CURRENT AND POTENTIAL ECONOMIC RENT IN THE NAMIBIAN HAKE FISHERY

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ABSTRACT

We estimated the economic rent obtained currently (that is, in 2002) in the Namibian hake fishery and the rent that might potentially be obtainable if the fishery were managed optimally in the sense of economics. We first reviewed previous economic and biological studies. We then used the theory and model of Arnason [1] to estimate the current and potential rent in the Namibian hake fishery. Our estimates were that the current rent is 21 million USD (90% confidence interval in sensitivity analysis: 13-31) in 2002, with the potential for rent of approximately 112-118 million NAD (90% confidence intervals: 90-140 for logistic model and 84-135 for Fox model) annually if the fishery were managed optimally, i.e., with a much larger stock and a smaller fishing fleet. These estimates were particularly sensitive to some parameters, especially the cost parameter, but in general appeared to be fairly robust. Our estimate of current rent is roughly in line with previous estimates of the same number, while our estimate of potential rent is somewhat higher. We find that approximately 5-6 times greater wealth could be generated from this fishery if it were managed in a way closer to the economic optimum.

Keywords: Economic rent; cape hake; Namibian hake.

INTRODUCTION

This paper presents estimates of the economic rent obtained in the Namibian hake fishery in 2002 (the current rent), and the rent that could potentially be earned if the fishery were to be managed at the economic optimum. Economic rent is often used by economists to measure the net benefits obtained from exploitation of a natural resource. Economic rent is defined as the difference between what a factor of production is actually paid and the minimum amount that it would have to be paid to remain in its current use. In the case of a fishery, the key factor in question is the fish stock, and the amount that it is 'paid' is the shadow price of the resource, i.e., the opportunity cost in terms of forgone future rent of reducing the stock.

Realized and potential economic rent in a fishery can be estimated in a variety of ways. First, one can construct a full bioeconomic model of the fishery and calculate rents in this model [2, 3]. A second approach is to use a green accounting method and calculate rent as total revenue minus values such as intermediate consumption, compensation of employees, consumption of capital and normal profit [4]. Third, economic theory suggests that the price of individual quotas should be directly related to the rent that is expected to be obtained by fishing those quotas, implying that rent can be estimated from these quota prices [5].

In this paper we first review existing economic studies of the Namibian hake fishery, with a focus on those that estimate economic rent in the fishery. We then use the model of Arnason [1], a version of the first approach described above, to estimate current and potential rent in the fishery, and examine the likely reasons for the observed dissipation of rent.

REVIEW OF EXISTING ECONOMIC STUDIES

Cost and earnings studies

We are aware of a series of costs-and-earnings studies, conducted by the Ministry of Fisheries and Marine Resources starting in 1994. This series was cited by Eide et al. [5] as a survey of the commercial industry that was begun in 1994 and conducted annually. These authors did not use the results of the surveys because: (1) the data are incomplete; (2)

the data are not a representative sample; (3) some companies catch on behalf of other quota holders; and (4) some company income from one species may include income from other species. Whatever the strengths and flaws in these data, we were unfortunately unable to obtain copies of any of the reports. However, Ithindi [6] presented much of the data from the 2002 survey (see Table II), and we therefore used these data, presented below, for our rent estimates.

Bioeconomic model findings

There is a relatively small bioeconomics literature on Namibian hake. The papers available in the literature address issues of allocation of catch between fishing fleets and between countries, with one article outlining a more general assessment of the implications of different policies. We review these articles below.

Sumaila [2] analyzed the allocation of quota between wet fish and freezer bottom trawlers, the two major fleets that catch Namibian hake. He assumed an average exogenous total allowable catch (TAC) of 150,000 tonnes, and then asked what would be the economically efficient allocation of this quota between the two fleets. He found that an allocation of 100% of the quota to wet fish trawlers yielded the economically optimal solution, with the present value of rent estimated to be 11.69 billion (billion = 10^9) Namibian dollars (NAD; 1 US dollar was worth 10.5 NAD in 2002, and 6.4-7.5 NAD in 2003-2006. We present many quantities in current-year NAD as this is the currency used in the original sources. However, we convert to 2002 USD in Table I), compared to 10.42 billion NAD for the current policy objective of a 60% allocation to wet fish trawlers. The 100% allocation also yielded the greatest number of jobs: 7804 with 100% allocated to wet fish trawlers as opposed to 5219 with the 60% allocation.

