Environment for Development

Discussion Paper Series

March 2009 ■ EfD DP 09-04

The Design, Compilation, and Interpretation of Satellite Accounts for South Africa's Fisheries

Some Critical Thoughts

Anthony Leiman and Timothy Harris

Environment for Development

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The Design, Compilation, and Interpretation of Satellite Accounts of South Africa's Fisheries: Some Critical Thoughts

Anthony Leiman and Timothy Harris

Abstract

Using South Africa's hake and rock lobster fisheries as examples, this paper argues the need for satellite accounts of South Africa's commercial fisheries. It stresses the policy role of satellite accounts, particularly where access to fish stocks is contested. Satellite accounts give all interested parties information on the extent of stock depletion, past and present fishing effort, and the returns-to-effort reduction. They can also present the resource rents generated from harvests and the value of the resource stock. Using the United Nations handbook on national accounting for fisheries (SEEAF) to construct physical accounts, the paper indicates the ease with which these could be compiled, albeit with a number of caveats. The paper then extends the results to include monetary accounts, but warns that the current guidelines embody flaws that can yield anomalous results.

Key Words: Satellite accounts, fisheries, operational management process

JEL Classification: Q22

Contents

The Design, Compilation, and Interpretation of Satellite Accounts of South Africa's Fisheries: Some Critical Thoughts

Anthony Leiman and Timothy Harris*

> *"…[N]atural resources are not purchased from mother nature who produced them so that their valuation must inevitably be artificial and controversial… the national accounts ought not to show the using up of assets whose creation has not first been recorded in the accounts.… Nature is not recognised as a factor of production by economists or national accountants and nature's production of resources is not, and perhaps could never be, recorded in the accounts."*
>
> *Derek Blades (1989)*

Introduction

Good policymaking needs good information. In the 1989 paper from the Organisation for Economic Co-operation and Development (OECD) cited above, Blades argued that the United Nation's *System of National Accounts* then in place gave little aid to resource planners and decision makers. Four years later, the UN adopted satellite accounting to mitigate this deficiency. This paper discusses some of the problems involved in compiling satellite accounts for South African fisheries (a process expected to begin in 2009) and uses examples to show how these can be addressed. It also looks at weaknesses in the current system of satellite fisheries accounts, particularly on the monetary side. Estimating resource rents for a fishery is a complex and controversial process. Such rents lie at the heart of the stock valuation process suggested in the UN/FAO's (2004) *Integrated Environmental and Economic Accounting for Fisheries* (also

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The authors gratefully acknowledge the contribution of the Division of Marine and Coastal Management in the Department of Environmental Affairs of Tourism.

referred to as the SEEAF handbook[1]). In addition, the process itself has an innate tendency to provide volatile valuations.

It is sensible to begin by asking whether South Africa's fishing industry warrants the effort. A skeptic could point out that it contributes less than 0.5 percent to gross domestic product and is already well managed by international standards. Nonetheless, the industry has local importance as a source of income and employment, especially in the coastal areas between the Namibian border and Port Elizabeth. Moreover, South African fisheries managers do face some profound challenges. The communities most dependent on the industry have few alternative sources of income, the fish stocks on which it depends are generally depleted below their maximum sustainable yields (both economic and physical), and the evolution of harvesting technologies perennially presents new management challenges. Add the asymmetrical information that typifies the relationship between resource managers and harvesters and a frequent result is friction between fishermen and the scientists and administrators trying to regulate the resource. Since satellite accounts are public documents, a set that offers good quality and verifiable data could ameliorate this problem.

Much of fisheries economics involves Nash equilibria. The standard lessons drawn from these involve coercive policies that, while providing real benefits to all in the long run, are individually unpalatable in the short term. For such policies to work, their potential benefits should be demonstrable. This is a primary function of satellite accounts.

The principle is simple: if a fishery is depleted beyond its economic optimum then continued harvesting imposes a user cost. A country's fish stocks can be regarded as an asset in a portfolio—fish left uncaught multiply and grow. The result is fish that are bigger, more valuable, and more abundant; a drop in catches is therefore an investment in the industry. At present such an investment in the fish stock offers an internal rate of return far greater than the real interest rate. In most of South Africa's fisheries, this premium is currently more than 20 percent per annum. In economic terms, catch reduction makes clear sense. Unfortunately, the short-term

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[1] The United Nations/Food and Agricultural Organization's *Integrated Environmental and Economic Accounts for Fisheries* (SEEAF) is one of a "series of handbooks, which supports the implementation of the UN *System of Integrated Environmental and Economic Accounting 2003* (SEEA 2003) by providing methodological and practical guidelines on specific resources. This [SEEAF] handbook provides a common framework for organizing economic and environmental information related to fisheries…" (UNEP web site, http://www.unep.ch/etb/areas/VRC_category.php?category=2).

costs of deferred harvesting tend to fall on those least able to meet them - fishermen and their families.

Satellite accounting is not just about estimating the condition of fish stocks. To establish optimal policies, a clear picture of the industry is needed—one that looks beyond current and historic stocks, harvests, and profits and takes account of capitalization, value chains, and employment. It is such a picture that fisheries satellite accounts should aim to provide.

While the need to adjust the UN's *System of National Accounts 1993* to ensure a consistent treatment of the incomes generated by natural resources has long been recognized, agreement on the means took time. During the 1980s and early 1990s, the environmental economics community lengthily debated how best to treat the natural assets depleted in the course of income generation. In the case of mineral resources, the debates were between schools: "user cost," "net rent," and "present value" were methods advocated. The discussions were heated, but relatively straightforward. Unfortunately, this simplicity evaporated when the debate later shifted to renewable resources, such as fish.

One source of confusion was the simple single-species models (such as Schaeffer and Fox) that fisheries economists often used. These assume that in pristine fish stocks annual recruitment is balanced by natural mortalities. This means that a *pristine* fish stock has a *sustainable* harvest of zero and that mining such a stock to some point *increases* the sustainable yield; only thereafter does increased harvesting reduce sustainable yields.

Given such models, one can infer that a "maximum sustainable yield" and a "maximum economic yield" exist, and that there is a stock level consistent with each. Such inferences are untenable in reality. There is no commercial fish species that exists in isolation; rather, the different species interact as predators, prey, and competitors for space within broad ecosystems. Any depletion or recovery in the stock of one species has implications for the stocks of others.

Does this mean that accurate and meaningful accounts, capable of pointing the way to optimal sustainable rents, cannot be contemplated until a reliable ecosystem modeling process is in place? While it would certainly be ideal, such a process does not yet exist. Although modeling work for the Benguela Marine Ecosystem has been under way for some years (Pauly et al. 2000; Shannon et al. 2000; and Shannon et al. 2004, et seq. *African Journal of Marine Science* 26[1]), the data that would inform any fisheries satellite accounts in the near future would necessarily come from Bayesian single species models.[2] In their favor, these are not naïve Schaefer type models and, while they may be poor at representing ecosystem impacts and their implications for system wide rents, the data they provide can still serve a useful policy function, especially if the historic stocks and harvests gleaned from such models go back far enough in time. With such data, satellite accounts can demonstrate both the opportunity costs of shortsighted fisheries policies and the potential benefits of remedying them.

Raison d'Être: Do We Need Fisheries Accounts?

Fisheries have been depleted worldwide. A simple profit and loss statement does not assist policymakers who need to know the condition of the resource (physical accounts) and its potential economic significance (monetary accounts). Ideally, the latter would be expressed in terms of its capacity to generate jobs, foreign exchange, and local value-added; however, the SEEAF recommends valuing both the resource and its yield, a flawed approach that warrants further discussion. The key point is that the passions roused by fisheries policy can be both intense and politically significant. The data on which it is based should, therefore, be sound, easily comprehended, publicly available, and above all expressed in units comparable to those used by other sectors in the economy.

A small set of examples drawn from local experience will clarify the problem and reinforce the potential benefits to be drawn from sound satellite accounts if they lead to appropriate policy interventions. Figure 1 below shows the condition of domestic hake (*Merluccius spp*.) stocks. For over 30 years, the exploitable biomass of South Africa's two hake stocks has stayed at less than a quarter of its pre-exploitation level.

West coast rock lobster (*Jasus lalandii*) is in even poorer shape than hake, with a harvestable biomass that has remained at approximately 8 percent of the pre-exploitation level for the past 15 years (BCLME LMR/SE/03/03, 35). It is clear that both of these important commercial species have been over-harvested, but recognizing overfishing is only a first step. Good accounts would allow far stronger policy responses.

