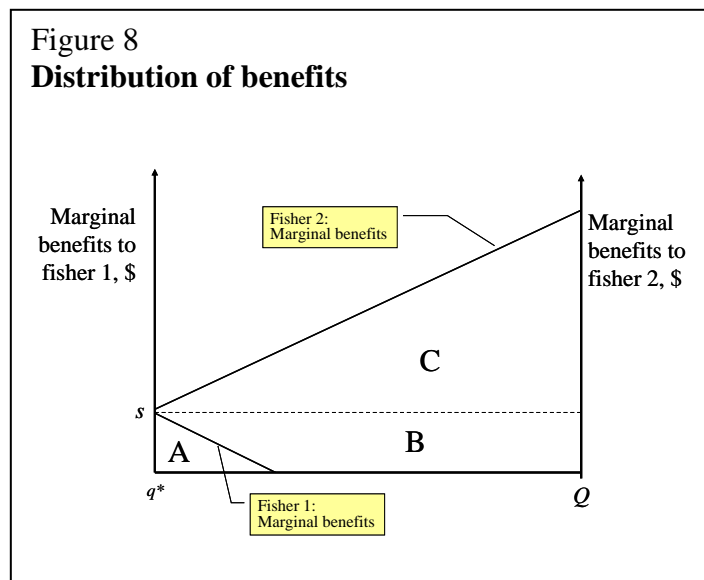
buy all his rights gets a part of the total benefits of the resource use. This establishes the basic result:

#### Result 4

The recipients of use rights allocations do not generally get all the benefits of using these resources.

From the diagram in Figure 7, it may appear that the recipient of rights gets the bulk of the total benefits. This, however, is only a feature of how the diagram is drawn and is not a does not have to be the case at all. Imagine for instance the case where the recipient of the right, i.e. fisher 1, is very inefficient while the other fisher (or, more generally, group

of fishers) is much more efficient. This case is illustrated in Figure 8. In this case, fisher 1 will not do any fishing, although he can do that profitably. He will get all his benefits from selling his quota allocation. Thus, he will receive benefits indicated by areas A and B in Figure 8. All of these benefits are rents. Fisher 2, on the other hand will get C which, as the diagram is drawn, is actually larger than the rents. Obviously, other configurations of the situation can make fisher's 1 share arbitrarily low.

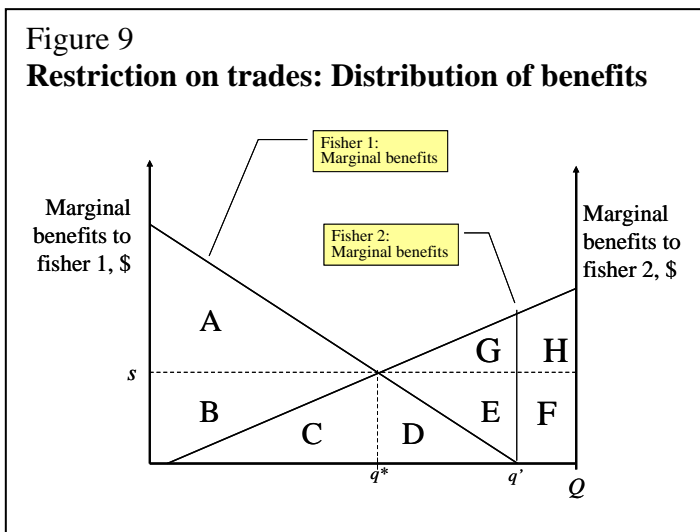


So, this analysis shows that, contrary to what is often asserted in the political debate about rights to resources, that efficiency is actually rewarded. Irrespective of the allocation of resource rights, the most efficient entities (firms and individuals) according to the above analysis generally receive a significant part of the benefits of resource use. If they are really highly efficient compared to the rest they may even receive the bulk of the benefits. This analytical result seems to be supported by everyday observations. Oil companies for instance generally have not been allocated many oil rights for free. In fact, most of their production is under licence with oil rich states which are both well informed and powerful. Many oil companies nevertheless make a lot of money. The most likely explanation is not that they are monopolistic and dishonest (although they may well be). The most likely explanation is that they make money primarily because they are more efficient in using oil reserves than the owners of the same reserves.

Sometimes, it is proposed to restrict transferability in order to achieve a fairer or at least more equitable distribution of the benefits. We can use the diagrammatic tool in Figure 7 to examine the validity of this claim. Consider again the situation depicted in Figure 7, with fisher 1 getting all the allocation and receiving the bulk of

the total benefits of resource use. As we pointed out when discussing Figure 7, a good deal of these benefits are from selling use rights to fisher 2. Faced with this situation, let us assume that the authorities decide to restrict fisher 1's sales of use rights to  $Q - q'$ . This basically forces fisher 1 to fish at  $q'$  as illustrated in Figure 9.

