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From drain to gain in capture fisheries rents

A synthesis study

Cover photograph:

Unloading fish as part of the daily arrival of fishing boats on Lake Victoria near Entebbe, Uganda; ©FAO/Roberto Faidutti.

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Preparation of this document

This document presents a synthesis of case studies undertaken to assess resource rent losses in the world's marine capture fisheries. The synthesis covers both studies undertaken within the World Bank and FAO Rent Drain Project as well as other case studies. The document also contains a summary of the key findings of the World Bank and FAO study *The Sunken Billions: The Economic Justification for Fisheries Reform*.

Abstract

The World Bank/FAO report, *The Sunken Billions*, argues that the world's capture fishery resources are non-performing assets with rates of return, or yields, not exceeding zero. The cost to the world economy is in the order of US$50 billion per annum in forgone resource rent. Cases studies commissioned by the World Bank and FAO support these conclusions and show that economic overexploitation of capture fishery resources is spread throughout the world, to be found both within developed and developing fishing states regardless of their economic systems.

The question is what needs to be done to reverse the situation and ensure that the world's capture fishery resources come to make their full potential contribution to the world economy. In order for this potential to be realized, there will need to be a programme of massive resource investment in the overexploited fish stocks. As with any such programme, positive investment requires that costs and sacrifices be borne today in the hope of an economic return in the future. Establishing effective resource investment programmes within coastal state exclusive economic zones will be difficult, particularly in the developing world. However, the greatest challenges are likely to be found in establishing such investment programmes for shared stocks in the high seas. That said, some of the case studies provide encouraging lessons with examples of fish stock restorations that are successful in economic, as well as biological, terms.

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Abbreviations and acronyms

DWFS	distant-water fishing state
EEZ	exclusive economic zone
EU	European Union
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Commission for the Exploration of the Sea
IPHC	International Pacific Halibut Commission
IQ	individual quota
ITQ	individual transferable quota
MEY	maximum economic yield
MSY	maximum sustainable yield
PA	principal–agent
PROFISH	Global Program on Fisheries
PV	present value
RFMO	regional fisheries management organization
SSB	spawning stock biomass
TAC	total allowable catch
UNEP	United Nations Environment Programme

1. Introduction

In 2005, the World Bank published the report *Where is the Wealth of Nations? Measuring Capital for the 21st Century* (World Bank, 2005). The report contains a significant gap in that, owing to the then unavailable data, it has nothing to say on natural capital in the form of fishery resources. In response to this gap, the World Bank, under its Global Program on Fisheries (PROFISH), mounted a workshop in 2006 in cooperation with FAO with the objective of correcting the knowledge deficit (Kelleher and Willmann, 2006).

The workshop recognized the need to focus on, and highlight, the current level of global economic rent loss in marine capture fisheries and to raise awareness on the economic objectives of fisheries management. In so doing, the workshop identified two alternative approaches to the task.

One approach is to estimate the rent and rent loss in each of the world's fisheries, or in a representative sample of them. This is a major undertaking. An alternative simpler approach is to regard the global ocean fishery as one aggregate fishery. This second approach has several advantages. The data requirements are considerably reduced. Many of these global fisheries data are readily available and the model manipulation and calculations are a fraction of those required for a study of a high number of individual fisheries. The aggregate approach, regarding the fisheries as a single fishery, was considered by the workshop to be the only way to obtain, quickly and inexpensively, reasonable estimates of the global fisheries rent loss, and to do so in a transparent and replicable manner.

On this basis, the workshop recommended that two independent studies be prepared on the estimation of the loss of economic rents in global marine fisheries. Each estimate would serve as a cross-check on the other. The first study would estimate the global rent drain (or potential loss of net benefits) through an aggregate model of the global fishery. The second companion study would consist of a set of case studies on economic rents in a representative group of fisheries and endeavour to extrapolate the results of the case studies to the global level.

In essence, *The Sunken Billions: The Economic Justification for Fisheries Reform* (World Bank and FAO, 2009) is a report on the first study. With the case studies not available to its authors, the report has a very limited number of illustrations and examples.

The commissioned set of case studies is now largely complete. The purposes of this synthesis report is to summarize the major findings of *The Sunken Billions* report, and then to supplement and buttress these findings by drawing upon the available case studies. Thus, for example, where *The Sunken Billions* report talks in general terms of the overexploitation of capture fishery resources, it is now possible to point to specific examples of such overexploitation from both the developed and developing world.

While the case studies commissioned by the World Bank and FAO will provide the basis for most of the supplementary material, the synthesis report will not restrict itself to these studies. Other case studies, and articles, will be drawn upon as deemed appropriate.

2. The rent loss from marine capture fishery resources: an overview

2.1 CAPTURE FISHERY RESOURCES AND NATURAL CAPITAL

The World Bank report *Where is the Wealth of Nations?* (World Bank, 2005) argues that both the current national income and the prospects for future development of any nation rest upon that nation's portfolio of real capital assets. This portfolio is seen to consist of produced, natural and intangible capital assets, with the latter, in turn, to be seen as a mix of human and social capital. Development is to be viewed as a process of real asset portfolio management (World Bank, 2005, pp. 1–5).

The World Bank 2005 report divides natural capital into two components: exhaustible natural resources, such as hydrocarbons and minerals; and living, or renewable, natural resources, such as agricultural land, forests and fisheries. Unlike exhaustible natural resources, renewable natural resources are capable of providing a sustainable flow of net economic benefits into the indefinite future and are, to quote the World Bank, "truly a gift of nature" (World Bank, 2005, p. 7). Marine capture fishery resources constitute a segment of the world's stock of natural capital in the form of renewable natural resources and are thus "truly a gift of nature".

The report *Where is the Wealth of Nations?* points out that natural capital is particularly important in the real capital portfolios of developing nations. According to the report (World Bank, 2005, p. 8) the net economic returns from natural capital, loosely referred to as resource rent, play two key roles in development:

- providing the basis of subsistence, particularly in the poorest nations;
- providing a source of development finance, by furnishing the wherewithal for investment in other forms of capital, e.g. produced and human capital.

2.2 CAPTURE FISHERY RESOURCES AND RESOURCE RENT

The potential significance of the natural capital in the form of capture fishery resources to the world economy can be gauged from the facts that fisheries based upon these resources are yielding annual harvests in the order of 85 million tonnes, which have a "first" gross value of slightly less than US$80 billion. Furthermore, these fisheries provide employment, direct and indirect, to more than 120 million people (World Bank and FAO, 2009). Thus, the significance of world capture fishery resources, actual and potential, to the world economy is not in dispute.

The question that has to be asked of any set of capital assets, produced or natural, is what economic returns, what flow of net economic benefits, the assets are providing to society through time. In the case of capture fishery resources, as with other forms of natural capital, these net economic benefits are referred to as resource rents. Using 2004 as its base year, *The Sunken Billions* report, estimates that, if these capture fishery resources were being managed optimally, they would be yielding approximately US$50 billion per annum more in resource rent than they are currently doing. The cumulative loss to society from this less than optimal resource management in the period 1974–2008, is estimated to be in excess of US$2 trillion (World Bank and FAO, 2009).

The estimated per annum rent loss of US$50 billion demands further investigation. It could be that world capture fisheries are yielding significant resource rent but that, through improved management, the net economic yields, or returns, could be somewhat higher. Thus, for example, the hake fishery, shared by Angola, Namibia and South Africa, and the Iceland cod fishery, both fit the pattern. Both fishery resources are subject to reasonably effective resource management, and the fisheries based on the resources are producing positive resource rents. However, the fishery resources are not realizing their full economic potential.

The Angolan–Namibian–South African hake resource and the Icelandic cod resource were overexploited in the past. In order for the two fisheries to yield their maximum net economic returns through time, a programme of resource investment, i.e. building up the resources, would have to be undertaken (Sumaila and Marsden, 2008; Arnason, 2008).

However, *The Sunken Billions* report is not stating simply that overall world marine capture fisheries are yielding positive resource rents but could do better. Rather, the report is stating that, if optimally managed, these fisheries could be expected to yield resource rents in the order of US$45 billion per year. The resources are, in fact, yielding resource rents in the order of *minus* US$5 billion per year. In other words, overall world capture fisheries are currently making a *negative* contribution to economic development and to the alleviation of poverty (World Bank and FAO, 2009, Table 4.1).

Negative capture fishery resource rents are not just a developed fishing state phenomenon. They are to be found in developing fishery states as well. To take one example, a case study from Malaysia focuses on capture fisheries in the Straits of Malacca (Yew, 2008). There is convincing evidence that both demersal and pelagic fisheries in the northern Straits of Malacca are yielding negative rents, and that the fisheries are thus making a negative contribution towards Malaysia's economic development (Yew, 2008, Table 3.4).

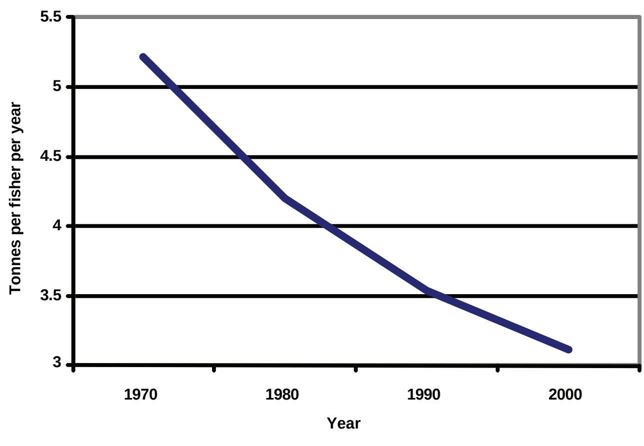
The negative resource rents reported in *The Sunken Billions* report are net of subsidies, which means that they may not be sustainable. However, one is given no assurance that the global rents from marine capture fishery resources will rise above zero.

The negative to zero rents yielded by world capture fishery resources are reflected in the state of the resources themselves. FAO estimates that 25 percent of the capture fishery resources are overexploited, depleted or recovering, from a biological point of view, i.e. the resources are below their maximum sustainable yield (MSY) levels. Another 50 percent are "fully exploited" from a biological standpoint. As *The Sunken Billions* report emphasizes, "fully exploited" from a biological perspective invariably means overexploited from an economic perspective. Thus, from an economic perspective, 75 percent of the capture fishery resources are overexploited (World Bank and FAO, 2009).

The economic overexploitation of world capture fishery resources is not fully reflected in the fish stock levels. It also manifests itself in the fish stock mix. The more valuable species have been exploited to a much greater degree than those of lower value. Indeed, the global harvests from capture fishery resources are concentrated to an ever-increasing degree on the lower valued species (World Bank and FAO, 2009).

The effects of the economic deterioration of world capture fisheries show up dramatically in terms of fisher and vessel productivity (Figure 1).

FIGURE 1
Annual catch (marine and inland) per capture fisher, 1970–2000



Source: World Bank and FAO, 2009, Figure 2.8.

The significance of this decline in average output per fisher has to be seen in the context of the enormous technological developments that have taken place in the world's capture fisheries during this period, including large-scale motorization of traditional small-scale fisheries, the expansion of active fishing techniques such as trawling and purse-seining, the introduction of increasingly sophisticated fish-finding and navigation equipment, and the growing use of modern means of communication. This technological progress has increased labour productivity in many fisheries. However, at the aggregate global level, the resource constraint in combination with widespread open-access conditions (discussed below) has prevented an increase in average labour productivity in the world's capture fisheries. On the contrary, productivity has declined significantly, a decline caused by a shrinking resource base and a growing number of fishers.

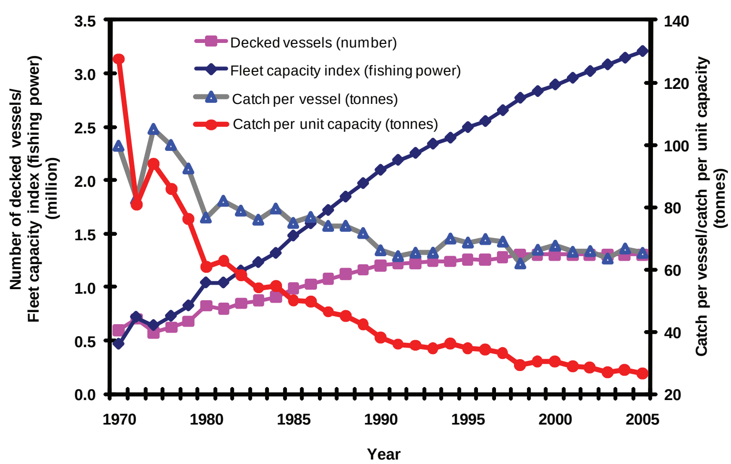
As the number of fishing vessels has also increased significantly in recent decades, by 75 percent in numerical terms in the past 30 years (World Bank and FAO, 2009), at the global level the productivity-enhancing investments in capture fisheries have on average yielded small returns and have stymied growth in labour productivity and incomes in the sector.