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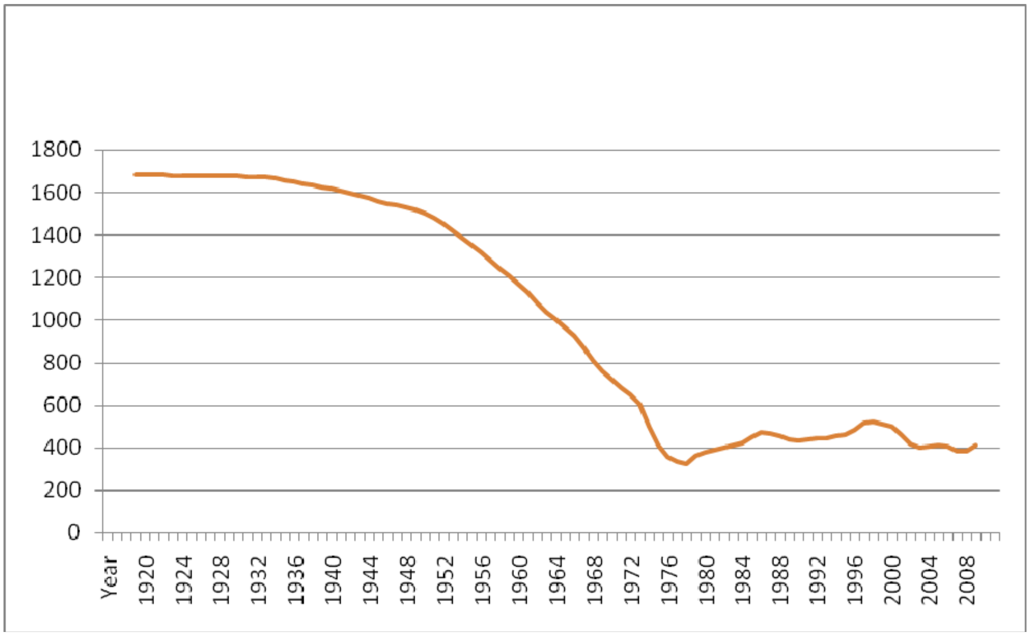
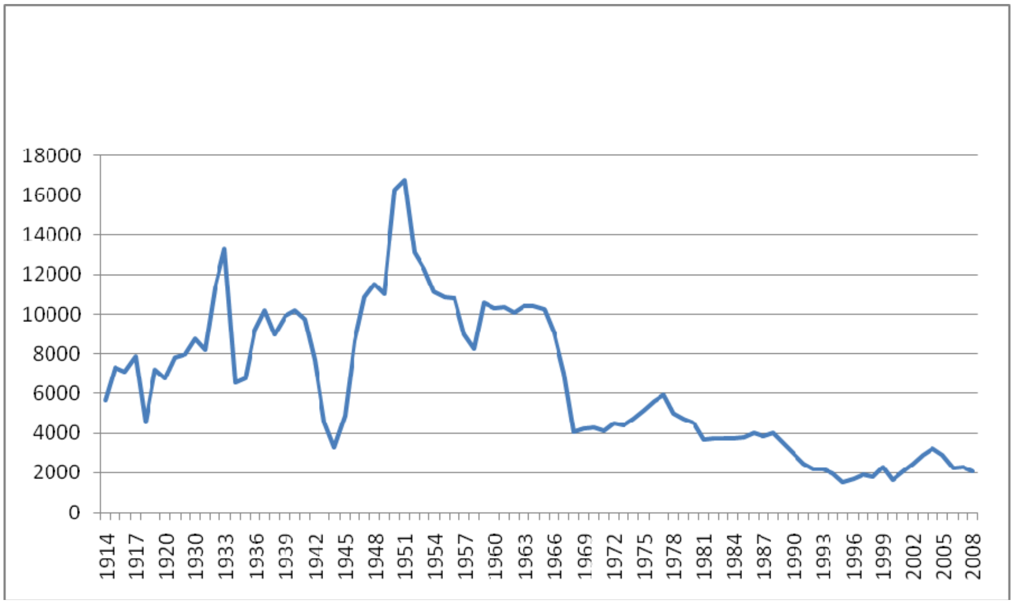
[2] In fact, some predator/prey interactions are already included: the hake fishery jointly models two species, *M. capensis* and *M. paradoxus*, where adult members of the former cannibalize juveniles of the latter. The small pelagic fishery also models two species (pilchard and anchovy), largely because they are shoaling fish and are caught together.

Figure 1. Hake (*Merluccius spp.)* Estimated Exploitable Biomass, 1917–2008 (000 metric tons)



Source: From primary data collected for MCM by MARAM (2008), Department of Mathematics and Applied Mathematics, University of Cape Town (hereafter MARAM/MCM)

Figure 2. West Coast Rock Lobster Commercial Catches, 1912–2008



Sources: Melville and Van Sittert (2005); Johnston and Butterworth (2005); and S. Johnston (2008), personal communication.

As figure 2 above shows, the west coast rock lobster industry operated sustainably for decades, generating work and a high-value product in large quantities. For nearly 40 years, from the 1920s to the 1960s, commercial catches were four-to-five times their present levels, while subsistence catches were also higher. (Some estimates suggest that annual catches were 10 and 15 times their current levels.) There was a decline in the late 1960s, after which catches appeared sustainable at 5000 metric tons per annum. Only in the late 1980s did the current serious decline in the stock begin. Although some research mentions changing somatic growth rates and lobster migration, the key problem has clearly been persistent overfishing.

A moratorium on fishing would allow the stock to recover and individual lobsters to increase in size and value.[3] This would be expensive in the short run, but it would also be a high-yielding and productive investment in the lobster stock. The OMP (operational management procedure) model currently in use suggests that a five-year moratorium on harvesting west coast rock lobster would increase the exploitable biomass of the population by 167 percent. Because the lobster is both larger and more abundant, this would increase the price per kilogram as well as the catch-per-unit effort (CPUE).[4]

As mentioned, all fish species exist in interacting ecosystems. Single species models cannot capture the impacts of depleting one species on the value of the fishery of another. Despite this limitation, these models can make clear when a stock has been excessively depleted, and when it is sensible to reduce harvests and invest in the resource.

The hake fishery illustrates the need for this sort of statistic in satellite accounts if they are to be policy relevant. Hakes (*M. paradoxus and M. capensis*) are South Africa's most valuable fisheries. The potential internal rate of return from an "investment in the stock of fish" can again be assessed using the current OMP model. If one uses the 2006 estimated exploitable biomass of 422,000 metric tons and projects the impacts of a five-year harvesting moratorium, even for a slow-growing species such as hake, the exploitable biomass increases by roughly 140 percent. This is roughly a 9-percent real internal rate of return, to which one can add the accompanying improvements in CPUE and in price per kilogram. Few financial assets can

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[3] Repetto (2002) showed how the returns on an effort moratorium could be determined for a fishery operating out of equilibrium and used this to argue the need for satellite accounts. In South Africa, the effort involved would be far less because of the pre-existing modeling that underlies the industry's OMPs.

[4] Supply effects on price are not significant since this is an export fishery into markets where South Africa is a price taker.

compete with this sort of return. Accepting the unknown effects of ecosystem-wide constraints as a caveat, table 1 above (drawn from the OMP model) shows the stock approaching its pre-exploitation levels within 14 years.

Table 1. Hake: Projected Exploitable Mass in South African Waters, 2007–2020

Year	Exploitable biomass (000 metric tons)	% increase
2007	481	–
2008	461	33.2
2009	792	23.5
2010	914	15.4
2011	1036	13.3
2012	1148	10.8
2013	1249	8.8
2020	1669	

Source: MARAM model; S. Rademeyer (2007), MARAM, personal communication.

Growth in physical biomass is only part of the return on such an investment. Fisheries offer a "stock externality" in the form of rising CPUE, i.e., the cost of catching a ton of fish falls as the fish population rises. In addition, an effort moratorium would give individual fish a chance to grow. Most cohort-based models show that overfishing leads to a fall in the mean lengths of fish, which has economic consequences. In addition to being more fecund, big fish fetch a higher price per unit weight than small fish, and they are also more marketable internationally and present far more alternatives for adding value. Thus, the landed price per kilogram for large hake (size ranges 1–3) is typically 200–300 percent more than that of small hake (size ranges 5–7). In recent times, the rising proportion of "baby hake" in the catch has driven down the average price. A decision to defer harvesting into the future would thus be an investment in future rents all along the value chain. It is against this background that the need for satellite accounts to better inform both policymakers and industry participants should be seen.

The Data Problem

In 2004 the Food and Agricultural Organization (FAO) of the United Nations published its *Integrated Environmental and Economic Accounting for Fisheries*, which provided a standard for the design of fisheries satellite accounts. It contained a number of case studies, including one from Namibia, and opened the way for satellite national accounts for fisheries in many parts of the globe.

South African statisticians who wish to launch a satellite have the advantage of a convenient benchmark against which future stocks, catches, and investments can be compared. In 2004–2005, South Africa's Marine and Coastal Management (MCM) division of the Department of Environmental Affairs and Tourism issued long-term rights and permits (via the long-term rights allocation management process, or LTRAMP). Applications required extensive firm-level information on historic effort, investment, and catches. The LTRAMP dataset could make 2004 a reasonable base year. This paper is a preliminary attempt to use this data (still incompletely cleaned) to produce a benchmark and stimulate the publication of fisheries accounts in South Africa.

