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Strong User Rights in Fisheries: A Case Study
of Assessing the Impacts

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Strong User Rights in Fisheries: A Case Study of Assessing the Impacts[1]

Abstract

In previous research it was concluded that a transition to SURFs (strong user rights in fisheries) has several economic, environmental, and social impacts. In this paper, the problem of assessing the values of these impacts is considered. First, this kind of an assessment is considered in general terms. It is found that the values of the impacts depend in general on the empirical situation at hand. Therefore, a broad result that a transition to SURFs is either beneficial or detrimental does not seem to be available. Following this finding, it is attempted to evaluate empirically prominent impacts of installing SURFs in the Philippines Marine fisheries. Based on the available data and some simple bioeconomic modelling, it is concluded that the economic and biological impacts are mostly beneficial and their sum highly positive. Because of lack of data, the social impacts of SURFs could not be evaluated. It appears unlikely that they are detrimental enough to render a transition to SURFs inadvisable.

Keywords: Strong user rights in fisheries, SURFs, evaluating the impacts of SURFs, Philippine fisheries, fisheries management

JEL classification: Q20, Q22, Q28, D61

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1. Introduction

Arnason and Runolfsson (2022) identified several impacts of strong user rights in fisheries (SURFs). These impacts were sorted into three broad categories: economic, environmental, and social, each encompassing several more specific impacts.[2]

Identifying and classifying the various impacts of SURFs is a first step toward assessing their advantages and disadvantages. The second and more complicated step is to assign values to the various impacts and, if possible, provide an overall economic valuation (calculate the net benefits) of a transition to SURFs. This paper represents an attempt in this direction. It does so essentially in two ways:

> First, in section 2, the problem of evaluating the impacts of SURFs is considered in general terms. The main conclusion of this section is that the various benefits and costs of introducing SURFs depend on the empirical situation. This suggests that a general conclusion about the advisability of adopting SURFs is almost surely not available. Adopting SURFs may be beneficial in some fisheries and not in others. Therefore, to reach a conclusion, each fisheries case must be considered on its own merits employing essentially the cost-benefit methodology.
>
> Second, in sections 3 and 4 of the paper, it is attempted to evaluate the advantages and disadvantages (benefits and costs) of SURFs in the case of the Philippine fisheries. It is found, not surprisingly, that the available data is insufficient to reach a definite conclusion. However, according to the available data, mostly economic and environmental, a transition to SURFs seems hugely beneficial.

Before proceeding to the main content of this paper, it may be helpful to draw attention to a few basic simplifying assumptions:

Obviously, all impacts are relative to something else. In this paper, the impacts of SURFs are defined relative to the impacts of weak user rights (WURFs) such as those prevailing under a common property (or common pool) arrangement.

Many SURFs require extraneous, centralized fisheries management measures, such as restrictive TACs, to be fully effective. In the following assessment of the impacts of SURFs, it will be assumed that these extraneous management measures are set to maximize the economic efficiency of the fishery in the sense of maximizing the present value of the flow of net economic surplus (i.e., profits) from the fishing operations.

The impacts of SURFs on the utility of individuals and, therefore, the economic value of these impacts obviously depend on the reactions of these individuals to altered conditions. In the following assessment it will be assumed that they always maximize their utility subject to the prevailing conditions.

[2] In presenting this classification, Arnason and Runolfsson (2022) made clear that it was primarily to facilitate analysis and presentation and was by no means perfect. For instance, some of the impacts of SURFs, such as altered income distribution, may be regarded as both economic and social and, thus, not limited to a particular category. Also, some impacts may be regarded as political or even socio-psychological and, thus, outside the three categories.

The impacts of SURFs on the utility of individuals also depends on the various collective responses to the introduction of the SURFs that may be undertaken. Examples of such responses are unemployment benefits to those who lose their jobs because of SURFs or taxation on those who gain. It follows that the net benefits of SURFs depend on these responses. To avoid these complications, the assessment of the impacts of SURFs will be conducted as if no such responses take place.

2. The assessment problem: General considerations

It may be helpful to lay out the essence of the assessment task within a simple formal framework. A framework of this kind can both serve as a summary view of the problem and provide guidance for more detailed studies of its various aspects.

It is analytically convenient to assume there are always user rights in fisheries although their strength may vary. Following Arnason (2000), let the strength of the user rights be measured by the variable Q which ranges continuously over the interval [0,1] with zero denoting no strength (equivalent to no user rights) and unity full strength user rights. Strong user rights in fisheries (SURFs) will have Q-values that are relatively high on this scale. Weak user rights in fisheries (WURFs) will have low Q-values.

Assuming that the impacts of user rights in fisheries are identifiable and constitute a finite list; i=1,2…I, a convenient expression for these impacts for individual j at time t is:

$$x(i,j,t),$$

where the index i refers to a particular impact, the index j refers to an individual affected by the impact and t to time. Thus, $x(i,j,t)$ is the magnitude of impact i experienced by individual j at time t. One example of this impact might be the individual's income. Another might be the level of an environmental variable. A third might be a social variable.

A convenient shorthand for these impacts for individual j at time t is the I-dimensional vector:

$$\mathbf{x}(j,t).$$

If the individual has sufficiently well-defined preferences over these impacts, they may be expressed by a utility function.[3] Utility theory offers several different versions of utility functions. For our purposes, it is convenient to consider the impacts of SURFs on individuals' utility in terms of the direct money metric utility function (see e.g., Varian 1992, Hammond 1994). Money metric utility functions have all the usual properties of utility functions with the added advantage of measuring utility in money. In a sense, the direct money metric utility function is the utility function rescaled such that the marginal utility of money is unity (see Hammond 1994). Write this money metric utility function as:

(1) $U(\mathbf{x}(j,t),t;j).$

[3] The conditions for the existence of an individual utility function are extensively researched. See e.g., Debreu 1959, Rader 1963, Voorneveld and Weibull 2016.