With regard to vessel productivity, it can be noted to begin with that fishing capacity is the amount of fishing effort that can be produced in a given time by a fishing vessel or fleet under full utilization for a given fishery resource condition (FAO, 2000).

Both the increase in vessel numbers and in vessel technology have enhanced the capacity of the global fleet and facilitated access to an expanding range of marine fishery resources and more efficient use of these resources.

Fitzpatrick (1996) estimated that the technological coefficient, a parameter of vessel capacity, had grown at a rate of 4.3 percent per annum. Assuming that this trend has continued, growth in technological efficiency coupled with growth in the number of vessels suggests a steeply rising global fleet capacity. The capacity index shown in Figure 2 is a multiple of the total number of decked vessels and the technological coefficient. The trend line of the catch/capacity index demonstrates that the global harvesting productivity has on average declined by a factor of six.

FIGURE 2
Fleet productivity development (total decked vessels)



Source: World Bank and FAO, 2009, Figure 2.11.

The exploitation of a growing number of marginal fish stocks partly explains this decline, but the buildup of fishing overcapacity is clearly a major contributing factor. Thus, the gains from technological progress have generally not been realized because the fish stocks limits call for a concomitant reduction in the number of vessels in order to allow for improved vessel productivity.

The decline in physical productivity is compounded by a decreasing spread between average harvesting costs and average ex-vessel fish prices, causing depressed profit margins and reinvestment. Although this has a dampening effect on growth in fleet capacity, depressed fleet reinvestment may retard a shift to more energy-efficient harvesting technologies and a reduction in the carbon footprint of the fishing industry.

Many countries have adopted policies to limit the growth of national fishing capacity, both to protect the aquatic resources and to make fishing more economically viable for the harvesting enterprises (FAO, 2007). This has proved difficult and costly to implement in many instances. Even where numbers of vessels have been successfully reduced (Curtis and Squires 2007), the reduction in fishing effort has been considerably less than proportional. This is because it is the less efficient vessels that tend to exit the fishery and expansion in technical efficiency counters the reduction in vessel numbers.

The global fleet has attempted to maintain its profitability in several ways: by reducing real labour costs; by fleet modernization; and by introducing fuel-efficient technologies and practices, particularly in developed countries. Vessels are also reported to remain in harbour for increasingly longer periods of the year, focusing harvesting on peak fishing seasons.

The receipt of government financial support has also assisted both vessel operators and crews, for example, through income compensation for crews. Subsidies in the world's marine fisheries have received growing attention in recent years because of their generally destructive effects, and they are further discussed later in this report.

Thus, when one talks of the significance of world capture fishery resources to the world economy, the emphasis must be on the word *potential.* There are capture fishery resources in the world that are yielding significant positive net economic returns. However, overall, the world marine capture fishery resources have to be categorized as non-performing capital assets.

Two questions arise. The first is how the estimates of resource rent loss were determined. Are these estimates, in fact, alarmist? It will be argued that, if the estimates are open to criticism, it is because they are probably too conservative. It is likely that the estimates understate the true rent loss, and that they do so by a considerable margin.

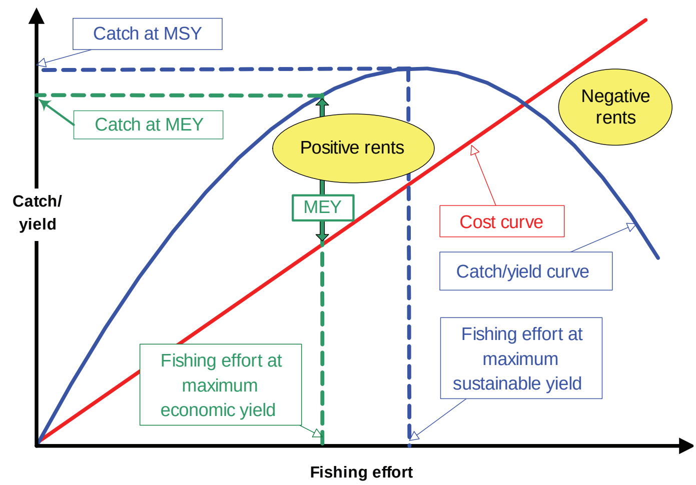
The second question to be addressed is how this dismaying state of affairs arose. Without an answer to this second question, it is not possible to explore and investigate means of correcting the state of affairs and ensuring that this fisheries component of the world's portfolio of natural capital assets begins to realize its economic potential by making a contribution, exceeding zero, to world economic development and to the alleviation of world poverty. The two questions are to be addressed in turn.

2.3 THE BASIS OF THE RENT LOSS ESTIMATES

2.3.1 Economic rent and maximum economic yield

The concepts of resource rent from the fishery and maximum economic yield (MEY) as opposed to maximum sustainable yield (MSY), as perceived by the authors of *The Sunken Billions* report, are illustrated in Figure 3.

FIGURE 3
Maximum sustainable yield (MSY) and maximum economic yield (MEY)



Source: World Bank and FAO, 2009, Box 3.2.

Thus, resource rent is seen as the difference between total revenue arising from fishing effort (catch times price of harvested fish) and total fishing effort cost.

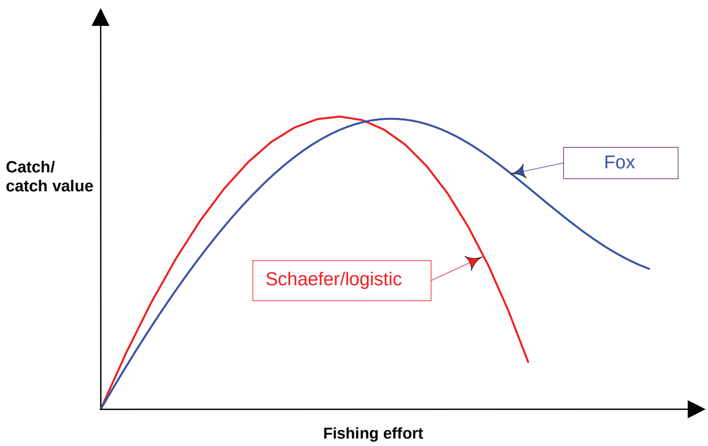
2.3.2 The aggregate model described

Based on work by Arnason (2007), the authors of *The Sunken Billions* report constructed an aggregate model to estimate rent loss for the global marine capture fishery. The model entails several major abstractions from the real world. In particular, the model assumes that global fisheries can be modelled as a single fish stock with an aggregate biomass growth function. Similarly, the global fishing industry is represented by an aggregate fisheries profit function, composed of an aggregate harvesting function, relating the harvest to fishing effort and biomass, and an aggregate cost function relating fishing effort to fisheries costs. The justification rests on the fact that treating the diverse global marine capture fisheries as a single aggregate fishery allows for a model with a manageable number of parameters. It should be added that the authors of *The Sunken Billions* report undertook extensive sensitivity analysis and stochastic simulations to establish reasonable upper and lower bounds and confidence limits for the global fishery rent losses.

Fisheries, and the rents that they generate, are dynamic and are rarely in equilibrium. This implies that there are several approaches to the calculation of rent losses. This study compares maximum sustainable resource rent to the actual resource rent in the base year (2004). The difference is taken to represent the rent loss in the base year. The rent loss estimate assumes that the existing biological overfishing is entirely reversible in the long run. Finally, the estimate does not take account of the costs of restoring the global fishery to economic health.

The population dynamics of the aggregate biomass (the global fishery) are modelled through two biological models: (i) a logistic, or Schaefer-type, model; and (ii) a Fox model. The main difference between these two biomass growth functions is that the Fox model assumes that the biomass is much more resilient to increasing fishing effort; in other words, the harvest will not decline proportionately as fishing effort increases (Figure 4).

FIGURE 4
Comparative yield–effort curves corresponding to the logistic (Schaefer) and Fox biomass growth functions



Source: World Bank and FAO, 2009, Figure 3.1.

This is consistent with the experience from the global fishery that, even though many of the most valuable demersal fish stocks have become depleted, the aggregate global harvest has continued to increase and has not contracted significantly in spite of ever-increasing fishing effort.

The shape of the yield–effort curve is given principally by the carrying capacity, or pristine state of the fish stock (or stocks), the MSY and the parameters of the harvesting (catch production) function. Of these parameters, estimates of the MSY are more robust than estimates of the other two parameters, as comprehensive global marine fish catch statistics are available for more than 50 years and harvest trends have been relatively stable for nearly two decades in the range of 79–88 million tonnes.

Table 1 lists the basic data used to estimate model parameters and model assumptions. The data sources and the justification for the assumptions are provided in the set of commentaries below.

The year 2004 is taken as the base year for the model as several robust data sets are available for that period. Where data for 2004 are deficient, adjusted data from other years, or series of years, are used.

TABLE 1
Empirical data used as model inputs and estimation of model parameters

	Model input values	Units of measurement
(i) Biological data		
Maximum sustainable yield	95.0	Million tonnes
Global biomass carrying capacity	453.0	Million tonnes
Biomass growth in 2004	–2.0	Million tonnes
(ii) Fishing industry data		
Landings in 2004	85.7	Million tonnes
Value of landings in 2004	78.8	Billion US$
Fisheries profits in 2004	–5.0	Billion US$
(iii) Parameter assumptions		
Schooling parameter	0.7	No units
Elasticity of demand with respect to biomass	0.2	No units

Source: World Bank and FAO, 2009, Table 3.1.

2.3.2.1 Global maximum sustainable yield and carrying capacity

The global MSY is assumed to be higher than the reported marine catch in the base year (85.7 million tonnes, FAO FISHSTAT) plus estimated discards (7.3 million tonnes), which gives a total of 93 million tonnes. A value of 95 million tonnes is used in the model. This value is higher than the 93 million tonnes given earlier, but lower than 101 million tonnes, the sum of the maximum reported catch for each species group in the past (FAO FISHSTAT). It is also in the same range as that of 100 million tonnes suggested by Gulland (1971) and lower than the maximum of 115 million tonnes suggested in the earlier work by Christy and Scott (1965).

This estimate of the global MSY refers to conventional fisheries only. For example, Antarctic krill is the subject of increasing attention as new harvesting technologies develop and markets for Omega-3 fish oils expand. A major expansion of this fishery could substantially raise the global MSY.

Since the 1990s, reported marine catches have fluctuated between 79 and 86 million tonnes without an apparent trend (FAO, 2007). In light of the estimate of MSY, this suggests that current global fish stocks are smaller than those corresponding to MSY.

2.3.2.2 Biomass growth in the base year

The fact that aggregate reported catches from the global marine fisheries have been relatively stable since the 1990s (above) is consistent with the aggregate global biomass being approximately constant. In this period, in response to fishing pressure, climatic factors and other influences, some stocks have declined markedly, for example, demersal stocks such as cod and hake in parts of the Atlantic Ocean. Other stocks have increased, such as some pelagics in the North Atlantic Ocean, while other large stocks have remained largely unchanged (FAO, 2005). Overall, it appears unlikely that in the base year, 2004, there was a significant net increase or decline in global stocks of commercial marine species. However, because global reported catches in 2004 were close to the upper bound of annual global catches since the 1990s and reported catches in 2005 were lower, it is conservatively assumed that in 2004 global marine commercial biomass growth was negative, or –2 million tonnes.

2.3.2.3 Volume of landing in the base year, and reported and real marine fisheries catches

In accordance with official FAO statistics (FAO FISHSTAT), the global catch in the base year (2004) is taken to be 85.7 million tonnes. Acknowledging the deficiencies of the FAO FISHSTAT records, FAO has repeatedly called for more comprehensive and accurate reporting of fish catches (Tietze *et al.*, 2001). The level of acknowledged misreporting and underreporting of catch has been addressed with varying degrees of success by different authors. The reasons for misreporting vary widely from deliberate underreporting of quota species and deficiencies in transmission of information to FAO, to widespread underestimates of small-scale fisheries production and possible substantial overestimates of fish production in the case of China and other countries. The estimates of underreporting vary widely from 1.2 to 1.8 times the catch reported to FAO in relatively well-managed fisheries, to several times the reported catch in countries with extensive and isolated small-scale fisheries, or with high levels of illegal fishing (Oceanic Développment, 2001; Kelleher, 2002; MRAG and UBC, 2008; Zeller and Pauly, 2007; Watson and Pauly, 2001). However, in the absence of a robust basis for adjusting the reported to the estimated real catch, the FAO FISHSTAT values remain the core data set for this study.

