Local Fishing Communities and Nature–Based Tourism in Baja, México

An Inter–Sectoral Valuation of Environmental Inputs

Alberto Ansuategi · Duncan Knowler · Tobias Schwoerer · Salvador García–Martínez

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Abstract Nature–based tourism is often advocated as a desirable conservation strategy for small–scale fishing communities as it gives local people motivation to protect wildlife and ecosystems that attract visitors, while benefiting the community. However, valuation of environmental inputs in nature-based tourism, for instance charismatic species or scenic amenities, needs to be done correctly. Often, there are inter–sectoral costs and benefits involved that are not counted, so that determining the value of the environmental inputs to local communities may be more complex than simpler calculations might indicate. We model whales as an input to the production of wildlife viewing trips, but recognize that this occurs within a community dependent on a seasonal fishery. Standard theory suggests that industry will switch from fishing to whale watching every year when whale watching becomes marginally more profitable than fishing. We develop a simple theoretical model that allows us to analyze the interaction between the extractive and the non–extractive activities. As a case study, we use whale watching in the small coastal communities of the Bahía Magdalena lagoon complex in Baja, México.

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A. Ansuategi
Instituto de Economía Pública , UPV/EHU, Lehendakari Agirre 83, 48015 Bilbao, Spain
Tel.: +34-94-6013824
Fax: +34-94-6013891
E-mail: alberto.ansuategi@ehu.eus

D. Knowler
Simon Fraser University, 8888 University Dr., Burnaby, BC V5A 1S6, Canada

T. Schwoerer
University of Alaska Anchorage, 3211 Providence Dr., Anchorage, AK 99508, USA

S. García–Martínez
Universidad Autónoma de Baja California Sur, Carretera al Sur Km 5.5, 23080 La Paz, B.C.S. México

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1 Introduction

Biodiversity conservation is crucial for communities in developing countries where family survival may depend on access to a diverse set of environmental resources. Certainly, it is recognized that for biodiversity conservation to be viable, it must make sense at the community level, where most day-to-day decisions about resource use are made. In this sense, it can be argued that the value of biodiversity at the local scale is distinct and has an importance that contrasts with that at the global scale. As Martínez-Alier [26] has put it, there is a need to be clear about whose values are being counted in valuation exercises, and whose values are given weight. While economists typically cast the net widely in valuing the environment or performing cost-benefit analysis, we would argue for the usefulness of also considering a narrower local accounting stance in devising local conservation strategies.

One way of dealing with the biodiversity problem at the local level is to support strategies that provide the right incentives for local people to use their natural resources sustainably [35]. Nature–based tourism is often advocated as a desirable conservation strategy for developing countries, as it gives local people motivation to protect the wildlife and ecosystems that attract visitors, while benefiting the community [18]. This economic incentive is essential for achieving economic development and nature conservation, especially where no environmental regulation and enforcement occurs, such as outside of conventional protected areas [35]. However, valuation of environmental inputs in nature–based tourism, for instance charismatic species or scenic amenities, needs to be done correctly. In less rigorous valuations it is assumed that use of these environmental inputs does not interact with other economic activities in the local community, but this may not be so. Often, there are other possible economic benefits and costs involved, so that the true value of the environmental input may be more complex than the simpler calculation might indicate.

In this paper we follow Martinez-Alier [26] in spirit by counting only local valuations of an environmental resource but consider the more complex case where these involve inter–sectoral trade–offs. As a case study, we use the example of whale watching and its interaction with fishing in the small coastal communities of Baja, México.

The "Baja born" Eastern North Pacific gray whale (*Eschrichtius robustus*) is among México's most charismatic wildlife species. Gray whales migrate annually from their feeding grounds in the Arctic Ocean to their breeding sites in bays off the west coast of Baja, where they stay from January until March. Along their migratory route, the whales have become an icon for coastal communities in México, Canada, and the United States, that seek alternative income through nature–based tourism [19, 20].

Quantifying the economic value of nature provides information for better decision making and offers an important bridge between people with different interests but common long-term goals [6]. Much of valuation methodology focuses on the demand side, such as the travel cost method or contingent valuation techniques. For example, these have been used to estimate the value associated with gray whales as they migrate past California [24]. However, valuation of environmental resources can also take a supply side approach based on production theory [3,12]. Previous valuation attempts measuring the economic contribution of gray whales to communities in Baja estimated revenue from whale watching activity only [13,31]. While this serves as a first approximation of the commercial importance of whale watching, compared to other economic activities, it fails to value the species using proper welfare criteria.

In this paper we develop a more theoretically valid approach that models a wildlife species (whales) as an input to the production of wildlife viewing trips, but recognizes that this occurs within a fishery dependent community. We model the local shrimp fishery as an annual industry with a finite number of identical vessels participating each year. We assume that some of these vessels hold permits that allow them to switch from fishing to whale watching activities. This allows us to provide a very simple theoretical framework to study how these vessels decide when to switch from fishing to whale watching but also reflects the current situation. Another key feature of our model is that the fishing production function incorporates two elements, a congestion coefficient and a variable catchability coefficient. These elements allow us to consider both positive and negative interactions between fishing and whale watching activities.

The literature contains many examples of conflicts between resource–based industries and resource–based tourism [4,1,25] and the shrimp fishing and whale watching activities in Bahía Magdalena may not be an exception. The principal threat to the eastern population of gray whales likely lies in increased human activity in the breeding lagoons [9]. Whales are susceptible to human activities in their four breeding lagoons in México as well as to entanglement in fishing gear and collisions with boats. Over the 1970's and 80's, to ensure that the gray whale population remained healthy and that large numbers of whales returned to whale watching destinations along the Pacific West Coast, the Mexican Government set aside marine protected areas in three of these lagoons: Ojo de Liebre, Guerrero Negro and San Ignacio. Yet the Bahía Magdalena lagoon has not received the same fully protected status. Instead, access to critical nursing areas is regulated and only permitted in designated areas. Thus, once a significant number of whales enter the Bay shrimp fishing is restricted to areas not utilized by the whales to protect them from becoming entangled in fishing gear [28]. This implies additional costs for shrimp fishing that should also be taken into account.

