CONTROL OF FOREIGN FISHERIES: DEVELOPING MANAGEMENT STRATEGIES TO MAXIMISE NATIONAL ECONOMIC BENEFITS

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ABSTRACT

Under the provisions of the United Nations Convention for the Law of the Sea (UNCLOS), coastal states must provide for access to harvest the living resources within their EEZs. Where the state does not have the capacity to harvest the entire sustainable catch, it must grant other states access to the "surplus allowable catch" through access agreements. High global demand for fish products means there is continuing pressure for distant water fleets to maintain or increase fish supplies to international markets. Attendant economic incentives for foreign vessels to fish illegally are well known. Without sufficient means, developing coastal states are unable to enforce regulations putting the resource under increased pressure from over-exploitation. However, legitimate fishing can be encouraged given sufficient levels of surveillance, penalties and appropriate licence fees. Moreover, revenue generated from licensing foreign vessels can be used to fund monitoring, control and surveillance operations. The optimum terms and conditions that developing coastal states can expect from licensing foreign vessels can be determined. An earlier study to derive maximum economic benefits from foreign fishing for coastal developing countries has been applied to eight case studies around the world to provide specific management recommendations and policy advice to key stakeholders. A spreadsheet-based learning tool to assist the decision-making process was used at a regional workshop in east Africa. Here we detail the underlying issues governing the approach and its use to improve decision-making in developing countries.

Keywords: Fisheries, Access Agreements, Illegal Unreported and Unregulated, Licence Fees, Penalties, Surveillance.

INTRODUCTION

Under the terms of the United Nations Convention for the Law of the Sea (UNCLOS), coastal states' maritime jurisdiction was extended to 200 nautical miles, formalising in international law the unilateral declarations made by many states throughout the 1970s and 80s. With this came an obligation to manage sustainably the marine resources within their jurisdiction (usually represented by an Exclusive Economic Zone (EEZ)). The extension of jurisdiction deprived distant water fishing nations (DWFN), of large areas of sea where they had traditionally fished; 95 percent of fish stocks and 35 percent of the ocean became under the jurisdiction of coastal states, largely from the less developed group of countries.

Now that distant-water fishing nations must negotiate access to fish resources which were previously open-access, the resource wealth theoretically rests with the coastal states. In practice, the capacity of coastal states to derive net benefit from these resources depends on a number of key factors, including: domestic (coastal state) fishing capacity; the estimation of surplus yield available for foreign fishers; the potential benefits to foreign fishers of fishing within the EEZ; and the capacity of the coastal state to effectively monitor and control fishing activity and enforce fisheries regulations within the EEZ.

For developed countries with large domestic fleets that were already exploiting fish stocks in what became their EEZs, the experience with extended fisheries jurisdiction has generally been good. This is particularly true in cases where the domestic fleet was capable of fully exploiting stocks that generally remained within a single country's EEZ; extended fisheries jurisdiction granted the right to deny access to

foreign fishers, thus easing the pressure on heavily fished stocks. The experience for developing countries has been more variable. In principle, permitted access to foreign fishing, can be of considerable value to a developing country, especially if it is unable to exploit the resource fully itself. In addition to the transfer of income from the DWFN to the coastal state through licence fees, benefits such as increased local landings and local fishery development through joint ventures with DWFN may also be realised. In practice, however, developing coastal states have been severely hampered by the lack of local expertise and of monitoring, control and surveillance (MCS) frameworks that could be used to manage newly acquired fish stocks to ensure their conservation, while securing optimal economic benefits from their exploitation. Most, with a few exceptions, have proceeded by trial and error. In particular, developing countries have a dilemma in deciding to what extent they should develop a fishing industry of their own, or seek instead to derive benefits from licensing foreign fleets to access their fish resources.

If the decision is taken to permit foreign fishing, then it is essential that terms and conditions of access that are optimal for the coastal state are imposed upon the distant water fleets. Devising such terms and conditions involves a series of secondary decisions, for example, what level of licence fees should be set, what amount of money should be spent on surveillance and enforcement, and what legal framework should be developed, especially what levels of penalties for illegal fishing activities should be imposed.

The primary purpose of this paper is to examine the opportunity for providing structured guidance to developing coastal states with a view to maximising their economic opportunities and benefits derived from foreign fishing activities within sustainable harvesting limits. This pre-supposes that the coastal state is in a position where there is a surplus yield available for foreign fishers and that there is an interest from foreign fleets to fish within the coastal state's EEZ.

