The Control of Foreign Fishing within Developing Coastal States

Contents

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1. 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 that many states had made 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 Zones (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.

Under the provisions of Articles 62, 69, 70 and 71 of UNCLOS, coastal states must make provision for access to their EEZs by foreign fishers. Article 62 requires the coastal states to determine its capacity to harvest the living resources in its EEZ, and where the CS does not have the capacity to harvest the entire allowable catch, it is required to grant other States access to the 'surplus allowable catch' through the conclusion of access agreements[1]. UNCLOS is not specific, nor could it be, about how optimum levels of fishing should be determined, but Article 61 provides guidelines on the sorts of objectives which should form the basis of resource management strategy - "... not endangered by over-exploitation. ... maximum sustainable yield ... maintaining or restoring populations ... above levels at which their reproduction may become seriously threatened etc.". A strong emphasis is placed on the importance of regional co-operation in resource management and protection. UNCLOS therefore leaves it to the CS to decide how to determine the optimum level of fishing within its EEZ (although "scientific information etc. should be exchanged on a regular basis through competent international organisations").

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. However, 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;

[1] UNCLOS includes various additional detailed provisions related to the preferential treatment of land-locked States (Article 69), and geographically disadvantaged States (Article 70); Article 62 also acknowledges the requirements of developing States in the sub-region or region in harvesting part of the surplus, and the need to minimise 'economic dislocation' in States whose nationals have habitually fished in the zone or which have made substantial efforts in research and identification of stocks.

- 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. Where fish stocks range across several EEZs, the same rights apply for each country concerned regarding granting of access to foreign fishers, but proper management of the stocks requires cooperation between the countries.

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, such as the Indian Ocean Tuna Commission (IOTC) and International Commission for the Conservation of Atlantic Tunas (ICCAT).

In contrast to developed coastal states, the experience with extended fisheries jurisdiction for developing countries has been more mixed. At least in principle, permitted access to foreign fishing, usually involving transfer of income from the DWFN to the coastal state, can be of considerable value to a developing country, especially if it is unable to exploit the resource fully itself. Benefits other than just licence fees may also be realised by coastal states, such as increased local landings and local fishery development through joint ventures with distant water fishing nations.

In practice, however, the lack of local expertise in developing countries 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, has severely hampered developing coastal states. 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 fines for illegal fishing activities should

be imposed. The primary purpose of this article is to review the literature that provides guidance to 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 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. We will therefore concentrate on the last two bullet points in the above list and will not be dealing with the issues of local fishing capacity and the estimation of surplus yield, except insofar as they impact the availability and types of licences for foreign vessels.

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 review.

