APPENDIX

USE OF ANALYTICAL AND SIMULATION STUDIES IN THE DEVELOPMENT OF STRATEGIES TOWARDS IMPROVEMENTS IN ACCESS BENEFITS

A paper submitted to FFA for consideration of possible future collaborative adaptive research on the issue of Control of Foreign Fishing and extension into the Economics of Compliance Control

David Evans
Projects Director
Marine Resources Assessment Group Ltd

FISHERIES MANAGEMENT SCIENCE PROGRAMME
on behalf of the
Renewable Natural Resources Research Strategy
UK Overseas Development Administration

February 1994

USE OF ANALYTICAL AND SIMULATION STUDIES IN THE DEVELOPMENT OF STRATEGIES TOWARDS IMPROVEMENTS IN ACCESS BENEFITS

Contents

BACKGROUND:

Access revenues from DWFNs have changed and they are likely to change again in the future across all countries in the region. There may be several factors contributing both positively and negatively to the general upward trend. In fact that trend has been relatively slow in the past, sometimes patchy and almost always in a stepwise manner, with sudden increments, rather than a gradual increase.

For years the Japanese agreements have been generating 4% of the overall reported catch value. Improvements to the understanding of the market, prices, relative values within markets and other features have enabled improving estimations of catch value. Improvements to compliance with catch reporting requirements have also enabled higher average catch amounts to enter into the licensing equation. In recent times the Japanese have agreed to increase the percentage return, effectively the only negotiable parameter under the current ubiquitous licence fee formula, from 4% to 5%, thus greatly increasing (by an immediate step of 25%) the overall access fee returns.

Similarly but more dramatically the US Treaty (1986) massively increased access income from the US purse seine fleets to an estimated 10% of gross landed value. Such was the success of that new arrangement that it caused countries to reassess their position and to push for further increases from other DWFNs. Indeed, Papua New Guinea immediately insisted on an equivalence within the Japanese agreements. This was unsuccessful - the Japanese arguing that the US overall fee included a large element of subsidy from the US government (effectively aid) and that their fisheries aid programme was as big if not bigger in both total amount and relative contribution than the US contribution through the treaty. In the face of a clear resolve on both sides to maintain their opening positions - although PNG eventually reduced their demand to 6% - PNG closed the fishery to Japanese vessels and all arrangements, including fisheries aid, have lapsed there since 1987.

Current regional activities towards multilateral agreements similar to the US Treaty face severe resistance from the Japanese but have been accepted by Taiwan (at least for the purse seiners) and there should be a multilateral treaty with Taiwan in the very near future. It is likely that Korea, almost the largest purse seine operator, will follow suit soon thereafter.

A major change to the distribution of the Japanese purse seine fleet has taken place in recent times with the limited fleet of 32 medium size single seiners now being able to also fish (by Japanese regulations) in the waters of Kiribati and Marshall Islands. The previous limit to waters of FSM and the high seas had been retained at the insistence of other lobbies within the Japanese tuna industry (principally the pole and line and longline fleets). It is yet to be analysed whether this major distributional change has adversely affected the income of FSM to the advantage of Kiribati and Marshall Islands. Other changes to the Japanese fleets may well also be in the pipeline. Informed opinion suggests that the pole and line fleets (now less than 90 vessels from several hundred in the early 80s) has stabilised and may well be able to offer increased licence fees as they return to profitability through exclusive production of B1 grade skipjack. Longline fleets may also undertake restructuring and perhaps focus on narrower ranges (fewer zones) in order to minimise both steaming and access fee costs - a focussing of their attention on particular areas. The changes to proportion of trip time spent in Kiribati compared to other zones has changed over the years perhaps reinforcing that argument.

TOWARDS A STRATEGY FOR IMPROVING ACCESS RETURNS:

The current level of access returns with the Japanese at 5% of reported catch value appears to be satisfying the requirements of many regional governments for a 'fair return'. The pressure to increase levels of return from Japanese fleets has waned as a result of this, and countries are looking at different aspects of the fishery and new means to extract other forms of benefit. Attention is becoming focussed on, and significant achievements being made through local participation by the foreign fleets through joint venture, charter operations and the regional transhipment requirements. Although these changes to the structure and operations of the fishery are laudable and certainly beneficial in the long term, it is unlikely in the short to medium term that the whole issue of licensed access will disappear. There will always be foreign vessel licensing requirements in most of the countries of the region, many of which have neither the infrastructure nor capital to penetrate the fishery to any great extent. Indeed, there will almost certainly continue to be issues of regional cooperation on access, including what might be considered the value and cost of preferential access.