At the heart of national accounting as a discipline lies Hicks's definition of a person's income, as "the maximum value which he can consume during a week, and still expect to be as well off at the end of the week as he was at the beginning"(1939, 172). This means that if fishing has depleted stocks, the resulting net revenues may not all be true income.

Unfortunately, applying Hicks's definition of income presents a number of problems. An obvious one is that the sustainable yield (on which the Hicksian approach would be predicated) is maximized only after pristine stocks have been considerably depleted. Another problem is that maximum economic yield and the maximum sustainable yield are likely to differ. In this they add to distinctions Hicks made (1939, 172–75) between income calculated when interest rates and prices are assumed fixed, and income when they are assumed variable. Last, the very concepts of maximum sustainable or economic yield may only be artifacts of naïve modeling and have no place in the real world.

Fisheries accounts present real data difficulties, which a comparison with agriculture makes clear. In accounting for farmed livestock, national accountants allow for changes in the size of the national herd. Unfortunately, while one can easily count cattle, one cannot count the fish in the sea. This is the fundamental problem that faces anyone wishing to compile fisheries satellite accounts. The culling of herds in a drought year, for example, is seen as disinvestment, and the resulting revenues are not all taken as income. The fish stock similarly enjoys years with high recruitment rates and suffers years when recruitment is poor. These good and bad years affect the fish stock just as drought affects a nation's herds. Unfortunately, we have no annual count of fish numbers and do not normally describe the resulting estimated changes in fish stock in terms of increased or decreased wealth.

There is a way around the problem. While we cannot count the fish in the sea, well-tuned models can be used to estimate whether stocks have been rising or falling. There are numerous proxies for the condition of the fish stock, but they are not all equally suitable across species. Thus, for theoretical fish that swim individually and randomly in the water column, CPUE is a good proxy for the stock. The more fish caught per hour of trawling at a given speed, the more fish there are. Of course, this has far less value for shoaling fish, like pilchard, and even less for fish, like orange roughy (*Hoplostethus atlanticus*), that accumulate in highly vulnerable breeding aggregations at specific points at specific times of year. For these fish, there are other proxies, such as echo location, samples in which specimen's length and estimated age are collected, etc.

Despite these proxies, scientists and fishermen often disagree on the size and condition of fish stocks. One reason is that experience counts. An experienced vessel captain and crew will typically catch more fish on a given run in a given area than will an inexperienced captain. Another is the innate tendency to attach greater weight to recent events than to past events. If a fisherman's catch today is better than it was a year earlier, this apparent rise in the stock may have more weight than the reality that the catch is far lower than it would have been 50 years earlier. There are also real difficulties in estimating stocks: equipment on survey vessels and the timing of their trips may vary from year to year, and the interpretation of fish sizes and otolith examinations[5] (used to determine age in sample catches) can be disputed. Stock estimates cannot be based solely on trends in commercial catches either; the fuel price or the weather can affect the number of vessel days spent at sea and the selection of fishing grounds.

The estimation of stocks, relative to either pristine levels or to a base year, is clearly not a trivial exercise or one to be undertaken lightly by a national accounting statistician.

Operational Management Procedures as Data Sources

South Africa's major marine fisheries are managed using operational management procedures. An OMP is based on the precautionary principle and derives total allowable catches (TACs) using simulations run in Bayesian models that explicitly allow for scientific uncertainties. In each fishery, non-tradable quota is allocated as a share of the species TAC,

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[5] Otoliths are small structures found in the head of all fishes. Growth rings in the otolith, similar to trees, record the age and growth of a fish from hatch date to death in exquisite detail. Sophisticated techniques allow scientists to reconstruct huge amounts of information from hatch year to migration routes to water temperature, for example (Otolith Research Laboratory 2008).

which is annually adjusted in accordance with projections from the models. Data are perpetually updated, iteratively improving estimates of historic fish stocks and allowing conditional estimates of current stocks and sustainable harvests. Such models have been in place for the major commercial species for some time: hakes (modeled jointly for the two sub-species, *M. capensis and M. paradoxus*) since 1990, small pelagics (jointly pilchard [*S. sagax*] and anchovy [*E. capensis*]) since 1991, and west coast rock lobster (*J. lalandii*) since 1997. OMPs are also in process for south coast rock lobster (*P. gilchristi*) and Patagonian toothfish (*D. eleginoides*).

From a national accounting perspective, these models can also provide the physical estimates that underlie satellite accounts of fisheries. An advantage of the system is that each OMP is rooted in an annual meeting at which modelers, scientists, and commercial fishermen exchange views while working toward consensus on the year's estimates. These figures go into the model, which is then more finely tuned during the season. The longer the system runs, the more robust it becomes, provided the quality of the data input is maintained.

The Structure of Fisheries Accounts

All natural resource accounts begin with a representation of the physical status quo. In the case of a renewable resource, this includes estimates of output, sustainability of current extraction rates and methods, and the extent to which the resource is depleted. Also recommended, but less commonly seen, are monetary accounts, which translate the data from physical to pecuniary. Such economic data could allow direct comparison with the conventional accounts; such integration could inform policy far beyond the immediate industry concerned. As an example, a measure commonly used in formulating a fiscal rule of thumb is "budget deficit as a percentage of national income." If an economy treats unsustainable resource extraction as "income" rather than as "depreciation," then the national income is overstated and the fiscal rule of thumb becomes deceptive. Unfortunately, as we will show, the transition from physical to monetary units in the accounts is controversial.

Physical Accounts

Physical accounts provide the foundation of fisheries satellite accounts. Ideally, they should detail the estimated stock of each major species, its condition, and changes in it. In other words, it describes how many fish there were at the end of the previous time period, what natural change (i.e., natural increase minus natural mortality) and what level of fishing-related mortality occurred, and what the closing stock level was at the conclusion of the current period. The unit of measurement is simply weight (thousands of tons) of fish.

To increase their value, the accounts should also show the total allowable commercial catch and its subdivisions if they are relevant (e.g., hake longline, handline, and demersal trawl[6]), and any recreational or artisanal/small-scale fishery allocation that is significant. They should also detail estimated landings and the capital involved. Illegal catches are difficult to estimate, but they have been significant for some species in recent years, particularly for abalone among the minor fisheries, and rock lobster among the major commercial species (see section 4.2).

Although logic suggests that the satellite accounts should reflect only wild capture fisheries, SEEAF includes aquaculture, a growing sector in South Africa. Importantly, its products are monitored and measured like those of any farm and should be captured in the regular national accounts. However, since it may have policy relevance, it also has a coding (EA 1431) in the SEEAF statistics.

Fugitive and straddling stocks and the impacts of foreign fleets present problems in many countries. The physical accounts should reflect “the extent to which a country shares its fish stock with other nations” (UN/FAO 2004, paragraph 85–87: 37, and paragraph 165: 47). This problem is fortunately not relevant for South African national income accountants, even though South Africa shares a marine boundary with Namibia. This is a strong statement, not universally shared,[7] and thus warrants further elaboration.

There are two aspects to this assertion. One is biological: scientists are still debating the possibility of a “Luderitz cut-off.” The essence of the argument is that many fish stocks north of Luderitz Bay (in southern Namibia) appear genetically separate from those south of the bay. The second issue is economic. There are only four major fisheries common to both Namibia and South Africa: horse mackerel, rock lobster, small pelagics, and hake; however there is little overlap in their exploitation since there is little fishing in the northern waters of South Africa’s west coast.

The horse mackerel fishery dominates the Namibian industry. While Namibian juvenile horse mackerel have made incursions into South African waters in the past, they have become increasingly rare in recent years. In South African waters, the fishery no longer targets small

[6] Longlining is a method of fishing where lines of baited hooks are set and left for some time before being retrieved. Demersal trawls are drag-nets used to fish the sea bed.

[7] See, for example, Sumaila et al. (2005) who estimated shared stocks and landings on the basis of Stuttaford’s work in the *Fishing Industry Handbook: South Africa, Namibia, and Moçambique* (1999).

west coast mackerel but larger adult fish caught off the Cape South Coast between Cape Point and Port Elizabeth. These are part of a stock seemingly not shared with Namibia. The juvenile fish are now landed only as a by-catch of small-pelagic seiners (with an annual limit of 5000 metric tons).

The west coast rock lobster fishery in northern waters is small—better volumes, quality, and costs keep the fishing effort further south. In Namibian waters (i.e., north of the South African border), the rock lobster fishery has been marginalized by problems with product quality and transport costs. In consequence, the lobster stock in border waters has little economic significance.

The small pelagic fishery, though largely located off the Cape South Coast, was formerly a West Coast fishery and may well return there in the future. The Namibian small pelagic sector was formerly substantial, but is now in collapse. Even when pilchard and anchovy were abundant off the West Coast, fuel costs made access to South Africa's far northern waters expensive for vessels from Cape Town and Saldanha. From a biological perspective—although sardines, round herring, and anchovy are described as "pelagic,"—there is little evidence of a significant fugitive stock migrating between South African and Namibian waters.