This official restriction on trading will firstly, as we have already seen in section 1(3) on no tradability above, lead to a loss in total benefits amounting to  $G+E$  as illustrated in Figure 9. Secondly, it will obviously cause a disequilibrium situation in the use rights market — at least one of the parties, if not both, would like to trade more at the market price. However, if we are willing to assume for the sake of argument, that the price will remain the same, i.e. at  $s$ , it is easy to check the distribution of benefits between the partners before and after the imposition of the trading restriction. The result is summarized in Table 1.



	Benefits		
	Fisher 1	Fisher 2	Total
No trading restrictions	$A+B+C+D+E+F$	$G+H$	$A+B+C+D+E+F+G+H$
Trading restrictions	$A+B+C+D+F$	$H$	$A+B+C+D+F+H$
Difference	$E$	$G$	$G+E$

Table 1 verifies our assertion that total benefits are reduced by the trading restriction. It also shows that fisher 1 is certainly hurt by the restriction. However, possibly unexpectedly so is fisher 2. In fact, depending on the shape of the two marginal benefit curves, he could well suffer even more from the restriction than fisher 1. Indeed, as should be clear from Table 1, it is by no means clear that fisher's 2 share of the new (and lower) total benefits is greater than before. We summarize these results as follows:

*Result 4*

Restrictions on trade will:

- (i) Generally reduce overall benefits of resource use.
- (ii) Possibly lead to a more inequitable situation

Taxes on the trade in rights, will generally lead to a sub-optimal use of the fishing rights. In this way they work very much like transaction costs. However,

unlike transaction costs they are not economic losses, at least not right away. Thus, they could in principle be reallocated to those deemed disadvantaged by the configuration of rights ownership. However, even so, it is quite possible that the reduction in efficiency and the allocation of that loss will more than outweigh the potential gain from reallocated tax revenues.

### 3. Conclusions

Good (high quality) property rights have been found to promote efficiency as well as sustainability in many fisheries around the world. This makes the creation of these types of fishing rights an appealing option for fisheries authorities.

The creation of fishing rights, however, implies the need to allocate these rights. This is a task with both technical and political ramifications. Technically, one allocation may be more efficient than another. Politically, allocation of rights (as well as duties) is always subject to controversy. This controversy tends to be the more heated the more valuable the rights are. It so happens that in commercial fisheries high quality rights are often quite valuable.

This paper has attempted to illuminate these questions. Primarily it has investigated the problem of efficient allocations. However, it has also examined the distributional impacts of particular allocations.

On the question of allocation and efficiency, the analysis has established the following basic results:

- If there is perfect tradability and no transactions costs, the allocation of rights has no effect on efficiency — the division of resource use will be optimal independently of the allocation.
- If there is either limited tradability or transaction costs, then the allocation of rights has implications for efficiency — only an allocation identical to the optimal division of resource will be efficient.

If efficiency is of concern, these results have certain fairly obvious policy implications:

- (1) It is generally not a good idea to restrict tradability of resource use rights.
- (2) Instead the authorities should consider taking steps to facilitate trades (by legislation, regulations, institutions etc.) in order to minimize transaction costs.
- (3) Since, there are always certain transaction costs, even when they are low, the authorities should attempt to allocate use rights to the most likely users.

The most likely users of fisheries rights are indeed existing fishermen. So, policy implication (3), provides support for the usual government procedure of allocating fisheries rights to those already established and with a track record in the fishery.

On the question of allocation of rights and the distribution of the benefits obtainable from using these rights, the analysis produced the following basic result:

- The recipients of use rights allocations do not generally get all the benefits of using these resources.

This result directly contradicts the conventional wisdom, much branded about in public debates about fisheries quota rights, that the initial receivers of quotas receive all the benefits of the resource. It may be true, as a general empirical pattern in fisheries, that most of the benefits from use of fisheries property rights will be reflected in quota values. However, the analysis shows that this does not have to be the case. Therefore, to assert otherwise can only be done on the basis of an empirical study of the fisheries situation in question.

While this paper may have managed to clarify the issues and, hopefully, correct some of the most glaring misconceptions concerning the allocation of fisheries rights, the reader should be warned that it does not represent a deep or comprehensive analysis —far from it. The allocation of rights and the resulting efficiency and distribution of benefits is a complicated issue. This paper has done little more than scratch the surface of that issue. Among the things, of apparent importance but completely ignored in the paper are:

(1) What are the benefits?