Note that, although not explicitly expressed in (1), this utility function contains many other variables besides $\boldsymbol{x}(j,t)$.

The utility function in (1) implicitly defines the value of the marginal impact i to the individual at each time as the derivative (provided it exists)

$$U_{x(i,j,t)}(\boldsymbol{x}(j,t),t;j).$$

And the value of a discrete change in impact i as the difference:

$$\Delta U(j,t) = U\left(\boldsymbol{x}_1(j,t),t;j\right) - U\left(\boldsymbol{x}_0(j,t),t;j\right),$$

where $\boldsymbol{x}_0(j,t)$ is the vector of initial impacts and $\boldsymbol{x}_1(j,t)$ the vector of impacts with the ith entry altered.

To describe the relationship between a particular user right in fisheries and its impacts obviously requires a comprehensive, economy or society-wide model. Let us for simplicity[4] assume that the impacts depend on their strength, Q, and possibly other variables, z and write this model succinctly as the vector mapping:

(2) $$\boldsymbol{x}(j,t) = \boldsymbol{\Gamma}(Q,z;j,t),$$

where the vector valued function $\boldsymbol{\Gamma}$ maps Q into impacts on individual j and z represents a set of other variables (such as mitigating policies) that affect the mapping.

So, in terms of the strength of the user rights, the utility function in (1) can be rewritten as:

$$U((\boldsymbol{\Gamma}(Q,z,j,t),t;j).$$

The present value of the utility flowing from user rights arrangement Q on individual j is:

(3) $$PV(j) = \int_0^T U(\boldsymbol{\Gamma}(Q,z;j,t),t;j)dt.$$

And the change in utility from a discrete change in user rights, e.g., from weak user rights (WURFs) to strong ones (SURFs), is

(4) $$\Delta PV(j) = \int_0^T U(\boldsymbol{\Gamma}(Q_1,z;j,t),t;j) - U(\boldsymbol{\Gamma}(Q_0,z;j,t),t;j)dt,$$

where Q_1 represents the new user rights and Q_0 the initial ones.

With sufficient differentiability this change may be written as:

$$\Delta PV(j) = \int_0^T \left(\sum_{i=1}^{I} U_{\Gamma(i)}(\boldsymbol{\Gamma}(\bar{Q},z;j,t),t;j) \right) \cdot \Delta Q dt,$$

---

[4] This is a simplification because user rights are generally multi-dimensional, and their impacts may depend on their configuration as well as their overall strength.

where the functions Γ are evaluated at a certain $\bar{Q}$, the appropriate level of Q (mean value theorem).

For the impact of SURFs on society, we need to aggregate over all the individuals. A particularly simple aggregation consists of unweighted summing over individuals yielding:

$$(5) \qquad \Delta PV = \sum_{j=1}^{J} \Delta PV(j) = \sum_{j=1}^{J} \int_0^T U(\Gamma(Q_1, z; j, t), t; j) - U(\Gamma(Q_0, z; j, t), t; j) dt \; .$$

This summation represents a particular social welfare function, namely one that is additive in utilities often referred to as classical utilitarianism (Driver 2014) It, moreover, relies on the highly questionable assumption that individual utilities are comparable.

The above formulation of the assessment problem immediately provides several useful insights:

(i) The impacts of SURFs generally depend on their strength.

(ii) The value of a particular impact from SURFs for an individual depends in general on all the other factors affecting the individual's utility, such as his income, wealth and opportunities, discount rates, as well as the other impacts of the SURFs. This immediately shows that the value of any given impact of SURFs will in general be different across individuals, societies, economic development stages and time.

(iii) Transition to SURFs is extremely likely to affect different individuals differently. This is both because they may experience different impacts and they will in general value the same impact differently.

(iv) The value of a transition to SURFs generally varies over time. For instance, the transition may reduce utility during the initial stages and increase it later. It follows that the value of such a transition depends among other things on the individuals' age giving rise to problems of intergenerational fairness.

2.1 Transition to SURFs is generally not a Pareto improvement

The foregoing section makes it clear that the impact of a transition to SURFs will generally affect different individuals in different ways. This may be because of their different utility functions or different placement in society (constraints) or both. More importantly, the sign of the utility impact may differ, that is, for the same change in user rights some individuals may gain while others may suffer a loss in utility. For instance, those receiving SURFs may gain income while those that must leave the fishery may suffer an income loss. It immediately follows that a transition to SURFs will not in general constitute a Pareto improvement. That, by itself, suggests such a transition will be socially controversial.[5]

[5] The controversy and sometimes conflicts associated with movement to stronger property rights is of course well known from history. The European enclosure movement is one well-documented case (see e.g., Dahlman 1980, Turner 1984). Another not too dissimilar case are the enclosures of the American and Australian grasslands. Many instances of SURFs have also been met with opposition and controversy.

It should also be noted that even if we restrict our attention to specific impacts, the same would apply in general. Some individuals would prefer this impact while others would dislike it. Thus, it would not be possible to state unequivocally that a particular impact is socially desirable or undesirable without further investigation.

2.2 How to proceed? The Kaldor-Hicks compensation criterion

It should be noted that the above difficulties in assessing the social desirability of a transition to SURFs is by no means rare in the evaluation of economic policy options. On the contrary, it is generally found, even for the most beneficial projects, that there are losers. Hence, it soon became apparent to the profession of economists that requiring a proposed social project to constitute a Pareto improvement was unreasonably demanding.