GENERAL PRINCIPLES

Provision of access arrangements for foreign fishing is contained within a framework of MCS. MCS covers a broad range of activities that support sustainable management of fisheries, including the development and establishment of data collection systems, the enactment of fisheries legislation, and the enforcement of regulations. There are important linkages between these activities, which should be considered when developing a control of foreign fishing strategy (Figure 1). In essence, a foreign fisher contemplating fishing within the area of a coastal state's EEZ has to make a decision about whether to comply with local requirements or to fish illegally and risk the consequences of being detected, arrested, prosecuted and punished. It is the potential interactions between specific variables that are under the control of the coastal state, which form the basis for this paper.

There are essentially two types of analysis that underpin the control of foreign fishing: the first relates to the calculation of catch and effort both inside and outside the coastal state's EEZ in order to determine the potential benefits to foreign fishers of fishing within the EEZ; the second requires the estimation of the probabilities of detection and successful prosecution of unlicensed foreign fishing vessels inside the EEZ arising from different surveillance operations. In both cases, it is important to tailor the analysis to the particular fisheries and surveillance characteristics of the region or country. This can be relatively straightforward in cases where there is only a single fishery, fishing fleet and state involved. The situation becomes more complicated as the number of fleets taking different species at different times of the year increases, thus requiring a more complex analysis of the catch and effort data. Highly migratory fish, such as tunas are a special case, in that their range frequently includes parts of the EEZs of several coastal states, as well as large areas of international waters. Management of these stocks generally is carried out under the provisions of international fishery management bodies governed by international convention.

In developing countries, the funds available to the coastal state to pay for surveillance activities are often very limited. If there are significant potential benefits for foreign fishing within the state's EEZ, then it is reasonable for the coastal state to set relatively high licence fees. This is only possible, however, provided the expected fine faced by the fishers for fishing illegally considerably exceeds the licence fee. If the amount of surveillance that can be afforded is strictly limited, this can only be assured by imposing very high fines. It is important, however not to treat fines as a primary source of income from the fishery. The reason to control access to a fishery is to limit the catch and to help conserve the long term sustainability of the stock. By basing revenue expectations on the opportunity to impose fines without addressing the central problem of illegal vessels catching too many fish, the stock comes under increased pressure and risk from overfishing. The management aim should therefore be to strongly deter any unlicensed fishing, thereby effectively eliminating revenues from fines, and supporting a long term sustainable fishery from which licence revenue can be generated over the long term.

In addition to setting high fines, it is important to maintain a high perceived risk of detection of IUU (Illegal, Unreported and Unregulated) fishing. Fishing companies do not generally have access to the information required to calculate the actual level of risk (e.g. from the distribution of the fishery and the cruise path of a fisheries patrol vessel). The perceived risk of detection may therefore not necessarily be directly related to the actual risk. In a newly established fishing regime, it may be only following a highly publicised arrest and the imposition of high fines that the perceived risk of being detected and fined will rise to a level at which fishers decide to operate legally, even though the actual risk has not changed at all. Following a high profile surveillance operation, it is important that the perceived increase in risk is maintained. This can be achieved, for example, by increasing the number of patrols throughout the year so as to elevate the actual probability of detection. A degree of targeting can be used to increase the chance of detection during surveillance patrols by making use of reports from other sources that illegal fishing activities are occurring.

Monitoring and assessment of the status of the resource plays an essential role in maximising the long-term economic benefits of the resource to the state. However, for many developing coastal states, the cost of resource surveys and stock assessments is prohibitively expensive. Instead, catch and effort information obtained from commercial vessel logbooks are used to monitor trends in the level of stock abundance. Submitting regular vessel catch reports is therefore a requirement of access agreements, but this has proved difficult to enforce, particularly if the vessel is not required to have an observer on board or make routine port visits. Foreign fishing vessels have the ability to tranship their catches at-sea, and unless obligated to do so may not enter designated ports within the coastal state. This can create a number of serious problems, which could lead to misreporting of total catches and thus under-estimate the total catch and catch value. Under-reporting of catches can put the stock under increasing pressure of over-exploitation and prevent coastal states from realising the full economic value of the resource. Under these circumstances, it is essential to conduct regular offshore surveillance through the use of patrol vessels and aircraft (see [1] for a review of options). Operation of these types of facilities is expensive and the total costs depend on the length of time each surveillance platform is needed to maintain a high perceived risk of detection of illegal vessels.