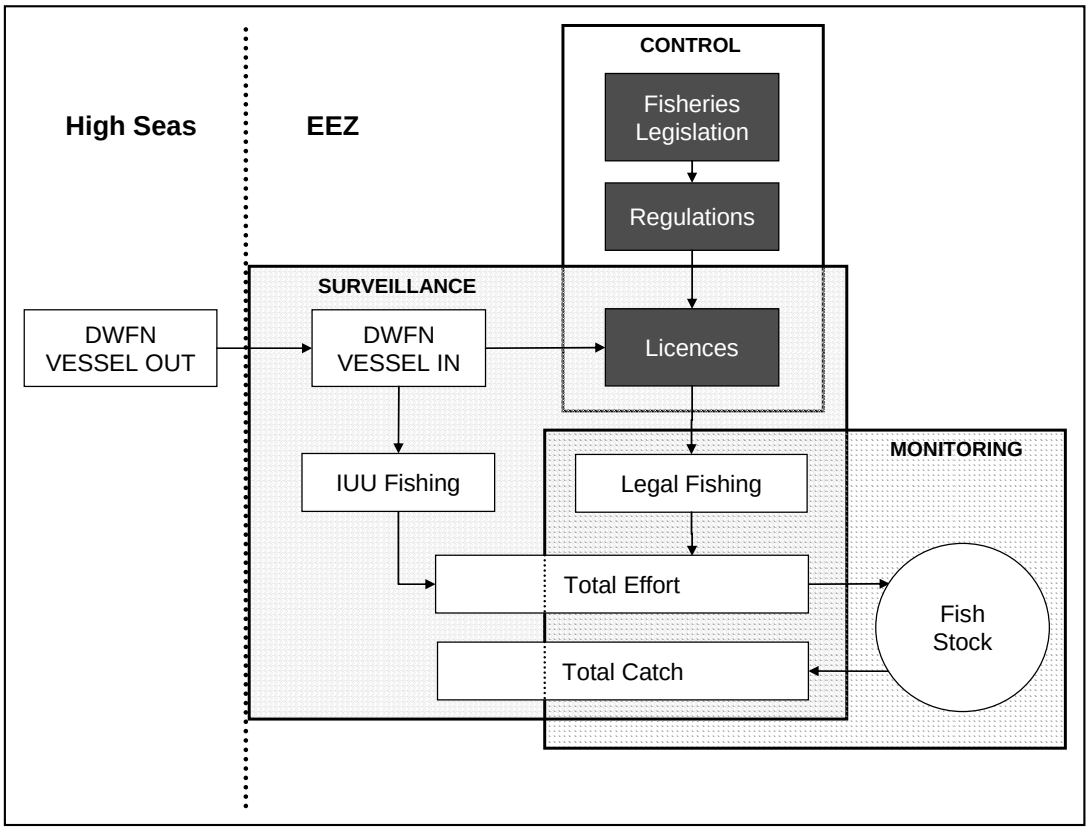

Figure 1 Framework for monitoring, control and surveillance of foreign fishing activities within the EEZ of a coastal state. DWNF vessels may fish legally by applying for and receiving a licence issued through the control system, in accordance with the coastal state's legislation. In this case the fishing 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 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 Agnew and Kirkwood (2005) and a review of the impacts of IUU fishing on developing countries by MRAG Ltd[2]).

[2] Funded by the UK Department for International Development, the output of this study is available at http://www.dfid.gov.uk/news/files/illegal-fishing.asp

2. Developing a strategy for the control of foreign fishing

2.1. General principles

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 were 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.

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 license 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 the revenue from fines as a positive benefit. Although high values of revenue can be obtained from fines alone, this could lead to unpredictable and unsustainable levels of revenue and put the status of the resource as risk of over-exploitation. 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. Only if this is successful, thereby effectively eliminating revenues from fines, will there be a long term sustainable fishery from which licence revenue can be generated sustainably.

In addition to setting high fines, it is important to maintain a high perceived risk of detection, such that the expected fine for illegal fishing exceeds the cost of obtaining a licence. 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.

2.2. Estimating economic value

2.2.1. Allocation of fishing rights

Although the declaration of EEZs was intended to improve sustainability of the resource, increased fishing pressure means that many resources are now even more heavily exploited and depleted than before. Increased fishing pressure comes from both legitimate and IUU catches. Steps are being taken by international agencies to reduce or eliminate IUU fishing (e.g. International Plan Of Action; FAO 2001).

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 (Beddington & Clarke 1984; Munro 1985). Queirolo and Johnston (1989) have shown that coastal states which opt for domestic fleets and processors rather than foreign fleets can loose out on both market access and profitable joint ventures.

Whether the fishers are domestic or foreign, there are various means of allocating the right to go fishing in a particular area, held collectively under the term "property rights". Schlager and Ostrom (1992) divide property rights into two categories: "use rights" and "control rights". Use rights relate to the use of the resource, while control rights allow the holder to determine who may use the resource. Use rights are further divided into "access rights" and "withdrawal" or "harvesting rights". Access rights authorize entry into the fishery or into a specific fishing ground. Harvesting rights typically involve the right to a specific amount of fishing effort (for example access to an EEZ for a specific amount of time) or catch (e.g. a limited quota). In this review we are concerned primarily with the allocation of harvesting rights to foreign fishers by the coastal state, which retains the control rights.