Given this analysis there is scope to develop analyses that support the contention that access fee revenues are less than might be expected and what realistic estimates might be achieved. This same argument applies globally, almost wherever distant water fleets operate. Clearly, the internal argument and position of the Japanese is that while alternative zones remain available they are controlling the market. What might be done, and it is the principal subject of this paper, is the development of a strategy - together with the estimation of costs and benefits - that might be used towards changing this position in favour of the resource owners rather than the exploiters. The requirements for such a strategy are outlined.

It has also been the objective of the modelling exercise described below to assess and use a surveillance function in the calculation of net benefits. There are a number of features of surveillance and enforcement that are largely unknown, particularly economics. This paper also suggests ways, in appendix, to improve the understanding of the economics of surveillance with a better chance of developing a realistic surveillance function rather than the simplistic version currently employed.

MODELLING THE MAXIMISATION OF ACCESS BENEFITS:

MRAG has developed a generic model that attempts to analyse the potential net benefits from access by DWFNs to any fishery. This model uses a number of assumptions as follows:

- fishermen will be prepared to pay up to the value of the marginal catch rate, this rate being the difference between the catch rate taken outside a particular zone and that which can be obtained inside.
  (Such an approach has been successfully used in the access fee negotiations between Japan and Australia on the southern bluefin fishery, and as the basis for setting licence fees in the Falkland Islands squid fishery)

- the probability of capture increases according to a surveillance function that is not linear with surveillance effort (in the model quantified as cost).

- there is some measure of the risk that fishermen take, effectively their 'honesty coefficient' - the proportion of risk prone to risk neutral behaviours.

The model then goes on to calculate the expected net benefits (after surveillance costs) from both licence fees and fine penalties following inputs of vessel characteristics (by category: fleet type, nationality or fishing power) including:

- catch rates inside and outside zones.
- product prices and values of vessels (as a proxy for the fine for unlicensed fishing).
- the total fleet size.
- the expected catch per season.
- an 'honesty coefficient'.

THE MANAGEMENT GAME:

The above broad outline of the modelling approach has been prepared as a detailed research report and a management game written for QuattroPro: *Decision modelling and the Optimisation of Benefits to Coastal State Developing Countries from the Control of Foreign Fisheries, and Prototype Management Game - MRAG/ODA, 1993.* These documents (including the management game software) are attached to this paper.

The game has not been developed as a rigorous analytical tool to be directly used by fishery managers although the results are believed to be robust and perfectly general. The objective was to provide some indications to managers of the ways in which such a tool can be used, together with judgements and other information, in assessing the general effects of changes in fleet characteristics and activities. However, following a presentation of the game to the South Pacific Forum Fisheries Agency in November 1993, it became clear that a number of features of the game could be improved and should be adapted to the particular circumstances of the South Pacific tuna fishery. Indeed, there are features of the modelling that lead directly to additional research that might profitably be undertaken for the benefit of the wider issue of management of this fishery at both national and regional levels. This additional research is detailed later in this paper, and proposals for them presented in appendix.

As a result of discussions at MRAG and with members of the SP regional fishery institutions a number of issues have been raised. These fall under four general headings: further development of the game; information requirements for the operation of the game; use of the game and/or further analytical and simulation work in the development of strategies for improving benefits, and additional research into the estimation of a number of the model's parameters, including the further research mentioned above. This paper follows with some expansion of these headings.

FURTHER DEVELOPMENT OF THE GAME:

General:

- The simple presentation of the outputs from the model - catch values and net revenues (inside and outside zones), licence and fine incomes, fleet decisions and dispositions - as exact numbers could be construed as a limitation. There is therefore a strong case for undertaking some degree of sensitivity analysis on the outputs in order to produce a range of values for each of the above parameters that would be more acceptable and which, with the use of other information and judgement, might be more useful.

- The game requires a tutor text to accompany it, possibly in the form of both HELP screens and an on-screen TUTORIAL.

- The game should give an ability to the user to introduce different surveillance scenarios. It does this at the moment with the ability to input any level of surveillance cost. However, it does not allow for direct comparisons to be made between the effects of various levels of surveillance cost.

- It should be possible to offer a much more complex game for each fishing fleet (each column in the input and output tables) by introducing various distributions of fishing power and catch rates.

- In future the management simulation game, and the detailed analysis that it will produce and which underlies the mathematical approach, will be specially designed and programmed in executable software (probably Turbopascal) so that recipients/users are not reliant on having any particular spreadsheet software.

Extension to Multi Zone Modelling:

- The model could be prepared to consider the relationship between country A, country B and outside. By extension it may be possible to simulate the effect of changes to licensing regimes in individual or groups of countries.