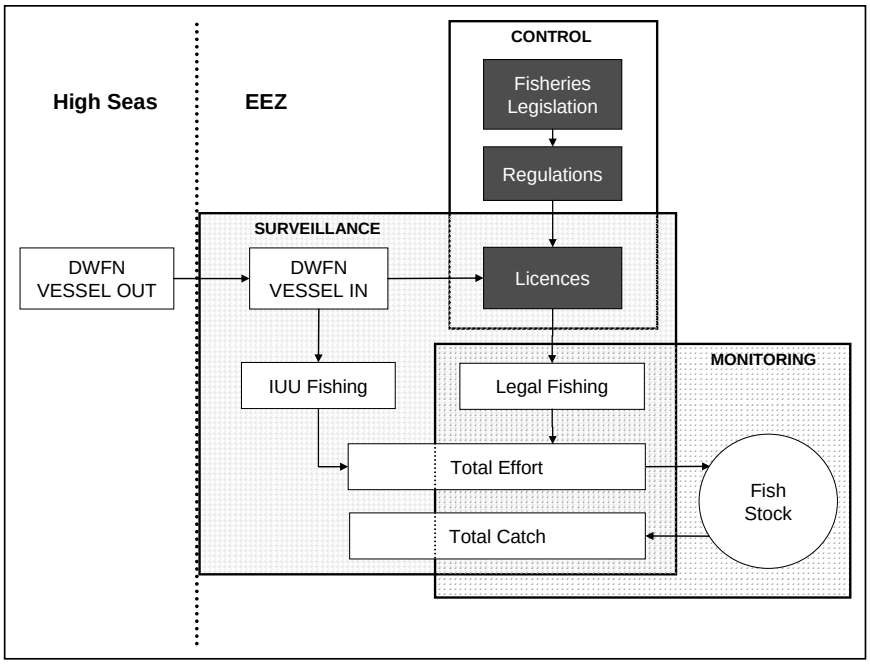

Figure 1. Framework illustrating the monitoring, control and surveillance of foreign fishing activities within the EEZ of a coastal state. DWNF vessels may fish legally by applying for and receiving a licence issued through the control system, in accordance with the coastal state's legislation. In this case the fishing activity and ensuing catch can be monitored. Note that monitoring can be considered to cover not just the fishing activity, but directly on the stock itself, for example through fishery independent surveys. If the vessel fishes illegally (i.e. without a licence), the fishing effort and catch will fall outside the scope of regular monitoring and may use illegal fishing methods (unreported and unregulated). Detection of this illegal activity and estimation of the fishing effort and resulting catch (target and non-target) falls within the arena of surveillance activities. Total fishing effort is a combination of legal, monitored fishing activity and IUU (Illegal, Unreported and Unregulated) fishing activity that may be detected through surveillance, or other means, such as market information. Various approaches have been developed for estimating the level of IUU fishing based on surveillance records (e.g. see [2] and [3]).

ALLOCATION OF FISHING RIGHTS

It is important for developing coastal states to develop sustainable strategies that also maximise the potential economic benefits within their EEZ. In many situations a mix of both domestic and foreign fishing has been shown to provide the optimal fleet allocation policy [4,5]. Queirolo and Johnston [6] have shown that coastal states that opt for domestic fleets and processors rather than foreign fleets can loose out on both market access and profitable joint ventures.

By far the most common method of distributing harvesting rights is allocation by administrative decision. This is usually accompanied by some form of licence fee or tax associated with the granting of the right. A tax may take the form of a profits tax, or a tax based on the price or amount of the quota [7,8,9]. Due to the heavy information requirements of the calculations associated with these taxes, and the incentives to misreport that arise, fishery managers may opt for an effort-based regime in which a fixed price is paid for a period of access to the fishery. Such access may or may not be accompanied by a quota-based tax or restriction on the amount of catch, or quota that can be taken during the period.

While it is administratively straightforward, one of the problems with this approach is how to set the licence fee at a level that is both optimal for the coastal state in terms of generating revenue, and acceptable to the fishers in terms of the economics of the fishing operation. In addition to setting the fee level, the coastal state also needs to determine the overall level of effort to allow: set it too low and the opportunity to generate maximum economic benefits from the resource is lost; set it too high and the long term prospects of the fishery are at risk. This may be further confounded depending on whether the stock is contained entirely within the jurisdictional control of the coastal state, or whether it straddles between two or more political boundaries, such as highly migratory tuna.