Sumaila [3] developed his 2000 work [2] in two directions in a subsequent study, by: (1) using an age-structured biological model and examining outcomes in terms of biodiversity, using what he called a "demographic diversity index;" and (2) allowing the TAC to be set endogenously in the model. The diversity index measured the deviation of the age structure of the population from that observed when there is no fishing, with 100% signifying a system identical to that with no fishing. It was assumed that the fishers themselves decided on a TAC, and the two fleets then decided whether or not to cooperate in managing the fishery. Like the previous study, this one found that a full allocation of quota to the wet fish trawlers, along with side-payments from the wet fish trawlers to the freezer trawlers, yielded the most economically efficient outcome, with present value of rents of 10.24 billion NAD and a diversity index of 65%. Without side-payments, the best solution allocated most catch to the wet fish trawlers, and yielded a total rent of 7.14 billion NAD and a diversity index of 78%. If the two fleets did not cooperate in allocating catches and instead maximized their individual rents, the total rent was 5.13 billion NAD with a diversity index of 56%.

Sumaila and Vasconcellos [7] used a mass-balance ecosystem model [8] and a standard bioeconomic model to assess the impacts of distant-water fishing fleets (DWFs) on Namibia's fisheries. They compared twenty-year simulations with and without DWFs in terms of biomass, catch and rent time series. They found that, from 1970-1989, the annual average rent from the hake fishery for the Namibian fleets was 71 million NAD, but could have been 138 million NAD if the DWFs had not been present. The authors attributed these losses incurred by the Namibian fleet to the depletion of fish stocks by the DWFs.

Armstrong and Sumaila [9] examined the effects of non-cooperation between Namibia and South Africa in managing their fisheries for the trans-boundary hake stocks. They used the logistic growth function to describe the stock dynamics, and then calculated the equilibrium with a sole owner, under open access, and under cooperation by the two countries in managing the stocks. They ran simulations for 1990-2000, and estimated that total economic rent over these 11 years could have been 8.6 billion NAD if the fishery were optimally managed by a sole owner, while under open access, by definition, there would be no economic rent. They characterized the actual management situation at that time as non-cooperation, and estimated that this state of affairs cost the fishery about 30% of potential economic rent, or 327 million NAD annually.

Finally, Heymans and co-authors used an Ecopath with Ecosim ecosystem model and bioeconomic model to assess tradeoffs between objectives for fisheries management under different management approaches (JJ Heymans, UR Sumaila, V Christensen, Scottish Association for Marine Science and University of British Columbia, unpublished data). They used the dynamic model of Heymans et al. [10] and explored policies that maximized profit, employment, or "ecosystem status" [11], and then examined how much of each of these objectives must be forgone to gain in terms of another objective. The authors found that profit in Namibia's fisheries as a whole could be increased 2.6-fold relative to the 1997 level, and employment increased 2.7-fold, by increasing effort in the demersal fishery 20-fold and adjusting effort in other fisheries up or down less drastically. These changes would have relatively little effect on the

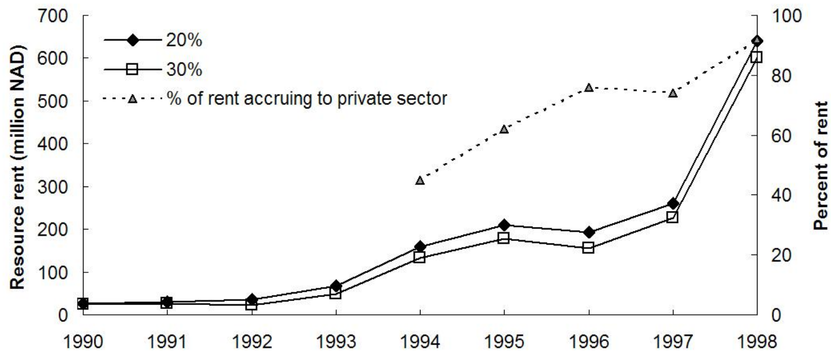

Figure 1: Resource rent accruing in the Namibian hake fishery as estimated by [4], assuming either a 20% or 30% return to fixed capital.

ecosystem status indicator. The authors gave no absolute estimates of profit or rent for either their simulations or the base model.

Estimates of resource rents, profitability, and economic health of the fishery

Some of the bioeconomic models above give estimates of resource rent obtained or obtainable in the fishery. We summarize these estimates in Table I. Two other studies also provide estimates of resource rent; those studies are also summarized in Table I, and we review them below.