2.3.2.4 Value of landings in the base year

The value of landings in 2004 is discussed in detail in *The Sunken Billions* report. The details are not repeated here. Based on published production value data and other information, it is estimated that this value was US$78.8 billion (FAO, 2007). This corresponds to an average landed price of US$0.918 per kilogram.

2.3.2.5 Harvesting costs

Harvesting costs have to be treated with due caution because of the weak and incomplete data on the world's fishing fleets. The data sets used include:

- A robust set of fleet and productivity data for 21 major fishing nations that contribute about 40 percent to global marine capture production. These data are biased towards industrial fisheries, but are considered to be representative of industrial fisheries.

- Detailed cost data available for the European fleets (EU 25), which contribute about 6 percent to the global marine catch.
- A recent set of costs and earnings data for India's industrial and small-scale fisheries (Kurien, 2007). These fisheries contribute about 2.5 percent to global marine fish harvest. This data set has been taken to represent tropical developing countries' small-scale fisheries.

The reader is encouraged to turn to *The Sunken Billions* report for an in-depth discussion of the harvesting cost estimates.

2.3.2.6 Profitability

The world's fishing fleet is estimated to have had an operating profit of US$5.5 billion in 2004. However, the fleet incurred an additional cost of capital estimated at US$10.5 billion. Consequently, the global fisheries profitability is estimated to be negative in the order of US$5 billion (a deficit of US$5 billion) in 2004, the base year. These estimates are net of financial subsidies, that is, subsidies have already been subtracted.

Once again, the reader may turn to *The Sunken Billions* report for a detailed discussion of the profitability estimates.

Table 2 presents details of estimates for the base year 2004, and compares these with estimates undertaken in the study *Marine Fisheries and the Law of the Sea: A Decade of Change* (FAO, 1993). The base year for the 1993 study was 1989.

Profit estimates for the global fishing fleet suffer from a scarcity of reliable fleet cost and earnings data. Fisheries cost and earnings or profitability data are not systematically collected by many countries, and these data are particularly deficient for small-scale, artisanal and subsistence fishing. Even where such data are collected, fishers are often reluctant to provide complete and accurate global information, and available information is often distorted by subsidies or taxes. Nonetheless, although based on limited samples, there are indications that substantial numbers of fisheries are unprofitable or are experiencing declining profitability (Lery, Prado and Tietze, 1999; Tietze *et al.*, 2001; Tietze *et al.*, 2005; Watson and Seidel, 2003; Hoshino and Matsuda, 2007).

TABLE 2
Fleet profits: 2004 base year and 1993 FAO study

	1993 FAO study	2004 base year
	(US$ billions)	
Value of catch	70.0	78.8
Fuel costs	14.0	22.5
Labour costs	22.7	22.7
Other operating costs	55.9	28.1
Operating profit/loss	–22.6	5.5
Total cost of capital	31.9	10.5
Global fleet profitability (deficit)	–54.4	–5.0

Source: World Bank and FAO, 2009, Table 3.3.

2.3.2.7 Schooling parameters

Harvests from species with a strong tendency to congregate in relatively dense schools or shoals (such as herrings, anchovies and sardines) are often little influenced by the overall biomass of the stock (Hannesson, 1993). The opposite is true for species that are relatively uniformly distributed over the fishing grounds (such as cod or sharks). For these species, harvests tend to vary proportionately with the available biomass for any given level of fishing effort.

The schooling parameter reflects these features of fisheries and normally has a value between zero and unity. The lower the schooling parameter, the more pronounced the schooling behaviour, and the less dependent the harvest is on biomass. For many commercial species (for example, many bottom-dwelling or demersal species and shellfish), it would be close to unity (Arnason, 1984). For pelagic species (such as tuna, herring and sardine), it is often much lower (Bjørndal, 1987).

The significance of the schooling parameter lies in the vulnerability of the resource to overexploitation. A high schooling parameter leads to the result that harvesting costs rise significantly as the resource is depleted. If the schooling parameter is, for example, equal to unity, harvesting costs will go to infinity as the resource biomass approaches zero (Bjørndal and Munro, 1998; Clark, Munro and Sumaila, 2010). In other words, there is a powerful economic brake guarding against severe resource exploitation. On the other hand, if the schooling parameter is very low, the aforementioned economic brake is non-functioning – harvesting costs do not soar as the resource is depleted. The fishery resource can readily be driven to the verge of extinction, as will be seen at a later point in this chapter (Clark, Munro and Sumaila, 2010).

In the harvesting function for the global fishery, the average schooling parameter should reflect the schooling behaviour of the different fisheries. An average of schooling parameters by fishery groups weighted by their MSY levels gives an aggregate schooling parameter of about 0.7.

2.3.2.8 Elasticity of demand with respect to biomass

In the global fisheries model employed in *The Sunken Billions* report, the average price of landings depends on the global marine commercial biomass according to a coefficient referred to as the elasticity of demand with respect to biomass. The model uses a value of 0.2 for this parameter, which means that, if the global biomass doubles, then the average price of landing increases by 20 percent. The coefficient and the value of the coefficient are based on following rationale.

Fishing activities initially target the most valuable fish stocks and the most profitable fisheries. These high-value species tend to be those high in the marine food chain. As the fishing effort increases, the most valuable stocks become depleted and the fishing activity targets less valuable fish stocks (in some cases in deeper waters on the continental slopes) or targets species at lower trophic levels.

This is known as "fishing down and through the food webs". With an ever-larger share of the catch being accounted for by lower-valued species, the average price of the aggregate catch is steadily reduced.

However, when the reverse takes place, under a governance regime that restores biomasses and the health of fish stocks, the average price will tend to rise. However, this generalization must be qualified in terms of the trophic level of the target species. If the target species is a high-value prey species (e.g. shrimp), then rebuilding the stock of predators (e.g. fish at a higher trophic level that eat shrimp) may in fact reduce average prices (Hannesson, 2002). Nevertheless, in general, as stocks rebuild there will tend to be more larger fish in the catch. Larger fish are generally more valuable, which results in a higher average price for the global catch.

Under an effective fisheries management system, the unit price of landed fish usually increases substantially (Homans and Wilen, 1997; Homans and Wilen, 2005). For example, in fisheries based on individual transferable quotas (ITQs) (one of many choices for improved fisheries management), the average price of landings increases substantially compared with the price before introduction of the ITQ scheme (Herrmann, 1996). The reasons include more selective fishing practices, better handling of caught fish and better coordination between demand for fish and the supply of landings. The increased price is not necessarily related to the more valuable composition of the catch referred to earlier. Finally, there is growing evidence that heavily fished resources are less stable (Anderson *et al.*, 2008), so that stock recovery is likely to stabilize supplies and prices and improve the efficiency of harvesting.

2.3.2.9 Management costs and subsidies

In its modelling, *The Sunken Billions* report does not consider the costs of resource management, which are very real costs from the point of view of society. Furthermore, subsidies are not separately identified in the cost estimates. The existence of subsidies has the effect of reducing the observed costs. In light of these major omissions, the estimated rent drain indicated in *The Sunken Billions* report must be seen as being decidedly conservative. The true rent drain loss quite possibly exceeds by a significant margin the estimate of US$50 million per annum.

In addition, the rent loss estimate does not take into account all economic benefits, actual and potential, from the fisheries. Downstream (through processing) economic benefits go unaccounted for, as do those associated with recreational fisheries, marine tourism and those arising from healthy coral reefs.

2.4 RENT LOSS ESTIMATES: THE RESULTS

As indicated above, the loss of net economic benefits, expressed as forgone rents, is estimated to be in the order of US$50 billion in the base year, 2004. Owing to model and input limitations, this estimate is to be seen as the most probable of possible values, with an 80 percent confidence level that the true level lies between US$37 billion and US$67 billion.

The rent loss estimate ranges between US$45 and US$59 billion in the base year depending on whether the underlying biomass growth function applied is the Schaefer logistic or the Fox function. Table 3 summarizes the main results of these calculations for the two biomass growth functions. The Fox biomass growth function estimates a higher current fisheries rent loss primarily because the current level of overexploitation is substantially greater when the Fox function applies. A priori, there is no reason to choose one biomass growth function above the other and the point estimate of US$50 billion assumes an equal probability of each function applying.

TABLE 3
Main results: point estimates of resource rents

		Current		Optimal		Difference	
	Units	Schaefer logistic	Fox	Schaefer logistic	Fox	Schaefer logistic	Fox
Biomass	Million tonnes	148.4	92.3	314.2	262.9	165.8	170.6
Harvest	Million tonnes	85.7	85.7	80.8	81.6	–4.9	–4.1
Effort	Index	1.0	1.0	0.56	0.46	–0.44	–0.54
Rents	US$ billion	–5.0	–5.0	39.502	54.035	44.502	59.035

Source: World Bank and FAO, 2009, Table 4.1.

Based on the loss of net benefits in 2004, the real cumulative global loss of wealth in the last three decades period is estimated at US$2.2 trillion. This estimate is made by assuming a linear relationship between the rents and the state of the world's fish stocks as reported by FAO at various intervals since 1974. The estimated rent loss in the base year (2004) is projected from 1974 to 2007, and raised on the basis of the changing percentage of global fish stocks, reported by FAO as fully exploited or overexploited. A conservative opportunity cost of capital of 3.5 percent is assumed. For further details, readers may refer to *The Sunken Billions* report.

An important "main result" is that, if sustainable resource rents from the fisheries are even to approach the maximum, a substantial programme of investment in natural fisheries capital and a concomitant reduction in fishing effort are required. The Schaefer logistic and Fox estimates differ only in terms of the magnitude of the investment required.

The implication of this result is that markedly excessive *disinvestment* in the natural fisheries capital occurred in the past, and could be still ongoing. Why this massive natural capital *disinvestment*, and accompanying rent drain, transpired is the question now to be explored.

3. Origins of the rent drain

3.1 THE INHERENT DIFFICULTIES OF CAPTURE FISHERIES MANAGEMENT

It has long been recognized that marine capture fisheries are very difficult to manage effectively. Generally, the fish cannot be seen prior to capture; the fish are, with few exceptions, mobile. Moreover, there are species interactions and the effects of environmental shocks that are unobservable. As a consequence, in the past, it was difficult, or more to the point costly, to establish effective property rights to the resources, be these property rights private or public. Capture fishery resources were seen as the quintessential "common pool" (open to all) resources.

3.2 THE INEXHAUSTIBILITY OF OCEAN CAPTURE FISHERY RESOURCES

Up until the twentieth century, the inherent and inescapable difficulties of capture fisheries management did not seem to matter a great deal. Capture fishery resources were viewed as "free capital", beyond overexploitation.

Arguably, one of the greatest biologists in nineteenth century Britain was Thomas Huxley. During the first half of the 1880s, he held the position of Inspector of Fisheries. While in that position, he stated:

> *"The cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all of the great sea fisheries, are inexhaustible: that is to say that nothing we do seriously affects the number of fish. And any attempt to regulate these fisheries seems consequently … to be useless."*
> *(cited in Gordon, 1954, p. 126)*

The belief that the great sea fishery resources were inexhaustible helped to enshrine the "common pool" nature of high-seas ocean fisheries in international law, in the form of the "freedom of the seas", first set forth in the early seventeenth century. The high seas were seen to consist of all ocean waters beyond the narrow coastal state territorial seas (historically extending out from shore to only three nautical miles).

Under the "freedom of the seas" doctrine, the resources of the high seas, including fishery resources, were deemed to be *res communis*. That is to say, they were to be seen as the property of all (Orrego Vicuña, 1999). The belief in the inexhaustibility of the ocean fishery resources had an economic basis. When the "freedom of the seas" doctrine was first propounded, the state of fisheries technology was such that heavy exploitation of high-seas fishery resources was prohibitively costly (not to say dangerous). This remained more or less true until after the mid-nineteenth century.

3.3 MINING THE "INEXHAUSTIBLE" CAPTURE FISHERY RESOURCES

The economic protection of high-seas fishery resources was, in fact, beginning to fray even as Huxley spoke in the early 1880s. Fishing technology was changing rapidly, bringing with it a fall in harvesting costs. The shift from sail to steam is a prime example.