Congestion among fishing vessels is also a common occurrence on fishing grounds where fish are highly concentrated. As an explicit result of congestion, the production function of the fishery exhibits decreasing marginal returns to effort [10]. To the best of our knowledge there are no studies analyzing the presence of congestion externalities in the shrimp fishery in Bahía Magdalena, but Huang and Smith [21] provide empirical evidence of the presence of congestion externalities in North Carolina's shrimp fishery and argue that this may be due to the fact that the trawl fishery disperses fish aggregations. Should congestion externalities be involved in our fishery, then opening up the whale watching season and diverting part of the fishing effort to that activity would imply some sort of congestion–relief benefit that should be taken into account.

Therefore, the main objective of this article is to build a simple model that allows us to analyze the interaction between extractive and non–extractive activities in the small–scale fishing communities of Bahía Magdalena and illustrate how this interaction should be incorporated when deriving the marginal value (economic contribution) of an increase in whale abundance to the local community.

The article is organized into six sections. After this brief introduction, section 2 describes the modeling approach for both the shrimp fishery and the whale watching industry. Section 3 analyzes the interaction between the extractive and the non–extractive activities. In Section 4 the model is used to study the impact of a higher presence of whales in both the whale watching industry and the fishery. In section 5 the theoretical results are illustrated with a numerically calibrated version of the model applied to the whale watching industry and the shrimp fishery in two small coastal communities of Baja, México. Section 6 discusses the results and suggests further research directions.

2 Modeling Approach

In this section, we develop a model to illustrate the resource dynamics and associated profitability of two activities that occur in sequence over a one–year time horizon: an extractive shrimp fishing activity and a non–extractive nature–based tourism activity (whale watching).[1]

2.1 Shrimp Fishery

With regard to the extractive (shrimp fishing) activity, we assume that there is an instantaneous Schaefer-type harvest function with congestion defined by:

$$h\left(t\right) = qE^{\alpha}S\left(t\right) \tag{1}$$

where $\alpha \in (0, 1]$ represents the congestion parameter [10, p. 223–224].

[1] The fishing activity is approximated by shrimp fishing for two reasons. First, shrimp fishing is the most profitable fishery in the Bay and therefore the next best alternative to whale watching, and therefore a good measure of the opportunity cost of whale watching. Second, from a seasonal perspective shrimp fishing precedes whale watching. Note that participants require permits for both whale watching and fishing; the former are limited, while normally the latter are not.

Natural mortality during the season is ignored for analytical convenience. Total cumulative harvest for the industry over a season of length T will be:

$$H(T) = S_0 - S(T) = S_0\left(1 - e^{-qE^{\alpha}T}\right) \tag{2}$$

which is determined by integrating the instantaneous harvest function over the season length T, assuming that E is constant and the initial shrimp stock S_0 is given.

Let P_S represent the ex-vessel price per unit of catch. Thus, annual revenues of the fishing industry are obtained by multiplying this price and the cumulative seasonal harvest. With respect to costs, we assume simple linear costs related to both the level of fixed fishing capacity and to the cumulative level of variable effort devoted to fishing over the season. We assume fixed costs of z per season per unit of capacity E must be incurred to participate in the fishery. We also assume that there are variable costs v per unit of capacity used per unit of time associated with the (assumed constant) rate of input use over the season.

With both cost and revenue formulations as described above, we write total industry rents in the shrimp fishery (π_S) for a season of length T_S as:

$$\pi_S = \left[P_S S_0\left(1 - e^{-qE^{\alpha}T_S}\right)\right] - [vET_S + zE] \tag{3}$$

We assume a Fisheries Management Authority exists to oversee the operation of the shrimp fishery and prevent biological/economic overfishing.[2] Thus the stated aim of such an agency is to achieve the maximum sustainable yield (MSY) by such methods as restricting the length of the fishing season, setting total catch limitation and regulating the type of fishing gear used. Thus, we are assuming that every season the fishery captures a volume of shrimp $(\bar{Q})$ equivalent to the MSY.[3]

Assuming that cumulative harvest for the industry over the season is equal to the harvest quota[4], which is set at $\bar{Q}$, we can solve for the season length T_S:

$$T_S = \frac{1}{qE^{\alpha}} \ln\left[\frac{S_0}{S_0 - \bar{Q}}\right] \tag{4}$$

[2] The National Commission for Aquaculture and Fisheries (CONAPESCA) is a decentralized federal body in charge of the management of Mexican fisheries and aquaculture resources. The responsibility is shared with state governments and municipalities.

[3] According to the OECD Review on Fisheries[27] and in reference to shrimp fisheries in México, *"the most important fishing zone is concentrated in the states around the California Gulf at the Pacific Ocean (Baja California, Baja California Sur, Sonora and Sinaloa) with a second zone in the Gulf of Mexico located in the states of Tamaulipas and Campeche. The fishery as a whole is considered utilized at its maximum sustainable level"*.

[4] Our model only deals with within-season dynamics of the fishery and we are assuming that each season the fishery is subject to some quota-regulation. If the quota is an equilibrium quota (any quota at which harvest and natural reproduction of the resource are equal), the biomass will remain constant and the regulated fishery will be in a full steady state.

Substituting (4) into (3), total industry rents in the shrimp fishery (in the absence of nature–based tourism activity) would be:

$$\pi_S = P_S\bar{Q} - \frac{v}{q}E^{1-\alpha}\ln\left(\frac{S_0}{S_0-\bar{Q}}\right) - zE \tag{5}$$

2.2 Whale Watching Industry

With regard to the non-extractive (whale watching) activity, we assume that the average seasonal peak abundance of the Western Pacific gray whale stock visiting the Bay, $\bar{W}$, is fixed and model the daily presence of whales in the Bay, W_t, according to White [33].[5] He uses a parabolic trajectory to describe the dynamics of the whale population visiting a coastal bay or lagoon[6], as depicted in Figure 1. If t_0 refers to the time the first whale enters the Bay and the last whale departure time is represented as $\bar{T}$, then we can represent the dynamics of the whale population visiting the lagoon in the following way:

$$W_t = \begin{cases} 0 & t < t_0 \\ b\,(t-t_0) - a(t-t_0)^2 & t_0 \le t \le \bar{T} \\ 0 & t > \bar{T} \end{cases} \tag{6}$$

where a and b are parameters such that $b = a\left(\bar{T}-t_0\right)$ and $\frac{b^2}{4a} = \bar{W}$. Accordingly, the equation for W_t, which is graphically represented in Figure 1, will be the following:

$$\begin{aligned} W_t &= \left(\frac{4\bar{W}}{\bar{T}}\right)(t-t_0) - \left(\frac{4\bar{W}}{\bar{T}-t_0}\right)(t-t_0)^2 = \\ &= \frac{4\bar{W}}{\left(\bar{T}-t_0\right)^2}(t-t_0)\left(\bar{T}-t\right) \qquad if\ t_0 \le t \le \bar{T} \end{aligned} \tag{7}$$

We are assuming that a θ share of the total effort in the fishery is also in possession of a whale watching permit each year, where $0 < \theta < 1$. From a seasonal perspective, the start of the shrimp fishing precedes the whale watching season. At some point in time during the fishing season (at $t = T_S{}'$), fishers in possession of a whale watching permit are assumed to switch from fishing to whale watching. This switch involves some cost (basically, cleaning up and painting the boats) that we will represent as $m > 0$.