The maximum benefits associated with rights depend among other things on the quality of these rights. Certain fishing rights, e.g. access licences, the right to invest etc., are of low quality and therefore not worth much. Other rights such as TURFs and ITQs are of high quality and can be very valuable. This distinction is completely ignored in the paper. One might say, although this is not accurate, that the paper proceeds as if the rights in question are always of high quality. The main thing is that with low quality property right the question of allocation and efficiency and allocation and distribution becomes largely irrelevant as there is very little efficiency to lose and very little benefits to distribute.

(2) Mistakes by players.

Fishers, like everyone else make mistakes. They may trade or fish erroneously. These mistakes will have implications for both efficiency and distribution. Taking the mistakes to be stochastic, the question rises what are the implication for policy. This is not at all dealt with in the paper.

(3) Fairness

The question of fairness is also completely ignored in this paper. This is partly because economics, as, I believe, every science, has very little to say about justice and fairness. However, although it is probably not a topic for scientific inquire, a great deal of sensible things can be said about fairness. To attempt that, however, would be beyond the scope of this paper. This is the main reason why this topic was dropped from the paper.

Finally, it is interesting to note that historically speaking property rights are often takings. Over time, many of these takings become established as a part of the

social order, almost as if they belong to the nature of things. Takings, at least when it is creating private property rights from previously common or totally un-owned natural resources, have many good economic properties. For one thing they constitute a solution or at least an alleviation of the common property problem as is very well known. It is less recognized that the social custom of recognizing property rights on the basis of takings generates a powerful incentive to entrepreneurs to invent and establish new types of property rights. If takings entail socially accepted property rights they will gain personally by these kinds of effort. And by their personal gain and the increased economic efficiency generated by a more extensive property rights system, most of the other members of society will gain as well.

These observations on the benefits of takings as a means of creating property rights seem to undermine the validity of public allocations of rights to individuals. Perhaps that is the wrong way to look at the problem. Perhaps, the state, the entity most people seem to have in mind as an allocator of rights, would be of more service if it just concentrated on establishing and supporting the property rights quality of takings. If so, the problem of allocation, with which this paper is concerned, would simply cease to be of relevance.

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## Appendices

### 1. Optimal division of resource use

Let  $Q$  represent total rights and the rights usage of fisher 1 be  $q$ . It follows that the usage of fisher 2 is  $q(2)=Q-q$ . Social benefits of this usage is

$$W = B(q;1) + B(Q - q;2)$$

In what follows, explicit reference to the two fishers will generally be dropped from the benefit functions unless confusion may arise.

Maximizing  $W$  with respect to  $q$  yields:

$$(A.1) \quad B_{q(1)}(q(1)) = B_{q(2)}(q(2)).$$

In other words, maximum total benefits occur at the point where the two marginal benefits of resource use are equal.

### 2. No trade barriers imply optimal division of resource use

Let  $\bar{q}$  be the allocation to fisher 1. it follows that the allocation to fisher 2 is  $Q - \bar{q}$ . Let  $z$  be the purchase of rights by fisher 1 from fisher 2. Obviously, if the fisher 1 sells rights to fisher 2,  $z < 0$ . With trades the rights usage of fisher 1 will be  $\bar{q} + z$  and that of fisher 2  $Q - \bar{q} - z$ .

With costless trading, private benefits for the fisher 1 will be:

$$B(\bar{q} + z) - s \cdot z,$$

where  $s$  is the market price of quota. For him profit maximization (assuming no corner solutions) implies:

$$(A.2) \quad B_{q(1)}(q(1)) \equiv B_{q(1)}(\bar{q}(1) + z(1)) = s.$$

For fisher 2 the private benefits will similarly be:

$$B(Q - \bar{q} + z) - s \cdot z.$$

And his profit maximization (assuming no corner solutions) implies:

$$(A.3) \quad B_{q(2)}(q(2)) \equiv B_{q(2)}(Q - \bar{q}(2) + z) = s.$$

It follows immediately from (A.2) and A.3) that market equilibrium requires:

$$B_{q(1)}(q(1)) = B_{q(2)}(q(2)),$$

Which identical to the social optimum expressed in (A.1).

### 3. Transactions cost imply sub-optimal division of resource use

Let there be transaction costs defined by  $T=t \cdot z$ . Then one or both of the traders will have to bear this cost if trades occur. For convenience, and with no impact on the results, let the buyer bear this cost. His private benefits under trading then become:

$$B(\bar{q} + z) - s \cdot z - t \cdot z.$$

His profit maximizing condition under trade becomes (assuming no corner solutions):

$$(A.4) \quad B_{q(1)}(q(1)) = s + t.$$

The seller's profit maximizing conditions are unchanged and given by condition (A.3) above.