In 1939, Nicholas Kaldor and John Hicks, apparently independently, proposed a conceptual solution to the problem. Briefly put, they suggested that a project with the property that those who gained could compensate the losers fully while still being better off themselves was socially beneficial and should be undertaken. Importantly, they made it very clear that actual compensation need not take place. To them, the mere fact that the losers could be compensated proved that the project was socially beneficial. Whether or not the losers were actually compensated was another social decision problem.

The Kaldor-Hicks criterion, while conceptually pleasing, was only a step toward a solution. It left the practical problem of determining whether the proposed project met the Kaldor-Hicks criterion. This task requires assessing all the impacts of the project, some of which may be non-market, calculating their values in terms of a common measure to be able assess the project's net value. If the net value was positive, losers could in principle be compensated and vice versa.

Applying the Kaldor-Hicks criterion is generally very demanding. As we have seen, most projects have many impacts affecting numerous individuals. Moreover, typically, many of these impacts do not have market prices and some cannot have them because they are public goods (e.g., many environmental impacts). Therefore, typically, a great deal of estimation and assessment work is needed to find out whether a project meets the Kaldor-Hicks criterion or not.

2.3 Cost-benefit analysis

A transition to SURFs may be regarded as a project. Assessing the relative magnitudes of advantages and disadvantages of any project is an empirical task. A special methodology, cost-benefit analysis (see e.g., Layard and Glaister 1994) has been developed to guide researchers in this kind of work. Essentially, cost-benefit analysis tries to measure whether the project meets the Kaldor-Hicks criterion. This, as discussed above, is in general a major undertaking. Experience shows that a properly conducted cost-benefit analysis is generally a large and complicated task. Nevertheless, in fisheries for which an introduction of SURFs is being contemplated and the net benefits are not clearly positive, it may be necessary to conduct such a study.

3. The Philippines marine fisheries

Above we have established that the introduction of SURFs has in general both advantages and disadvantages. Moreover, the gains and losses generally befall different individuals, and they are variable over time. It follows that whether a transition to SURFs constitutes an overall gain or not is fundamentally an empirical question. To throw a light on the relative values of the impacts of SURFs in a typical fishery it may be a good idea to consider a real fishery. The example chosen for that purpose is the Philippines marine fisheries.

3.1 The Philippines marine fisheries

The Republic of the Philippines claims one of the largest Exclusive Economic Zone (EEZ) in the world measuring some 2264,000 km^2 (World Atlas 2022).[6] While much of this EEZ consists of deep waters (especially in the Philippine Sea to the west of the islands; see figure 1) and is not particularly fertile[7], its continental shelf, which measures approximately 250,000 km^2 and is to a large extend located between the islands (see figure 1), provides a habitat for a large number of species and is biologically highly productive (Palomares and Pauly 2014).

6 A part of this EEZ, in the South China sea (see the so-called nine-dash-line), is also claimed by the Republic of China (see Baumert and Melchior 2014).

7 See e.g., Encyclopedia Britannica 2022.

Figure 1
Philippine EEZ

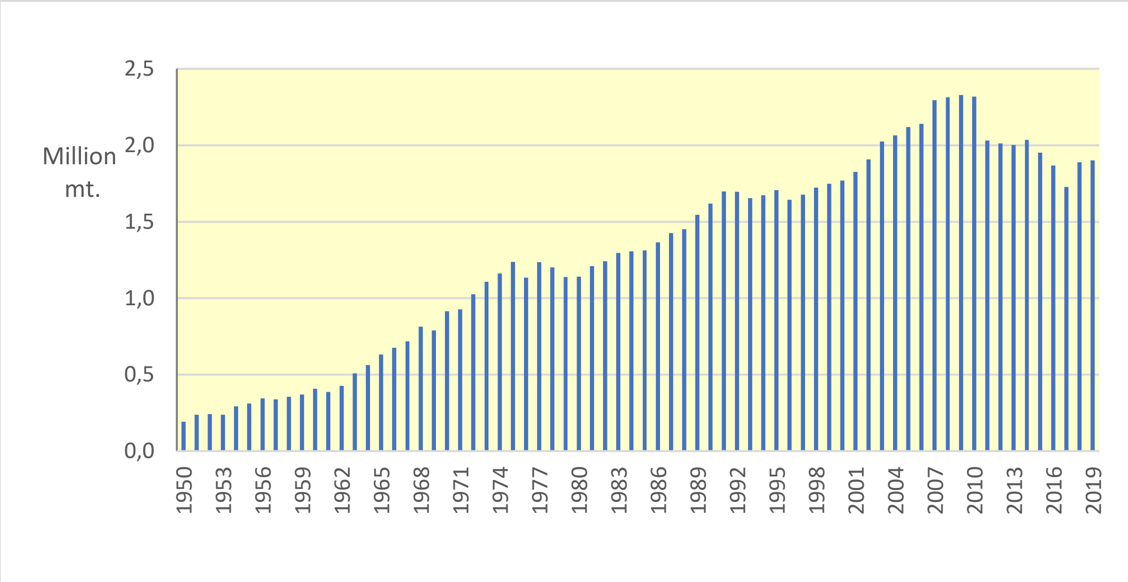
The great majority of the Philippines population lives in coastal areas (Palomares et al. 2014). Given this, the Philippines geographical features and the biological productivity of the inshore areas, it is not surprising that fisheries play a significant role in the nation's economic and social makeup. Fish consumption is high compared to the rest of the world. According to Lamarca (2018) it was about 40 kg/capita per year in 2017 or almost 110 grams/capita per day.

The marine capture fisheries are based on a high number of species. Thus, the catch records in 2018 and 2019 (DA-BFBAR 2021; SEAFDEC 2022) list about 60 different species. These cover both pelagic species and demersal species. However, in terms of volume, pelagic species dominate. Thus, the largest volume of catch is accounted for by sardinellas and tunas. Most of the tuna catch are small tunas such as skipjack.