Whale watching tour operators can provide an average amount of $g > 0$ trips per vessel per day and P_W is the constant price per whale watching trip. Whale watching trip costs will be negatively related to the presence of whales in the whale watching area.[7] We model whale watching trip costs as:

[5] The presence of whales will be measured by an index of instantaneous abundance, that is, an index of instantaneous whale population density.

[6] This is consistent with the shape of whale abundance graphs for adult whales counted in Laguna San Ignacio during the 2007-2018 winter seasons reported in [32].

[7] When more whales are present in the Bay they tend to be closer and easier to locate and, consequently, operators require less fuel [28].

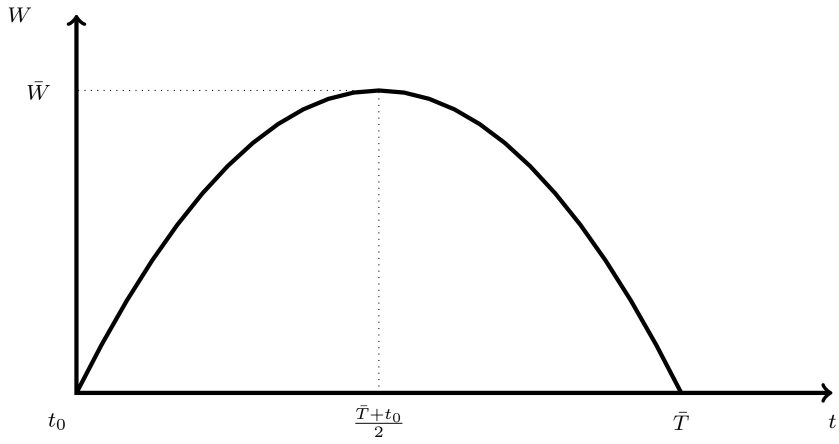

Fig. 1: Dynamics of the whale population

$$C_W = \begin{cases} d & if \quad W_t > W' \\ d + f\,(W' - W_t) & if \quad 0 < W_t \leq W' \end{cases} \tag{8}$$

where $d > 0$ represents those operating costs of a trip that are not related to whale abundance (i.e. no search costs), W' represents the threshold in the index of presence of whales beyond which searching costs would be reduced to the minimum and $f\,(W' - W_t)$ represents the extra cost of searching for whales when $0 < W_t \leq W'$. Figure 2 shows the evolution of whale watching trip costs from t_0 to $\bar{T}$, which depends on whether the peak abundance $(\bar{W})$ is higher, lower or equal to the threshold level of whale abundance mentioned above (W').

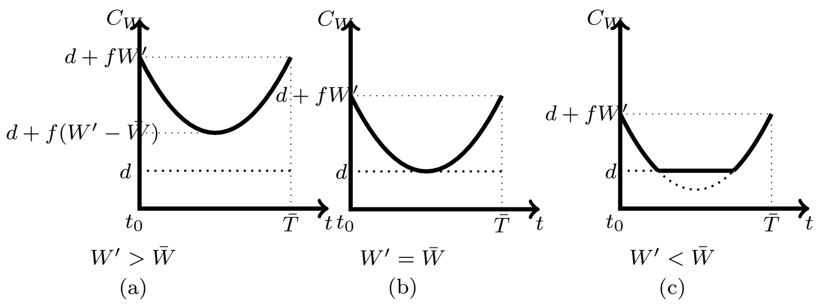

Fig. 2: Whale watching trip costs over time

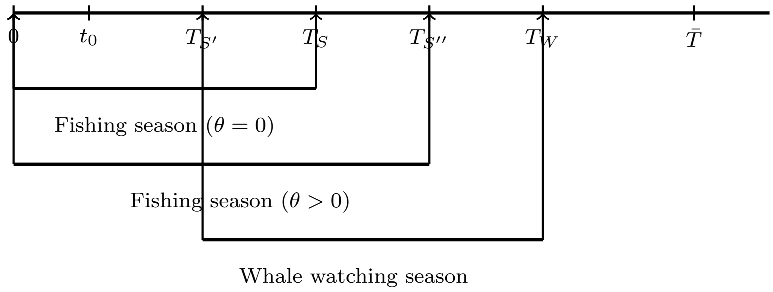

Fig. 3: Fishing and whale watching seasons

3 Interaction between Extractive and Non–Extractive Activities

In this section, we analyze the interaction between the extractive and the non–extractive activities described above. As mentioned in the introductory section, from a seasonal perspective fishing precedes whale watching. Note that this is also a feature of our model, since from equation (7) there are no whales in the Bay at the beginning of the fishing season.

In the trivial case where non-extractive activities are not economically viable (this would be the case if: either *(i)* $P_W < d$ or *(ii)* $\bar{W} = 0$ or *(iii)* $\theta = 0$) the only activity for the local industry would be shrimp fishing and the (fishing) season length and total industry rents would be those described in equations (4) and (5), respectively. In this case the fishing season runs until T_S.

However, let us assume that we are not dealing with the trivial case but that the local community is involved in both fishing and whale watching activities. We will also consider that the fishing and the whale watching seasons do overlap over time.[8] Then the length of the fishing season will be ${T_S}''$ and will be split into two parts: the first one from 0 to ${T_S}'$, in which all the fleet will be involved in fishing activity, and the second one from ${T_S}'$to ${T_S}''$, in which a $1 - \theta$ share of the fleet will continue fishing and a θ share of the fleet will switch to whale watching.[9] Then, the whale watching season will end at some point in time that we will denote by T_W, so that the whale watching season will be from ${T_S}'$ to T_W. Figure 3 summarizes the overlap of the fishing and whale watching seasons over time.