The hake sector involves two species, Cape hake (*M. capensis*) and deep sea hake (*M. paradoxus*). The former is only fished commercially in southern waters and there is no straddling stock. Regarding the latter, although the stock exists on both sides of the South African-Namibian border, there is little indication that adult fish migrate in any numbers. It does seem, however, that the Namibian fishery can be affected by recruitment levels in South Africa. Again, economic considerations depress effort levels in South Africa's northern waters.[8] Catch rates, fish quality, and costs are generally more attractive further south, though some fishing does occur in the north during winter months.

Fishing in the country's exclusive economic zone (EEZ) by non-residents is technically not an issue, although a problem with "paper-quota holders," ostensibly engaged in joint ventures with foreign vessel owners, has arisen, and there are a few legitimate joint ventures between foreign owners and local holders of large pelagic rights. Permits to fish in South African

[8] The Benguela current runs along the Cape West Coast where the bulk of fishing has traditionally occurred. South Africa's northern waters are proximate to the Namibian border, and the southern waters are closer to Cape Town (but still in the Benguela current). The southern end of South Africa is not a point but a rectangle, with Cape Town on the southwest corner and East London on the southeast corner. The Cape South Coast lies between them.

waters are not allocated to non-resident firms, and all legally caught fish have to be landed locally. Trans-shipping to foreign vessels is not permitted. The only difficulty is caused by shark and tuna longliners who fish in international waters. Their catch, if landed locally, should be excluded from the physical accounts.

Monetary Accounts

More problematic are the monetary accounts, which parallel the physical accounts, but involve monetary rather than physical estimates. Such accounts should begin with the value of a particular fish stock at the end of the previous time period, to which is added (or subtracted) the value of the net natural stock increase (decrease). The value of the harvest is then subtracted, and the final entry is the value of the fish stock at the end of the current time period.

While the value of the catch can be monitored, valuing the stock is more difficult. Importantly, even in a price-taking market, it is *not* the stock of fish multiplied by the price per ton; instead it is the present value of the net earnings stream (economic rent) that the fish stock could sustainably generate.[9] This means that at the center of the monetary accounts lies a specific problem: how best to estimate the rents generated in each sub-sector of the industry. Rent is effectively revenue minus economic costs. The industry has remarkably little control over either aspect. In each sub-sector, revenue is typically determined by the extent and size distribution of the catch, international prices, and the prevailing exchange rate. The costs are not just driven by the CPUE but also by the fuel price, the geographic location of the fish, and the assessment of capital depreciation. Some of the determinants of rent, therefore, are exogenous factors, such as fuel prices and exchange rates, while others are accounting assumptions, such as depreciation paths and the opportunity cost of capital.

Since the stock's value is the present value of a rent stream, two further questions arise. One, will the existing regime be the future management regime or should one assume a hypothetically optimal regime for the future? And two, what discount rate should be used? These issues are not yet resolved in the literature, and the SEEAF has no final comment on them,

[9] An alternative approach, the "net price method," was suggested by Repetto (1989), who took the net price as a proxy for the marginal user cost. The value of the resource then is this net price applied to the entire remaining stock of the resource (if a mineral) or to the yield it could provide in perpetuity (if renewable). This approach is problematic, if—as in South Africa—there is insecurity regarding future permits. It is also problematic if there are monopoly rents; however, in this regard, it is worth noting that even monopolistic South African fishing firms are price takers in world markets.

although the general sentiment is that the current management regime should be assumed. It is also worth noting that the mandate of South Africa's Marine and Coastal Management does not include maximizing the rents generated by the country's fish stocks; instead, it has a broad objective function in which stock maintenance and a range of socio-economic objectives co-exist.

Another suggested approach is to use the price of traded fishing permits. Where such a quota is fully tradable in a competitive quota market, the price of the quota should be only marginally below the present value of the expected rents it could generate. However, as Danielsson (UN/FAO 2004, 117) pointed out, this method can considerably understate the value of fish stocks if property rights are insecure. Unfortunately, quotas are not sold officially in South Africa, although unofficial transfers do occur. While the prices of these "paper quotas" can be informative, it has to be remembered that the trade in them is limited and can be penalized. The result is lack of competition, high transaction costs, and unequal power between buyer and seller. As such, the market-price method of rent evaluation appears to be a relatively inaccurate tool for the valuation of South African fisheries.

Using local prices of paper quotas, the rent estimates for the hake trawl and west coast rock lobster sectors were roughly 50 percent of those obtained when the rent was calculated using the "residual value" method.[10] The market price approach, therefore, considerably understates both the rent from, and the value of, South African fisheries.

Alternative methods of rent estimation also tend to be contentious and can require considerable assumptions. The ideal is to have a theoretically defensible approach and to use it consistently. In this paper, we follow the residual approach used by Lange (elaborated further in section 4.1) in the Namibian fisheries case study, which forms part of the SEEAF handbook (UN/FAO 2004: 102–114). This technique treats rent as the value of landings minus their full marginal exploitation cost. An important caveat is that this assumes constant catches, costs, and prices. (See Sorenson and Hass's Norwegian case study [UN/FAO 2004, paragraph 313: 96].) These assumptions are not only strong, they are also destabilizing. Profits in fisheries are notoriously volatile, so assuming that the year's catches, costs, and prices will be perpetuated is

[10] An exception was in the hake longline sector, where the residual method of rent calculation presented a negative resource rent, while the "market-price" assessment indicated that the resource rent was significantly positive. This dichotomy could be explained by the extreme size of the capital stock, relative to the fishery's output, which—via an opportunity cost effect—lowers the rent estimate in the residual method's equation.

likely to grossly overstate or understate the value of a fishery. A short-term decline in fish stocks or rise in fuel prices can apparently render the resource valueless, while a short-term upswing in catches or prices might indicate the resource to be more valuable than rational thinking would allow. Some form of "rent smoothing" will clearly be necessary to obviate these problems in published accounts.

Defining the value of a resource as the present value of its future rent stream can also have other policy consequences. Thus, theory predicts that open access fisheries will be harvested until rents are totally depleted. In such a scenario, there could be considerable fish caught and jobs provided by a resource that technically has no value. At the same time, policies that reduced the short-term harvest would increase the resource's value, not decrease it. In South Africa, MCM restricts access rights in all major fisheries, but also promotes competition in the industry. It is worth noting that in a price-taking market, such competition typically reduces rents. Many of the inefficient practices common in fisheries (high grading, capital stuffing, trans-shipping, etc.) would fall away if access to a fishery was restricted to a small number of firms with established long-term tradable rights. In such a case, the rents would be akin to Keynesian user costs rather than conventional monopoly rents.[11]

Methodology

The rent a fishery can generate is clearly of interest to the state, especially where the fish stock is seen as a national resource. The problem facing policymakers, who wish to appropriate a share of them for the state, is that such rents are typically unstable over time. Moreover, before rents can be taxed, they have to be defined and estimated; neither is a trivial exercise.

Rent

The rent earned in a fishery is effectively the abnormal profit, i.e., total revenue minus total cost. (Normal profit is included as an imputed cost.) The rent *I* in any time period is that period's total revenue (Qp) minus the marginal exploitation costs, MC:

$$R = Q\,p - MC$$
$$\Rightarrow \quad R = Q\,p - (IC + CE + CFC + NP)$$
$$\Rightarrow \quad R = Q\,p - (IC + CE + CFC + iK)$$

[11] This point is elegantly made in Arnason (2007).

where *Qp* = total revenue, *IC* = intermediate consumption, *CE* = compensation of employees, *CFC* = consumption of fixed capital (depreciation), *NP* = normal profit, *i* = opportunity cost of capital, and *K* = value of fixed capital stock invested in the industry (UN/FAO 2004, 53).

Marginal costs

Marginal costs differ slightly from those in conventional microeconomics, which include only variable costs. As expected, marginal costs include incremental consumption of variable factors, e.g., fuel (intermediate consumption) and labor (incremental wages, salaries, and mixed incomes, i.e., earnings of self-employed fishers). However, in the SEEAF approach, they also include *all* capital depreciation whether it varies directly with production (included in intermediate consumption) or not (consumption of fixed capital).

Accounting records rarely mention marginal costs; instead, average costs are widely treated as proxies for them. The SEEAF handbook warns that such an approach is likely to bias the rent estimate upward because average costs usually lie below marginal costs (UN/FAO 2004, 29). We argue, however, that while using average costs is not ideal, doing so will *not* consistently bias the result upward. The SEEAF caveat emerges from the theoretical short run, which is the focus of neoclassical microeconomics. When looking at satellite accounts for the fishing industry, the theoretical world of one fixed and one variable factor has little relevance. A firm trying to meet an unexpected demand for fish will certainly find that the incremental cost of increasing the catch is above average; however, the calculation of rent for the national accounts involves *long-run* marginal costs. The real issue is whether or not the industry enjoys economies of scale. If it does, then its average costs lie *above* its marginal costs. Since most of South Africa’s fisheries show signs of natural monopoly, with higher profit margins accruing to the larger quota holders, the handbook’s warning seems unwarranted.