The vanishing of this economic protection and transformation of "free" natural fisheries capital to scarce natural capital took time to be recognized fully. While there were a few attempts at serious resource conservation in the early twentieth century, such as in the North Pacific fur seal fishery (1911) and the Pacific halibut fishery (1923), the management of ocean fisheries remained minimal until after the close of the Second World War (National Research Council, 1999).

Once the economic protection of ocean fishery resources had been stripped away by fisheries technological progress, the perverse (from society's point of view) incentive consequences of the "common pool" nature of the resources manifested themselves. The primary consequence pertains to investment/disinvestment in this form of natural capital.

No rational would-be investor will undertake an investment unless the expected stream of net economic returns from the investment (discounted at the appropriate rate of interest) – the so-called present value (PV) of the net economic returns – is at least equal to the cost of the investment. In a "common pool" fishery, an individual fisher can count on no positive return on an investment in the resource. If some fishers refrain from harvesting in order to build up the resource, they may do nothing more than increase the harvests of their competitors.

It can be shown that fishers in such fisheries will act as if they are applying a rate of discount (interest) to future returns from the fishery equal to infinity. Tomorrow's returns from the fishery count essentially for nothing (Clark and Munro, 1975). This, in turn, means that the rational fisher is given every incentive to treat the resource as a non-renewable resource, namely as a resource to be mined.

It has already been noted that the most valuable species have been subject to the most intensive exploitation. This is consistent with the mining pattern. Easy-to-reach and most valuable species are exploited first. After they have been depleted, fleets move on to less valuable species. One of the more dramatic examples involves whaling. By the turn of the twentieth century, the most valuable of the whale species, the southern right whale, had been severely depleted. The whaling industry then turned to and depleted successively less valuable species, namely the humpback, blue, fin, sperm and sei species (Hilborn, Oresanz and Parma, 2005).

The sequential exploitation follows the classic pattern of the mining of minerals (or the exploitation of hydrocarbons). The most valuable ore bodies are exploited first. Less and less valuable ore bodies are then exploited until the point is reached at which mining ceases to be profitable and the mine is abandoned.

A particularly clear example is provided by a 2002 study sponsored by the United Nations Environment Programme (UNEP) on Argentinean fisheries.

Prior to the late 1980s, the Argentine fishing sector had been underdeveloped. Then, particularly after signing fisheries exploitation agreements with the European Union (EU), the fishing sector began expanding, with the focus being on hake stocks and to a lesser degree on blue whiting stocks (UNEP, 2002).

In the late 1980s and the 1990s, the fisheries sector became one of the most dynamic sectors of the Argentinean economy. What the UNEP refers to as the "happy years" was a period of ineffectively controlled growth in the fisheries, in which massive total allowable catch TAC "overages" were commonplace. By the end of the 1990s, there was clear evidence of severe overexploitation of both hake and blue whiting stocks (UNEP, 2002). The high economic fishery returns and rapid growth had been a "fool's paradise" type of prosperity based, to a marked degree, on the running down, the mining, of the natural fisheries capital.

The UNEP study estimates that the loss to future Argentinean generations of the resource overexploitation (expressed in PV terms and assuming no stock restoration) is equal to ten times the net economic benefits enjoyed during the "fool's paradise" prosperity of the late 1980s and 1990s. Indeed, assuming no stock recovery, the net PV of future returns from the resources (using a reasonable discount rate) is negative (UNEP, 2002).

Another example is provided by the Norwegian spring-spawning herring resource of the North Atlantic. Historically one of the largest fishery resources of that ocean region, the resource is characterized by a low schooling parameter, and is thus vulnerable to overexploitation.

Until the 1960s, segments of the resource in the middle of the North Atlantic were protected economically from gross overexploitation. However, by the 1960s, technological developments in fishing led to this economic protection being eliminated.

The International Commission for the Exploration of the Sea (ICES) estimates that the minimum level of the spawning stock biomass (SSB) of the resource, below which it should not be allowed to fall, is 2.5 million tonnes (Bjørndal, 2008). In the late 1960s, the evidence of gross overexploitation of the resource, of the clear breaching of this minimum, became overwhelming. A harvest moratorium was declared. The SSB continued to decline, reaching an estimated low of two *thousand* tonnes in 1972, i.e. 0.08 percent of the ICES declared SSB minimum. In other words, the resource had been mined almost to the point of extinction (Arnason, Magnusson and Agnarsson, 2000, pp. 293–319).

Partly through good fortune, the herring resource recovered, but only after a 20-year harvest moratorium. The Norwegian spring-spawning herring example will be drawn upon again in the discussion to follow, at a later point, on the way forward.

While the Argentinean fisheries and Norwegian spring-spawning herring provide particularly striking examples of capture fishery resource mining, the World Bank–FAO commissioned case studies provide numerous additional examples from both developed and developing fishing states. The commissioned case studies employed modelling techniques identical to those used in *The Sunken Billions* report.

A few such additional examples may suffice. The case study on the Japanese squid fishery reports that the fishery has been operating under close to open-access conditions. The rent from the fishery is negligible and the biomass is estimated to be no more than 10 percent of the economically optimal level (Hoshino and Matsuda, 2007, p. 25). In the Bangladeshi hilsa shad artisanal fishery, the biomass is estimated to be less than 50 percent of the economically optimal levels (Moma, 2007). The same holds true for the Lake Victoria Nile perch fishery resource, which is shared by Kenya, Uganda and the United Republic of Tanzania (Warui, 2008), and for the Bali Strait sardine fishery (Purwanto, 2008a). Similar results are to be found in the Bohai Sea and Yellow Sea fisheries off China (Yang and Nie, 2008) and the Gulf of Thailand (Boonchuwong and Dechboo, 2008). The catch per unit of effort in the Bohai Sea has declined to less than one-tenth of its value at the end of the 1950s and there has been a massive shift in catch composition to short-lived less valuable species. A similar development has been observed in the Yellow Sea even though the decline in the catch per unit of effort has been less drastic. Yang and Nie estimate the combined rent loss in the Bohai and Yellow Seas at US$1 billion per annum. The fishery resources in the Gulf of Thailand have been subjected to excessive levels of fishing effort for perhaps as long as two to three decades. Significant rent losses are associated with overfishing and greatly excessive fleet sizes for all three of the studied fisheries, namely for demersal resources, Indo-Pacific mackeral and anchovy (Boonchuwong and Dechboo, 2008).

The situation is no different in the Vietnamese fisheries of the Gulf of Tonkin (Long, 2008). During the last two decades (i.e. 1986–2006), with the rapid development of marine capture fisheries all over the country, the fisheries in the Gulf of Tonkin have shown strong growth. However, deployed aggregate horsepower, an indicator of fishing effort, increased nearly 12-fold while catches increased by less than 3 times. As a consequence of overfishing, marine resources have declined severely, especially in near shore waters. This decline and the increasing number of fishing boats have led to reduced incomes for fishers.

Reference was made above to the Icelandic cod and Namibian hake fisheries, in which successful resource management schemes have been introduced. However, even these successfully managed fisheries display the effects of past mining of the resources. It is estimated that the Icelandic cod resource is at least 40 percent below the economically optimal level (Arnason, 2008), while the hake resource, which Namibia shares with Angola and South Africa, is estimated to be 80 percent below the optimal level (Sumaila and Marsden, 2008).

An especially interesting case is the octopus fishery of Mauritania, which is the country's most valuable fishery and which is under active management. While resource rent estimation is difficult owing to the inherent variability of this very short-lived species, global production models suggest that rent is in the order of US$60 million per annum. The development of age-structured bioeconomic models that attempt to integrate resource variability suggests that maximum resource rents are higher and at least US$75 million dollars per annum. However, some part of this is currently being recovered so that lost resource rents are around US$40 million. Part of current fishing capacity consists of EU vessels fishing under an agreement between Mauritania and the EU. While this agreement provides a substantial financial return to Mauritania, this return is different to the resource rent available from good fisheries management. Under the present management system, the financial gain from the licensing agreement comes at the cost of excessive capacity and effort. Therefore, the main challenge is to design institutional arrangements that will allow genuine resource rents to be generated sustainably (Cunningham *et al.*, 2008).

3.4 RESOURCE MANAGEMENT MEASURES: PARTIALLY CONSERVATIONIST, BUT ECONOMICALLY DESTRUCTIVE

The growing recognition, after the end of the Second World War, of the fishery resource mining problem led to responses such as domestic and international controls on harvesting, and the placing of much of the ocean capture fishery resources under coastal state jurisdiction, through the implementation of the exclusive economic zone (EEZ) regime under the 1982 UN Convention on the Law of the Sea. That these measures have been less than entirely successful is evidenced by the continued mining of the resources.

The controls on harvesting, domestic and international, did nothing to change the fisher incentives to mine the resources, and did nothing to halt the harvesting-cost-reducing advances in fishing technology. As harvesting costs fell over time, fishery resources that had hitherto enjoyed economic protection became open to exploitation, thereby necessitating yet further harvest controls. Typically, the new controls have been implemented only after extensive resource overexploitation has occurred. With the perverse fisher incentives in place, there has, in effect, been a race between harvest control measures and advances in fishing technology.

There is more. Many fishery resources should be viewed as spatially linked substocks (Sanchirico and Wilen, 2005). If the substocks far from shore are commercially unexploitable, then these substocks constitute natural reserves, which prevent the stock complex from severe overexploitation. With technological advances and the ongoing fall in harvesting costs, what was hitherto commercially unexploitable becomes profitable to exploit. The natural reserves disappear and the stock complex becomes vulnerable, e.g. Norwegian spring-spawning herring.

Even where harvest control measures have been effective in halting the mining of the resources, the control measures, when applied in the past, often had destructive economic consequences. Introducing harvest controls through the implementation of TACs, or the equivalent hereof, and doing nothing else all but guarantees the emergence of excess fleet capacity and severe economic waste.

Under these conditions, the restricted season-by-season harvest becomes the “common pool”. As fishers compete for shares of the “common pool” harvest, excess fleet capacity inevitably emerges. An example is provided by the large pollock fishery off Alaska in the Bering Sea and Gulf of Alaska. Prior to the advent of the EEZ regime, United States exploitation of the fishery had been minimal. Exploitation of the fishery had been the domain of distant-water fleets. With the coming of the EEZ regime, the distant-water fleets were phased out of the Alaska pollock fishery, to be replaced by a new United States fleet.

The United States resource managers were very successful in protecting the resource from overexploitation, but they did nothing to control the fleet size. By the time measures were finally taken to control the fleet size in the early 1990s, it was estimated that the United States fleet capacity was two and a half times greater than that required to take the TAC (National Research Council, 1999).

Economic waste emerges in such fisheries, first through the very existence of redundant vessel capital. Economic waste also arises from the steadily declining season length. As fleet capacity grows, the shorter is the time required for the TAC to be taken. Reduced season length can easily lead to inferior products, inefficient fishing methods, and to processing plants facing cost-magnifying cycles of throughput gluts followed by throughput famines.

The usual response to the competition for shares of the "common pool" harvest – the "race for the fish" – as exemplified by the United States pollock fishery, is to introduce measures to restrict the number of vessels allowed to engage in the fishery. These schemes, commonly referred to as limited entry, or licence limitation, schemes are often accompanied by decommissioning schemes designed to remove excess fleet capacity built up before the introduction of licence limitation.

Traditionally, under such licence limitation schemes, the owners of the licensed fishing vessels are allowed to compete for shares of the TAC, or the equivalent. It seemed clear that, if the fleet were reduced to a size commensurate with the expected TAC, nothing more would be required.

The experience in many such fisheries has been that effective fleet capacity is, in fact, difficult to control. With the fishers competing for harvest shares, capacity continues to grow, even if the number of vessels remains constant. Fishing capacity has many components. Controlling all of them is beyond the capabilities of most resource managers.

An example is provided by the Canadian Pacific halibut fishery. Canada shares the Pacific halibut resource with the United States of America, in Alaska. At a very early stage (1923), Canada and the United States of America established a cooperative resource management arrangement – the International Pacific Halibut Commission (IPHC), which produced exemplary results in terms of resource conservation.

In 1979, after Canada had implemented its EEZs, the Canadian authorities introduced a limited entry scheme for its share of the Pacific halibut fishery. The licensed vessels competed for shares of the halibut TAC.