The time during the season at which fishermen in possession of a whale watching permit will decide to switch from fishing to whale watching (${T_S}'$) will be characterized by the equalization of the instantaneous fishing rents per ves-

[8] Note that the overlap between both activities over time is not something that will always take place. Imagine, for example, a situation where the total allowable catch of shrimp is set at a very low level so that the fishing season ends before a substantial number of whales enters the Bay.

[9] We will implicitly assume, for the sake of simplicity, that the total allowable catch of shrimp is not high enough as to give the option to return to fishing from whale watching.

sel with the instantaneous whale watching rents per vessel. The instantaneous fishing rent per vessel $\left(FRPV\left(T_S{'}\right)\right)$ would be the following:

$$FRPV\left(T_S{'}\right) = P_S h\left(T_S{'}\right)/E = P_S q E^{\alpha-1} S_0 e^{-qE^{\alpha}T_S{'}} - v \tag{9}$$

The instantaneous whale watching rent per vessel $\left(WRPV\left(T_S{'}\right)\right)$ would be the following:

$$\begin{aligned} &WRPV(T_S{'}) = g\left[P_W - d - f\left(W' - W(T_S{'})\right)\right] = \\ &g\left[P_W - d - fW'\right] + \frac{4gf\bar{W}}{\left(\bar{T}-t_0\right)^2}\left(T_S{'} - t_0\right)\left(\bar{T} - T_S{'}\right) \end{aligned} \tag{10}$$

Equalizing (9) and (10) results in an implicit equation that has to be solved numerically for $T_S{'}$.

Next, if we want to obtain the time at which the fishing season ends $\left(T_S{''}\right)$, we first compute the total cumulative harvest of the fishing industry from $t = 0$ to $t = T_S{'}$, which we will represent as $H\left(T_S{'}\right)$:

$$H\left(T_S{'}\right) = S_0\left(1 - e^{-qE^{\alpha}T_S{'}}\right) = S_0 - S_{T_S{'}} \tag{11}$$

We will also consider that during the whale watching season, the Environmental Protection Agency may set up fishing restrictions and this may lower the catchability coefficient to a value that we will represent as $q_{low} \leq q$.Thus, the total cumulative harvest of the fishing industry from T_S' to T_S'', which we will represent as $H\left(T_S{''} - T_S{'}\right)$, is the following:

$$H\left(T_S{''} - T_S{'}\right) = S_{T_S{'}}\left(1 - e^{q_{low}((1-\theta)E)^{\alpha}(T_S{''}-T_S{'})}\right) = S_{T_S{'}} - S_{T_S{''}} \tag{12}$$

Knowing that the Fishing Management Authority will set up a limit in catches so that total fishing catches during the whole fishing season must equal the MSY $\left(\bar{Q}\right)$, we have that:

$$\bar{Q} = H\left(T_S{'}\right) + H\left(T_S{''} - T_S{'}\right) = S_0 - S_{T_S'} e^{-q_{low}(1-\theta)^{\alpha}E^{\alpha}\left(T_S{''}-T_S{'}\right)} \tag{13}$$

This leads us to:

$$T_S{''} = T_S{'} + \frac{1}{q_{low}(1-\theta)^{\alpha}E^{\alpha}} \ln\left(\frac{S_{T_S{'}}}{S_0 - \bar{Q}}\right) \tag{14}$$

Finally, the time at which the whale watching season ends (T_W) will be obtained by establishing the condition that the net revenue of whale watching becomes zero:

$$g\left[P_W - d - fW'\right] + \frac{4gf\bar{W}}{\left(\bar{T}-t_0\right)^2}\left(T_W - t_0\right)\left(\bar{T} - T_W\right) = 0 \tag{15}$$

Solving (15) for T_W we obtain:

$$T_W = \frac{-b' \pm \sqrt{b'^2 - 4a'c'}}{2a'} \tag{16}$$

where:

$$a' = \frac{4gf\bar{W}}{\left(\bar{T} - t_0\right)^2} \tag{17}$$

$$b' = -\frac{4gf\bar{W}\left(\bar{T} + t_0\right)}{\left(\bar{T} - t_0\right)^2} \tag{18}$$

$$c' = g\left[fW' + d + \frac{4f\bar{W}t_0\bar{T}}{\left(\bar{T} - t_0\right)^2} - P_W\right] \tag{19}$$

We will also define total local industry rents (π) as the summation of fishing rents (π_S) and whale watching rents (π_W):[10]

$$\pi = \pi_S + \pi_W \tag{20}$$

where:

$$\pi_S = P_S\bar{Q} - vET_S{}' - v(1-\theta)E\left(T_S{}'' - T_S{}'\right) - zE \tag{21}$$

$$\pi_W = \theta E \left[\begin{array}{l} a'\left[\frac{\left(T_W{}^2 - T_S{}'^2\right)\left(\bar{T} + t_0\right)}{2} - \frac{\left(T_W{}^3 - T_S{}'^3\right)}{3} - \bar{T}t_0\left(T_W - T_S{}'\right)\right] \\ + g\left(P_W - d - fW'\right)\left(T_W - T_S{}'\right) - m \end{array}\right] \tag{22}$$

4 The Effects of an increase in whale abundance on local economic activities

The modeling framework presented in the previous section allows us to analyze the effects of an increase in whale abundance on local economic rents. In this section we consider an exogenous increase in the average peak abundance during the whale watching season $\left(\bar{W}\right)$ and discuss its effect on the point in time at which permit holders switch to whale watching activities $\left(T_S{}'\right)$, on the length of the fishing season $\left(T_S{}''\right)$, on the length of the whale watching season $\left(T_W - T_S{}'\right)$ and on the rents earned in local economic activities (π_S and π_W). We will distinguish four different cases with regard to the interaction between

[10] Note that $\frac{\partial}{\partial t}\left(\frac{t^2}{2}\left(\bar{T} + t_0\right) - \frac{t^3}{3} - t\bar{T}t_0\right) = \left(\bar{T} - t\right)\left(t - t_0\right)$. Thus, equation (22) would be the result of measuring in continuous time the whale watching rents for the cases in which $W' \geq \bar{W}$. In the case in which $W' < \bar{W}$, equation (22) would overestimate the benefits of the whale watching industry due to the fact that once reached $W_t = W'$ further increases in the abundance of whales will not result in reductions of searching costs.

extractive and non-extractive activities: (i) no congestion and no fishing restrictions ($\alpha = 1$ and $q_{low} = q$), (ii) congestion without fishing restrictions ($\alpha < 1$ and $q_{low} = q$), (iii) fishing restrictions without congestion ($\alpha = 1$ and $q_{low} < q$) and (iv) congestion and fishing restrictions ($\alpha < 1$ and $q_{low} < q$).