Combining (A.4) and (A.3) yields the market equilibrium condition:

$$(A.5) \quad B_{q(1)}(q(1)) - t = B_{q(2)}(q(2)).$$

This expression shows that in market equilibrium the marginal benefits of resource use to the rights buyer will in general be higher than that to the resource seller, the difference being the unit transaction costs,  $t$ . So, comparing (A.5) to the social optimality condition (A.1), above shows that under transaction costs, division of resource use will generally not be optimal. More to the point it will not be optimal unless the allocation of rights will be perfect, i.e. precisely the same as the optimal division of resource use (i.e. trade is not necessary).

The inefficiency or loss in benefits associated with the less than perfect allocation of rights is difficult to work out in general. It depends as already indicated on (i) the initial allocation, (ii) the size of transaction costs and (iii) the shape of the two marginal benefit curves. Assuming that (A.5) holds, i.e. no corner solutions, we may write this loss for any allocation  $q_1 < q'$  as

$$(A.6) \quad L = \int_{q_1}^{q^*} (B_q(\bar{q}(1); 1) - B_q(Q - \bar{q}(1); 2)) dq + \int_{q_1}^{q'} (B_q(\bar{q}(1); 1) - t - B_q(Q - \bar{q}(1); 2)) dq,$$

where  $q'$  refers to the actual and  $q^*$  to the optimal division of resource use.

Qualitatively similar results can be obtained with other types of transaction costs such as transaction costs depending on the volume of the transaction and transaction costs that are fixed per transaction, i.e. independent of the volume of transaction.

#### 4. Nontradability implies sub-optimal division of resource use

Non-tradability may be seen as an extreme case of transaction costs (infinite transaction costs) so that no trade can occur. In that case, the allocation of rights is also the division of resource use. The two marginal benefits will be  $B_{q(1)}(\bar{q}(1))$  and  $B_{q(2)}(Q - q(1))$ . And it is obvious that only perfect allocation will result in socially optimal division of resource use, (A.1).

Assuming both fishers receive allocation of rights, the loss will be given by:

$$(A.7) \quad L = \int_{\bar{q}}^{q^*} B_q(\bar{q}(1);1) - B(Q - \bar{q}(1);2) dq,$$

where  $q^*$  refers to the optimal division of resource use and we have assumed that the allocation to fisher 1 is less than his socially optimal use of the resource.

#### 5. Size of loss

According to (A.6) and (A.7) the loss due to transaction costs (including nontradability lies in the interval  $[0, \Delta]$ , where  $\Delta$  is the maximum total benefits from the resources. The lower bound, 0, is reached when the allocation of rights is perfect. The upper bound,  $\Delta$ , is reached when all allocation is to a totally inefficient fisher,  $B_q \equiv 0$  and transaction costs exceed maximum marginal benefits of the other fishers.

#### 6. Allocation of rights and distribution of income

Assume that one of the fishers, e.g. fisher 1, receives the allocation  $\bar{q}$ . Assume he finds it beneficial sell a part or all of this allocation,  $z$ , say. The resulting resource use is:  $\tilde{q} = \bar{q} - z$ .

Fisher 1's benefits are now:

$$B(1) = \int_0^{\tilde{q}} B_q(q) dq + z \cdot s,$$

where, as before,  $B_q(q)$  represents his marginal benefits from the harvest level  $q$  and  $s$  is the price at which he can sell his quota. So, the first term in this expression represents his benefits from fishing and the last term his benefits from selling a part of his right.

The benefits of the buyer, i.e. fisher 2, from buying and using the purchased quantity  $z$  is:

$$B(2) = \int_0^z B_q(q;2) dq - s \cdot z.$$

But  $B(2) \geq 0$ . Otherwise fisher 2 would not undertake the trade. Moreover, if  $B(q(2);2)$  is concave, which is the normal case, the marginal benefit function would be falling in

the  $q$  and  $B(2)$  would be strictly positive (note that by market principles  $s \leq B_q(z)$ ).

This proves, that provided there exist more efficient (for some part of the allocation) fishers than the one receiving the allocation, i.e. the receiver elects to trade some of his allocation, others will share in the total benefits of the right.

How much of the total benefits others will share depends on the parameters of the situation. It increases with the efficiency of the buyer and it falls with the efficiency of the one who receives the allocation. In principle, the buyer or the allocation, i.e. the one who ultimately uses the right may receive virtually all of the benefits.