A notable feature of the total marine catches is a relatively steady increase for 60 years from 1950 to 2010 of about 4.1% per annum on average, followed by a declining trend of about -

2.2% per annum between 2010 and 2020.This development is illustrated in figure 2. Since fishing effort may have been increasing throughout the period (SEAFDEC 2022), this evolution of the volume of catch is consistent with significantly declining marine fish stocks.

Figure 2
Philippines marine capture fisheries production
(Million mt. Source: FAO 2022)



The Philippines marine fisheries may be divided into offshore and inshore fisheries with a significant part of the latter consisting of non-commercial artisanal fisheries (see Palomares et al. 2014 and Lamarca 2018). Both fisheries sectors employ, for the most part, small fishing vessels. Even the offshore fisheries do not generally employ vessels above 150 GT (gross tons). The total number of fishing vessels in the country may be about 250 thousand (Lamarca 2018). By far the largest number of fishing vessels belong to the small-scale inshore fishery consisting of vessels under 3 GT about 1/3 of which are nonmotorized.

The fishing industry is a significant source of employment in the Philippines. In 2017, the fishing sector is estimated to have provided employment to over 1.6 million people (Lamarca 2018) or to approximately 3.6% of the working population. Estimate of the actual number of fishers vary greatly. A reasonable guess is that they may count between 500 and 600 thousand. The remainder of fisheries employment is land-based, fish processers, fish traders and the suppliers of inputs to the fisheries. The great majority of those employed in the fishing sector are in the inshore fishing sector. In 2015, the fishing industry is thought to have contributed between 1.5% and 1.7% to the Philippine GDP (Lamarca 2018).

Fisheries management in the Philippines is quite rudimentary and does very little to counteract the detrimental effects of the common property feature of the marine resources. The most significant fisheries management measures are zonal separations between the offshore and inshore fleet and licensing for the offshore fleet. The offshore fleet is restricted to fishing outside 15 km (about 9 miles) from the shore. Offshore fishing requires licenses but those seem to be liberally issued for a small fee. Thus, marine fisheries are, for all intents and purposes, common pool, open access fisheries. In accordance with this, it appears that the profitability in the Philippine marine fisheries is poor.

3.2 Modelling the Philippines marine fisheries

The modelling of the Philippine marine fisheries follows the so-called Sunken billions methodology designed to deal with data poor fisheries (World Bank 2017).

The basic bioeconomic model employed in this example is in accordance with modelling standards set in fisheries economics (see e.g., Anderson 1977, Clark 1990, Anderson and Seijo 2010). In a concentrated form, this model consists of four equations:

(6) $\dot{x} = G(x) - y$ (Biomass evolution).

(7) $y = Y(e,x)$ (Harvesting function).

(8) $\pi = p \cdot y - C(e)$ (Profits).

(9) $p = P(x)$ (Landings price function)

The variable *x* denotes the level of biomass and *y* harvest. The function *G*(*x*) represents the natural growth of the biomass before harvesting and $\dot{x}$ the net change in biomass. Equation (7) explains the harvest as a function of fishing effort, *e*, and biomass, *x*. Equation (8) defines net economic benefits or profits as the difference between fishing revenues denoted by $p \cdot Y(e,x)$, where *p* denotes the net price of landed catch, and costs represented by the cost function *C*(*e*). Equation (9) is an addition to the standard fisheries model. It defines a price as a function of landed catch. This is supposed to reflect the observation that as fish stocks increase, landings will increasingly consist of more valuable species and larger individuals which typically fetch a higher price (Herrmann 1996, Homans and Wilen 2005).

Although not explicitly stated, all the variables in this model depend on time. The symbol $\dot{x} \equiv \partial x / \partial t$, where *t* denotes time, expresses the instantaneous change in biomass. However, in this study we for the most part consider the fishery in equilibrium in which case $\dot{x} \equiv 0$.

The model expressed in (6) to (9) involves four unspecified functions, the biomass growth function, *G*(*x*); the harvesting function *Y*(*e*,*x*); the cost function *C*(*e*) and the fish price equation *P*(*x*). The functional specifications for these four functions are as follows:

For the biomass growth function, the Pella-Tomlinson (Pella and Tomlinson 1969) form[8] is adopted.

(10) $G(x) = \alpha \cdot x - \beta \cdot x^{\gamma}$,

where *x* represents biomass as before and α, β and γ are parameters. The parameter γ may be referred to as the Pella-Tomlinson exponent.

For the harvesting function, the generalized Schaefer (1954) form is adopted:

[8] This form includes the logistic and the Fox (1970) functions as special cases.

(11) $Y(e,x) = q \cdot e \cdot x^b$,

where, as before, *e* refers to fishing effort and *x* biomass and *q* and *b* are positive parameters. The coefficient *q* is often referred to as the catchability coefficient. The coefficient *b* indicates the degree of schooling behaviour by the fish.

For the cost function, the following linear form is chosen:

(12) $C(e) = c \cdot e + fk$,

where the positive parameter *c* represents marginal variable costs and *fk* fixed costs which must be nonnegative.

Finally, the landings price function is defined as:

(13) $P(x) = a \cdot x^d$,

where *a* and *d* are positive parameters. Importantly *d* is the elasticity of landings price with respect to biomass.

Expressions (6)-(9) with the functional specifications in (10)-(13) define the specific bioeconomic model of this study.

3.3 Fishery specifications

To apply the Sunken billions methodology, certain numerical specifications of the Philippines marine fisheries need to be adopted. These specifications, based on the available data from various sources, are listed in table 1.