4.1 CASE I: $\alpha = 1$ and $q_{low} = q$

This case could be considered the *"benchmark case"*, the point of reference for evaluating the importance of inter–sectoral effects when studying the impact of an increase in whale abundance on local economic rents.

It should be noted that an increase in $\bar{W}$ implies an increase in the marginal cost of waiting to switch to whale watching activities for any switching point after the first whale enters the Bay. As a result, equalization of the marginal cost and benefit of waiting (see equations (9) and (10)) will take place earlier $\left(\partial T_S{}'/\partial \bar{W} \ < 0\right)$.

With regard to $T_S{}''$, an increase in $\bar{W}$ implies that the fishing season will last longer, since the total seasonal catch is fixed and a reduced fleet with constant returns to effort will be operating from an earlier time. This can be proved using the first derivative of equation (18):

$$\begin{aligned} \frac{\partial T_S{}''}{\partial \bar{W}} &= \frac{\partial T_S{}'}{\partial \bar{W}} + \frac{1}{q\left(1-\theta\right) E S_{T_S{}'}} \frac{\partial S_{T_S{}'}}{\partial T_S{}'} \frac{\partial T_S{}'}{\partial \bar{W}} \\ &= \frac{\partial T_S{}'}{\partial \bar{W}} - \frac{1}{\left(1-\theta\right)} \frac{\partial T_S{}'}{\partial \bar{W}} = -\frac{\theta}{1-\theta} \frac{\partial T_S{}'}{\partial \bar{W}} > 0 \end{aligned} \tag{23}$$

For T_W, an increase in $\bar{W}$ implies that the net revenue from whale watching will be higher for any point in time $t \in \left(t_0, \bar{T}\right)$ [see left hand side of equation (19)] and this implies that the net revenue from whale watching will fall to zero at a later time $\left(\partial T_W/\partial \bar{W} \ > 0\right)$.

Regarding $T_W - T_S{}'$, it is straightforward to show that the length of the whale watching season increases in response to an increase in $\bar{W}$:

$$\frac{\partial\left(T_W - T_S{}'\right)}{\partial \bar{W}} = \frac{\partial T_W}{\partial \bar{W}} - \frac{\partial T_S{}'}{\partial \bar{W}} > 0 \tag{24}$$

With regard to π_S, note that in this *"benchmark case"* there are no inter–sectoral effects and therefore fishing rents will not be affected by an increase in whale abundance. This can be proved taking the first derivative of (21):

$$\frac{\partial \pi_S}{\partial \bar{W}} = -v\left(1-\theta\right) E \frac{\partial T_S{}''}{\partial \bar{W}} - v\theta E \frac{\partial T_S{}'}{\partial \bar{W}} \tag{25}$$

and, then, substituting (23) into (25):

$$\frac{\partial \pi_S}{\partial \bar{W}} = -v\left(1-\theta\right) E \left(-\frac{\theta}{1-\theta} \frac{\partial T_S{}'}{\partial \bar{W}}\right) - v\theta E \frac{\partial T_S{}'}{\partial \bar{W}} = 0 \tag{26}$$

However, an increase in $\bar{W}$ causes the rents in the whale watching industry π_W to rise for two reasons: first, there will be more whale watching trips due to an increase in the length of the whale watching season; second, the increase in the abundance of whales will reduce the costs related to searching for whales. Thus, we have that $\left(\partial \pi_W / \partial \bar{W} \ > 0\right)$.

4.2 CASE II: $\alpha < 1$ and $q_{low} = q$

When we consider that congestion takes place in the fishery, the main qualitative difference in the results in comparison to those of the *"reference case"* is the sign of the impact from an increase in $\bar{W}$ on fishing rents. Note that in this case:

$$\frac{\partial T_S{}''}{\partial \bar{W}} = \left[1 - \frac{1}{(1-\theta)^{\alpha}}\right] \frac{\partial T_S{}'}{\partial \bar{W}} \tag{27}$$

Thus, substituting (27) into (25) we have that:

$$\frac{\partial \pi_S}{\partial \bar{W}} = -\left[1 - (1-\theta)^{1-\alpha}\right] vE \frac{\partial T_S{}'}{\partial \bar{W}} > 0 \tag{28}$$

We can see that the increase in the abundance of whales results in an increase in shrimp fishing rents due to a congestion–relief effect.

4.3 CASE III: $\alpha = 1$ and $q_{low} < q$

When we consider that fishing restrictions take place during the whale watching season, the main qualitative difference in the results in comparison with those of the *"reference case"* is again the sign of the impact from an increase in $\bar{W}$ on fishing rents. Note that in this case:

$$\frac{\partial T_S{}''}{\partial \bar{W}} = -\left[\frac{q}{q_{low}(1-\theta)} - 1\right] \frac{\partial T_S{}'}{\partial \bar{W}} \tag{29}$$

Thus, substituting (29) into (25) we have that:

$$\frac{\partial \pi_S}{\partial \bar{W}} = \left[\frac{q}{q_{low}} - 1\right] vE \frac{\partial T_S{}'}{\partial \bar{W}} < 0 \tag{30}$$

In this case the increase in the abundance of whales results in a reduction in shrimp fishery rents due to the lower catchability associated with restrictions in fishing activity.

Table 1: The effect of changes in whale abundance on season length and rents in fishing and whale watching activities

	$\partial T_S'/\partial\bar{W}$	$\partial T_S''/\partial\bar{W}$	$\partial T_W/\partial\bar{W}$	$\partial\pi_W/\partial\bar{W}$	$\partial\pi_S/\partial\bar{W}$
$\alpha = 1, q_{low} = q$	-	+	+	+	0
$\alpha < 1, q_{low} = q$	-	+	+	+	+
$\alpha = 1, q_{low} < q$	-	+	+	+	-
$\alpha < 1, q_{low} < q$	-	+	+	+	?