Eide et al. [5] assessed the potential and realized rent in three fisheries, including the Namibian hake fishery, and examined how the potential rent is dissipated. The authors estimated rent accruing in the fishery using the price at which quota is informally leased among fishers. For 2000-2002, they estimated actual rent accrual of 81-140 million NAD for wet fish trawlers and 171-234 million NAD for freezer trawlers. Using firm-level data, the authors suggested that that vast majority of resource rent accrues to large, established companies in the fishery, rather than to smaller, newcomer companies. By comparing the export value of hake as it leaves Namibia with the import value of hake as it arrives in the European Union, the major importer of Namibia's hake products, the authors deduced that a significant portion of resource rent (6-43% of the export value) is accrued abroad in the EU. Upon comparing government expenditures on fisheries management (3.7-5.9% of landed value) with government revenues from quota, bycatch, and license fees and other levies, they found that there is a net transfer of rent from the fishery to the government.

Lange et al. [12] and Lange [4] used an accounting approach to calculate rent in the fishery and compare this to other components of Namibia's national wealth. They obtained data from Namibia's national accounts on the following aspects of the fishery: total revenue; intermediate consumption; compensation of employees; consumption of fixed capital; normal profit; and the value of the fixed capital stock. They then estimated rent in the hake fishery for 1990-98 using these values, and two plausible values for the opportunity cost of capital (20% and 30%; Fig. 1). Lange et al. [12] also estimated the percentage of the rent accruing to the private sector for 1994-98 (Fig. 1).

State of the stock and level of exploitation

Several studies have recently examined the status of the hake stock and the level of exploitation using single-species stock-assessment models as well as ecosystem models. We review two key studies below.

Butterworth and Rademeyer [13] reviewed stock assessments, stock status, and fisheries management for southern African hake stocks. They assessed the stock by fitting an age-structure production model (ASPM) to abundance indices and catch-at-age data from the commercial fishery and research surveys. Their estimates of spawning biomass as a fraction of carrying capacity (line) and annual catches (bars) are shown in Fig. 2. Their assessment showed a gradual depletion of spawning biomass from the 1960s through to about 1990, since which time the stock rebounded slightly and apparently stabilized somewhat at 25-30% of the carrying capacity. This biomass level is well below that which would produce maximum sustainable yield.

Table I: Summary of rent estimates from bioeconomic and other studies of Namibia's hake fisheries. Rent estimates are given both in million current NAD as presented in the original source, and in million 2002 USD.

Study	Type of model or calculations	Year(s)	Type of rent estimate	Rent (curr. NAD)	Rent (2002 USD)	Comments
Sumaila [2]	exogenous stock dynamics, fixed exogenous TAC	mid 1990s	potential NPV	11,700	1999	With 100% of quota to wet fish trawlers.
			NPV under gov't policy	10,400	1777	With 60% of quota to wet fish trawlers.
Sumaila [3]	age-structured biology, endogenous TAC set strategically by fishers in two fleets	mid 1990s	potential NPV	10,200	1743	With 100% of quota to wet fish trawlers, achieved by cooperation, with side-payments from wet fish trawlers to freezers.
			potential NPV	7100	1213	With cooperation, and most quota to wet fish trawlers, but no side-payments possible.
			potential NPV	4900	837	With cooperation, and emphasis placed on conserving demographic diversity of fish population.
			actual NPV	5100	871	Non-cooperation: each fleet catches to maximize its individual profit.
Sumaila and Vasconcellos [7]	mass-balance ecosystem model (Ecopath with Ecosim)	1970-1989	annual average for Nam. fleet	71	19	With competition from distant-water fleets.
			annual average for Nam. fleet	138	37	Without competition from distant-water fleets.
Armstrong and Sumaila [9]	logistic growth function, game-theoretic interactions between countries	1990-2000	potential NPV over 11 years	8600	1250	With cooperation to apply sole-owner solution. Namibian and SA fleets.
			actual NPV over 11 years	5000	727	Without cooperation. Namibian and SA fleets.
Eide et al. [5]	based on quota lease price	2000-2002	actual annual value	250-370	32-40	Approx. 65-70% of rent accrues to freezer trawlers.
Lange et al. [12]	based on data from national accounts	1990-1998	actual annual value	24-640	3.3-88	Increasing trend over time: see Fig. 1.