Morgan (1995) provides the following categorisation of means of allocating harvesting rights:

1. allocation by administrative decision
2. allocation by ballot (or lottery)
3. allocation by auction

Allocation by administrative decision is by far the most common method of distributing harvesting rights (Morgan 1995). 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 (Grafton 1992; 1994; 1996). However, due to the heavy information requirements of the calculations associated with these taxes, fishery managers may opt for an effort based regime in which a fixed price is paid for a period of access. 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 (See Section 2.2.2).

Allocation by ballot is not generally used in fisheries; and while allocation by auction is thought to have potential attractions for the coastal state, in terms of maximising rent capture, this method is used only rarely. We therefore focus in this review on the administrative decision scenario in which the coastal state charges a fixed fee for a period of access to the EEZ, which may or may not be linked to a limit on the catch.

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 (see following section). 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.

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.

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 often a requirement of access agreements, but this has often proven difficult to enforce, particularly if the vessel is not required to have an observer on board or make routine port visits. 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.

2.2.2. 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 (Parkes 1998). 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 both 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.

Distant water fleets usually prefer to pay a fee on the basis of the weight of fish actually caught during the licensed period. The EU partnership agreements, 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. The latest EU partnership agreement with the Seychelles which runs from 2005 to 2011 includes a total EC contribution of €24.75 million, with €1.455 million for defining and implementing a sectoral fisheries policy in Seychelles with a view to promoting responsible fisheries. In this context, by 2006 Seychelles will reduce fishing effort of tuna longline vessels by 15%. Licence fees paid by vessel owners have been increased to €15,000 for purse seiners and €3,000 for longliners. The annual allowable catch has also increased from 46,000 t to 55,000 t. Some agreements have also specified the total aggregate GRT of the vessels permitted to

access the fishery. This implies an assumed relationship between GRT and fishing power, which is considered further in the following section.

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 (e.g. as with some migratory species such as tuna), 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 mis-report their catch. The coastal state, however, must be in a position to make a reasonable 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, there is no guarantee of catch associated with the purchase of a licence. 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 licensees 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.

Generally speaking, fishing companies are now quite familiar with the idea of paying access fees in advance for a period of access without necessarily receiving a guaranteed quota. They are also adept at estimating the likely catch and thereby how much they are willing to pay. In the case of highly variable fisheries, however, such as those for migratory tuna in the western Indian Ocean, this is extremely difficult. The commodity that the coastal state is selling is the opportunity to enter the EEZ for the purposes of fishing. In some years this opportunity may be very valuable because catch rates are high, but in other years it may not. Fishing companies are understandably wary when it comes to paying out large sums of money for something with such an uncertain return. Negotiation between these companies and the licence issuer therefore becomes extremely important. One of the keys to the negotiation process for the coastal state, therefore, is preparation based on good data about the fishery.

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:

(i) 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).

(ii) 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, such as tunas, it is very difficult to develop a general picture that is in any way representative of the situation in a given year

(iii) 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 Section 3).

2.3. Costs to the Coastal State: Control and Surveillance

The state is aiming not necessarily for the highest possible licence fees, but for the highest possible net revenue. All other things being equal[3], higher catch rates inside the zone will lead to an increase in the potential for the coastal state to generate revenue from foreign fishing (Section 2.2.2). However, this may not always lead directly to an increase in actual revenue. Individuals from foreign fleets may choose to risk fishing illegally inside the zone to maximise their own potential profit, without having to pay for a licence.

As indicated above, the minimal goal is to at least recover the costs of administering and managing the fishery and assessing the status of the stock(s). Effective fisheries management is often lacking in developing countries, 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 (MRAG 2005).