4.4 CASE IV: $\alpha < 1$ and $q_{low} < q$

When congestion and fishing restrictions are combined, the main qualitative difference in the results in comparison with those of the *"reference case"* is again the sign of the impact from an increase in $\bar{W}$ on fishing rents. Note that in this case:

$$\frac{\partial T_S''}{\partial \bar{W}} = \left[1 - \frac{q}{q_{low}(1-\theta)^{\alpha}}\right] \frac{\partial T_S'}{\partial \bar{W}} \tag{31}$$

Thus, substituting (31) into (25) we have that:

$$\frac{\partial \pi_S}{\partial \bar{W}} = \left[\frac{q}{q_{low}}(1-\theta)^{1-\alpha} - 1\right] vE\frac{\partial T_S'}{\partial \bar{W}} \tag{32}$$

In this case the sign of the impact from an increase in $\bar{W}$ on fishing rents is ambiguous:

$$\frac{\partial \pi_S}{\partial \bar{W}} = \begin{cases} \geq 0, & \text{if} \quad (1-\theta)^{1-\alpha} \leq \frac{q_{low}}{q} \\ < 0, & \text{otherwise} \end{cases} \tag{33}$$

Figure 4 contains a 3D-contour plot showing the combinations of θ, α and q_{low}/q that result in no impact from an increase in peak whale abundance on shrimp fishing industry rents. Combinations above such a contour will lead to a positive impact, and combinations below such a contour will lead to a negative impact. This figure also implies that for each combination of congestion and catchability reduction effects there exists some margin for regulators to correct inter–sectoral effects through a change in the numbers of whale watching permits issued.

The effect of changes in whale abundance on season length and rents in fishing and whale watching activities is summarized in Table 1. A 0 indicates that an increase in whale abundance does not have any effect on the variable in question, a plus sign indicates that an increase in whale abundance will increase the variable in question, a negative sign indicates that an increase in whale abundance will reduce the variable in question, and a question mark indicates that the effect is qualitatively ambiguous.

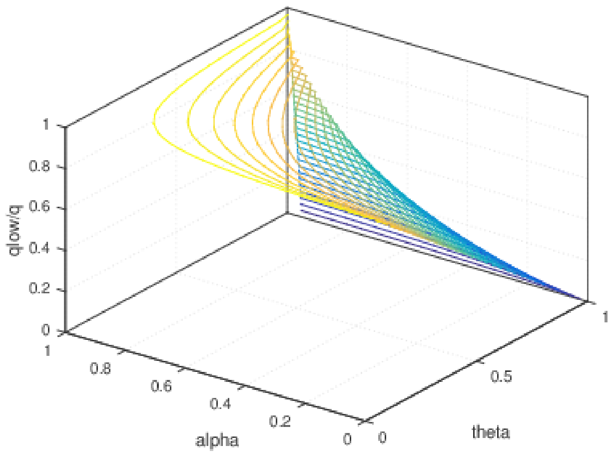

Fig. 4: Combinations of θ, α and $\frac{q_{low}}{q}$ that lead to no impact from changes in $\bar{W}$ on fishing rents

5 A numerical illustration

In this section, we calibrate the model using data related to the shrimp fishery and the whale watching industry in two small coastal communities of the Bahía Magdalena lagoon complex in the state of Baja California Sur in México. In the following sub-sections, we develop our empirical specifications for the model and present our parameter assumptions and results.

5.1 Shrimp fishery: biology of the resource

We assume a logistic growth function to describe the net biological growth of shrimp:

$$F(X) = rX\left(1 - \frac{X}{K}\right) \tag{34}$$

where $F(\cdot)$ is the net growth function, X represents the biomass of the resource, $r > 0$ is the intrinsic growth rate of the resource, and $K > 0$ is the environmental carrying capacity. The MSY associated with a logistic growth function is the stock level where $X_{MSY} = {}^{K}/_{2}$ and $MSY = F\left(X_{MSY}\right) = {}^{rK}/_{4}$.

Chávez-Rosales et al.[8] report the average annual shrimp captures in Bahía Magdalena as approximately 100 tons, and this is corroborated by García-Martínez and Chávez-Ortiz [17]. Taking this value as an approximation for MSY, we get:

$$\bar{Q} = 100 \tag{35}$$

Since no published estimates of the intrinsic growth rate for the shrimp fishery in Baja California could be found, we borrow an estimate for the blue shrimp fishery in the Upper Gulf of California [16], where $r = 1.18$. With this value of r, we can estimate the carrying capacity of the fishery as:

$$K = \frac{4\bar{Q}}{r} = \frac{400}{1.18} \simeq 340 \tag{36}$$

which then yields an estimate for the stock level at MSY ($X_{MSY} = S_0$):

$$S_0 = \frac{K}{2} = 170 \tag{37}$$

5.2 Shrimp fishery: extractive industry

García-Martínez and Chávez-Ortíz [17] estimate the number of shrimp fishing boats (E) as:

$$E = 170 \tag{38}$$

With regard to the length of the fishing season, we know that shrimping in Bahía Magdalena goes from early September to the end of February when both fishing and whale watching activities take place. Thus, we will assume that the length of the fishing season in the absence of whale watching activity (T_S) is slightly shorter (120 days) since no boats would be diverted from fishing to whale watching.

There are no estimates of the catchability coefficient for the shrimp fishery in Bahía Magdalena, so we borrow the catchability coefficient estimated for the blue shrimp fishery in the Upper Gulf of California [16], where $q = 0.00032$. Using (4) and knowing that $S_0 = 170$, $\bar{Q} = 100$, $E = 170$ and $T_S = 120$, we can determine the congestion factor:

$$\alpha = 0.61 \tag{39}$$

García-Martínez [15] reports the price per kilogram of shrimp at 220 pesos for the 2000/2001 season. In order to express these prices in 2006 pesos, we use Mexico's National Institute of Statistics' estimates of accumulated inflation for the 2001-2006 period [23]. Accordingly, we obtain shrimp prices expressed in 2006 pesos per tonne:

$$P_S = 220{,}000 * 1.234 = 273{,}460 \quad \text{pesos} \tag{40}$$

Aranceta-Garza [2, Table 29] estimates that the variable costs of small-scale shrimp fisheries in the Gulf of California was 17.00 2014 US dollars per day. Using the US Dollar/ Mexican peso exchange rate for 31st December 2014 and correcting for the accumulated inflation for the 2006-2014 period [23] we obtain the variable cost per vessel expressed in 2006 pesos:

$$v = 17 * 17.76/1.39 = 217 \quad \text{pesos} \tag{41}$$

According to Schwoerer et al. [31, Table 6], annual fixed costs in the whale watching industry are approximately 989,500 pesos altogether, which means 15,960 pesos per vessel assuming 62 whale watching boats. Applying this figure to the 170 vessels in our simulation provides an estimate of the total annual fixed costs across both economic activities (fishing and whale watching). For the sake of simplicity we assume that in the case of holders of whale watching permits, these fixed costs are 100% accounted for when calculating the rents of fishing activity and are not included in the calculus of whale watching rents.[11]