In the following decade, the number of vessels remained effectively controlled. However, the actual resource harvesting capacity was not controlled. The harvesting season steadily decreased, clearly indicating growing capacity. The

Pacific halibut harvest season has a maximum length of about 240 days per year. By the end of the 1980s, the season length had been reduced to six days per year.

There was no evidence of resource depletion. Indeed, the TAC was actually increased over the decade because of increased resource abundance. However, with respect to economic rent, such evidence as exists suggests strongly that, once resource management costs are factored in, the resource rent being generated by the fishery was distinctly negative (Munro *et al*., 2009).

3.5 SUBSIDIES

Both the problem of the mining of the capture fishery resources and the problem of economic waste associated with fleet overcapacity, even when the resources are maintained, have been severely aggravated by the widespread use of government subsidies. While not all subsidies are harmful, it has been estimated that about 50 percent are damaging, both biologically and economically (Munro and Sumaila, 2002). *The Sunken Billions* report presents an estimate of annual subsidies that have a direct impact on fishing capacity.

TABLE 4
Estimate of fisheries subsidies with direct impact on fishing capacity per year, 2000

Subsidy types	Developing countries	Developed countries	Global total	% of global total
		(US$ billion)		*(%)*
Fuel	1.30	5.08	6.38	63.5
Surplus fish purchases	0.00	0.03	0.03	0.3
Vessel construction, renewal and modernization	0.60	1.30	1.90	18.9
Tax exemption programmes	0.40	0.34	0.74	7.3
Fishing access agreements	0.00	1.00	1.00	9.9
Global total	2.30	7.75	10.05	100.0

Source: World Bank and FAO, 2009, Table 2.2.

More than US$10 billion in subsidies that directly influence fishing capacity and foster rent dissipation were provided in 2000 (Table 4). Almost 80 percent of the total global subsidy is provided by developed countries. Transfers of public funds and support to the fisheries sector are directed at a spectrum of goods ranging from the purely public to the purely private. The issue of subsidies is closely linked to the policies and principles underlying fiscal regimes for fisheries, which must untangle the web of weak property rights prevalent in most fisheries.

3.6 SHARED FISH STOCKS

Lastly, there is a major source of difficulty in the management of capture fishery resources management that has come to be recognized fully only following the advent of the EEZ regime. The establishment of the EEZ regime was seen as placing large amounts of hitherto international "common pool" capture fishery resources under coastal state jurisdiction. However, most capture fishery resources are mobile, with the consequence that the typical coastal state finds that it is sharing some of its EEZ fishery resources with neighbouring coastal states (transboundary stocks) or with distant-water fishing states (DWFSs) in the high seas adjacent to the EEZ (highly migratory and straddling stocks). It can be demonstrated that, if states sharing such resources do not cooperate effectively in the management of the resources, the outcome will be comparable to a classic open-access fishery, i.e. resource overexploitation (Munro, Van Houtte and Willmann, 2004; Lodge *et al*., 2007).

Indeed, the lack of effective cooperative management of highly migratory and straddling stocks, and the resultant resource overexploitation following the close of the UN Third Conference on the Law of the Sea in 1982, led to the UN convening another international conference to address the management of these resources, the 1993–95 UN Fish Stocks Conference. The 1995 UN Fish Stocks Agreement arising therefrom has led to the now ongoing implementation of the regional fisheries management organization (RFMO) regime.

What the 1995 UN Fish Stocks Agreement does not address are the remaining discrete high-seas stocks. Hitherto, most of these stocks had not offered commercially viable fishing opportunities – in other words, they had enjoyed economic protection. The history of world ocean capture fisheries provides all but absolute assurance that the protection will prove to be temporary.

The significance of these shared fish stocks – transboundary, highly migratory, straddling and discrete high seas – is not trivial. It is estimated that harvests of these stocks may account for as much as one-third of the global ocean capture fishery harvests (Munro, Van Houtte and Willmann, 2004). Thus, in looking forward to the optimal economic management of world capture fishery resources, the shared fish-stock management problem becomes impossible to ignore.

4. The way forward

It is not the intention in this chapter to set forth detailed, concrete plans for achieving the maximization of capture fisheries resource rent. The aim is to set forth some general principles and what amounts to a research agenda. Developing a set of detailed plans for resource rent maximization requires a second, and companion, project (perhaps with a title like "Rent Lost and Rent Regained").

4.1 ORIGINS OF THE RENT DRAIN RECALLED, AND LEVELS OF FISHERIES IN NEED OF ECONOMIC REFORM

It will be recalled that the root cause of the rent drain in capture fisheries lies in the perverse (from society's point of view) incentive structure confronting fishers in "common pool" types of fisheries. The fishers are given every incentive to regard the fishery resources as non-renewable resources to be mined. If measures are taken to restrict harvesting (in order to conserve the fishery resources) but nothing effective is done to limit fleet access to the fishery, the restricted harvest, TAC or the equivalent, becomes the "common pool", with the inevitable emergence of excess fleet and human capital, leading to resource rent dissipation. Unless the fishers are effectively blocked in responding to the perverse incentives, or the incentives themselves are altered, reversing the rent drain becomes an all but hopeless task.

Realizing the goal of maximizing resource rent requires: (i) that the perverse incentive problem be resolved; and (ii) that a major rebuilding of the resources be undertaken. It will be recalled that resource rent maximization requires that world capture fishery resources be at least doubled in size.

On this basis, one can think of fisheries requiring reform being at three levels. Level 1 consists of fisheries in which the resource managers have, by some means, succeeded in maintaining the stocks at, or building the stocks up to, the optimal level, but in which, through continued existence of perverse fisher incentives, the resource rent has been allowed to drain away. Resource investment is not required, but the correction of fisher incentives is. For these fisheries, the reversal of the rent drain, while not without its difficulties, is a simpler undertaking than is the case in Level 2 and Level 3 fisheries.

Level 2 consists of fisheries that are essentially the reverse of Level 1 fisheries. The perverse fisher incentive problem has been effectively addressed. Resource rent is being generated, but not maximized, because the resource is well below the optimal level owing to past overexploitation. Rebuilding the resource to the optimal level is an exercise in investment in natural capital in the form of fishery resources. Any investment in real capital, be the capital produced or natural, is a costly, and possibly lengthy and uncertain, undertaking. The fact that the incentive problem has been dealt with gives hope that the required resource investment programme can be undertaken, with some reasonable hope of success.

Level 3 consists of fisheries in which the perverse fisher incentives are unaddressed, in which the resource is well below the optimal level, and in which any resource investment that is occurring is negative. The first objective of management in such fisheries must be to ensure that the rate of resource investment is no lower than zero.

4.2 LEVEL 1 FISHERIES

Level 1 fisheries are fisheries where goals are easiest to achieve as far rent generation is concerned.

Level 1 fisheries may well be uncommon, but specific examples can be identified. Two such examples are provided by the recent study commissioned by Fisheries and Oceans Canada, referred to at an earlier point (Munro *et al.*, 2009). The two fisheries in question are the Canadian Pacific halibut fishery and the British Columbia sablefish fishery. Both have unusual histories.

4.2.1 The Canadian Pacific halibut and British Columbia sablefish fisheries

The Pacific halibut fishery of Canada and the United States of America began slowly in the 1880s, as the Atlantic halibut fleet began relocating to Pacific waters, after the severe depletion of the Atlantic halibut stocks (a counter example to Huxley's assertion on the inexhaustibility of ocean fish stocks [above]). The Pacific halibut fishery grew, particularly as the expanding North American transcontinental railways, with refrigerated rail cars, and the completion of the Panama Canal opened up eastern North American markets for the fish.

During the First World War, the Pacific halibut fishing industry coalesced and began exerting pressure on the governments of Canada and the United States of America to come together to exert international control over the fishery. With the experience of the Atlantic halibut fishery in mind, the industry's efforts resulted in the establishment of the IPHC in 1923 (IPHC, 2009). Pacific halibut stands as one of those rare instances in which the fishing industry demands the implementation of government fisheries regulation before serious damage has been done to the stocks.

The British Columbia sablefish fishery was a very minor fishery until the implementation of the Canadian EEZs after the mid-1970s. When the fishery showed signs of significant development, after the mid-1970s, the Government of Canada, fully aware of the consequences of non-action on its part, introduced harvest controls (Munro *et al.*, 2009).

The harvest controls were, and are, effective, for both Pacific halibut and British Columbia sablefish. The stocks were saved from significant depletion, with the result that both fisheries were candidates for inclusion in the Level 1 category.

Pacific halibut is a good example of a shared (transboundary) stock. The fact that there was, and is, a strong cooperative management regime in place meant that the first requirement for effective economic management of the resource had been met. It is now widely recognized that non-cooperative management of a shared fish stock can easily lead to results comparable with a wholly unregulated open-access fishery (Munro, Van Houtte and Willmann, 2004).

The Government of Canada was also aware of the consequences of harvest controls unaccompanied by controls over fleet size. Indeed, it had pioneered the introduction of limited entry schemes, commencing with the British Columbia salmon fishery. The implementation of the Canadian EEZs gave the Government of Canada the opportunity to introduce limited entry schemes in both its sablefish fishery and in Canada's segment of the Pacific halibut fishery. It had seized these opportunities by the early 1980s. As indicated above, both limited entry schemes were accompanied by what can be described an Olympics style TAC, i.e. the vessels granted access to the fishery were to compete for shares of the TAC. This was standard practice for limited entry schemes in general at that time.

Several years ago, FAO introduced the concepts of incentive-blocking and incentive-adjusting approaches to fisheries management (Gréboval *et al.*, 1999). The former approaches concern measures designed to prevent fishers from responding to the perverse incentives described earlier. Incentive-adjusting approaches are concerned with measures designed to transform perverse fisher incentives into benign ones. Both the imposition of TACs and the limited entry schemes described above could be seen as incentive-blocking approaches. In the case of the two fisheries under consideration, the incentive-blocking approach in the form of TACs was successful in conserving the resources.

In attempting to analyse the history of the two British Columbia fisheries, the study carried out for Fisheries and Oceans Canada (Munro *et al.*, 2009) employs two closely related modes of analysis that will be useful in examining Level 2 and Level 3 category fisheries, as well as Level 1 fisheries. The authors of the study note one inescapable fact of life in the two fisheries, namely the strategic interaction between and among the fishers, and between the fishers as a group and the resource managers, which in the case of Canada are to be found wholly within Fisheries and Oceans Canada. The obvious mode of analysis then is the theory of strategic interaction, more popularly known as the theory of games, which has been used extensively in the study of international fisheries (Munro, Van Houtte and Willmann, 2004).

There are two broad categories of games: non-cooperative, or competitive, games; and cooperative games. In cooperative games, the "players" are assumed to be coldly rational, with each "player" being prepared to cooperate only if it believes that it will be better off by cooperating than it would be by playing competitively. The stability of such cooperative games is always at risk of being undermined by "player" non-compliance (cheating) and by free riding, which can be defined as the enjoyment of the fruits of cooperation by non-participants in the game (i.e. poaching). The concepts of non-cooperative and cooperative games will be seen to be of relevance to the strategic interaction among the fishers. The pre-1923 Pacific halibut industry could be seen as a fisher cooperative game in operation.

Within the theory of games, there is subclass of non-cooperative games known as leader–follower games, a version of which is referred to as principal–agent analysis (PA analysis), used widely used by economists in many fields. This PA analysis is of direct relevance to the interaction between the fishers in the two British Columbia fisheries and Fisheries and Oceans Canada.

The principal, be it a person, a firm, a country or a state/province, wishes to see undertaken certain tasks that it is unable to do itself. Therefore, it acquires the services of one or more agents to undertake these tasks. Classic examples are an owner of a firm hiring a manager, and a landowner leasing farmland to a tenant farmer. The PA analysis has application far beyond these simple examples, e.g. industry regulators and the firms being regulated (Sappington, 1991).

In any event, in the context of Canadian fisheries, Fisheries and Oceans Canada could be seen as constituting the principal, while the fishers constituted the agents. The PA paradigm can be formally described as follows (see Clarke and Munro, 1987, pp. 83–86).

A strict hierarchical relationship exists in which the principal (leader) chooses an incentive scheme (e.g. set of regulations) to be applied to the agents (followers). The principal's incentive scheme, along with the actions taken by the agents, determines both the returns to the agents and to the principal. As seen from the perspective of the principal, a first-best situation exists where the principal can, at minimal cost, contractually and enforceably specify the actions of the agents. Wishes, urges and desires of the agents contrary to the best interests of the principal are entirely suppressed. The agents are essentially robots.