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 (Viswanathan et al. 1997). The decision-making behaviour of fishers is discussed in more detail in Section 3. In the control of foreign fishing, the most significant cost item usually considered by developing coastal states is fisheries surveillance. The efficiency of the surveillance operation in maintaining the perceived probability of detection of IUU activity (a major factor in the "certainty" of sanctions) therefore becomes a major factor in maximising net revenue. Arnason (1999) 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.

The total costs associated with fisheries management in the North Atlantic have been estimated to range between less than 3% and 28% of the total landed value of the catch (Arnason 1999). Within developing coastal states, however, surveillance efficiency can be dramatically increased through

[3] "All other things" includes the cost of fishing; there is an assumption here that the operational cost (i.e. other than the licence fee) of fishing inside the EEZ is not significantly greater than that of fishing outside the EEZ.

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 (see following sections) .

2.3.1. Means of surveillance

The resources required to undertake effective and efficient MCS activities extend from acquiring a basic infrastructure to communication systems, various surveillance platforms and the development of institutions and human resources (Kelleher 2002; Flewwelling et. al 2002). In the control of foreign fishing, the most significant costs relate specifically to the type of offshore surveillance platform used.

Foreign fishing vessels have the ability to tranship their catches at-sea, and therefore do not enter designated ports within the coastal state to land their catch. This can create a number of serious problems for monitoring and surveillance from the coastal state, which could otherwise lead to misreporting of total catches and thus under-estimate the total catch value. Under these circumstances, it is essential to conduct regular offshore surveillance through (i) patrol vessels and (ii) aircraft.

In general, an offshore patrol vessel should be capable of patrolling the entire 200-mile EEZ, with the ability to stay at sea for at least 20 days. When considering vessel types, Kelleher (2002) has identified three potential types of platform with vastly different costs associated with their purchase, operation and maintenance:

- Naval vessels
- High speed offshore patrol vessels
- Converted fishing vessel or similar

Clearly, the low market value of second-hand patrol vessels must be weighed against the higher cost of refitting and maintenance of the older vessels. Alternatively, offshore surveillance patrols may be chartered, which can avoid expensive start-up costs. This might include a regional vessel sharing scheme under a bi- or multi-lateral agreement or through a contract with a private agency. Regional cooperation however, in terms of sharing platforms may not be that effective in a national perspective. For example, increasing the patrol time in one area will reduce it in another, thus increasing the risk of IUU fishing in the country where it is based.

With regard to aerial surveillance, many different small aircraft can be fitted with long-range fuel tanks to extend their geographic range, although safety considerations should remain paramount. Kelleher

(2002) estimates the cost of a range of light aircraft to be approximately US$2-3 million. However, similar to offshore patrol vessels, aerial surveillance can be chartered, which can substantially reduce the initial capital outlay.

Obviously, the total costs associated with deployment of both offshore vessels and light aircraft depend on the length of time each surveillance platform is needed to maintain a high perceived risk of detection of illegal vessels.

2.3.2. Probability of detection

Developing a successful surveillance strategy depends on maintaining the probability of detection, or the likelihood of spotting illegal fishing activities within the coastal state's EEZ. In theory, the probability of detecting an illegal vessel will increase with the level of surveillance (Fig. 2; MRAG 1993). However, it is very unlikely that surveillance can be 100% efficient, and only a proportion (i.e. Q) of all IUU vessels will be detected, even at very high surveillance levels. Studies have shown that the probability of detecting a violation of fisheries regulations is normally below 1% (Sutinen and Gauvin 1989; Furlong 1991).