Setting fee levels for foreign access

The basis for setting the level of licence fees for access by foreign vessels varies from State to State [10]. As suggested by the FAO Code of Conduct, "where appropriate, and when possible" a basic minimum target should be to seek to cover the incremental cost to the coastal state of effectively monitoring and controlling the fishing activity resulting from the agreement. This includes the scientific research work necessary to generate sound management advice. Anything less than this will result in inadequate management and increase the scope for fishing practices which threaten the sustainability of the resource. This is likely to be detrimental to the foreign fishing operation (and hence future licence fee revenues to the coastal state) and may also adversely affect the coastal state's domestic fisheries.

In fact, there may be scope for generating considerably more revenue from licensing than is needed to cover the cost of fishery management. In theory, the maximum fee a foreign vessel would be prepared to pay for access to an EEZ is equivalent to the marginal revenue. This is the difference between the economic net benefits of fishing inside the EEZ and those of fishing outside the zone. Expected gross catch value is calculated from the predicted catch rate and the predicted sale price of the species being caught, both of which may be different inside and outside the EEZ. For straddling stocks, where the species composition of the catch inside and outside the zone is more or less the same, this equates to the difference between the catch rates. In practice, firms will generally make different valuations of the value of the access and/or quota on offer. This may be for several reasons: the firms may differ in terms of the ease with which they can shift labour and capital to other fisheries; they may differ in terms of their access to and use of information about the fishery and its future prospects; and they may differ with respect to the cost of credit that they will face in financing their fishing operation.

Distant water fleets usually prefer to pay a fee on the basis of the weight of fish actually caught during the licensed period. Access agreements for the EU external fleet, for example, have often included an agreed lump sum payable for a fixed level of catch. In agreements covering tuna fishing in the EEZs of island states in the western Indian Ocean, catches of tuna over and above the fixed level are charged at a supplementary rate per tonne caught. A fee per tonne amounts to a tax on the catch taken and protects the DWFN and/or fishing companies from paying relatively high licence fees when the fishing is poor. This is particularly relevant in the case of highly migratory fisheries such as tuna, when the inter-annual variability of catches is likely to be high. However, such an arrangement can be unfavourable to the coastal state for several reasons:

- it imposes a substantial monitoring burden on the coastal state's fishing authority;
- it creates a great incentive on the part of the fishers to under-report the catch;
- in the case of highly variable catches, it provides an irregular revenue stream from licences to the coastal state; and,
- a fixed level of catch often results in variable levels of fishing effort, resulting in problems for assessment and management of the fishery.

The problems of monitoring and the incentive to under-report are not insurmountable. In recent years, the development of sophisticated vessel monitoring systems and the routine placement of independent observers on fishing vessels have improved monitoring and made it more difficult for vessels to misreport without being detected. Nevertheless, rather than linking the licence fee retrospectively to the actual catch taken, for some fisheries, coastal states sometimes prefer to charge a fee based on a level of effort. Under this scenario, the fee is not linked explicitly to the amount of catch actually taken. Once a vessel is licensed there is no restriction on the amount of fish they are permitted to catch. This removes the incentive for vessels to misreport their catch. The coastal state, however, must be in a position to make a realistic estimate of the expected catch rates of the vessels to be licensed, in order to set the licence fee at a reasonable level, and limit total effort so that the expected total catch is in line with conservation guidelines. Expected catch rates can be estimated using data from previous fishing seasons, or for new fisheries, may be derived from data on fisheries in adjacent areas or similar fisheries in non-adjacent areas. Examples where this approach is taken include migratory tuna fisheries in the Indian Ocean, where as yet there are no specific catch limits, and squid fisheries in the south west Atlantic.

It has been argued that effort control is generally inferior to management strategies that directly allocate an allowable catch, or quota, to different components of the industry. Compared to quota allocation mechanisms, effort controls are an indirect approach to defining the right to harvest fish. In order to achieve a target catch level under effort controls, the management authority must fix every element of the operation necessary to harvest the fish. However, in situations where the fishing operation is reasonably uniform across the harvesting units (vessels), this task becomes less of a problem. Administration of this type of licensing system requires detailed analysis of fishing patterns, market information and catch and effort data, in order to provide advice on appropriate types of licences, levels of licence fees and allocations of fishing effort (number and duration of licences) compatible with conservation. Nevertheless, removal of the incentive to misreport catches is a powerful motivation.