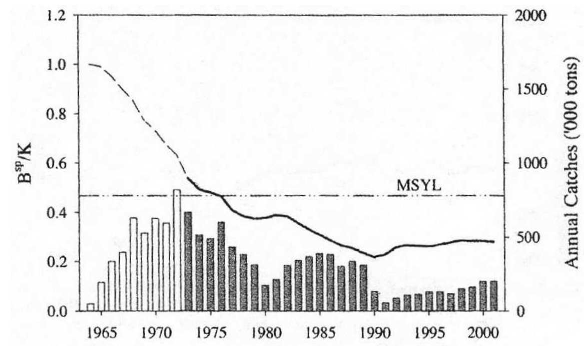

Figure 2: Time series of spawning biomass (B^{sp}) as a fraction of carrying capacity (K; line) and annual catch (bars) from [13]. MSYL is the B^{sp}/K level that would produce maximum sustainable yield.

Kirchner and Ianelli [14] conducted a more recent stock-assessment based on the same ASPM as Butterworth and Rademeyer [13]. They fit a variety of models to the data, but their conclusion was consistently pessimistic: they estimated the 2006 biomass to be between 25% and 55% (median approx. 30%) of that required to produce MSY, and about 13% of carrying capacity. They concluded that the stock was clearly depleted and in need of recovery if there is to be hope of improving future yields. Their analysis also indicated that TACs above 130,000 tonnes are likely to result in further declines in spawning biomass and commercial catch rates. This is somewhat alarming, since catches in 2005 and 2006 were in the area of 140,000 tonnes, well above the maximum suggested by these authors.

Transfers to and from the fisheries sector

Transfers to the fishery. We consider any government expenditure on the fishery, including transfers of funds to the industry and/or its participants and expenditures on fisheries management, to be transfers to the fishery.

Wiium and Uulenga [15] examined expenditures on management of all fisheries in Namibia, and divided these expenditures into those borne by Namibians (the government and the industry), and by foreign donors. The total cost of fisheries management to the Namibian government from 1994-1999 averaged 66 million NAD (range 52-82 million NAD). On average, 57% of this spending was on monitoring, control and surveillance (MCS), 32% was spent on research, and the remaining 11% was spent on other activities (e.g., administration). These costs accounted for 3.6-6.1% of the total landed value from Namibia's fisheries. These authors also reported that contributions to fisheries management from foreign donors declined from 39 million NAD in 1996 to 25 million NAD in 1999. We can roughly attribute a specific portion of these amounts to the hake fishery in proportion to the value of Namibia's three main fisheries (sardine, hake, horse mackerel) during the years in question [4]. Hake accounted on average for 60% of Namibia's total fisheries wealth during these years, so we can estimate that the average annual cost of managing the hake fishery was 40 million NAD.

Transfers from the fishery. Wiium and Uulenga [15] quantified the government's receipts obtained from the fishing industry on this basis. These receipts averaged 104 million NAD between 1994 and 1999 (range 72-132 million NAD), with about 80% of this amount coming from quota fees. These payments comprised 6-15% of the landed value in any given year. Eide et al. [5] estimated that 56-66% of total government revenue paid through fees and levies on the fisheries sector was obtained specifically from the hake fishery.

Net transfer to/from the fishery. Wiium and Uulenga [15], based on their estimates of transfers to and from the fishery (described above), estimated annual resource rent extracted by the government from all of Namibia's fisheries during 1994-99 to have been 3-80 million NAD, averaging 37 million NAD.

We can combine the Eide et al. [5] estimate of revenues from the fishery with our estimate of fishery management expenditure on the fishery, to yield an estimate of net government revenue from the fishery (Fig. 3). Net revenue has varied substantially, and was even negative in 1996, when catches in the fishery were unusually low. The average annual net revenue from the fishery over this period was 19.7 million NAD.

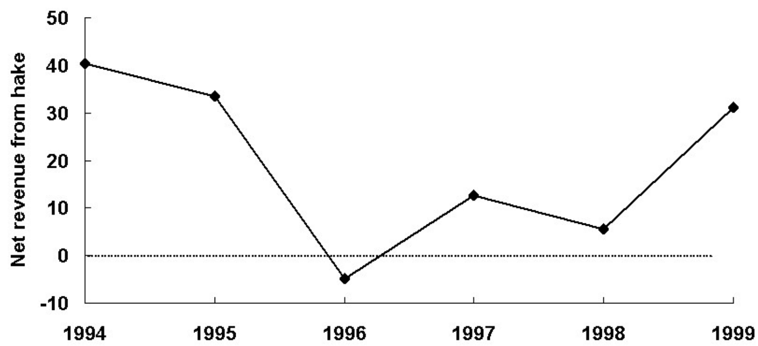

Figure 3: Net revenue (million NAD) to the state from the hake fishery. Based on data from [5] and [15].