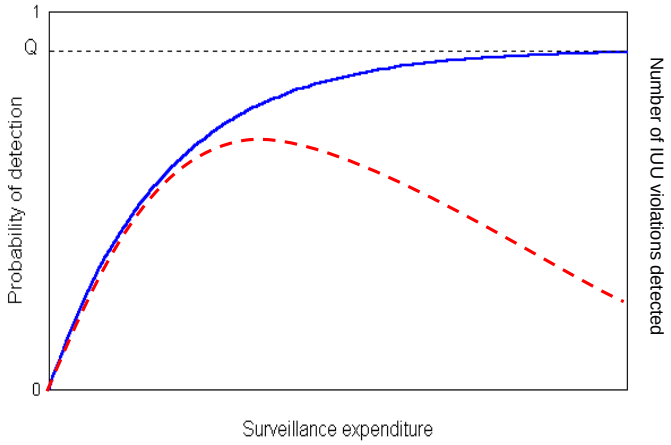

Figure 2 Probability of detection (solid line) and number of IUU violations detected (dashed line) with increase in level of surveillance.

As surveillance expenditure, and the probability of detection increases towards an asymptote, 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 2). Obviously to reduce surveillance costs, the actual number and/or duration of offshore patrols should be minimised, whilst maintaining a high perceived risk of detection. Alternatively, Russell (1990) showed through a game modelling approach that if large increases in the

enforcement budget and draconian fines that would compensate for low probabilities of detection are dismissed as politically infeasible, that very specific targeted monitoring as a result of previous records of violations considerably increased the overall level of compliance.

MRAG (1993) represented the probability of detection based on the theory of random search (Koopman 1957; 1980). 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.

In general, it is very difficult to link the cost of surveillance to a probability of detection. Furthermore, even when an IUU vessel is detected by a surveillance platform, this does not always lead to the coastal state collecting the maximum fine. Cases are often settled out of court to avoid costly legal fees for both sides, and outcomes are therefore frequently undisclosed under the terms of the agreement.

2.3.3. Optimising surveillance

The cost of offshore patrolling can be substantial. Methods are needed to optimise surveillance operations to reduce costs, whilst maintaining a high perceived risk of detection. 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.

Several programming methods have been developed to determine the optimal level of fisheries surveillance. Lepiz and Sutinen (1985) 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 (1995) 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.

An increase in the efficiency of surveillance operations can also 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 (Doulman and Terawasi 1990).

3. Development of control models to assist decision-making by coastal states

In control of foreign fishing, to assist in decision-making about granting regulated access to distant water fishing vessels, developing coastal states require estimates of the expected total costs (e.g. surveillance) and the total economic revenue (e.g. licence fees) (MRAG 1993). There are several interactions between these variables, which enable the maximum economic benefit to be derived. In addition to licence fee revenue, economic benefits may include revenues from fining IUU fishing vessels. However, although considerable sums can be generated from prosecuting illegal vessels, this strategy is unsustainable both in terms of conserving the resource and generating a long term source of income. Following the successful and well publicised prosecution of a single vessel, the behaviour of the fleet can change such that compliance is increased and fine revenue diminishes.

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 (MR) 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 actual level of fine. We have already mentioned that the actual level of fine should be set as high as possible, reflecting the value of the vessel, gear and catch. Within a tuna purse seine fishery this can amount to several million dollars. However, it has been shown that penalties are usually not large relative to the potential gains from illegal fishing (Sutinen 1988; Sutinen et al. 1990). 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, it is important to realise that there may be a considerable 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 decision-making by individuals to violate rules. Sutinen and Andersen (1985), Anderson and Lee (1986) and Milliman (1986) have used economic deterrent models to address the issue of optimal quantities of enforcement services and management policies. The model framework assumes that individuals gauge the overall benefits of fishing illegally against the severity and certainty of the sanctions (level of fine) applied when deciding whether to comply or not with the regulations. However, Viswanathan and Sutinen (1994) and Viswanathan et al. (1997) use econometric models 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.

In the control of foreign fishing, 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 on the combination of these variables is illustrated in Figure 3.

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 3.

In theory, the maximum licence fee payable is equivalent to the marginal revenue (MR) available from fishing inside the EEZ as opposed to fishing outside the EEZ. In reality however, fishermen would only be prepared to pay a proportion of the marginal revenue, indicated 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 3, 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 3), and the level of surveillance is good, fishermen would 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 3.