Table 1
Philippines marine fishery specifications

Variable	Units	Values
Base year, t_0		2020
Maximum sustainable yield; msy	1000 mt	1700
Carrying capacity; *xmax*	1000 mt	13600
Pella-Tomlinson exponent	None	1.188
Schooling parameter; *b*	None	0.65
Fixed cost ratio, ε	None	0
Elasticity of price w.r.t. biomass, *d*	None	0.2
Landings in base year, $y(t_0)$	1000 mt	1827
Landings price in base year, $p(t_0)$	US$/kg.	1.40
Biomass growth in base year, $\dot{x}(t_0)$	1000 mt	-150
Profits in base year, $\pi(t_0)$	M.US$	10
Fishing effort in base year, $e(t_0)$	1000 boats	250

The resulting estimates of the model coefficients and initial biomass according to the Sunken billions methodology (World Bank 2017) are:

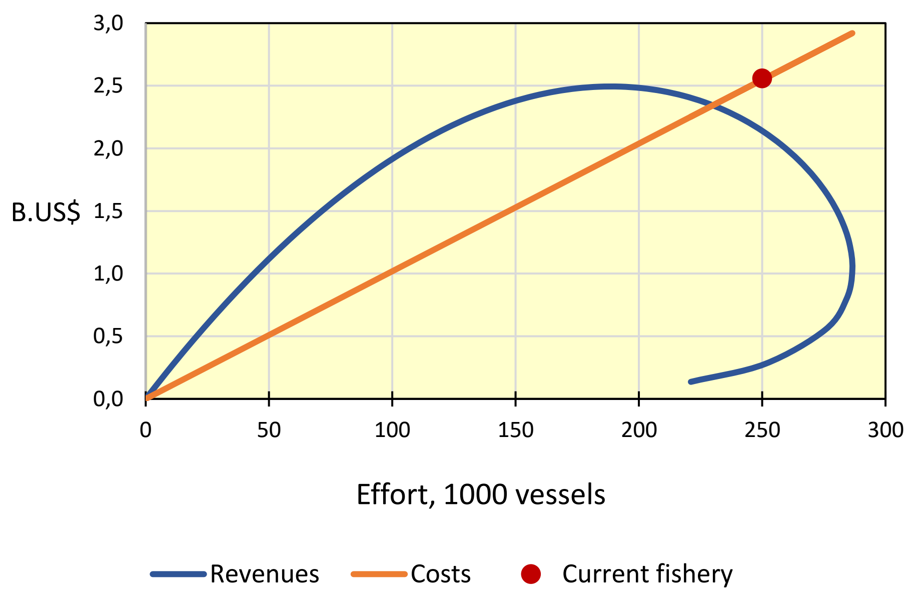
Table 2
Model estimates

Estimates	Symbols	Values	Units
Growth parameter	α	1.9748	$1/t$
Growth parameter	β	1.20899	$1/(\text{m.mt}\cdot t)$
Initial biomass	$x(t_0)$	4636	1000 metric tonnes
Catchability	q	$2.697\cdot10^{-3}$	1/1000 vessels
Cost coefficient	c	0.01019	M US$/1000 vessels
Price coefficient	a	1.030154	M. US$/(m.mt)^2

3.4 The optimal fishery: Transition to SURFs

We only consider the optimal fishery in an equilibrium. A depiction of the sustainable fishery and its current position is provided in figure 3:

Figure 3
Philippines marine fisheries: The sustainable fishery



From figure 3 it is obvious that the current position of the fishery is hugely economically inefficient. Moreover, it is biologically unsustainable; current harvest levels are above the sustainable yield function, so the fishery is heading in an even lower biomass.

Some of the consequences of moving to the profit maximizing sustainable state are listed in table 3. Note that to be economically meaningful, this table as well as figure 2 are based on the presumption that all prices are socially correct, i.e., measure the true marginal costs and benefits.

Table 3
Transition to SURFs in the Philippines marine fisheries

	Units	**Current**	**Optimal**	**Difference**	**% Difference**
Biomass	M. mt.	4.636	8.980	4.345	94%
Harvest	M. mt.	1.827	1.331	-0.496	-27%
Effort	1000 vessels	250.000	118.512	-131.488	-53%
Labour use in fishing	1000 individ.	550.000	286.799	-263.200	-48%
Landings Price	US$/kg	1.400	1.598	0.198	14%
Revenues	B. US$	2.558	2.127	-0.431	-17%
Costs	B. US$	2.548	1.208	-1.340	-53%
Economic surplus (profits)	B. US$	0.010	0.919	0.909	9093%
Surplus per unit revenue	Ratio (percent)	0.004	0.432	0.428	10954%
Surplus per unit effort	US$/vessel	40.00	7756.94	7716.94	19292%
Surplus per unit harvest	US$/kg.	0.0055	0.691	0.685	12517%

4. Evaluating the impacts of SURFs

In Arnason and Runolfsson (2022) the impacts on SURFs were divided into (1) economic, (2) environmental and (3) social impacts. It is convenient to follow the same classification here. The theoretical basis for assessing the value of these impacts is outlined in section 2. It is essentially the same as in the usual cost-benefit studies. It is assumed that these impacts affect the utility of individuals either directly via variables such as environmental factors in the utility functions or indirectly via impacts on incomes and prices.

4.1 Economic impacts

Arnason and Runolfsson (2022) identified 13 economic impacts of a transition to SURFs. We will now consider these impacts in the light of the predicted outcomes for the Philippine marine fisheries.

(i) Less fishing effort and use of fishing capital in fishing.

According to table 3, a transition to SURFs (and profit maximizing fishing) in the Philippine marine fisheries is likely to entail about 53% reduction in fishing effort. This corresponds to reduction in the number of active fishing vessels by about 131 thousand vessels and about 263 thousand fishers. This implies, ceteris paribus, a significant reduction in the demand for fishing vessels and the associated inputs, i.e., fishing labour as well as fishing gear, vessel engines and maintenance.