METHODS

Estimates of current and potential rent

Arnason [1] presented a theory of resource rent in fisheries, and based on this theory built a relatively simple model to estimate potential and actual rents in the entire global fishery. The key relationship in the theory is rent $= \Pi_q \cdot q$, where q is the quantity of fish supplied and Π_q is the partial derivative of rent with respect to q.

We use this theory here to estimate rent in the Namibian hake fishery. While current stock assessments of the resource are conducted using an age-structured production model (ASPM), we use surplus production models (logistic and Fox) for the sake of simplicity but use biological model parameters obtained from the ASPM. Due to our relative lack of information about fishing costs, we apply the simple harvest and cost functions applied by Arnason:

$$Y(e,x) = qeB_{sp}^{b}$$

$$C(e) = ce + fk$$

where Y is catch, q is a catchability coefficient, e is fishing effort, B_{sp} is spawning biomass, b reflects the degree of schooling seen in hake, C is total cost of the fishery, and fk is fixed cost. We ran all calculations and simulations for the model in R (http://www.r-project.org).

Model inputs

The model requires nine inputs, the sources of which are described below. Given the availability of economic data on the fishery (MFMR [16], as cited by Ithindi [6]), we used 2002 as our base year.

- **Maximum sustainable yield (MSY).** Kirchner and Ianelli [14] estimated MSY from 10 different variations on their stock assessment model. The mean of their estimates from the eight models that converged in their estimations was 308 thousand tonnes (range 278-335).
- **Virgin stock biomass (K^{sp}).** Estimates by Kirchner and Ianelli [14] of virgin spawning biomass in the eight models that converged averaged 4977 thousand tonnes (range 4004-5598).
- **Biomass growth in base year.** Kirchner and Ianelli [14] reported that spawning biomass (B_{sp}) grew from 0.22 to 0.24 of spawning biomass at MSY (B_{sp}^{MSY}) from 2002 to 2003, so biomass growth ($\dot{x}$) in 2002 is $\dot{x} = 0.02 \cdot B_{sp}^{\mathrm{MSY}}$. These authors estimate B_{sp}^{MSY} as 1593-2411 thousand tonnes, with an average estimate of 2100 thousand tonnes.
- **Landings in base year.** Kirchner and Ianelli [14] reported landings in 2002 as 156 thousand tonnes.
- **Price of landings in base year.** We can compute an implied ex-vessel price of fish from the landings (above) and the total revenue from fish sales reported by the MFMR [16]: 733 million NAD. The implied price is therefore 4.70 NAD per kg.

Table II: Revenue and expenses in the 2002 Namibian hake fishery as reported in [6] from data in [16].

Revenue	Amount (million NAD)	Expense	Amount (million NAD)	Variable or fixed
Fish sales	734	Employment and payments	256	Variable
Commission for catches	7	Materials, insurance, repair and maintenance	151	50% fixed
Fees from use of quota	13	Fuel and lubrication	165	Variable
Vessel charter fees	17	Fishing gear	11	Variable
		Fishery fees and levies	26	Fixed
		Depreciation	34	Fixed
		Opportunity cost	50	Fixed
		Unloading, storage and freight, harbour and charter fees	37	Variable
		Bank charges and other expenses	14	Fixed
Total revenue	**771**	**Total expenses**	**744**	

Table III: Biological and economic parameters of the Namibian hake fishery implied by the input parameters outlined above.