The decision area that the coastal state would most like to issue licences is therefore in the centre of Figure 3. Clearly, fishermen would not be prepared to pay more than a.MR for a licence, while maximising the level of surveillance (S') will be less profitable to the developing coastal state. In this example, the optimal licence fee (L*) is the point at which the licence fee minus the surveillance cost per vessel is the greatest, which also coincides with a.MR.

This type of analysis is useful for fishery managers in that they portray the decision space in a manner that is easy to interpret. The white are within Figure 3 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 3, 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. Fishing activities can also be destructive to the environment, without proper control of vessel discharges and waste.

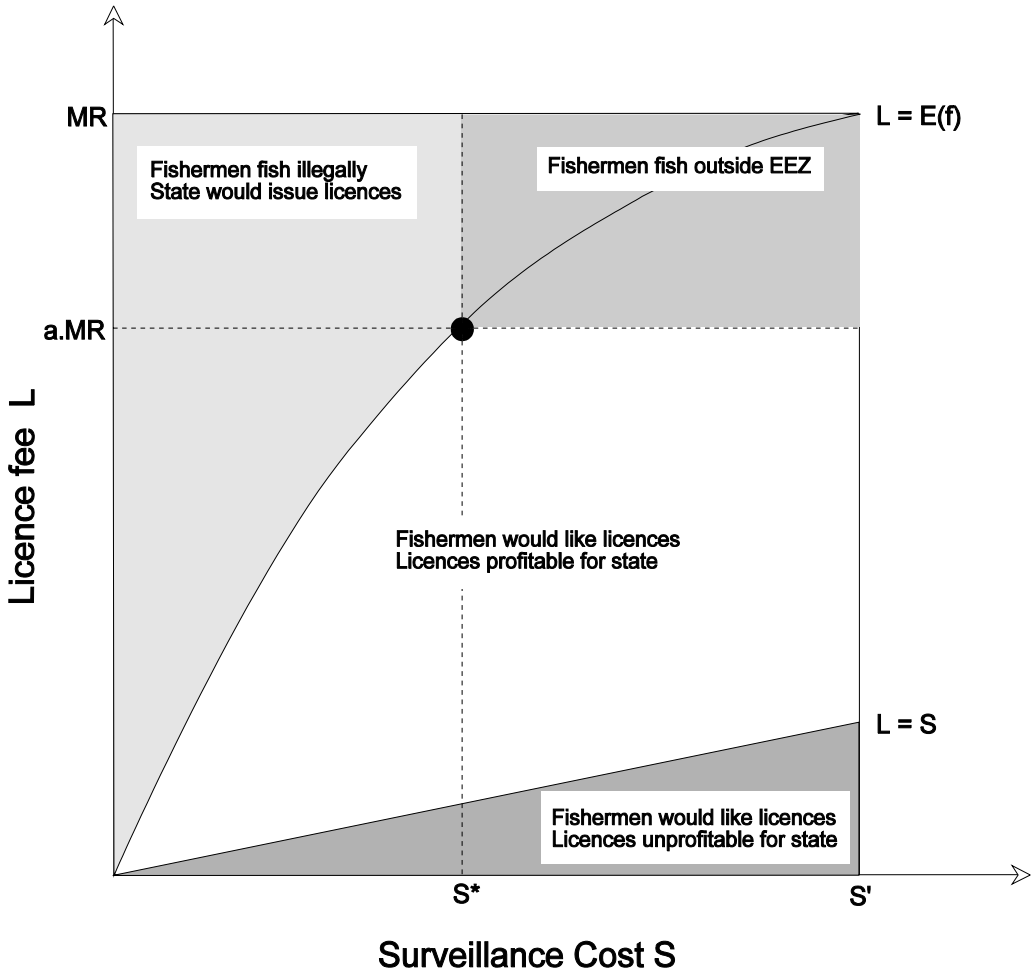

Figure 3 Decision rules and optima for state and fishermen with changes in licence fee and surveillance cost per vessel (source: MRAG 1993).