The economic cost of this depends on (a) the alternative opportunities and (b) the cost of adjustments. Two extreme cases may be considered: The optimistic case under which the suppliers of the now redundant fishing inputs will quickly find equally well-paying alternatives and the pessimistic case under which they will become idle.

The optimistic case: Since the transition to SURFs will almost certainly increase GDP and therefore overall demand in the economy, this case is not unlikely. If so, the economic cost is only that of adopting the alternative opportunities.

The pessimistic case: In this case, the net income previously enjoyed by the suppliers of the now redundant inputs will be lost to them. In the case of the Philippines, the amount in question is very substantial. The loss of earnings to the redundant fishers would be approximately 789 million US$ per year[9] compared to 919 million US$ in increased profits. The loss to suppliers of other inputs is harder to assess because they presumably have significant costs of supply. In the pessimistic case, these additional costs could be about 100 million US$ per year.[10]

For the pessimistic case, it is important to realize two things: First, if it prevails, the true cost of fishing is much less than assumed in section 3 (see figure 3). This is because the shadow value of the inputs is much less than what they are paid. So, in that case the profit maximizing fishery would take place at a point much closer to the MSY (maximum sustainable yield) than reported in section 3. Therefore, the reduction in input use would be correspondingly less and the gain in profits higher than reported in table 3.

Second, the loss of employment and value-added under the pessimistic case is almost certainly not a permanent feature. It is highly likely that adjustments will gradually take place and the unemployed resources will find work which, if GDP has increased (which is highly likely) will be better paying opportunities than before. Assuming this cost is reduced by 10% per annum and the rate of discount is 4%, the annualized cost in the pessimistic case is 264 m. US$

(ii) Reduced cost of fishing per unit of landings

This effect, as may be inferred from table 3, is very substantial. Broadly the costs per unit of harvest go from about 1.39 to 0.91 US$/kg. The economic impact of this is subsumed in the change in profits so we need not discuss this further.

(iii) **Increased profitability in fishing**

According to table 3, a transition to SURFs will lead to an increase in profits of about 489 million US$ per year. If all prices are correct (including those of labour), this is also the economic gain (the increase in value-added) from the transition. If some of the fishery inputs are initially overpriced (the pessimistic case under item (i)), the gain in value-added will (almost surely) be less.

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[9] This assumes annual income of about 3000 US$ per average fisher and a 48% reduction in the number of fishers.

[10] This assumes value-added of 25% of the market value of other inputs and a 48% reduction in the use of these inputs

(iv) Alteration in the volume of fish supply.

Depending on the initial state of overexploitation and other factors, a transition to the optimal fishery may increase or reduce the sustainable supply of fish. In the case of the Philippine marine fisheries, there is a considerable (27%) reduction in fish supply compared to the base year. However, as pointed out in section 3.4, the current harvest is not sustainable since in that year biomass is falling. Further calculations show that maintaining the base year fishing effort, the sustainable supply of fish from the Philippine marine fisheries is about 12% less than under the optimal fishery.

A reduction in the supply of fish is, ceteris paribus, a disadvantage to fish consumers, albeit a likely gain to fish producers due to the associated price increase (not modelled in section 3). Back-of-an-envelope calculation assuming reasonable demand elasticities suggests the loss in consumer surplus is unlikely to exceed US$ 10 million per year and almost surely less than US$ 50 million.

(v) Greater quality and higher unit value of landings.

The price increase is already included in the profitability calculations. However, that leaves out the gain in consumer surplus from being able to enjoy the higher quality (a deadweight gain corresponding to the deadweight loss discussed under the previous item). The same applies as to the relative magnitude of this effect as that of altered fish supply. It is unlikely to be significant compared to the other magnitudes of the project. It will, however, be of opposite sign to the possible loss due to reduced fish supply and, probably, somewhat larger.

(vi) Increased stability of fish harvest and, consequently, more operational stability in the fishing industry.

This effect, as discussed in Arnason (2021) is generally found in optimally run fisheries. The reasons are larger stocks and greater collective control making it both possible and desirable to stabilize catch levels and, consequently, other operations. The economic value of this is difficult to state. If this increases profits by 1% on average, the annual value would by about 9 million US$ in equilibrium.

(vii) Increase in the value of the user rights.

The value of user rights equals the expected benefits of having them. Thus, this increase in value is a direct consequence of increased annual profitability under SURFs and, as such, not an additional gain. However, there is also a financial aspect to this. Valuable user rights inherently constitute an asset that may be taken as collateral or, more generally, a security for the repayment of borrowed (and share) capital. Thus, SURFs are likely to reduce the capital costs to the agents receiving them.[11] The size of this effect is difficult to judge. Clearly it depends on the size and capital structure of the fishing industry which itself is likely to be altered following the introduction of SURFs. If, as an example, the capital is 50% of the annual turnover and the reduction in capital costs is 1%, it is quickly found from table 3 that the amount saved (essentially due to less risk) would be about 25 million US$ annually.

(viii) Reduced employment in the harvesting activity.

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[11] Hernando De Soto (2000) has referred to this effect as transforming dead capital into living.

As discussed under item (i), this is potentially a very sizable item. However, this was estimated under item (i) and there is nothing to add to those estimates here.

(ix) Costly implementation and enforcement of SURFs.

This is potentially a significant item. Implementing, managing, and enforcing SURFs is generally a costly undertaking. Studies conducted (see e.g., Schrank et al. 2003) indicate that the additional costs of SURFs-based fisheries management can easily amount to 2-3% of the gross revenues of the fishery. So, taking this to apply to the Philippine fisheries, the annual management and enforcement cost could be 40-60 million US$ annually.