There are other advantages to the coastal state from effort regulation. For example, depending on the precise terms of the access arrangement, in years when the catches are unexpectedly low (as can happen, for example, in fisheries for seasonally migrating species, such as tunas and squid) there may be no drop in revenue, even though the licences may have derived little or no benefit from being licensed. This is an advantage for the coastal state, because the expenditure on the fishery management system is likely to be much the same as in years when the fishing is good.

Assessing the relative benefits of fishing inside the EEZ and the licence fee levels that are likely to be acceptable to the fishers can be done in several ways, for example:

- the simple ratio between the licence fees paid and the estimated value of the catch taken under those licences. To the extent that the data allow, this should be done for individual vessels and for the overall fishery. For highly variable fisheries, this can be investigated from two perspectives; the first being value of a licence in “good” years and the second being the value over the longer term (depending on information on the frequency of the “good” years).
- the marginal value of fishing inside the EEZ compared to fishing with the same vessel(s) and gear, outside the EEZ, but in the same region. This is more complex essentially because of the greater data requirements, and because it is necessary to have a good understanding of the relative benefits of fishing inside the EEZ compared to the options for fishing outside. In principle, this provides a more accurate picture of the value of a licence, but in the case of highly variable migratory stocks, it is very difficult to develop a general picture that is representative of the situation in any given year
- a model can be used to optimise the licence fee, expenditure on surveillance, and expected level of fine in order to maximise the total state revenue generated from the sale of licences and vessel fines (see below).

USING MODELS TO SUPPORT DECISION-MAKING BY COASTAL STATES

Several programming methods have been developed to determine the optimal level of fisheries surveillance. Lepiz and Sutinen [11] used a zero-one integer programming model to optimise the allocation of sea patrol vessels and assess the cost of a surveillance programme within Costa Rican tuna fishery. A practical application of planning cost-effective surveillance programmes has also been reported by Miller [12] using a tactical linear programme model. These models are helpful in developing annual plans for the deployment of surface, aerial and observer surveillance effort although they cannot be used to measure the deterrent effect, or probability of detection.

To support decision-making in the control of foreign fishing, developing coastal states require estimates of the expected total costs (principally surveillance) and the total economic revenue (e.g. access fees). MRAG [13] described several interactions between these variables, which enable the maximum economic benefit to be derived. For example, in principle, the marginal cost of surveillance to the coastal state should not be higher than the marginal revenue generated from foreign fishing. If it is, then the coastal state is operating at a loss, and decisions need to be made regarding the possible discontinuation of surveillance activity and the potential consequences for the resources and the state.

In developing models to investigate optimal income and expenditure scenarios, it is possible to describe several basic principles of decision-making by fishermen. In general, foreign vessel owners would not be expected to pay a licence fee that is higher than the expected marginal revenue available from fishing inside the EEZ. If the expected fine the fishermen would face if they were caught fishing illegally inside the EEZ is also greater than the marginal revenue, risk-averse fishermen will prefer to fish outside the EEZ. If, however, the expected fine were equal to or less than the licence fee and less than the marginal revenue, risk-prone fishers might be expected to fish illegally (i.e. without a licence) inside the EEZ.

The expected fine may be increased by changing either the probability of detection and/or the level of fine. The fine should be set as high as possible, reflecting the value of the vessel, the gear, and the catch (both from the illegal activity and into the future). Within a tuna purse seine fishery this can amount to several million dollars. We note, however, that very high fines may be impossible to collect in practice. Vessel owners may chose instead to forfeit the vessel, particularly when vessel value is low. Nevertheless, it has been shown that penalties are usually not large relative to the potential gains from illegal fishing [14, 15]. It is also imperative to have a judicial system that is capable of successfully prosecuting IUU vessels or else the expected fine will remain relatively small. This may require revisions to the legal framework and fisheries regulations.