Parameter	Value
Marginal cost (c)	4.14 million NAD per vessel
Fixed costs (fk)	188 million NAD
Logistic model	
intrinsic growth (α)	0.248
scale parameter (β)	4.97×10^{-5}
catchability (q)	2.46×10^{-3} vessel^{-1}
Fox model	
intrinsic growth (α)	1.43
scale parameter (β)	0.168
catchability (q)	2.42×10^{-3} vessel^{-1}

- **Profits in base year.** From MFMR [16] data, with minor adjustments to allow for depreciation of assets and opportunity cost of capital, Ithindi [6] estimated total profit in the fishery in 2002 as 34.176 million NAD.
- **Fishing effort in base year.** Ithindi [6] reported the number of vessels in the fishery in 2001/02 as 121, and in 2002/03 as 126. We will therefore take the effort (i.e., fleet size) to be 123.5 vessels.
- **Fixed costs as a ratio of total costs.** From MFMR [16] data, Ithindi [6] reported costs for the fishery in 2002 (Table II). The costs that we consider as fixed costs are labeled as such in the table. Note that we are uncomfortable designating materials, insurance, repair and maintenance as either fixed or variable, as this item is quite likely to contain substantial portions of each kind of cost. We have therefore designated this item as 50% fixed and 50% variable, and test the sensitivity to this assumption below. On this basis, fixed costs comprise 0.27 of total costs.
- **Schooling parameter for the production function.** Kirchner and Ianelli [14] assumed that commercial CPUE provides an index of relative abundance, implicitly assuming a schooling parameter of 1. With no information to suggest that this is unreasonable, we also make this assumption

These inputs imply a set of biological and economic parameters of the fishery (Table III; see Arnason [1] for details of the equations.

Table IV: Descriptions of the current and potential states of the Namibian hake fishery as estimated by the model, using two different biological models. The difference columns show potential gains in moving from the current situation to the optimal one. Profit is defined as revenue minus all costs, while rent is defined as revenue minus variable cost. Profit and rent values are in 2002 currencies. The values in parentheses in the last row are 90% confidence intervals calculated in the sensitivity analysis.

	Current		**Optimal**		**Difference**	
	Logistic	**Fox**	**Logistic**	**Fox**	**Logistic**	**Fox**
Biomass (thousand tonnes)	514	522	2668	2166	2154	1644
Harvest (thousand tonnes)	156	156	306	303	1510	147
Effort (vessels)	124	124	47 (42-71)	58 (51-82)	-77	-66
Profits (million NAD)	34	34	1059	998	1025	963
Profits (million USD)	3.2	3.2	100	95	97	91
Rents (million NAD)	222	222	1247	1185	1025	963
Rents (million USD)	21 (13-31)	21 (13-31)	118 (90-140)	112 (84-135)	97 (59-127)	91 (53-122)

RESULTS

Model outputs

Given the above specification, the model estimates the current and potential rent in the Namibian hake fishery (Table IV). Both models suggest that the biomass should be allowed to grow to four to five times greater levels than currently, which would allow twice as much harvest to be taken by fewer than half as many vessels. This would allow rents 5-6 times greater than those currently generated.

Sensitivity analyses

We conducted two sensitivity analyses to assess the degree to which our input parameters would affect the rent estimates. The first analysis (Table V) consisted of increasing and decreasing the individual parameters (as shown in the table) within reasonable ranges and recording the change in the effort and rent estimates obtained. Current and optimal rent estimates were somewhat sensitive to landings and price values, but this should not be problematic as we can be reasonably certain that the base values for landings and prices are accurate. There are two other instances where our parameter perturbations caused changes in outcomes >15%: the fixed cost to total cost ratio causes large changes in current rent estimates, and the schooling parameter causes large changes in optimal effort estimates. However, the optimal rent estimate is insensitive to both of these values, and the schooling parameter must be changed drastically (to 0.8) before substantial changes are seen in the effort estimate.

The second sensitivity analysis involved a Monte Carlo approach, as follows. For each of the parameters except MSY and the virgin stock biomass (K^{sp}), we used the same range as in the first sensitivity analysis and took random draws from a uniform distribution over this range. Since our estimates of MSY and K^{sp} are based on the different models used by Kirchner and Ianelli [14], for each run of the sensitivity analysis we randomly selected one of their models and used the MSY and K^{sp} associated with that model. For each draw of the complete set of parameters we then ran the full set of calculations, and repeated this process 5000 times. The $(5000(1-p)/2)$th and $(5000p/2)$th values in a sorted list are then taken to be the lower and upper, respectively, bounds of a $100p\%$ confidence interval. The confidence intervals are shown in Table IV, and the distributions of effort and rent obtained in the analysis are shown in Fig. 4.

Table V: Sensitivity analyses of effort and rent estimates. Effort is in vessels, rent is in million NAD. The 'range' referred to is the range of values estimated by the different models of Kirchner and Ianelli [14].