In the normal second-best situation, the principal lacks the power or, more to the point, finds it too costly to force a set of actions upon the agents. Thus, the agents have some freedom of choice. The principal can hope to influence the agents' choices only indirectly through the incentive scheme. This gives rise to the concept of an *incentive gap*, which is the difference between the actual return to the principal and what it would receive under a first-best situation. It reflects the insufficiency of the principal's incentive scheme in compensating for its inability to monitor perfectly the agents' actions. At the heart of the PA problem is monitoring imperfection (Clarke and Munro, 1987).

One can now consider two closely related modes of analysis in the case of the two British Columbia fisheries. The comfortable view of many economists at the beginning of the 1980s was that, while there would be competition among the licensed fishers in a limited entry fishery, the competition (interaction) would be minor and easily controlled. If the vessels plus crew had been identical, if input substitution in the fishing fleet had been impossible, and if the technology had been frozen in the two Canadian fisheries, then indeed the competition (interaction) would have been minor and easily controlled. However, none of these conditions held. For example, technology was anything but frozen in the two fisheries.

The result was that circumvention of the intent of the limited entry scheme was feasible, which meant, in turn, that competition among the licence holders was definitely possible. Even if all fishers had been aware that such competition was mutually harmful in terms of their economic returns from the fishery, each and every fisher would, in the absence of scope for meaningful cooperation, have had no option but to compete. Any fishers who held back from competing were all but guaranteeing the loss of a part, if not all, of their share of the TAC.

One of the most famous of all non-cooperative games is known as the "prisoner's dilemma", which derives its name from a story told by the author to illustrate his point (Tucker, 1950). The author's point is that, in a non-cooperative game, the "players" will be driven to adopt strategies that they know are harmful. In the situation described in the two fisheries, the fishers were engaged in what might be described as a non-cooperative subgames, which provided, in turn, almost textbook examples of the prisoner's dilemma.

In both fisheries, season lengths declined to small fraction of their potentials, indicating severe excess capacity. While no precise estimates were possible, one could conjecture that the resource rents were negative from a national perspective. The authors of the study (Munro *et al*., 2009) state that, in PA analysis terms, the non-cooperative subgames among the fishers had led to a yawning and unsustainable incentive gap. Out of desperation, Fisheries and Oceans Canada, with industry support, shifted to an incentive-adjusting approach in the form of individual quotas (IQs), later to become individual transferable quotas (ITQs).

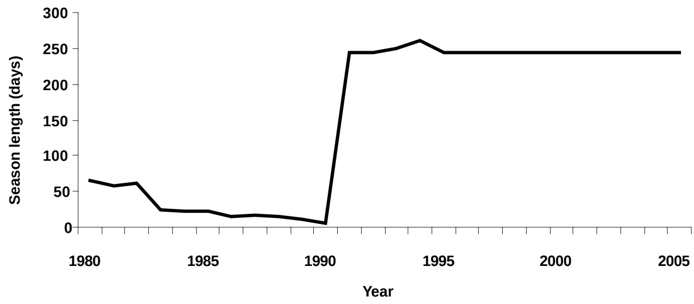
The authors of the study then ask if there was any evidence that the ITQs eliminated strategic interaction among the halibut fishers or among the sablefish fishers. The answer is that there was no such evidence. They conclude that, if the IQ schemes do no more than re-establish non-cooperative games among the two sets of fishers, perhaps under a different guise, then little or nothing is to be gained. They argue that success will only be achieved (the incentive gap reduced to tolerable proportions) if the IQ scheme leads to the fisher subgame being transformed from a competitive to a cooperative one.

In order for there to be a cooperative game, there must first be in place a workable mechanism for the sharing of the economic benefits among the "players". Initially, IQ schemes were seen to provide such a mechanism. However, the existence of the sharing mechanism is not in itself sufficient.

If a cooperative game is to have a stable solution, a fundamental condition that must be satisfied is that each and every player must be convinced that it will receive a return – a payoff – at least as great as it would under competition (see FAO, 2002). If non-compliance (cheating) is left unchecked or if free riding (poaching) is rampant, this condition, known as the individual rationality constraint, will not be met even if the allocated shares appear to be "fair".

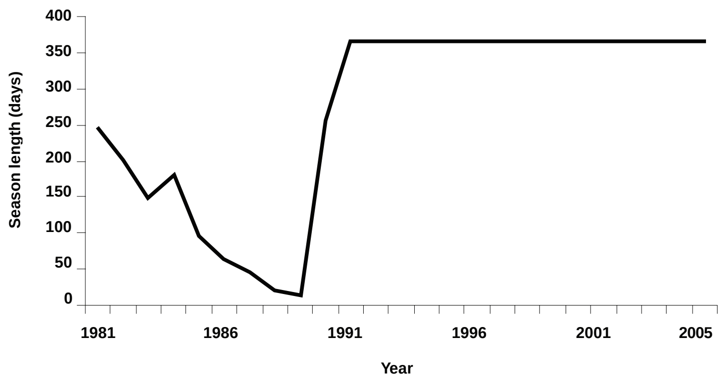
While not absolutely conclusive, the evidence that exists suggests that effective cooperative fisher games have replaced the destructive non-cooperative games in these two fisheries. Figures 5 and 6 indicate the season lengths in the two fisheries before and after the introduction of ITQs.

FIGURE 5
Pacific halibut season length, 1980–2005



Source: Munro *et al.*, 2009, Figure 1.

FIGURE 6
Sablefish season length, 1981–2005

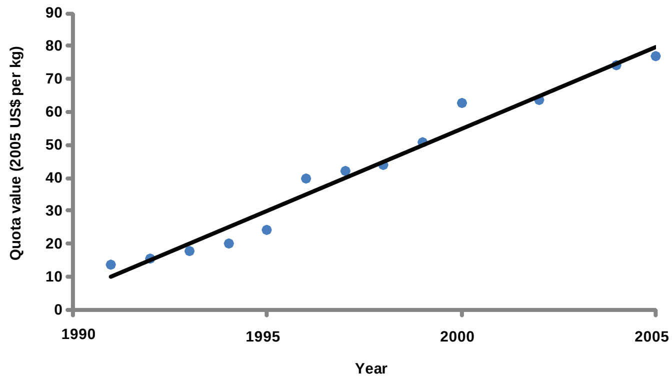


Source: Munro *et al.*, 2009, Figure 4.

Excess capacity, if not eliminated in physical terms, was "defanged". In the case of both fisheries, season length rose rapidly to the maximum after the introduction of ITQs.

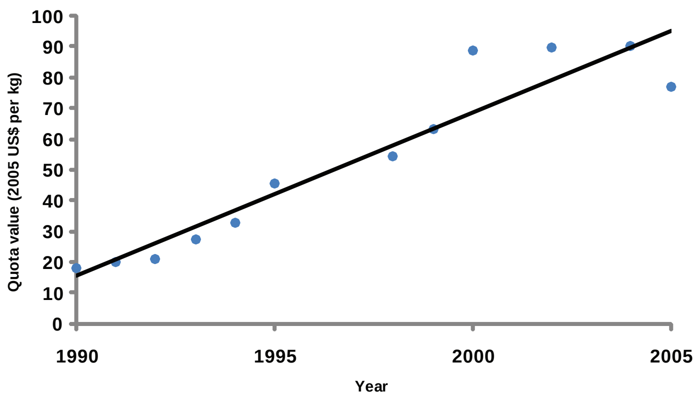
Adequate fleet cost data were not available to the authors of the study. The harvest quotas were and are actively traded. Quota price data are available (Figures 7 and 8). As the quotas are de facto long term (Munro *et al.*, 2009), the quota prices could be seen as reflecting the market participants' estimates of future private sector net returns from the fisheries.

FIGURE 7
Pacific halibut: quota values and trend line



Source: Munro *et al.*, 2009, Figure 3.

FIGURE 8
Sablefish: quota values and trend line



Source: Munro *et al.*, 2009, Figure 6.

The authors note that the ITQ schemes involve higher management costs, and they accompany the figures with tables showing substantially increased licence fees received by the government. Overall, the evidence suggests significant positive rent flowing from the fisheries.

What one can conclude from this Level 1 fishery experience is:

- The incentive-blocking approach to resource management, as it pertained to fleet and human capacity, was completely ineffective. The inability to control capacity led to a rent destroying non-cooperative game among the fishers.
- The introduction of catch shares in the form of ITQs did, in these instances, lead to a resource-rent-creating cooperative game among the fishers. That said, one must guard against concluding from this experience that ITQs offer

the only route to achieving cooperative games among fishers. There will be many cases in which ITQs are inappropriate. However, alternatives exist. In their detailed paper on small-scale fisheries in developing fishing states, Kurien and Willmann (2009) argue that ITQs are indeed inappropriate for many, if not most, of these fisheries. The desired results – turning fisher competition into cooperation –can, they argue, be achieved through the establishment of community-based fisheries management schemes. Public authorities would continue to play an important management role, so that the schemes might best be described as co-management schemes – the principal–agent paradigm again.

- In order to effect the transformation of fisher competition into cooperation, substantial management capacity is demanded of the resource managers. To take one example, if the resource managers in the Canadian case described had proved to be incapable of establishing an effective monitoring scheme, the ITQ schemes would have degenerated into non-cooperative fisher games, with all that that implies. Kurien and Willmann (2009) stress the critical importance of capacity building.

A question not hitherto considered is: Could the same results produced by catch-rights-based management be achieved through the traditional incentive-adjusting technique of taxes (positive and negative)? No answer is immediately available. It is noted that, for reasons good or ill, taxes have been little used in fisheries management.

The Canadian Level 1 experience leads to a further implicit conclusion. Suppose that resource rebuilding is called for, and that a successful resource investment programme is implemented. If the resource investment programme is not accompanied by a management scheme designed to prevent the emergence of excess capacity, the return on the resource investment – expressed as an increase in sustainable resource rent – will equal zero. Thus, it is all but pointless, from an economic perspective, to undertake a resource investment programme until the incentive problem has been resolved.

4.3 LEVEL 2 FISHERIES

The Icelandic cod fishery can be seen as the archetypal Level 2 fishery. The fishery is the most valuable of the Icelandic demersal fisheries, with a potential annual landed value of US$1 billion. An ITQ scheme was introduced into the fishery in 1984, and then strengthened in 1991 (Arnason, 2008). The perverse fisher incentive problem appears to have been dealt with successfully. The fishery is currently generating significant rents, estimated to be in the order of US$240 million per annum as of 2005 (Arnason, 2008, p. 6).

However, that said, the fishery had been heavily overexploited prior to the introduction of ITQs. The introduction of ITQs, combined with reductions in the TAC, has succeeded in bringing the overexploitation of the resource to a halt, but it has not succeeded in rebuilding the resource. It is estimated that the biomass is less than 60 percent of the optimal stock size. It is estimated further that the rent forthcoming from the fishery is no more than 36 percent of the maximum (Arnason, 2008, p. 6). Thus, if one accepts the estimates, one is forced to the conclusion that the potential return on investment in the resource is substantial. The problem is how to put into effect an effective resource investment programme.

The first question that has to be raised, and one which has to answered more by biologists than by economists, is to what extent the promises of investment returns are realities, and to what extent the promises are chimeras. *The Sunken Billions* report operates on the assumption that "existing biological overfishing is entirely reversible in the long run" (World Bank and FAO, 2009, p. 31). The assumption is of questionable validity for a significant number of fishery resources. There is evidence of depleted fishery resources that either cannot recover to their former levels of abundance or can be expected to do so only after many decades (Hutchings, 2000; Clark, Munro and Sumaila, 2010). What is required is an investigation to determine what one might term the set of feasible fishery resource investment opportunities. Thus, for example, does Icelandic cod represent a real investment opportunity – the non-recovery of the resource being due to the fact that the TAC has not been reduced sufficiently – or is the resource, to all intents and purposes, non-recoverable beyond its present level?

Consider now the feasible set of fishery resource investment opportunities, and the second and third questions that need to be addressed. The questions prove to be closely related. The second question pertains to the optimal resource investment programme, which, in turn, is concerned, in the first instance, with the optimal rate of positive resource investment. The most rapid rate of positive resource investment is achieved by declaring an outright harvest moratorium until the optimal biomass level is achieved. As a general rule of thumb, once the target stock of capital (of any form) is identified, one should move towards the target with all possible speed *unless there are penalties associated with rapid rates of investment*. The third question pertains to the incentive structure that must be in place for the relevant fishers in order for the resource investment programme to have any reasonable chance of success.