Intermediate consumption

When work began on this study, intermediate costs were estimated using an economic model developed by the Namibian Ministry of Fisheries and Marine Resources, which was adjusted for the South African market. In Namibia, intermediate costs—mainly fuel—accounted for 38 percent of the value of output (Lange 2003). Industry estimates of overall intermediate costs were slightly less than this in South Africa. Namibian and South African fishing firms have similar cost structures, and although levies and transport and processing costs are lower in South Africa, labor costs are higher. It was estimated that, in 2005 in South Africa, intermediate costs—dominated by fuel costs—averaged approximately 35 percent of total revenue across the spectrum of commercial fisheries (D. Japp [2006], managing director, CapFish, personal communication). Industry interviews in the demersal trawl (hake) sector placed operating costs at between 35 percent and 40 percent of revenues in 2007. The sharp oil price increases in 2007 and 2008 inflated these estimates even further. When oil prices were at their 2008 peak, one industry source (anonymous by request) suggested that fuel alone consumed roughly 50 percent of gross revenue in the hake sector.

The costs of fuel relative to revenue are expected to fall in the near future. Bross (2007) states that, "fuel and lubricants now make up fully 40 percent of operational costs." He adds the rider that, "energy optimisation technology is very mature. Historically the industry succeeded in lowering fuel consumption from 1100 liters per ton to 370 liters per ton. With the fuel price rises of 2007/8 this increased to 670,[12] there are virtually no further gains in efficiency in prospect against which to set off increasing costs."

Fixed capital

Consumption of fixed capital is another problem. This is conventionally classified as a fixed cost on the grounds that boats have fixed depreciation paths, but there should also be a variable component analogous to the Keynesian "user cost" since depreciation is affected by intensity of use.

When completing the LTRAMP forms, firms applying for long-term rights were required to disclose their *gross asset value* and the *insured value* of their asset base. Both measures overstate the vessel value, especially the former, which conflates land- and sea-based assets. To obviate the problem, fixed capital is taken to be the *book value of the fixed assets* in the fishing industry.

As table 2 shows, South Africa's fleet is old. Accounting for depreciation is consequently an important methodological issue. Anecdotal evidence and a small number of empirical studies suggest that hyperbolic rather than straight-line depreciation should be used for fishing vessels, since their relative efficiency declines rapidly at first and then at an ever-slowing rate asymptotically.

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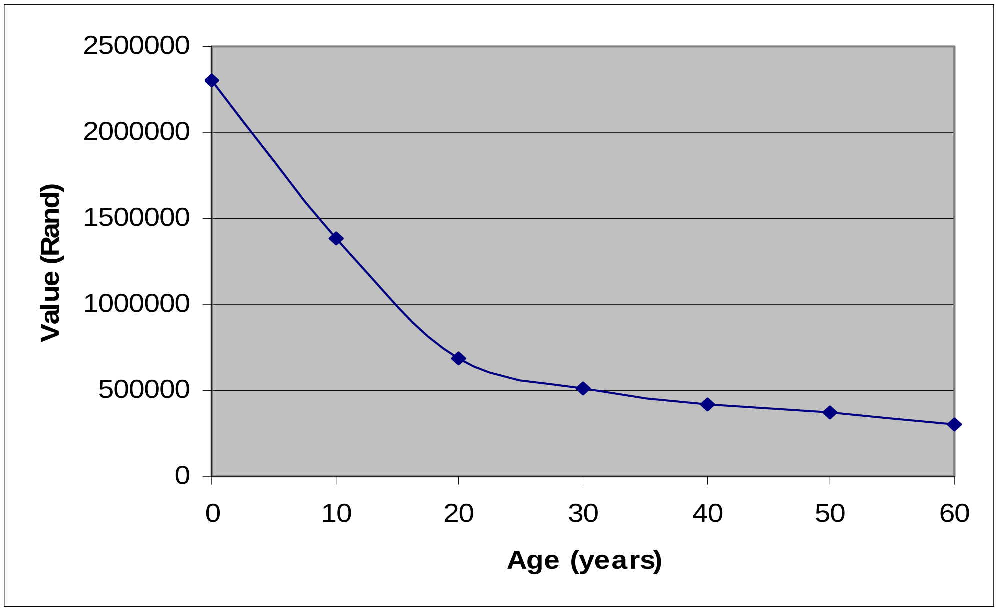
[12] The reason for this is that old generation wet-fish vessels operated on diesel. Newer freezer trawlers produce a high-value product and product processing costs are incurred on board rather than in land-based factories. These vessels thus are more fuel intensive. In the third quarter 2008, industry representatives estimated that fuel costs alone came to between ZAR 2700 and ZAR 3750 per metric ton. (ZAR = South African rand.)

Table 2. Average Vessel Age by Fishery

Fishery	Average age of fleet (years)
Hake average	29
- Hake deep sea trawl	28
- Hake inshore trawl	26
- Hake longline	33
Small pelagics	30
West coast rock lobster	30
South coast rock lobster	30
Squid	30
Horse mackerel	31
AVERAGE	**30**

Source: BCLME (2006b), "Rights-Holder Survey."

Figure 3. Vessel Depreciation with Age: West Coast Rock Lobster (Off-Shore Vessels)



Source: J. Goss (2006)

Figure 3 shows the results of a study of the depreciation of vessels in South Africa's west coast lobster fishery. The depreciation rate approximates straight-line depreciation for roughly 20 years, after which it extends asymptotically beyond 60 years. The technology on these vessels has been relatively stable over the years. Nonetheless, the kink coincides with a point observed by Fitzpatrick and Newton (1998) regarding wet-fish and freezer trawlers, where technologies have changed more radically. They observed that vessels depreciate steadily for approximately 20 years, after which their value stabilizes, albeit at a low level. If vessels are not then extensively refurbished or replaced, they are technologically outdated. Depreciation thus has two components: the first is age and use-related wear and tear, and the second is relative inefficiency caused by advances in catching technologies. According to Fitzpatrick and Newton (1998), "the vessel has high operational costs for fuel and maintenance and the insulation in its fish holds has poor 'k factors' requiring greater use of refrigeration compressors and associated higher fuel costs. To compete with the newer vessels, such a vessel has to minimize its operational costs, often resulting in lost sea-time and reduced catches."

While data constraints mean that straight-line depreciation was used to estimate the consumption of fixed capital in this study, it is clear that this was a poor reflection of reality and that formal satellite accounts will need a more realistic depreciation method. Equally important is the time involved. Even if straight line depreciation is adopted, it is clear that the depreciation period should be at least 20 years for fisheries' fixed capital.

The rate of return on capital (normal profit = *iK*)

A further component of the cost of capital is normal profit, i.e., the opportunity cost of the capital when invested in the best alternative employment.

The SEEAF handbook identifies three primary methods of calculating the opportunity cost of capital. The first is to find an industry that is "similar," but does not depend on fish. The ratio of net operating surplus to capital stock in this "counterpart" industry will give a "normal rate of return." The second looks at the financing cost of the capital, i.e., the return on frequently traded corporate bonds or shares in the fishing industry. The third alternative is to use the long-term rate on government bonds as the risk-free rate and to add an industry risk premium.[13]

[13] Sorenson and Hass's (2004) Norwegian case study cited in the SEAAF handbook suggested a 4.5% industry risk premium.

The first two options are not feasible. There is no equivalent domestic industry and very few fishing firms are now traded as individual enterprises on the Johannesburg Stock Exchange (although some still exist within conglomerates). Details of corporate borrowings are rarely available, although industry actors who were interviewed suggested that new investments need to satisfy real hurdle rates of 10–20 percent. Unfortunately, the apparently simple, remaining option also presents a complication: the real risk-free rate in the economy fluctuates markedly. Thus, while the long-dated bonds currently being traded were issued with coupons of 13–16 percent and real rates of 6–8 percent, at current prices, they offer nominal yields below 10 percent, implying a near zero real risk-free rate.

When Tietze and Lasch (2005) computed rents and returns on capital for worldwide fishing industries in 2002–2003, the returns observed in South Africa were generally higher than those elsewhere (see table 3 below). Although the authors merely attributed these high returns to "abundant and nearby resources," they did not indicate whether this was because of a well-managed local stock, nor did they comment that the South African industry was using vessels that were considerably older and less valuable than the global norm. A more considered view would also have allowed for a number of temporary external factors, including the extremely weak South African rand (ZAR) at the time, the low fuel price, and the strong state of the far-eastern and European markets for squid, rock lobster, and hake.

As the estimates in table 3 indicate, the returns in fishing can be high. However, fishing is an extremely risky industry, both financially and physically. In the five years since these estimates were compiled, vessels and lives have been lost and local fishermen have seen their profits evaporate due to such diverse factors as rising fuel prices, a stronger rand, the collapse of far-eastern markets during the SARS outbreak,[14] and falling fishmeal prices with better-than-average Peruvian pelagic catches and good soya seasons. In a caveat worth noting, Bross (2007, 1) contested the sustainability of sanguine profitability estimates (such as those of Tietze and Lasch 2005) and commented that "the industry is a very mature one and there are consequently no large-scale systematic rents in the business. The good profits enjoyed over a sustained period 1992 to 2001 were a unique historical aberration and (cannot) be expected again for the foreseeable future."