		Current				Optimal			
		Effort		Rent		Effort		Rent	
Parameter	**Modification**	**Logistic**	**Fox**	**Logistic**	**Fox**	**Logistic**	**Fox**	**Logistic**	**Fox**
Base case	**n/a**	**124**	**124**	**222**	**222**	**47**	**58**	**1247**	**1185**
Maximum sustainable yield	top of range	124	124	222	222	47	61	1104	1025
	bottom of range	124	124	222	222	47	56	1375	1325
Virgin stock biomass	top of range	124	124	222	222	47	58	1247	1185
	bottom of range	124	124	222	222	47	58	1247	1185
Biomass growth in base year	top of range	124	124	222	222	44	61	1259	1172
	bottom of range	124	124	222	222	51	54	1227	1207
Landings in base year	+20%	124	124	261	261	50	60	1183	1108
				(18%)	(18%)	(6.4%)	(3.4%)	(-5.1%)	(-6.5%)
	−20%	124	124	183	183	42	56	1307	1250
				(-18%)	(-18%)	(-11%)	(-3.4%)	(4.8%)	(5.5%)
Price of landings in base year	+20%	124	124	261	261	47	58	1494	1420
				(18%)	(18%)			(20%)	(20%)
	−20%	124	124	183	183	47	58	999	951
				(-18%)	(-18%)			(-20%)	(-20%)
Profits in base year	+5% of revenue	124	124	251	251	47	58	1258	1199
	−5% of revenue	124	124	193	193	46	57	1236	1172
Fishing effort in base year	+20%	148	148	222	222	56	69	1247	1185
		(+19%)	(+19%)			(+19%)	(+19%)		
	−20%	99	99	222	222	37	46	1247	1185
		(-20%)	(-20%)			(-21%)	(-21%)		
Fixed costs as ratio of total cost	0.17	124	124	153	153	46	57	1221	1153
				(-31%)	(-31%)	(-2.1%)	(-1.7%)	(-2.1%)	(-2.7%)
	0.37	124	124	293	293	47	59	1274	1219
				(+32%)	(+32%)		(1.7%)	(2.2%)	(2.9%)
Schooling parameter	0.9	124	124	222	222	55	66	1212	1149
						(17%)	(14%)	(-2.8%)	(-3.0%)
	0.8	124	124	222	222	64	76	1172	1107
						(36%)	(31%)	(-6.0%)	(-6.6%)

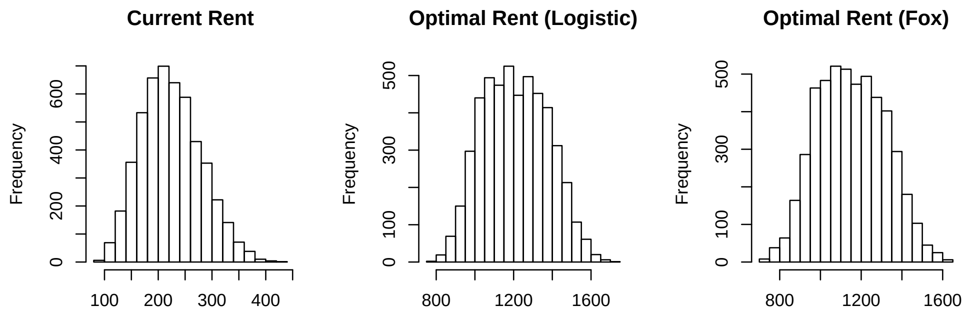

Figure 4: Distributions of outputs obtained in the Monte Carlo sensitivity analysis. The top graphs show optimal effort under the two different population models, while the bottom graphs show current rent (far left) and optimal rent under the different population models.

DISCUSSION

Comparison to past rent estimates

We compared (Table VI) our rent estimate with those described in the literature reviewed above. Our estimate of current rent lines up reasonably well with those of others. The estimates by Sumaila [3] and Armstrong and Sumaila [9] are within 25% of our estimate. Sumaila and Vasconcellos [7] included rent accruing to the foreign fleet during a period of depletion, so their rent estimate should be expected to be higher. Eide et al. [5] estimated rent in 2002 as substantially higher than we did, but they used a very different method of estimating rent based on the price of hake quota in a very informal market. Likewise, Lange et al. [12] used the national accounts to estimate rent, and so we might expect substantial differences between our estimates and theirs. Moreover, the 2000 estimate by Lange et al. [12] was much higher than their estimates in other years – the average of their estimates during 1990-98 was 180 million NAD, which is more in line with our estimate.