Concerning the second question, the optimal rate of positive resource investment, an example is provided by the case study on the Lake Victoria Nile perch fishery (Warui, 2008). The biomass of the resource is estimated to be between 37 and 50 percent of the optimal biomass, depending on whether the logistic or the Fox biological model is used. The study examines the possible resource investment programmes, and compares the one that would maximize the PV of rent from the resource through time with what the author terms a "reasonable" investment programme (Warui, 2008, pp. 46–49). The PV-maximizing programme involves declaring a harvest moratorium for about three years until the optimal biomass level, or close to the optimal biomass level, is achieved. In other words, the PV-maximizing resource investment programme consists of investing in the resource at the maximum rate of speed. The "reasonable" resource investment programme calls for some harvesting during the resource investment phase, and in so doing calls, in turn, for a slower rate of investment in the resource.

One could ask whether investing in the resource at the most rapid rate would not cause severe disruption to the fishing industry, and to the communities dependent upon the industry for employment. The answer depends critically upon what economists term the "malleability" of the produced capital in the fishing fleet and the human capital involved in the fishery. The "malleability" of such capital concerns the ease with which such capital can be shifted into and out of the fishery, with perfectly "malleable" fleet and human capital being capital that can be easily and costlessly shifted in and out of the fishery. The concept of "malleable" capital is analogous to the concept of "liquid" capital in finance. If the produced and human capital in the fishery is perfectly "malleable" (and if the price of harvested fish and the unit cost of fishing effort are independent of the harvest rate), then the most rapid rate of investment in the resource is economically optimal and should impose no social cost.

Consider once again the case of Norwegian spring-spawning herring. It will be recalled that the resource suffered a devastating decline in the late 1960s and early 1970s. The remnants of the resource were confined to Norwegian waters. The Norwegian resources managers declared an outright harvest moratorium that, more or less, remained in effect for 20 years. It proved easy for the Norwegian authorities to shift the vessels engaged in the herring fishery to other fisheries. In terms of the herring fishery in question, the fleet capital and human capital were both very malleable. Hence, one can argue that the Norwegian resource investment programme was optimal in economic terms (Gréboval and Munro, 1999).

One can reasonably assert that fisheries in which the relevant produced and human capital are perfectly malleable are the exceptions rather than the rule. In those many fisheries in which the produced and human capital in the fishery are not perfectly malleable, where there are significant costs and difficulties in shifting the capital out of the fishery, the most rapid rate of investment in the resource will have negative social consequences, perhaps severe ones. However, it is also the fact that, when the produced/human capital in the fishery is non-malleable, investing in the resource at the most rapid rate is decidedly suboptimal in strict economic terms. That is to say, such a resource investment programme will *not* maximize the PV of the rent from the fishery through time. As was demonstrated several decades ago, a resource investment programme closer to what Warui (2008) terms a "reasonable" investment programme is optimal in economic terms (Clark, Clarke and Munro, 1979).

There is an exception to this rule. If the resource has been severely depleted, a temporary harvest moratorium may be optimal. Having said this, with non-malleable fleet and human capital, the moratorium should not remain in place until the optimal biomass level has been achieved (for details, see Clark, Clarke and Munro, 1979).

From all of this, an obvious conclusion follows. The optimal resource investment programme must be expected to vary from Level 2/Level 3 fishery to fishery.

Concerning the third question, it is useful to return to the PA framework of analysis. The resource managers must design an incentive scheme that will give the fishers an incentive to invest in the resource. The first question is whether the fishers are to be called upon to bear all or part of the cost of the resource investment. If the fleet/human capital is perfectly malleable, then the problem does not arise. In the many cases in which the fleet/human capital is less than perfectly malleable, one could, in the first instance, think of a scheme in which the state bore the cost of investment by compensating the fishers for temporary reduced harvest opportunities (see Grafton, Kompass and Hilborn, 2007; Kurien and Willmann, 2009). That such schemes could be accompanied by the threat of possibly severe moral hazard problems is obvious.

If the fishers are to bear a part or all of the cost of the resource investment, then the incentive-adjusting schemes discussed in the context of Level 1 fisheries carry a much greater burden. Eliminating the "race for the fish" is not enough. The design must be such that the fishers are assured a significant share of the investment payoff, with the proviso that the payoff be contingent upon the success of the resource investment. Thus, it would seem to be obvious that, if harvest rights are employed, they should be long in term, in fact if not in strict law, and the harvest shares should be expressed as a percentage of the TAC.

It is also obvious that the fishers should have a considerable degree of certainty about future resource management policy. If, for example, the resource managers' policy is perceived by fishers as being capricious, then the fishers will, if rational, heavily discount all future returns from the resource investment.

Beyond this, one can say little about the optimal incentive scheme other than that it will require a great deal of planning and thought and that it is certain to vary from fishery to fishery.

4.4 LEVEL 3 FISHERIES

Level 3 fisheries, in which the fisher incentives have not been corrected and in which negative resource investment is still occurring, constitute the ultimate challenge in terms of rent restoration. The case studies indicate that, while difficult, progress can nonetheless be achieved in developing, as well as developed, fishing states. One of the more dramatic cases of success is that of the Indonesian Arafura shrimp fishery (Purwanto, 2008b).

Up until early in this decade, the fishery was plagued with rampant non-compliance and poaching by Indonesians and foreigners, with consequent overexploitation of the resource and dissipation of the resource rent. It is estimated that, in 2000, the biomass was no more than 50 percent of the optimal level. The resource rent was positive, but was equal to less than 6 percent of the optimal level (Purwanto, 2008b, Table 4.1). Under the new fisheries legalisation promulgated in 2004, surveillance and enforcement were greatly strengthened, the right incentives were created by devolving management authority upon the provincial government, which, in turn, gained the active support and cooperation of the relevant fishing communities.

By 2005, the biomass had increased to almost 75 percent of the optimal level. The resource rent was estimated to be more than 90 percent of the optimal level (Purwanto, 2008b, Table 4.1). As the shrimp resource is a fast-growing one, quick payoffs to resource investment are to be expected. Nonetheless, the results are remarkable.

In this section, particular emphasis will be given to a class of Level 3 fisheries where the problems of putting the fisheries on the path to recovery are displayed with particular clarity. The fisheries are of a type heretofore mentioned only in passing, namely internationally shared fishery resources. The discussion of fisheries under the heading of the "way forward" has to this point focused on fishery resources that are either not shared to any extent, or, if they are shared, it is found that the sharing leads to no significant resource management problems (e.g. Pacific halibut).

It will be recalled that internationally shared fishery resources are not insignificant with regard to the resource rent re-capture issue as they provide the basis of up to one-third of the harvests of marine capture fisheries (Munro, Van Houtte and Willmann, 2004). The economics of the management of such resources is now reasonably well understood, drawing by necessity upon the theory of strategic interaction (theory of games) – owing to the fact that strategic interaction between and among the states exploiting the resources lies at the heart of the problem.

The economics of non-cooperative management of shared fishery resources, based upon the theory of competitive games, is straightforward. Non-cooperative management carries with it the high risk of overexploitation of the resources. This is a manifestation of the "prisoner's dilemma" discussed above.

The complex part of the economics of the management of internationally shared fishery resources is focused on the means of ensuring stable cooperative management of these resources through time. The economics draws upon the theory of cooperative games. A cooperative game subject to instability that remains uncorrected soon degenerates into a competitive game, with all that that implies.

The theory informs us that the ease of achieving stability through time depends in the first instance upon the number of "players", i.e. the number of states involved in the exploitation of the resource. Where the number of "players" is only two, achieving stability is relatively easy. Thus, it is no surprise that the cooperative management of Pacific halibut and that of groundfish resources in the Barents Sea have proved to be stable over time. Only two states, Canada and the United States of America, are involved in the cooperative management of Pacific halibut; only two states are dominant in the cooperative management of Barents Sea groundfish resources, Norway and the Russian Federation. Once the number of "players" exceeds two, difficulties arise, with the difficulties increasing almost exponentially as the number of "players" increases.

The greatest difficulties are encountered in the management of internationally shared fishery resources found all or in part in the high seas, i.e. outside of the coastal state EEZs, namely highly migratory and straddling stocks that are to be found in the EEZs and the adjacent high seas, and discrete high-seas stocks. Under the terms of the 1995 UN Fish Stocks Agreement, highly migratory and straddling stocks are to be managed through RFMOs that are to have both coastal states and relevant DWFSs as members (Lodge *et al.*, 2007; UN, 1995). The Northwest Atlantic Fisheries Organization, the Northeast Atlantic Fisheries Commission, and the Western and Central Pacific Fisheries Commission are all examples.

Achieving the stability through time of the cooperative fishery games that are the RFMOs is aggravated by the fact that the number of "players" is typically large, and by the fact that the high-seas portions of areas under RFMO jurisdiction are, in many instances, plagued with "unregulated" fishing, i.e. free riding by non-RFMO members. An additional source of instability arises from the fact that RFMOs are required by the 1995 UN Fish Stocks Agreement (UN, 1995) to accommodate new members, which are typically DWFSs that could not, or did not see fit to, become "charter" members of the RFMO. The so-called "new member" problem is one of the most difficult confronting the emerging RFMO regime (Lodge *et al.*, 2007).

The case studies present an example of an RFMO that is working reasonably well, Norwegian spring-spawning herring (Bjørndal, 2008), and one that provides an example of a Level 3 fishery, namely the RFMO governing the Northeast Atlantic and Mediterranean bluefin tuna fisheries (Bjørndal, 2009). The RFMO for these bluefin tuna fisheries takes the form of the International Commission for the Conservation of Atlantic Tunas (ICCAT).

When in a healthy state, the Northeast Atlantic/Mediterranean bluefin tuna fishery ranges from the Canary Islands to Norway, through the Mediterranean to the Black Sea. The harvested fish are some of the most valuable in the world, with an individual fish being able to command a price of up to US$100 000 (Bjørndal, 2009).

At present, some 25–30 states are involved in the fishery. At the peak of the fishery, up to 50 states were involved. The fact that the number of active states involved in the fishery has been substantially reduced is due, argues Bjørndal (2009), to the fact that the resource has been severely depleted. Bjørndal maintains that the resource-rent-maximizing SSB is in the order of 800 000 tonnes. The current SSB is estimated to be in the order of 100 000 tonnes. This is the lowest SSB for the resource in recorded history. Indeed, the resource faces a significant risk of outright collapse (Bjørndal, 2009; MacKenzie, Mosegaard and Rosenberg, 2009).

The current resource rent is actually positive, being estimated by Bjørndal at about US$35 million per year. However, the continuation of this level of rent is uncertain given the parlous state of the biomass. The US$35 million per year can be compared with the Bjørndal estimate of annual resource rent, under optimal conditions, of about US$550 million (Bjørndal, 2009, p. 11).

The root of the problem is straightforward enough. The cooperative game that is the ICCAT-based RFMO governing the tuna resources has degenerated into a competitive game. The management advice provided by the ICCAT is largely ignored (Bjørndal, 2009). The economics of non-cooperative management of shared fishery resources predicts that the shared fishery can readily take on all of the characteristics of a pure open-access one. Bjørndal maintains that the fishery is to all intents and purposes just that. The steady, almost inexorable, decline in the SSB in the past 30 years is entirely consistent with a pure open-access fishery (Bjørndal, 2009).

With the support of the EU, the ICCAT has called for the implementation of a recovery programme, i.e. a programme of resource investment. However, given the severely reduced state of the biomass, MacKenzie, Mosegaard and Rosenberg (2009) argue that recovery may take many years even if fishing mortality is drastically reduced. In other words, the states currently exploiting the resource will be called upon to bear heavy investment costs.

The economics of cooperative fisheries management makes it clear that the needed cooperation will be forthcoming only if compliance is ensured. If a moral and otherwise law-abiding member state of the RFMO is convinced that cheating by other RFMO members will go unchecked, this otherwise law-abiding member state will probably conclude that it would be no better off under cooperation, and probably less well off, than it would be under competition. Cooperation will founder. Ensuring compliance in a cooperative fisheries game with 25–30 "players" is a formidable undertaking.

There is another problem. Suppose that somehow the compliance problem is effectively resolved, and suppose that substantial resource investment is achieved. At its peak, the fishery had up to 50 participating states. What is to prevent the 20–25 states that left the fishery demanding re-admission to the club once the resource investment programme has achieved success? If those returning states were re-admitted and granted significant shares of the TAC, they would effectively be free riders, having borne none of the cost of investment. It is not at all clear that, under the 1995 UN Fish Stocks Agreement, the would-be returning states could be denied re-admission.