(x) Altered structure of the fishing industry with respect to the number, size and operating focus of the fishing companies

As discussed in Arnason and Runolfsson (2022), this is an inevitable consequence of a transition to SURFs. Whether this constitutes a benefit, or a cost is a moot point, however. Arguments can be made for both. Even less is known about the size of this effect in terms of value.

(xi) Altered geographical location of the fishing industry

It is commonly found that under SURFs, the geographical location of the fishing industry is altered, often in the direction of fewer and larger operating places. While this generally benefits the populations living in the locations that are expanded, it is generally a cost to the people living in locations in which the fishing industry contracts or disappears altogether. To a certain extent this loss is covered under the items dealing with reduced fishing labour (items (i) and (viii)), but not completely. Having to move house to follow employment opportunities is a major cost for most households. In addition, there are sometimes sentiments associated with living locations.

To get an idea what this effect might amount to in the context of the Philippine marine fisheries, let us carry out very simple calculations. Let's assume that 50 thousand families (about 1/5 of the total number of fishers made redundant) need to relocate because of the SURFs. Then if they require US$ 1500 (50% of their average annual income) to be equally well off the cost is 75 million US$. If, on the other hand they require 5,000 US$, the total amount is 250 m. US$. This is a significant amount compared to the annual benefits but, importantly, it is a once and for all expenditure. The annualize value of this cost at 4% rate of discount is 3 to 10 million US$.

(xii) Shift to a higher economic growth path

Increased profits and almost surely gross domestic income from the introduction of SURFs offers a surplus that can be invested in profitable projects within or without the fishery. Thus, a transition to SURFs offers the opportunity to launch the economy onto a higher economic growth path. This effect can of course be significant compared to the other magnitudes of the fishery. But how significant? A cursory investigation into this effect suggests that it may well be very substantial. Thus, assuming 20% of the annual additional profits are invested at about 4% real annual rate of return suggests that annual returns from these new investments will converge to an equilibrium of about 445 m. US$ or just under 50% of the net profits from the fishery itself.[12]

(xiii) Unequal distribution of the costs and benefits following from SURFs.

As already discussed at some length, the costs and benefits from the introduction of SURFs are bound to be unequally distributed. This will hold even if all losers are compensated. It seems likely that this aspect of the matter is generally disliked compared to an equal distribution[13] and even compared to the initial distribution of benefits and costs. Thus, although the income distribution is perhaps more a matter of a social than economic impact, this unequal distribution of costs and benefits probably amounts to a social cost. How great that cost is, is a moot point. A priori, it appears that this cost could be significant, although it is likely to decline over time as the new income distribution becomes the familiar norm. A study of the general willingness to pay for equality in this respect would be helpful.

4.2 Environmental impacts

In Arnason and Runolfsson (2022), three environmental impacts of transition to SURFs were identified; (i) increased size of commercial stocks bringing the ecosystem closer to its pre-exploitation state, (ii) less fishing effort and application of fishing capital to the fishing grounds and therefore less pollution and other environmental damage associated with fishing effort and (iii) possibly reduced external (non-fishery) environmental damage as SURF-holders are likely to collude to protect the marine ecosystem from negative outside impacts.

These impacts are to a large extent social goods and, therefore, difficult to evaluate. However, from a collective perspective, they appear to be predominantly positive. Let’s now briefly consider their possible values.

(i) Increased size of commercial stocks

As mentioned, the environmental aspect of increased commercial stocks is a public good. Virtually nothing is known about its value and, since the good is enjoyed by the entire world, this value would be very hard to assess. Assuming these values to be in the interval 1 to 100 US$ per tonne of biomass/year (0.001 to 0.1 US$ per kg/year), the total value according to table 3 would be between 4 and 430 million US$ annually.[14]

(ii) Reducing fishing effort

The environmental value of reduced fishing effort in Philippine waters is no better known than that the stock rebuilding. It should be noted however that the Philippine marine fishing areas cover substantial coral reef and other environmentally desirable areas that are often negatively affected by fishing activity. Assuming this environmental impact to be between 10

[12] These calculations do not include reinvesting a portion of the investment returns and therefore probably constitute an underestimate.

[13] It may of course be questioned whether equal distribution of the benefits is compatible with optimality, but that is another matter.

[14] It may be mentioned that if this valuation would apply to the global marine capture fishery the environmental gain of global fish stock rebuilding to the optimal fishing level would be 0.4 to 36.3 billion US$ annually.

and 100 US$ per vessel year, the reduction in fishing effort listed in table 3 suggests that the environmental gain would be 1 and 13 million US$/year.

(iii) SURF-holders environmental protection

SURF holders have a strong collective interest in protecting the value of their assets. This implies that they will oppose detrimental exogenous impacts on the ecosystem that sustains the commercial fish stocks. This is likely to be an environmental benefit. However, the SURF-holders will also have an incentive to alter the ecosystem to their benefit. This may imply changes that may generally be considered negative (e.g., monoculture etc.). So, there are opposite impacts about which we know little. For this reason, perhaps the most prudent option is to provisionally set the value of this item to zero.

4.3 Social impacts

Arnason and Runolfsson (2022) identify eleven social impacts from a transition to SURFS. Many of them are the same or stem from the impacts of SURFs that have already been classified as economic in section 4.1. This is not surprising as economic impacts are also social and the borderline between what are economic and what are non-economic social impacts is blurry.

The following four social impacts are not included in the economic impacts of section 4.1:

(i) More technically advanced fishing industry and, therefore, more skilled labour.
(ii) Altered power and social status relationships.
(iii) Cultural shifts associated with a new rights arrangement and the ensuing new production methods and techniques.
(iv) A period of social disturbances as the adjustment from the previous arrangement to the new one takes place.