The estimates of potential rents are quite variable among studies, with our estimate being significantly higher than others'. This is generally because we estimate rent in an optimally managed fishery, whereas the other studies estimate potential rent given more specific policy modifications. Sumaila [2] had exogenous stock dynamics, and so did not account for possibility of allowing the stock to rebuild; his focus was on allocation of a set quota among fleets. Sumaila [3] examined a 'sole-owner' case, which is comparable to our optimal management calculation, but again included fleet structure in the calculation; this might explain some of the discrepancy between our estimates and his. Sumaila and Vasconcellos [7] studied an earlier system that had been depleted by DWFs, so their results are probably not very comparable with ours. As well, they used an ecosystem model; this might introduce more biological constraints on potential rent than our single-species model, but may also improve the realism of their model. Their simulations also included a rebuilding period, when catches and therefore rent would be lower. Finally, Armstrong and Sumaila [9] also found a sole-owner solution to their model. Their equilibrium stock size and harvest are comparable to ours (1900 and 370 thousand tonnes, respectively), suggesting that their economic parameters are probably different, e.g., the price-to-cost ratio might be different between the two studies. Another possible source of the discrepancy is that they assumed that the starting stock size is 900 thousand tonnes, so that there must be a rebuilding period with lower rent than the optimal.

Rent dissipation

Our analysis suggests that the dissipation of rent comes from two sources: (1) overcapacity – the optimal solution calls for the reduction of the fleet from the 124 vessels in 2002 to 47-58 vessels; and (2) the current (as of 2002) serious depletion of the fish stock – the calculations here suggest increasing the stock from its 2002 spawning biomass of 520 thousand tonnes to an optimal level in the range of 2100-2700 thousand tonnes. The current analysis cannot address

Table VI: Comparison of our rent estimates with those in previous studies. Rent estimates flagged with * were originally presented as NPV or discounted values over a number of years; we have converted these back to an annual value using the discount rate used in the study. All rent estimates are in million 2002 USD.

Study	Year of estimate	Rent	Comments
Current rent			
This study	2002	13-31	
Sumaila [3]	1994-95	44*	
Sumaila and Vasconcellos[7]	1970-1989	189	Includes rent to foreign fleet
	1970-1989	19	Namibian fleet only
Armstrong and Sumaila [9]	1990-2000	36*	
Eide et al. [5]	2002	40	
Lange et al. [12]	2000	88	
Potential rent			
This study	n/a	84-140	
Sumaila [2]	1990s	40*	With full quota on wet fish fleet
Sumaila [3]	1990s	87*	With cooperation, side-payments
Sumaila and Vasconcellos[7]	1970-1989	37	Namibian fleet, with no DWFs
Armstrong and Sumaila [9]	1990-2000	63*	International cooperation

issues of allocation within the fleet since, as an approximation, it considers the fleet to be a homogeneous group of vessels.

Several authors of previous studies concerned with rent have addressed the causes of rent dissipation. The analysis of Sumaila [2] suggested that allocation of quota to freezer trawlers accounted for some of the forgone rent. In contrast, Eide et al. [5] argued that substantial rent was being forgone because of the allocation of quota to wet fish trawlers. As discussed above, Armstrong and Sumaila [9] examined dissipation of rent by non-cooperation between Namibia and South Africa in managing the hake fishery, and found that this dissipation amounted to approximately 30% of total potential rent. Finally, Armstrong et al. [17] estimated that the government was forgoing some rent collection, averaging 74 million NAD annually, because of the lower quota fees charged under their Namibianisation policy. However, this last value does not represent dissipation of rent, since the rent is simply accruing to the industry rather than the government – it is simply a transfer of funds from the government to a sector of the industry.

SUMMARY

We estimated the current rent in the Namibian hake fishery as 21 million USD (90% confidence interval: 13-31) in 2002, with the potential for approximately 112-118 million USD (90% confidence interval: 90-140 for logistic model, 84-135 for Fox model) annually if the fishery were managed optimally, i.e., with a much larger stock and a smaller fishing fleet. These estimates are particularly sensitive to some parameters, especially the cost parameter, but in general appear to be fairly robust. Our estimate of current rent is roughly in line with previous estimates of the same number, while our estimate of potential rent is somewhat higher, for the reasons described above. What should not be in doubt, however, is that substantially greater wealth could be generated from this fishery if it were managed in a way closer to the economic optimum.

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