While it is perfectly rational to base decisions on the expectation of the fine, as mentioned earlier, there may be a substantial difference between the fishermen's perception of the probability of being detected and the actual probability based on the surveillance activities of the coastal state. There is considerable literature available on compliance behaviour, which has centred mainly on rational decisions by individuals to violate rules. Economic deterrent models have been used to address the issue of optimal quantities of enforcement services and management policies [16, 17, 18]. The model framework generally assumes that individuals gauge the overall benefits of fishing illegally against the severity and certainty of the sanctions applied when deciding whether to comply or not with the regulations. However, econometric models have also been used to demonstrate that compliance behaviour within commercial fisheries does not always concern the difference between the catch rates inside and outside a regulated area (e.g. EEZ), but indicate that moral, legitimacy factors and social influences can also be significant determinants of compliance behaviour [19, 20].

In the control of foreign fishing model [13], changes in the probability of detection, determined by the level of surveillance, and changes in the licence fee provide a rational set of decision rules for fishers' behaviour and optimal values for the developing coastal state. These can be used to derive the optimal licence fee payable and the maximum economic benefit available to the coastal state. The dependence of decision-making by fishers and managers on the combination of these variables is illustrated in Figure 2.

If the cost of surveillance increases (S), the coastal state must ensure that sufficient economic benefits, in this case through licence revenue (L), cover the total costs to the state. Although fishermen would like to purchase cheap licences, this would be an unprofitable cost-recovery strategy for the coastal state. This is represented by the area under the line where L=S at the bottom of Figure 2.

As suggested above, the marginal revenue (MR) limits possible licence fee payable. In practice, however, the maximum fishermen are prepared to pay is a proportion of MR, indicated in Figure 2 by the horizontal line, a.MR. In addition, licence fees should not be set higher than the expected fine E(f) or else it will be more profitable for fishermen to fish illegally inside the EEZ, and only pay a small fine, if caught. In Figure 2, the area above the curve L=E(f) is where fishermen would fish illegally inside the zone, if the perceived risk of detection was low.

Increasing the probability of detection, and hence the perceived risk of detection, will incur higher surveillance costs. In theory, the maximum expenditure (S') the coastal state should expect to pay for surveillance is equivalent to the maximum economic benefit or marginal revenue, MR. If the licence fee is set too high (i.e. above a.MR in Figure 2), and the level of surveillance is good, fishermen would not be willing to pay for a licence, nor risk fishing inside the EEZ. As such, fishermen would fish outside the EEZ, as shown as the shaded decision area in the top right in Figure 2.

This type of analysis is useful for fishery managers in that it portrays the decision space in a manner that is easy to interpret. The white area within Figure 2 represents a region of potential negotiation. Here, the fishermen would like the fees to be as low as possible, so they will try and negotiate to a point near the bottom of the region. The coastal state is prepared to issue licences even though it could make more revenue from fines, but the most profitable is at the top of the region.

In Figure 2, the optimal point for the coastal state is marked with a black dot. The optimal licence fee is set at the maximum that fishermen are willing to pay. The surveillance expenditure is then the minimum necessary to deter illegal fishing, given that fee. If the actual optimal points were used, then fishermen would theoretically have no clear preference between fishing legally, illegally or outside the EEZ. There may be some incentive for fishermen to act lawfully when there is no benefit in acting unlawfully, but as already noted, the licence fee is a certain cost to the fishermen whilst the expected marginal revenue and expected risk of detection when fishing illegally would be realised in any one year. It is probable that under these circumstances, fishermen will exhibit risk-prone behaviour. In brief, this reduces the level of expected fine and hence the optimal licence fee.

Although this approach can be helpful in guiding access negotiations, it requires a range of data types from the fishery, which are not always available. Lack of regular catch reports, for example can lead to misreporting of target species and quota taken, which can also undermine stock assessment advice and put the resource at risk from over-exploitation. In addition, without sufficient catch data, states are unable to properly gauge the true value of the resource taken for licensing purposes.