4. Lessons Learned

Modeling approaches such as the one described in Section 3 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 (MRAG 2006).

- **It is important to impose large fines for illegal fishing activities.**

  Funds available in developing coastal states to support surveillance activities are often limited. If there were significant potential benefits for foreign fishers within the coastal 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 license fee. Furthermore, if the amount of surveillance that can be afforded is strictly limited, this can only be assured by imposing very high penalties, potentially including the forfeiture of the catch and vessel.

- **Although high values of maximum net revenue can be obtained from fine proceeds alone, this could lead to unpredictable and unsustainable levels of revenue and put the status of the resource at risk of over-exploitation.**

  While it is important to set penalties as high as possible, the proceeds from fines should not be regarded as a long term source of revenue in the same way as proceeds from licence fee are. Access to a fishery is limited, when necessary, for the purpose of achieving conservation targets, not so that revenue can be generated from catching vessels fishing illegally. 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. Only if this is successful, thereby effectively eliminating revenues from fines, will there be a long term sustainable fishery from which licence revenue can be generated sustainably.

- **Estimates need to be made of the probabilities of detection and successful arrest of unlicensed fishing vessels arising from different levels of surveillance activities; the perceived and actual probability of detecting illegal vessels can be very different.**

  Even though the actual level of surveillance may remain constant, examples indicate that it may be only after a highly publicised and high fine imposed on one vessel caught fishing illegally that the perceived probability of detection increases and hence license applications increase. The

perceived risk of being detected and fined must rise to a level at which the expected fine exceeds the cost of obtaining a licence, even though the actual risk may not have changed at all.

- **Following a high profile surveillance operation, it is important that the perceived increase in the probability of detection is maintained.**

  This can be achieved, for example, by increasing the number of patrols throughout the year to enhance the appearance of surveillance, thereby maintaining or increasing the perception of the probability of detection. Depending on how the extra surveillance effort is applied, this may also 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 (e.g. overflights, or on-board observers).

- **Increasing the efficiency of surveillance can substantially reduce the cost as a proportion of the licence revenue.**

  When the maximum fine is reduced, surveillance can be increased to compensate by increasing the probability of detection and thereby maintaining the level of expected penalty. However, under these circumstances, the cost of surveillance can approach the total revenue from licence fees, hence net revenue may be reduced to zero. Where the deterrence of illegal fishing is the primary management issue, affordable surveillance is therefore vital. If the maximum fine must be reduced, and the cost of surveillance must be kept constant, to maintain the perceived level of expected penalty, the efficiency of surveillance must be improved.

- **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. The value of the vessel may be the best estimate of the maximum possible fine.

- **It is better to calculate licence fees as a proportion of the marginal benefit arising from fishing inside the EEZ, rather than as a proportion of the catch taken inside the EEZ.**

  This is because the value to the fishers of obtaining a license arises from the difference between the catches that can be taken inside and those taken outside, rather than just the amount of catch taken from the EEZ. Results from the case studies showed that strong inter-annual variability could occur from the expected benefits of fishing inside the zone. In calculating appropriate levels of license fee, average estimated benefits were mainly used, but this meant that in some years the cost of a license was greater than the expected benefits. If this were to occur several years in a row, foreign fishers may become reluctant to renew their licences. Under these circumstances, it might be necessary to develop innovative solutions to the problem.

- **Additional benefits can be generated from alternative sources of revenue.**

In addition to the two sources of revenue commonly used in models; from the sale of licence fees and fines generated from successfully prosecuting illegal vessels, there are a number of other benefits that can be generated from foreign fishing activities such as transhipment fees and port facilities offering goods, services and value added processing.

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