5.3 Presence and abundance of whales

Whale watching activity in Bahía Magdalena starts in mid-January and lasts less than two months. Thus, we define a six month time framework (from September to February, inclusive) for the analysis in days per year:

$$\bar{T} = 180 \tag{42}$$

We establish the beginning of December as the time of year when the first whale enters the Bay:

$$t_0 = 90 \tag{43}$$

With regard to peak whale abundance, visual surveys have been used to estimate whale abundance in Bahía Magdalena[12], which involves identifying the total number of whales inside the lagoon complex and calculating the average residence time. Nevertheless, in our model the most relevant attribute related to the presence of whales is neither the number of individuals nor their mean residence time, but the instantaneous whale population density in the Bay. Therefore, $\bar{W}$ and W' are meant to jointly determine how costly results to find whales in the Bay during the whale-watching season. We consider it reasonable to work with a range from 80 to 100 as our value for peak whale abundance $\left(\bar{W}\right)$ and a value of 100 as the abundance associated with minimum searching costs (W').

[11] Note that the distribution and scale of these fixed costs does not affect how changes in whale abundance influence the duration and rents associated with the two economic activities.

[12] Rosales–Nanduca et al. [29] conduct photographic identification surveys during the 2012 winter in the Bahía Magdalena lagoon complex and identify 275 individual whales visiting the entire complex over the entire season of which 234 were single whales and 41 were mother-calf pairs. The whales with longest residence time (duration of stay) inside the lagoon complex were mother-calf pairs, with the longest residence time of 27 days and an average residence time of 3.9 days. The longest residence time of a single whale was seven days and the average residence time was 1.2 days.

5.4 Revenues and costs in the whale watching industry

According to Schwoerer et al.[31, Table 1], the number of whale watching permits issued in Bahía Magdalena is 62, made up of 35 from Puerto San Carlos and 27 at Puerto Adolfo López Mateos. This means that the share of the fleet holding a whale watching permit[13] is the following:

$$\theta = \frac{62}{170} \simeq 0.36 \tag{44}$$

Schwoerer et al. [31, 7th row in Table 3] report mean switching cost estimates based on interview data. Based on these estimates:

$$m = 700 \quad \text{pesos} \tag{45}$$

Schwoerer et al. [31, rows 15th and 16th in Table 5] report data from SEMARNAT [30] indicating that 2,561 whale watching trips were offered in a season that lasted 44 days. Knowing that the number of permits was 62, this gives as $\frac{2561}{62*44} = 0.93 \simeq 1$ trips per boat (permit) per day.

Also from Schwoerer et al. [31, Table 6], we can compute average revenue and operating cost per trip as 2,550 pesos and 1,225 pesos, respectively. Thus, we use the following values:

$$P_W = 2,550 \quad \text{pesos} \tag{46}$$

$$C_W = d + f\,(W' - W_t) \quad d = 1,225, \quad f = 20, \quad W' = 100 \tag{47}$$

Note that the whale watching trip cost function establishes the operating cost per trip as falling within the range 1,225 to 3,225 pesos when $\bar{W} = 100$, and between 1,625 and 3,225 pesos when $\bar{W} = 80$.

Table 2 presents the numerical values of each of the parameters of the model.

5.5 Simulation results

Table 3 presents the simulation results for the case in which congestion externalities exist ($\alpha = 0.61$) but no restrictions in fishing activities are considered. It comes as no surprise that the increase in whale abundance has a positive effect in whale-watching rents. As explained in the previous section, this is due to the combined effect of an increase in the whale watching season length and a reduction of searching cost for whales. We can see that as whale abundance increases from 80 to 100, the length of the whale watching season increases from 57 days to 65 days (14% increase) and whale watching industry rents increase from 2,188,776 pesos to 3,652,930 pesos (67% increase). These estimates

[13] There are one or two operators in Puerto San Carlos who exclusively do tourism and whale watching and do not fish at present, but they represent a small share of the trips taken.

Table 2: Parameter assumptions for case study simulations

Parameter	**Description**	**Value**
r	shrimp's intrinsic growth rate	1.18
K	shrimp's carrying capacity (tonnes)	340
$\bar{Q}$	shrimp's MSY (tonnes)	100
S_0	shrimp's stock level associated to MSY (tonnes)	170
E	fishing effort (no of boats)	170
q	catchability coefficient (without fishing restrictions)	0.00032
α	congestion coefficient	0.61
P_S	price (pesos/ton) of shrimp	273,460
P_W	price (pesos/trip) of whale watching	2,550
θ	whale watching permit share (wrt fleet)	0.36
t_0	day the first whale enters the Bay	90
T	day of departure of the last whale	180
$\bar{W}$	whale abundance at peak	80–100
W'	whale abundance level at which searching costs are at a minimum	100
d	constant term of whale watching trip cost	1,225
f	parameter of the searching costs of whale watching trip	20
v	variable cost of shrimp fishing (per boat and day)	217
z	fixed cost of shrimp fishing (per boat)	15,960
g	number of whale watching trips per day	1

are in line with other recent estimates that state that gray whales generate a net benefit of 3.4 million pesos annually in Bahía Magdalena [31].

The benchmark level of fishing rents (when fishing and whale watching activities do not interact, that is, when no congestion and fishing restrictions are considered) is 20,173,600 pesos. This estimate is consistent with the 44.5 million pesos estimate for the 2004/05 season reported by García–Martínez [15] that uses a bioeconomic model that leads to a catch of 205.8 tonnes (twice as much as the catch considered in our simulation exercise). Our simulation results also show that when we incorporate congestion in the production function, fishing rents grow with the presence of whales due to the congestion–relief effect. Thus, as whale abundance increases from 80 to 100, the positive impact of whale watching activity on fishing rents increases from 0.14% to 0.33% (28,700 to 67,200 pesos).