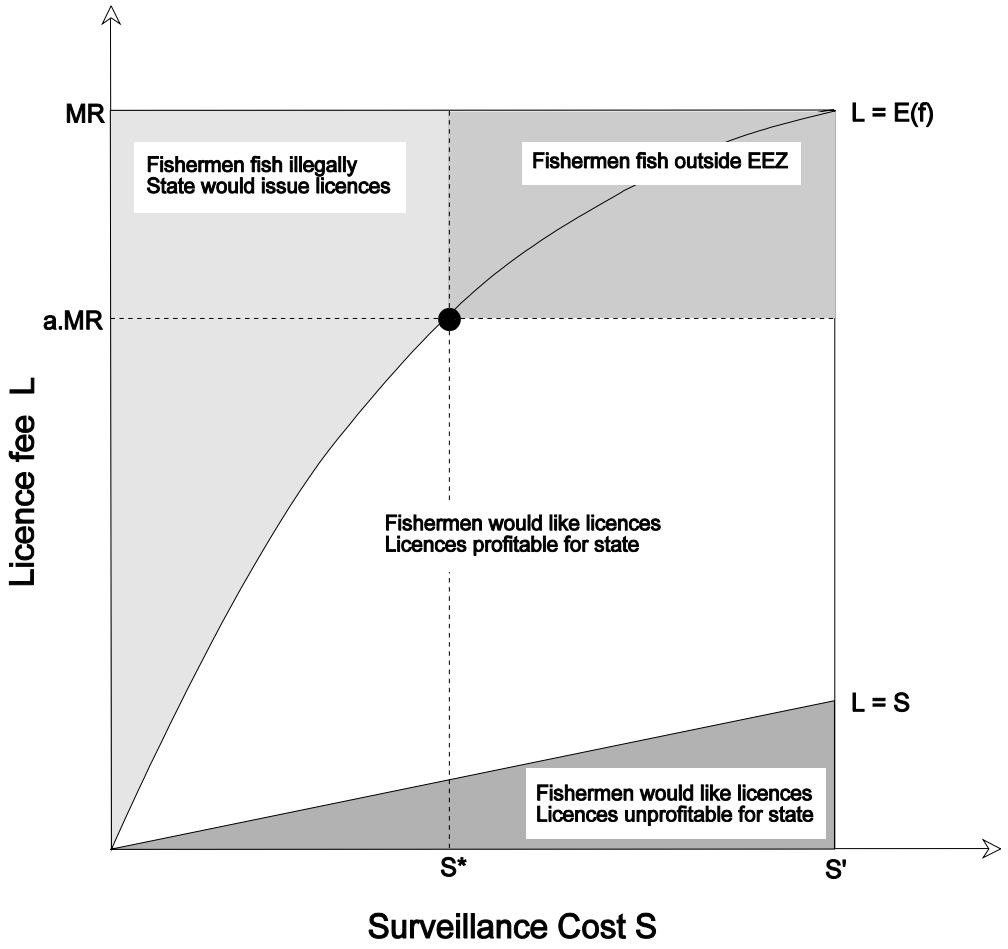

Figure 2. Decision rules and optima for state and fishermen with changes in licence fee and surveillance cost per vessel (source: [14])

The importance of efficient surveillance by the coastal state

As we have seen, the decision whether or not to fish illegally depends on several factors, including the severity and certainty of the sanctions imposed by the coastal state [20]. In modelling fishers' decisions on IUU fishing, [21] describe the significance of the combined effect of the probability of being caught and the penalty faced by the fisher if caught. This can be a problem in states where effective fisheries management is lacking, making them vulnerable to IUU fishing. A recent study funded by DFID showed that poor governance associated with developing coastal states is correlated highly with the level of IUU fishing [3]. As shown by the CFF model, high penalties go some way towards redressing the balance, but even so, if fishers perceive there is a very low chance of being caught, then IUU activity is likely to be high. As [21] put it: if there is no enforcement then the severity of the penalty is meaningless.

The efficiency of the surveillance operation in maintaining the perceived probability of detection of IUU activity therefore becomes a major factor in maximising net revenue. Surveillance efficiency can be dramatically increased through better knowledge and hence targeting of surveillance operations (e.g. through a combination of aircraft and vessel operations), night operations, use of more fisheries inspectors

and observers, sharing of facilities with other government departments (e.g. customs and excise) or the navy, or even neighbouring countries with similar fisheries and management objectives. Russell [22] showed through a game modelling approach that very specific targeted monitoring as a result of previous records of violations considerably increases the overall level of compliance.

Arnason [23] suggests a number of institutional arrangements to reduce the cost of surveillance activities, ranging from a top-down approach using the government to provide both a service and pay for it, to a bottom-up, self-management regime where industry both provides the service and pays for it. The provision of foreign licence fees is strictly a cost-recovery management arrangement, whereby the government provides the service, but industry (foreign fishing) is the payee.