There can be no doubt that these social impacts are significant to the people that experience them and that, as such, they will have an economic value. There is further little doubt that different individuals will value these impacts differently and often with opposite signs. Nevertheless, since most people appear to value the social aspects they are used to, it seems likely that these social changes will be overall detrimental. However, the associated costs are also likely to fade out gradually over time as the new social order settles. The appropriate monetary valuation of these effects, however, is totally murky.

4.4 An attempt at a summary

Table 4 represents an attempt to summarize the above valuations of the impacts of SURFs in the Philippine fisheries. For impacts that are temporary, the valuation reported is an annualized one, i.e., the present value of the valuation multiplied by the rate of discount. [15] Low and high estimates are reported.

Table 4 **Valuating the impacts: A summary**		
	Annual valuation (million US$)	
	Low	High
I. Economic impacts		
Increase in profitability	909	909
Increase in value of user rights	0	25
More operational stability	0	9
Higher quality of landed catch	0.5	1.0
Economic growth effects	0	445
Total economic benefits	909.5	1389
Reduced use of labour & inputs	-264	-50
Operation and enforcement	-60	-40
Reduced fish supply	-50	-10
Altered geographical location	-3	-10
Unequal distribution	?	?
Total economic costs	377	110
Net economic benefits	532.5	1279
II. Environmental impacts		
Increased commercial stocks	4	430
Reduced fishing effort	1	13
SURF-holder's environmental protection	?	?
Total environmental benefits	5	443
III. Social impacts	?	?
Grand total	537.5	1722

According to the results reported in table 4, a transition to SURFs in the Philippines marine fisheries appears to be hugely beneficial or between 537 and 1722 million US$ per year in equilibrium. At a discount rate of 4% the present value of these net benefits is between 13.4 and 43.1 billion US$.

By far the largest estimated benefits are the increase in net economic surplus (profits), positive impacts on economic growth and reduced environmental damage. The greatest costs are the possible reduced use of economic resources, especially labour and the fisheries management and enforcement costs of the SURFs.

[15] More precisely, the annualized valuation is defined as $r \cdot \sum_{t=1}^{\infty} \frac{x(t)}{(1+r)^t}$ where $x(t)$ is the annual valuation, t is the year and r is the rate of discount.

It should be noted, however, that these estimates omit the possibly large costs of the social impacts (including altered income distribution) of a transition to SURFs. At the same time, it should be observed the annualized magnitude of these impacts has to be very high indeed to render the net outcome negative.

As the preceding discussion makes clear, the valuations reported in table 4 are not based on detailed research and some are little more than informed guesses. Therefore, these results should be regarded as first approximations. To obtain a better-founded valuation of the impacts of SURFs in the Philippine marine fisheries or, for that matter, other fisheries, requires much more research along the lines of cost-benefit analysis. Fully-fledged cost - benefit studies are very expensive. Since, in the case of the Philippine marine fisheries the net benefits seem so highly positive, it is questionable whether the added precision from such a study is worth the expense.

5. Discussion

This paper argues that transition to SURFs has in general both negative and positive impacts affecting different individuals differently and in a varying way over time. Moreover, both the impacts and their valuations depend on the fishery and the society in which it is placed. It follows that it is not possible to assert that transition to SURFs (or, more generally, alteration in the strength of the user rights in the fishery) is in general either socially beneficial or detrimental. This kind of conclusion depends on each empirical situation as well as the type of SURFs that are being contemplated.

This suggests that to determine for any given fishery whether a transition to SURFs is advisable or not requires an empirical assessment of the costs and benefits involved. Reasonably well conducted cost-benefit studies typically require a great deal of work and are consequently expensive. This cost must, of course, be subtracted from the net benefits of the SURFs. So, whether to embark on such a study and, if so, how much effort to put into it is another decision problem, which depends, *inter alia*, on the expected net benefits of the SURFs. This shows that before any movement toward adopting SURFs some *a priori* expectation of the net benefits of doing so must be formed. If the *a priori* expected net benefits are hugely positive, there is little need for a careful cost-benefit study. If, on the other hand, the *a priori* expected net benefits are marginal, a more carefully conducted and, therefore, more expensive cost-benefit study is needed.

Despite the empirical dependence of the costs and benefits of SURFs, it is important to realize that there likely exists a sizable class of fishery-society combinations for which SURFs are almost surely highly beneficial. A possible example of this type of fishery-society combination is a large, high unit value fishery in an advanced economy. Similarly, there very likely exists a class of fishery-society combinations for which the net benefits of SURFs are almost sure to be highly negative. A possible example of a fishery-society combination in this class is a small, low unit value fishery in an underdeveloped economy.

Obviously, there is no need to conduct an extensive cost-benefit study on the various costs and benefits of the impacts of SURFs in these two classes of fisheries. Such a study would not be worth the time and expense. It is only for the fishery-society combinations in between these classes that a careful cost-benefit study of the impacts would be worth the effort.

These considerations suggest that it would be extremely useful if it were possible to specify in terms of widely available (or easily observed) characteristics of fisheries and societies the relevant boundaries of these two classes. A result of this kind would allow fisheries managers to focus their efforts at fisheries improvement on the most promising options and avoid the others. It seems plausible that as the number of empirical case studies of the impacts of SURFs accumulate these boundaries will become increasingly better defined.

According to the results of the specific case study presented in this study, that of the Philippine marine fisheries, the economic impacts of a transition to SURFs seem to be strongly positive. The environmental impacts, while reliable valuations are not available, seem to be generally positive. The social impacts could not be evaluated. There are reasons to think that they may generally be negative, although in the case of the Philippine marine fisheries it appears extremely unlikely that this value is anywhere close to the economic and environmental benefits. It appears likely that this pattern of relative valuation will be repeated in many commercial fisheries around the world.

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