[14] SARS = severe acute respiratory syndrome. Caused by the SARS corona virus, a pandemic spread rapidly from the Guangdong province in China to nearly 37 countries from November 2002 to July 2003 (WHO 2004, 8).

Table 3. Return on Investment and Cash Flow by Fishery Vessel Type and Country

Country and vessel type	Return on investment %	Net cash flow
South Africa fishery vessels		
Squid, 60-foot (18.29-meter)	184,700	39
Squid, 45-foot (13.7-meter)	127,200	40
Hake longline	99,000	58
Pelagic, 200–300-ton	622,800	24
Pelagic, 100–200-ton	242,300	17
Pelagic, 50–100-ton	133,500	23
Large hake freezer	1,747,700	31
Small hake freezer	680,800	29
Large hake trawler	659,300	27
Small hake trawler	481,900	28
Argentina fishery vessels		
Trawler, 25-meter	141,200	18
Trawler, 30-meter	294,500	25
Trawler, 35-meter	564,400	28
Peru fishery vessels		
Purse seiner, 26-meter	95,800	7
Purse seiner, 25-meter	120,600	6
Purse seiner, 38-meter	362,300	16
Other countries' fishery vessels		
Norway: Danish seiner, 18-meter	34,300	32
Germany: Pelagic trawler, 90–120-meter	5,662,700	25
France: Deep-sea trawler, 28–33-meter	59,200	5
France: Deep-sea trawler, 50–54-meter	399,500	20

Source: Tietze and Lasch (2005)

In her study of the Namibian fisheries, Lange used a 20-percent return as the opportunity of capital. She justified this "because…the very high risk due to unpredictable factors affecting the fish stock that business must be compensated for" (Lange 2003, 7; see also UN/FAO 2004, paragraph 355: 108). The Norwegian and Icelandic case studies[15] used real rates of 8 percent

[15] Sorenson and Hass (2004) and Danielsson (2004), respectively, as cited in the SEEAF handbook.

(UN/FAO 2004, paragraph 315: 96, and paragraph 387: 119), although in the latter Danielsson conceded that this may have been low.

The opportunity cost of capital in the South African economy has been estimated (Kuo et al. 2003). This study included a sensitivity analysis that placed the return on capital nationally at 10.73–11.87 percent and argued for a real rate of 11 percent as a reasonable estimate. Given these estimates, Lange’s comments, and the stated high industry-hurdle rate, a “high” rate seemed appropriate, but it is not clear which specific rate to use. Accordingly, this study uses two rates of return when estimating industry rents: 10 percent as a primary rate, and 20 percent as a sensitivity allowance to acknowledge the fishing industry’s unusually high risks.

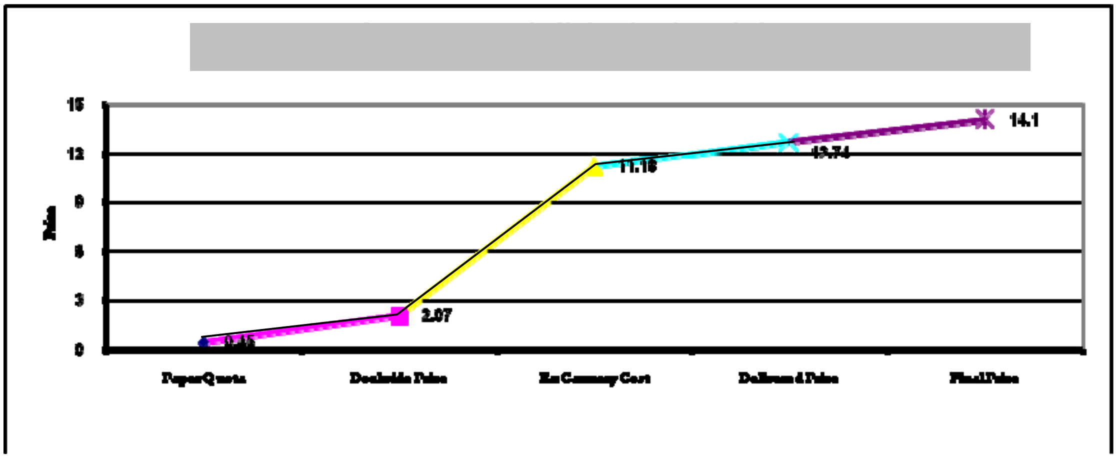
Vertical Integration

There is extensive vertical integration in South Africa’s fishing industry. While many small operators simply catch and sell to the public or the industry, or catch on behalf of others, larger enterprises reduce their risks by extending their operation along the value chain. SEEAF recommends that, in the case of vertical integration, “a true estimate of resource rent may only be obtainable if the boundary between the fishing and fish processing industries is relaxed and the residual method is applied to both activities” (UN/FAO 2004, paragraph 189: 54). Fishing presents a particularly clear case since the vertical integration exists at two levels. The first is conventional economic integration within firms that have internalized most of the value chain. The second is technological—many vessels (freezer trawlers, small pelagic fishmeal processors, and even squid boats with their onboard flash-freezers) combine catching with processing activities that could be performed as value-adding activities in factories ashore.

Few simple fishermen are rich. Rents in the actual harvesting of fish are typically low. There are “good years,” but access to a permit is no guarantee of wealth. Profit (as opposed to Ricardian rent) is made further up the value chain. As a simple example, figure 4 below shows the changing market price of a kilogram of pilchards in 2005 as it moved along the value chain. Its value in the sea, represented by the price of the paper quota, was ZAR 0.45. The expense and effort of catching and landing only raised this by ZAR 1.62, but de-heading, steam-cooking, adding tomato sauce, and packing in a tin lifted the value by more than ZAR 9.

Value chains can be far more complex. Hake processing options are remarkably varied, depending on the size of fish, catching technology (freezer trawl, wet-fish, longline, or handline), and market conditions.

Figure 4. Pilchard Value Chain (Canning)



It is clear that the steepest rises in value come further up the value chain. Clearly, treating such industrial profits as resource rents is problematic if rent levels are guides to policy. High rents invite taxes to extract them, especially when it is believed that such taxes provide a double dividend by simultaneously reducing catching effort in the industry. Inspection of the value chains, however, shows that such policies would penalize the small-scale, high-risk, low-margin producers who sell their catch at the quayside. Processors will continue making their profits. In our view, a strong and clearly visible caveat should be attached to all rent estimates (and stock valuations) that include processing and distributional profits earned further along the value chain.

Data

Tradition has maligned them. I am a fisherman myself, and I have never told a lie in my life.
P.G. Wodehouse

Unfortunately, fishing industry statistics rarely match Wodehouse's standards. They are often unreliable, which presents real problems for the compilation of satellite accounts. The most comprehensive recent survey of the local fishing industry is *An Economic and Sectoral Study of the South African Fishing Industry* (Mather et al. 2003). However, the data in this survey was collected in 2002. A more recent source is the data collected by MCM during its long-term rights allocation process in 2005. Applicants for commercial fishing permits (by species and by gear type) were required to specify numbers of employees, catching capacity, history in the industry, and BEE (black economic empowerment) credentials. A condition of the application was that it could (and would) be checked, and that false declarations would be penalized. This suggested that the data should be more reliable, so it was used for the rent estimates in this study.

The resource rent calculated is for 2004, the year that the 2005 LTRAMP treated as the test case. The full breadth of data was gathered only for that year. For reasons of confidentiality, MCM only provided raw data aggregated to the species/fishery level. It analyzed 1432 relevant applications and excluded data from applicants with no ownership history in the industry.

While most of the data seems sound, there are clear problems in certain fields. Many of the historic catch estimates look unrealistically high. It is plausible that some companies submitted catches in kilograms rather than in the metric tons specified. For this reason, estimated historic catch data from this source were not used in the rent calculation. This data is being "cleaned" and, with time, reliable catch statistics should become available.

Another problem in the data set is double counting. There are a number of feasible reasons for this. Some firms applied for multiple permits. If they intended to use the same crew and vessel to target a variety of species, this could mean an inadvertent double counting of employees and vessels. Comparison with the economic and sectoral study (ESS) by Mather et al. (2003) illustrates the likely extent of the problem. Regarding employment, responses to the 2004–2005 LTRAMP claimed 81,736 employees in the industry. The more-reliable ESS estimated direct employment in the fisheries sector at 27,730—one-third of the number suggested by LTRAMP three years later. Other reasons for this gap are inclusion of part-time employees and strategic double counting by respondents trying to inflate their industry contribution.