In theory, the probability of detecting an illegal vessel will increase with the level of surveillance (Figure 3; [13]). However, it is very unlikely that surveillance can be 100% efficient, and only a proportion (Q in Fig. 2) of all IUU vessels will be detected, even at very high surveillance levels. In practice, the probability of detecting a violation of fisheries regulations may be below 1% [24, 25]. As surveillance expenditure increases, at some stage the absolute number of IUU vessels detected is expected to decrease. This occurs once the deterrent effect is sufficiently high to effectively reduce the actual number of violations to low levels (Figure 3).

MRAG [13] represented the probability of detection based on the theory of random search [26, 27]. In the simplest form of that theory, it is assumed that the surveillance platform (offshore patrol vessel or aircraft) searches a known area for a single vessel randomly placed within that area. If the search is conducted in a random chosen trackline, the probability of detection is given by the size of the area, speed of the vessel, the duration and the search width. Further refinements have been made to this approach to take account that illegal vessels may not always be fishing illegally on the days in which the patrols are made [2].

As described, an increase in the efficiency of surveillance operations can be gained from targeted offshore patrols using prior knowledge of the expected distribution of vessels, thus reducing the area (and cost) of surveillance required. This prior information may be acquired either from knowledge gained about the expected position of resources within the EEZ and/or from regional vessel entry/exit reports, for example. A regional register has been established by the South Pacific Forum Fisheries Agency and used to monitor the activities of foreign vessels operating within the EEZ of member countries [28].

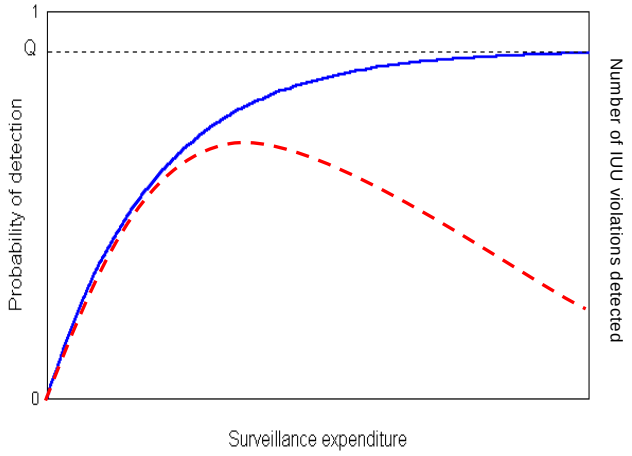

Figure 3. Probability of detection (solid line) and number of IUU violations detected (dashed line) with increase in level of surveillance.

Use of the control of foreign fishing model to support decision-making in developing countries

The Control of Foreign Fishing model has been tested through practical application in a number of case studies; starting in the mid-1990s with fisheries in Seychelles, British Indian Ocean Territory and South Georgia and extended in 2005 to Kenya and Tanzania. The initial project aimed to assist Developing Countries with the design of foreign fishing access arrangements and associated Monitoring, Control and Surveillance (MCS) to improve fisheries management and generate revenue for the coastal state. In a recent extension to the project, the model was developed into a spreadsheet-based Management Game for fishery managers in developing countries to use as a training and decision-making support tool. The tool was put to the test in an East African regional workshop in November 2005 that included participants from Kenya, Tanzania, Mozambique and Seychelles. Analysis of the project's impact showed improved knowledge across a range of CFF related topics among a high percentage of workshop participants. For example, all participants felt they had improved their knowledge of setting fine levels for maximum benefits to the coastal state. Additionally, eighty-nine percent of participants had improved knowledge of the role of licences in CFF; the importance of CFF strategies and setting licences in relation to the net benefits of fishing in the EEZ. Fifty-five percent of participants had improved knowledge of the importance of catch-effort/catch rates/state of stock data in determining CFF strategies, while, between sixty and seventy percent of participants had improved knowledge of the potential solutions to a lack of surveillance capacity; the means of increasing effectiveness of surveillance; and the benefits of regional CFF strategies.

The general conclusion is that modelling approaches such as the one described here may have value in assisting developing coastal states in making rational and informed decisions about foreign fishing access to their waters. While each case is undoubtedly different, and optimal decision-making should be based on detailed analyses of specific data, application of the model in a range of examples has provided a number of common lessons learned [29].

ACKNOWLEDGEMENTS

This project was funded by the Department for International Development under the Fisheries Management Science Programme. We would like to acknowledge the helpful comments and feedback on developing early drafts of the manuscript from Per Erik and Sandy Davies, Ian Shea and our colleagues at MRAG Ltd.

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