We have estimated the degree of congestion ($\alpha = 0.61$) substituting our estimates of S_0, $\bar{Q}$, E and T_S in equation (4), but there exists no information on the impact of fishing restrictions on the catchability coefficient of the fishing production function. However, we can (i) assess the sensitivity of fishing rents to changes in the catchability coefficient and (ii) calculate the change in the catchability coefficient that would offset the positive effect of an increase in whale abundance on fishing rents (for $\alpha = 0.61$ and $\theta = 0.36$). Table 3 shows how the positive effect of an increase in whale abundance on fishing rents vanishes as we impose fishing restrictions on the catchability coefficient. It also shows that beyond a 15.97% negative impact of the fishing restrictions on the catchability coefficient, the net effect of an increase in whale abundance on fishing rents becomes negative.

Table 3: The effects of increasing whale abundance on switch time, season lengths, and rents without fishing restrictions

	T'_S	T''_S	$T_W - T'_S$	π_S	π_W
$\bar{W} = 80$	116	122	57	20,202,362	2,188,776
$\bar{W} = 85$	114	123	60	20,214,478	2,556,491
$\bar{W} = 90$	112	124	62	20,224,617	2,922,622
$\bar{W} = 95$	111	124	63	20,233,275	3,287,964
$\bar{W} = 100$	109	125	65	20,240,781	3,652,930

Table 4: Whale abundance, fishing restrictions and fishing rents in Bahía Magdalena when $\alpha = 0.61$

<table>
<tr><th>$1 - \frac{q_{low}}{q}$</th><th>$\bar{W}$</th><th>π_S ($\theta = 0.36$)</th><th>π_S ($\theta = 0$)</th></tr>
<tr><td rowspan="5">0.05</td><td>80</td><td>20,194,400</td><td rowspan="5">20,173,600</td></tr>
<tr><td>85</td><td>20,203,161</td></tr>
<tr><td>90</td><td>20,210,494</td></tr>
<tr><td>95</td><td>20,216,756</td></tr>
<tr><td>100</td><td>20,222,183</td></tr>
<tr><td rowspan="5">0.1597</td><td>80</td><td rowspan="5">20,173,600</td><td rowspan="5">20,173,600</td></tr>
<tr><td>85</td></tr>
<tr><td>90</td></tr>
<tr><td>95</td></tr>
<tr><td>100</td></tr>
<tr><td rowspan="5">0.20</td><td>80</td><td>20,164,541</td><td rowspan="5">20,173,600</td></tr>
<tr><td>85</td><td>20,160,725</td></tr>
<tr><td>90</td><td>20,157,532</td></tr>
<tr><td>95</td><td>20,154,804</td></tr>
<tr><td>100</td><td>20,152,441</td></tr>
</table>

6 Conclusions

Wildlife and nature–based tourism can make an important contribution to national income in countries where sources of income, employment, and public sector earnings are limited. However, the main concern in economic analysis of community conservation is not so much the total economic value of wildlife but rather the extent to which local communities benefit from increased presence of wildlife. We are aware that wildlife may provide a local non-consumptive use value for local communities (apart from non-use or existence benefits more distantly from their conservation) but in this analysis we take a more narrow approach and focus on local producer benefits from nature–based tourism and other local activities. We argue that whether or not local communities have incentives to conserve wildlife and whether or not they are better–off with the increased presence of wildlife, depends not only on the local retention of nature–based tourism expenditures but also on the costs and benefits imposed on other economic activities which compete with wildlife. This is why we have focused on some possible indirect positive and negative impacts that nature–based tourism may have on local communities. If the valuation of environmental inputs in nature–based tourism is to be done correctly, then we should take into account that other local economic activities can be positively and/or negatively affected. We have therefore developed a simple theoretical model to explore the sensitivity of economic rents in the extractive and non extractive activities to the presence of indirect linkages. Since the analysis has been applied to gray whale watching and shrimp fishing in the small coastal communities of the Bahía Magdalena lagoon complex in Baja (México), the indirect linkages considered have been congestion externalities in the shrimp fishery and the presence of wildlife protection measures that impose additional opportunity costs in the fishery. There may be other indirect linkages that we have not considered in our modeling exercise, and this can be a matter for further research.

Our numerical simulation results suggest that in the particular case of whale watching and shrimp fishing industries in Bahía Magdalena inter–sectoral effects are very modest. Thus, focusing on the economic rent of the whale watching industry to determine the economic value of the presence of gray whales, as done by Schwoerer et al. [31], may constitute a good proxy to that value from the local producers' perspective. Yet our modeling approach can be considered a theoretically more sound basis for obtaining a true measure of value. It has long been argued in demand–side valuation literature that for policies involving species perservation it is important to collect not just average but also marginal conservation values [7]. This article shows how supply-side valuation studies can go beyond an average value of presence of whales (dividing the whale watching industry rents by the number of whales returning to the Bay) towards a marginal value, making it possible to study how a change in the number of whales returning to the Bay affects the profitability of local economic activities.

Our analysis is also important in a number of other contexts such as conflicts of small–scale agropastoral activities and wildlife–based tourism opportunities in Africa and Asia and the challenges of wolf management and conservation in North-America and Europe. In most of the studies dealing with such types of Human–Wildlife interactions the analysis centers only on a single form of (negative) interaction, which can be reduced to conflicts over livestock or land. However, the analysis may omit other possible types of interactions with local economic activities that could be relevant. For instance, wild animals exert significant influences on food production systems which may be positive or negative. Positive influences include the role of wild animals as pollinators and seed dispersers [14], whereas negative influences include their role as reservoirs of pathogens that threaten domestic animal and human health [11].

Sometimes the links are more complex. For example, several studies show that wolves can help improve conditions for fish by changing patterns of deer and elk browsing and reducing streamside grazing [5, 34]. We argue that if we are to measure the value of these environmental inputs to local communities we have to adapt the underlying bioeconomic modeling approaches to allow us to capture all these interactions between nature–based tourism and other local economic activities. Further studies need to be undertaken to deepen understanding of these indirect linkages so that this type of analysis can be used to better inform conservation decision–making.

Finally, a potentially fruitful area for further research that emerges from our study is looking at the assignment of whale-watching permits among fishermen as a policy variable that could help increase local economic rents and reallocate users to less congested resources. This type of research could add an intertemporal perspective to recent research focusing on the welfare implications of spatial shifts in harvesting effort when exploiting congestible resources [22].

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