If the would-be returnees cannot be denied re-admission, then it would be foolish to suppose that the current members of the RFMO could not anticipate the future free riding. The anticipated free riding could lead many current members to conclude that they would be better off under competition. Once again, the proposed cooperative resource investment programme would be stillborn (Kaitala and Munro, 1997; Munro, Van Houtte and Willmann, 2004). It can be argued that, without a resolution of the so-called "new member" problem, the outlook for the future of the resource is bleak.

A stark contrast is provided by the case of Norwegian spring-spawning herring, to which reference has already been made. When healthy, the resource has historically been one of the largest and most valuable in the Northeast Atlantic. When healthy, the resource migrates from its spawning grounds in Norwegian waters as far west as Iceland. In so doing, the resource passes through international waters, which means that it is to be classified as a straddling stock (Bjørndal, 2008).

It will be recalled that the resource crashed in the late 1960s and early 1970s, and that its SSB was reduced to 2 000 tonnes, 0.08 percent of the critical minimum level of 2.5 million tonnes. Massive resource re-investment was called for and it did occur. Today the resource is healthy, with the SSB at more than 6.5 million tonnes (Bjørndal, 2008). So what went right?

First, the remnants of the resource were confined to Norwegian waters. Thus, it ceased, for the time being, to be a shared fishery resource. Second, as indicated above, the Norwegian fleet and human capital involved in the fishery was highly malleable with respect to the fishery. It was politically easy for the Norwegian resource managers to declare a harvest moratorium, which more or less remained in place for 20 years. Finally, there was an element of luck in that environmental conditions allowed for a recovery of the resource from its desperately low state.

By 1994, there were signs that the recovered resource was re-commencing its migratory pattern, and was thus once again becoming a shared stock. There was a realization among the relevant states that cooperative management was required if another disaster was to be averted. Indeed, the states recognized that, if the stock were to crash again, no recovery might be forthcoming.

The first attempts to develop a cooperative regime involved the Faroe Islands, Iceland, Norway and the Russian Federation. These attempts were largely unsuccessful, with an important reason being that an important player, in the form of the EU, had been left out. The EU can claim a very small coastal state interest in the resource, but more importantly, its fleets were able to operate in the high seas through which the resource passed in its migration – the typical free rider problem.

By late 1996, the EU had been brought in to the cooperative arrangement. The recently concluded 1995 UN Fish Stocks Agreement provided a useful framework for the now inclusive agreement (Munro, 2001). The emerging RFMO was to operate under the Northeast Atlantic Fisheries Commission.

For several years, the cooperative game in the form of the Norwegian spring-spawning herring cooperative management arrangement seemed to be stable and to be effective in terms of both conservation and resource rent generation. In contrast to the Northeast Atlantic/Mediterranean bluefin tuna cooperative resource management arrangement, the number of “players” was small (a cooperative straddling stock fishery game with only five “players” is small indeed). There were no troublesome would-be new members appearing on the horizon. One can conjecture that the absence of a new member problem was not unconnected with the fact that two of the “players” were, and are, politically very powerful – the EU and the Russian Federation.

However, a problem arose in 2002, which was of a type that can afflict any RFMO. When one talks about the stability of the RFMO cooperative fisheries game, it is not enough to talk about current stability. One has to be concerned with the stability of the RFMO through time, what economists refer to as the "resiliency" or, more technically, the time consistency problem. Any RFMO can be expected to be subject to unpredictable shocks, which may be political, economic or environmental in nature. If the RFMO lacks the resilience and flexibility to respond to and absorb these shocks, the RFMO may founder (Miller and Munro, 2004; Munro, 2009).

The harvest-sharing rule in the Norwegian spring-spawning herring RFMO is based upon the so-called zonal attachment of the herring on its migratory path, with this being based, in turn, on the amount of the resource in each zone and the amount of time spent by the resource in each zone. In 2002, the Norwegians claimed that the zonal attachment of the resource to the Norwegian EEZ was in fact substantially greater than had been thought to be the case when the cooperative resource management arrangement (including the EU) had been agreed upon in 1996. The Norwegians demanded a greater share of the TAC. Iceland and other "players" refused. While not being formally terminated, the cooperative resource management arrangement seized up. There was no mechanism in the arrangement to deal with shocks such as those arising from shifting migratory patterns. Thus, the cooperative resource management arrangement was found to lack resilience. The cooperative fishery game began to show worrying signs of degenerating into a competitive one.

The "prisoner's dilemma" began slowly manifesting itself in different ways. The original cooperative resource management arrangement had various bilateral side arrangements, which had the effect of increasing the global economic rent from the fishery. Thus, for example, non-Norwegian "players" were granted permission to harvest parts of their quotas in the Norwegian zone in order to allow them to harvest the herring when the fish were at their most valuable state. With the exception of the Russian Federation, all non-Norwegian "players" were banned from the Norwegian EEZ after 2002, thereby reducing the global resource rent pie. In addition, the RFMO was in the practice of accepting ICES scientific advice in setting the global TAC. Players now began setting their own quotas unilaterally, with the to-be-expected result that the sum of the individual quotas exceeded the ICES recommended global TAC by a significant margin (Bjørndal, 2008).

By the end of 2006, a new cooperative management arrangement had been agreed to, with Norway gaining a modest increase in its quota. While the details on the negotiations leading to the new arrangement are not available in their entirety, it is not unlikely that, in looking into the abyss after a dangerous three-to-four year hiatus, all "players" realized that a cooperative arrangement, while less than perfectly satisfactory to all, was much to be preferred to no arrangement at all.

Bjørndal demonstrates that the resource rent from the fishery could be increased by fine tuning the harvesting arrangements. Nonetheless, the resource rent is very substantial and would have seemed unachievable 35 years ago (Bjørndal, 2008).

4.4.1 International and intra-EEZ incentive structures

In the discussion of Level 1 and 2 fisheries, emphasis was given to the importance of correct incentive structures within the EEZ. In the discussion of Level 3 fisheries, most of the discussion has been on internationally shared fishery resources, and the fundamental importance of states sharing the resources having the incentive to cooperate in the management of the resources through time. It is now appropriate to ask whether there is any interrelationship between the two sets of incentives. The answer is a straightforward one, namely that there is an interrelationship.

Consider a shared fishery resource in which the states sharing the resource have ineffective intra-EEZ management of their respective shares of the resource, so that the intra-EEZ rent from the resource is completely dissipated. In the theory of strategic interaction (theory of games), there is the concept of the cooperative surplus. This is the difference between the sum of the payoffs to the players under cooperation minus the sum of the payoffs to the players under competition. If the intra-EEZ rent from the resource is completely dissipated, the cooperative surplus maybe negligible, which means in turn that the incentive to establish a cooperative management regime will be at a minimum (Munro, 2007).

Conversely, suppose that each sharing state is attempting to establish an intra-EEZ effective harvesting-rights scheme, but suppose further that they are unsuccessful in establishing an effective cooperative resource management regime. It is easy to show that this lack of international success can readily undermine the attempts to establish intra-EEZ effective harvesting-rights schemes – the "prisoner's dilemma" again. After all, it was the realization that the non-cooperative management of the high-seas portions of highly migratory and straddling fish stocks was undermining the attempts at intra-EEZ management of these resources that led to the 1993–95 UN Fish Stocks Conference and the subsequent 1995 UN Fish Stocks Agreement (Munro, 2007).

5. Summary and conclusions

The Sunken Billions report (World Bank and FAO, 2009) estimates conservatively that, owing to inadequate management of marine capture fishery resources, the world is facing an ongoing resource rent loss of the order of US$50 billion per year. The case studies reveal that the rent loss is occurring in both developed and developing fishing states, independent of the nature of the states' political and economic regimes. Capitalist and socialist fishing states alike share in the rent loss dishonour.

However, far from being alarmist, this conclusion understates the gravity of the problem. A close reading of the report shows that, while there are prosperous capture fisheries, the overall resource rent from the world capture fisheries is, at best, equal to zero. Thus, the natural capital in the form of world capture fisheries resources must be seen as a set of non-performing assets that, on balance, are making no net contribution to world economic development.

The question then is how to correct this situation so that this great stock of natural capital will be seen as providing the world with a positive economic return.

This report attempts to provide no definitive answers. A second project, a "rent gain" project, is required to search out the answers. Rather, the present report can only hope to point to avenues of research that will need to be explored.

To begin, one has to ask how the world has come to find itself in this position. Up until 125 years ago, few worried about the overexploitation of ocean capture fishery resources as they appeared to be inexhaustible – free "natural" capital. The state of fishing technology was such that large amounts of these resources were protected by economics. It was too costly to exploit them extensively.

With ongoing advances in fishing technology reducing fishing costs, the economic protection afforded capture fishery resources steadily evaporated, with free "natural" capital being transformed into decidedly scarce "natural" capital. The world was then confronted with the full consequences of "common pool" fishery resources, in which the property rights to the resources, private or public, are ill defined or non-existent. As economists have recognized for more than half a century, in such circumstances, fishers are faced with a set of incentives that are perverse from society's point of view, leading inevitably to resource overexploitation and dissipation of resource rent.

Hence, the key issue in attempting rent recapture is that of dealing with perverse incentives. The incentives to be faced are first those that have to be addressed on an intra-EEZ basis, and second those that have to be dealt with on an international basis. It is suggested that, in examining fisheries in need of management reform, one can think of three levels of fisheries. The first, and easiest, consists of fisheries that can be viewed on a strictly intra-EEZ basis and that, through good fortune, have not experienced significant resource depletion but in which the resource rent has been nonetheless been dissipated through ineffective management.

In FAO terminology, intra-EEZ perverse incentives can be dealt with by incentive-blocking measures or by incentive-adjusting ones. The former have had some limited success blocking fisher incentives to overexploit the resource, but very little success in dealing with other incentives leading to other source of dissipation, such as the buildup of excess capacity. Incentive-adjusting measures are called for, with the most commonly used ones consisting of harvesting-rights schemes, such as ITQs, but also territorial use rights in fisheries and fisher cooperatives.

The Sunken Billions report makes it evident that, if anything approaching the resource rent potential of capture fisheries is to be achieved, there will have to be massive rebuilding of the hitherto depleted resources. In other words, a major investment programme in the "natural" capital of fisheries is called for. The second level of fisheries in need of reform is seen to consist of those fisheries that were subject to extensive overexploitation in the past but in which the fisher incentives have been adjusted to the extent that there is no longer an incentive on the part of the fishers to deplete the resource further and to the extent that some resource rent is forthcoming. However, as no positive investment in the resource has occurred, the rent re-capture process is thus incomplete.

Any positive investment in real capital involves a current cost that is borne in the hope of returns in the future. The question is how to adjust the fisher incentives further so that they will have an incentive to invest in the resources, or at least not impede the resource investment programme. There are no immediate answers to this question.

The third level of fisheries consists of fisheries in which the incentives remain uncorrected and in which resource investment, if it is occurring, is negative. For those third-level fisheries for which international considerations are not a significant issue, the first step is to introduce incentives schemes that will curb the fisher incentive to overexploit the resources, and that will lead to the generation of resource rent – in other words to transform the fisheries, at a minimum, into second-level fisheries.

The most difficult of the third-level fisheries are those in which international considerations are of paramount importance, in other words internationally shared fishery resources. Ineffective resource management cooperation among the relevant fishing states will result in incentives to overexploit the resources and dissipate resource rent arising, not just on a fisher basis, but on a state basis as well. Of these difficult third-level fisheries, the most difficult are those to be found either all or in part in the high seas. With respect to such high-seas fisheries, the case studies provide an example of a spectacular failure to prevent resource overexploitation and rent dissipation. However, encouragingly, they also provide an example of a spectacular success in positive resource investment and the regaining of resource rent.

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The World Bank/FAO report, *The Sunken Billions*, argues that world capture fishery resources are performing far below their economic potential. The cost to the world economy is in the order of US$50 billion per annum in forgone resource rent. Case studies commissioned by the World Bank and FAO support these conclusions and show that the economic overexploitation of capture fishery resources is spread throughout the world, in both developed and developing fishing states. The question now to be addressed is what needs to be done to reverse the situation. It is clear that, in order for world capture fishery resources to realize their full economic potential, there will need to be a programme of massive resource investment in the overexploited fish stocks. Establishing effective capture fishery resource investment programmes will be challenging, particularly for shared stocks in the high seas. That said, several of the case studies provide encouraging lessons with examples of highly successful fish stock rebuilding programmes.

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