Unfortunately, the ESS data was itself problematic: it reported 4669 licensed fishing vessels in South African waters, comprising 1969 small, inshore linefishing vessels and 2700 larger vessels. However, the definitive vessel study of South Africa's major commercial fisheries (BCLME, 2006, 128) found only 566 licensed commercial vessels in the hake, small pelagic, horse mackerel, and rock lobster fisheries, i.e., the sectors that contribute most of the industry's value.

To minimize the effects of this uncertainty, the catch data in this study was taken from the database underlying the OMPs that drive current TACs.[16] The stock data used to construct the physical accounts are also taken from this source.

Mean prices were calculated from information on landings and turnover in each fishery. Where feasible, the industry's operating costs have been divided along the lines used in the *System of National Accounts 1993* (UN 1993). These include variable costs, such as "intermediate consumption" and "compensation of employees"; and fixed costs, including "consumption of fixed capital" and an imputed "normal return on capital stock." Notably, these have undergone major changes over the past four years. Fuel is the major cost in most commercial fisheries. The recent high oil prices have had a particularly heavy impact on fishing costs. The fuel impact has been asymmetrical because certain types of vessels and fisheries are more fuel-intensive than others. The mid-water trawl, for example, pulls large nets in the mid-water column, targeting relatively low-value fish, such as horse mackerel. The surface seiners, which also target low-value fish, use smaller and more fuel-efficient vessels and capture systems. Many of them also do not need to freeze their catch, a further fuel saving. Similarly, the longliners, wet-fish trawlers, and freezer trawlers, which coexist in the hake sector, have very different fuel-use patterns.

This division of costs does involve significant simplification of the reality in the fishing industry. A number of variables have both fixed and variable components. An example is "compensation of employees." Part-time workers exist, but most workers are on fixed contracts, so labor is not a "variable" factor. However, although wages are fixed in part by South Africa's minimum wage legislation, the actual earnings of workers on the boats are also tied to catch levels. This effectively is a piecework wage and adds a significant variable component to labor cost.

The Fisheries Accounts

In this section, we show that fisheries accounts can be constructed for South Africa and give some examples from major fisheries. We also warn of likely problems. The results are not

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[16] Data was collected for MCM by the MARAM (Marine Resource Assessment and Management) research unit, Department of Mathematics and Applied Mathematics, University of Cape Town. Thanks for access to this primary database are due to Johann Augustyn of MCM and Doug Butterworth and his team at MARAM.

complete and some of the underlying data is imperfect; however, we believe that it has more than heuristic value.

Stock Valuation

The value of a fish stock is the net present value of the rent it will generate in the future. As Lange (2003, 8) points out, this presumes knowledge of future prices, technologies, stocks, exploitation paths, and costs. As mentioned earlier, rather than smoothing these with lagged historic data, SEEAF advocates assuming that they are constant.[17]

Since the stock value is a net present value (NPV), the assumption that stocks will remain fixed at present levels can increase the volatility of fish stock values, especially for *r* selected species (such as small pelagic), whose populations are naturally cyclical. In reality, any stock increase has a twofold effect. First, as an increase in wealth, its value would need to be entered as income. Second, it would also increase rents (CPUE rises and average costs fall) and hence would have a double impact on value. For *r* selected species, the assumption of constant stocks and sustainable harvesting provides only the illusion of a more tractable result. In justifying the assumption of constant stocks, the SEEAF handbook seemed to have *k* selected species in mind. It notes that “governments usually change management when a fish stock faces collapse…” and adds the rider that “most fisheries have not recovered as often, or as quickly, or to the levels that managers have set as objectives” (UN/FAO 2004, paragraph 196: 56).

Another problematic issue is the selection of discount rates. An NPV-based asset valuation would normally use the private rate of interest, but SEEAF suggests using a lower social discount rate. It gives several examples of discount rates used to calculate fisheries asset values elsewhere. These are typically in region of 3–4 percent in North America and northern Europe, although Iceland uses 8 percent. The only least-developed country cited is Namibia, with a rate of 10 percent. Mullins et al. (2007), in their update of the South African manual for cost-benefit analysis, recommended a real social discount rate of 8 percent, but allowed for a range of 6–10 percent in a sensitivity analysis. Given the shortage of investment capital, higher social rates are important if marginal state projects are not to crowd out the private sector.

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[17] It should be noted that costs of production in this model, although assumed to be constant, vary considerably over time. They are strongly positively tied to oil prices and inversely related to stock abundance.

Even with good management, the condition of fish stocks is uncertain. The discount rate here reflects the difference in value between the right to catch a fish today and the right to catch such a fish in a year's time. Given the uncertainties of price, exchange rate, stock, and harvest cost, a 10-percent discount rate does not seem excessive. A policy caveat to consider, however, is that both fish-stock volatility and the assumption of unchanging fish stocks and costs become less important as the discount rate rises.

Physical Accounts

Estimates of stocks and catches suited for use in physical accounts can be obtained through the OMP models run for all major commercial species. Other data sources are also available; in preparing this study, these sources included FIGIS (UN/FAO fisheries geographic information system), the fishing industry handbook (Jones 2003), and the outcomes of the 2002 and 2004 annual MCM surveys. It is clear, however, that the OMPs provide the most comprehensive and verifiable data. More to the point, these models operate over long periods and permit backward induction to estimate pre-exploitation stock levels. They thus offer insight into the health of these resources and into potential yields, which short-period stock and harvest figures would not.

For illustrative purposes, the physical accounts for two major commercial fisheries, hake (*M. capensis* and *M. paradoxus*) and west coast rock lobster (*J. lalandii*), are shown in tables 4 and 5. Despite being relatively long-lived species, they are influenced by natural variations in recruitment. Like most local commercial species, they have experienced significant autonomous shifts in biomass from year to year, highlighting the difficulty in managing catch rates.

Table 4. Estimated Stocks of Hakes (*M. capensis* and *M. paradoxus*)

Year	**Spawning biomass** (000 metric tons)	**Exploitable biomass** (000 metric tons)
1917	1843	1683
1927	1836	1677
1937	1788	1623
1947	1684	1519
1957	1325	1207
1967	795	760
1977	293	364
1982	378	427
1989	408	444
1993	496	463
1994	511	488
1995	527	518
1996	556	525
1997	554	512
1998	528	502
1999	514	463
2000	482	421
2001	436	405
2002	421	411
2003	442	416
2004	427	408
2005	422	387
2006	406	384
2007	410	413

Source: MARAM/MCM database

Table 5. Hakes (*Merluccius spp.)* Annual Catch and Other Volumes

Year	**Catch** (000 metric tons)	**Other volume changes** (000 metric tons)
1990	137	135
1991	141	145
1992	142	149
1993	141	166
1994	147	184
1995	141	138
1996	159	150
1997	148	135
1998	154	122
1999	137	88
2000	155	142
2001	159	174
2002	147	149
2003	155	145
2004	154	136
2005	144	125

Source: MARAM/MCM database

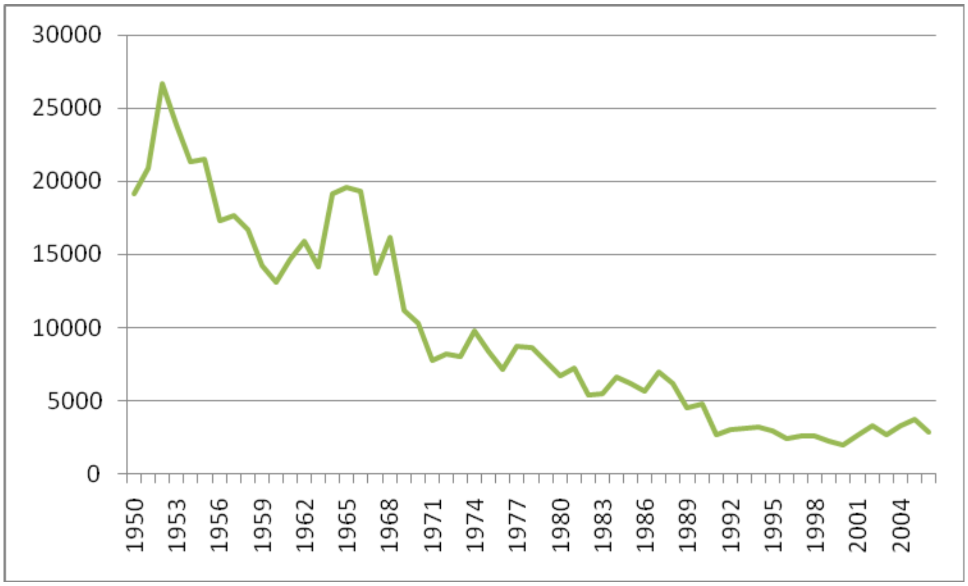
West coast rock lobster suffers from a volatile environmental, i.e., “other volume” changes. Despite this, however, its biomass has been reasonably stable over the last eight years, incurring only a moderate decline in biomass levels. To put the condition of the resource into context, however, it helps to have a longer time perspective, as table 6 and figure 5 demonstrate.

Table 6. West Coast Rock Lobster Biomass Estimates (metric tons)

Year	Opening biomass	Commercial Catch	Recreational catch estimate	Poaching estimate	Change in volume	Exploitable biomass (>75 mm)
1990	–	2996	441	500	–	31,854
1991	31854	2480	455	500	-409	28,010
1992	28010	2176	469	500	-165	24,700
1993	24700	2197	391	500	1483	23,096
1994	23096	1966	336	500	2098	22,391
1995	22391	1516	379	500	3195	23,192
1996	23192	1674	496	500	6514	27,035
1997	27035	1918	340	500	2739	27,016
1998	27016	1792	249	500	1626	26,102
1999	26102	2315	360	500	3046	25,972
2000	25972	1609	404	500	4815	28,275
2001	28275	2073	468	500	4084	29,318
2002	29318	2462	583	500	4404	30,177
2003	30177	2918	320	500	1060	27,499
2004	27499	3205	320	500	1213	24,687
2005	24687	2875	320	500	1062	22,054
2006	22054	2207	300	500	928	19,975
2007	19975	2314	257	500	1790	18,694
2008	18694	2083	257	500	1361	17,215

Source: MARAM/MCM database

Figure 5. West Coast Rock Lobster Catches (metric tons), 1950–2006



Source: Johnston and Butterworth (2005)

Monetary Accounts

These results are a "one off." Placed in a series, they would be more informative. A quick interpretation, however, is still interesting, especially given the emphasis on industry restructuring and permit allocation in recent years. The hake fishery generated the most rent of South Africa's fisheries in 2004, followed by the small pelagic, west coast rock lobster, and squid fisheries, respectively. The horse mackerel fishery generated a negative rent, reflecting the depressed state of this fishery and its associated market.

Interestingly, the hake longline fishery—identified as a high rent sub-sector by Tietze and Lasch (2005) and often touted as being suitable for black empowerment—also generated a negative rent. One plausible reason is that, being a relatively new fishery, it has younger vessels which are less fully amortized than others in the sector. The resulting relatively high values of capital stock in the fishery mean a higher capital/output ratio, and hence a higher opportunity cost of capital in the fishery as a whole. In this regard,[18] it is worth noting that reports on the

[18] Some hake operators were allegedly paying ZAR 3.50/kg. This price was described as economically unfeasible for legitimate operators, unless it was used to catch unreported fish or to target high value by-catches (Japp 2006, personal communication).

value of informally traded hake longline rights in 2006–2007 priced them at ZAR 8–20 per kilogram, while the right to trawl hake sold for ZAR 1.50–2.00 per kilogram. This aligns far better with the view that longlining is a high-return sub-sector.

It was suggested that in 2006–2007 west coast rock lobster rights fetched a price of roughly ZAR 35 per kilogram At these prices, a “market-price” assessment of the resource rent of the hake and rock lobster fisheries indicated the resource rent for west coast rock lobster at approximately ZAR 140 million,[19] while the resource rent for deep sea trawl hake was ZAR 200–266 million,[20] and for hake longline, ZAR 78–196 million.[21]

The following estimates (tables 7–10) use the SEEAF “residual” method to calculate rents. Note that both rock lobster fisheries generated extremely high rents per ton—several times the value generated by any of the other fisheries. This can be partially explained by the high international demand for lobster products and the associated high prices offered. A significant difference between the two is the greater sensitivity of south coast rock lobster (*P. gilchristi*) rents to the fuel price since this species is fished at greater depths and further from shore. The squid fishery also reports a high rent value per ton. In the horse mackerel fisheries, low prices and high costs suggested negative rents for 2004. Although it was a historically valuable fishery, and is expected to be so again in the future, it is worth stressing that the current SEEAF approach to stock valuation renders its stocks technically valueless.

[19] ZAR 3500/metric ton multiplied by the west coast rock lobster catch of 4025 metric tons.

[20] ZAR 1500–2000/metric ton multiplied by the hake deep sea trawl catch of 133,000 metric tons.

[21] ZAR 8000–20000/metric ton multiplied by the hake longline catch of 9798 metric tons.

Table 7. Rents Estimated for Major South African Fisheries, 2004

2004	Resource rent (ZAR millions) @ 10% OCC	Resource rent (ZAR millions) @ 20% OCC	Rent per ton (ZAR millions) @ 10% OCC	Asset value (ZAR millions)
Total hake	551	446	3571	5514 (41%)
- Deep sea trawl	431	342	3242	4311
- Inshore trawl	63	58	6333	633
- Longline	-14	-26	n/a	n/a
Small pelagics	310	249	549	3097 (23%)
West coast rock lobster	297	281	73,676	2965 (22%)
South coast rock lobster	36	33	95,046	363 (3%)
Squid	117	93	16,088	1170 (9%)
Horse mackerel	-31	-47	n/a	n/a
South African fisheries	**1357**	**1134**	**1840**	**13,572 (100%)**

Note: OCC = opportunity cost of capital.

Source: Authors' calculations from MARAM/MCM database.

Table 8. Estimation of Rents: South Africa Hake Fishery, 2004

2004	Total Hake
Number of companies	260
Stock estimate (metric tons)	460,634
Recruitment and mortality changes 2004 (metric tons)	130,841
Catch (metric tons)*	154,403
Price (ZAR/metric ton)	14,498
Jobs	34,477
Output (turnover generated by catch), in ZAR	2,238,581,421
Compensation of employees, in ZAR	655,278,405
Capital stock, in ZAR	1,054,964,457
Intermediate consumption	783,503,497
Consumption of fixed capital	142,857,143
Resource rent @ 10% opportunity cost of capital	***551,445,931***
Resource rent @ 20% opportunity cost of capital	***445,949,485***

* The initial raw data was taken largely from the 2004–2005 LTRAMP. The catch data had a number of problems and a cleaner version was drawn using figures provided by Doug Butterworth at MARAM.

Note: ZAR = South African rand.

Source: Authors' calculations from MARAM/MCM database.

Table 9. Hake: Sectoral Breakdown

2004	Hake deep sea trawl	Hake inshore trawl	Hake longline
Number of companies	53	17	141
Catch (metric tons)*	133,001	10,004	9,798
Price (ZAR/metric ton)	1,210	18,240	398
Jobs	19,017	4,558	10,902
Output (turnover generated by catch), in ZAR	1,812,482,906	188,947,757	174,609,536
Compensation of employees, in ZAR	543,635,569	51,597,371	59,680,047
Capital stock, in ZAR	890,121,630	50,034,247	114,808,580
Intermediate consumption, in ZAR	634,369,017	66,131,715	61,113,338
Consumption of fixed capital, in ZAR	114,285,714	2,857,143	57,142,857
Resource rent, in ZAR @ 10% opportunity cost of capital	***431,180,443***	***63,358,103***	***(14,807,563)***
@ 20% opportunity cost of capital	***342,168,280***	***58,354,679***	***(26,288,421)***

* Data from D. Butterworth/MARAM used instead of LTRAMP data.

Note: ZAR = South African rand. *Source*: Authors' calculations from MARAM/MCM database.

Table 10. Estimation of Rents: South Africa West Coast Rock Lobster Fishery, 2004

2004	Total west coast rock lobster
Number of companies	910
Stock estimate (metric tons)	24,825
Recruitment and mortality changes 2004 (metric tons)	1,459
Catch (metric tons)*	4,025
Price (ZAR/metric ton)	209,473
Jobs	16,286
Output (turnover generated by catch), in ZAR	843,127,338
Compensation of employees, in ZAR	219,255,962
Capital stock, in ZAR	150,863,912
Intermediate consumption, in ZAR	295,094,568
Consumption of fixed capital, in ZAR	17,142,857
Resource rent, in ZAR @ 10% opportunity cost of capital	***296,547,560***
@ 20% opportunity cost of capital	***281,461,168***

* Data from D. Butterworth/MARAM used instead of LTRAMP data.

Note: ZAR = South African rand. *Source*: Authors' calculations from MARAM/MCM database.

Conclusion

The message of this paper is simple: South Africa needs a working system of fisheries satellite accounts. If policymakers are to fully understand the situation of the resource and the implications of the various policy measures they have at their disposal, they need to understand how they relate to the catch allowed and the technologies permitted or to industry structure and the allocation of quota. Not only are such accounts needed, the operational management process currently in place means that they can be achieved with relative ease and at little cost. The SEEAF approach described and largely replicated here is not perfect and revisions to it are in fact under way. However it provides useful guidelines and has been widely used elsewhere. StatsSA has allocated resources for the compilation of satellite accounts for fisheries. South Africa's well established system of fisheries management through OMPs gives the compilers of satellite accounts a rare advantage: a data base and model that combine a stock of readily accessible current and historic data, with a range of future stock and harvest projections. Once the LTRAMP data has been fully cleaned, all of the ingredients for physical accounts should be in place. Monetary accounts will remain problematic, both in theory and in practice, but allowing for the caveats mentioned in this paper, the annual publication of fisheries satellite accounts is clearly a desirable and an achievable goal.

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