- In relation to the above it would be helpful to introduce conservation constraints through the use of any estimates or range of estimates of MSYs of the major species by individual country. It is recognised that in scientific terms this is unlikely. However, there have been attempts in the past to estimate the likely level of catch that meets the general consensus of a sustainable yield in some countries of the region. Similarly, it should be possible to introduce effort limitation constraints that are proposed (the Palau Agreement) or could be envisaged.

Improved Parameter Estimation and use:

The 'Honesty Coefficient' that describes the ways in which individual fleets respond to the need to licence is, in effect, the level of risk they (collectively) are prepared to take in fishing within zones without a licence. Judgements can be made about what level of honesty each fleet tends to exhibit. However, this would change under different licensing circumstances and therefore there is a case for including a range of 'honesty coefficients' within the model.
In order to properly assess the probability of capture this issue should be addressed from both the management and fishermen's perspectives. The model investigations have taken this into account There will almost certainly be differences between the perceived and actual probability of capture. The difficulty is in how to measure the relationship between actual and perceived probability of capture. The datasets that might reveal some of this relationship are likely to be the distribution and frequencies of incidents (perhaps broken down by sightings, apprehensions, convictions) and the history of changes to registration and licensing (including the activity of

vessels prior to and under the US Treaty).

INFORMATION REQUIREMENTS:

In order to approach the adaptation of the original modelling work to the particular requirements and characteristics of the South Pacific tuna fishery it will probably be necessary to obtain detailed or summary information (whichever is available to external researchers without difficulty) on a number of databases and information sources held at FFA and/or SPC. *(Whichever level of detail can be made available, it goes without saying that all information and the details of the analysis therefrom will be treated as strictly confidential and will not be published without the explicit approval of the information authorisers.)*

Not all the following information is absolutely essential for the actual modelling exercise. While the full range of information is needed much of the information acts as background from which judgements can be made of both policy and practical aspects of management.

Fishery Details:

VESSELS: Time series of registrations and licensing by country, including details of the vessels registered or licensed, perhaps in a way that simply masks the identification of the vessels such as removal of name, regional register number, country registration number etc. (A subset of the regional register details.)

VESSEL VALUES: Estimates of the values of vessels by vessel type and size class.

CATCHES: Time series (say 1987-92) of catch and effort aggregated by 1 degree or 5 degree square (whichever is available or acceptable) for all areas in the region, both inside and outside of zones. (*It is clear that for both the US and Japanese data there will be levels of confidentiality, availability and mechanisms for authorisation that will need to be agreed over and above that which might be applied simply by FFA and member countries.)*

Alternatively, and if this is simpler and more instantly available, some basic statistics on the average catches and values inside zones and on the high seas.

In the event that such data or information is not immediately available it is suggested that some other public domain data sets are used in the preliminary refinements to the model.

Management Details:

INCIDENTS: What is the history of incidents, including sightings and arrests?

FINES: What are the levels of fines currently used in the region? Are these applied? Are there any constraints? What is the history of fines applied or settlements made?

SURVEILLANCE CAPACITY: What is the time series of changes to surveillance capacity that have taken place, including the economic aspects? What projects/programmes should be included in any economic analysis?

Other aspects:

TRADE OFFS: What trade offs are employed in the overall compliance control scenario? What has been the effect of arrests etc on aid and trade and diplomatic relations?

LITERATURE: Is there any regional or global literature on the analysis of compliance control? Were economic justifications or any level of cost-benefit analysis ever made for the implementation of the Pacific Patrol Boat Project, VMS project etc?

IMPROVED PARAMETER ESTIMATION:

The above information should provided the means to improved parameter estimation for a number of the input requirements of the model. However, two significant features of the model and management game will require improved definition if the results are to approach a realistic evaluation of the situation; the honesty coefficients and the surveillance function.

Honesty coefficients:

Clearly some judgements on the level of honesty - as a reflection of the level of acceptable risk to both individual fishing vessels and collectively as a fleet - needs to be a part of any modelling procedure on the effects of surveillance on the behaviour of foreign fishermen.

There is no methodology for the direct estimation of honesty. Texts on this aspect of criminology reveal little on the determination of honesty coefficients. The bounds of such a coefficient are likely to change with circumstances;

- with the ability to comply with the rules, both from an economic and a social perspective
- with the perceived risk of getting caught and fear of the economic and social penalties;
- with external influences from cultural and political freedoms or constraints.

In addition, there will be distributions of honesty within fleets that reflect the sum of attitudes of individual fishermen. It is unlikely that, with the factors described above, these distributions will be normal, probably being skewed in various ways around the median.

Thus, honesty is multi dimensional with the significant contributions probably unquantifiable in a direct sense. Nevertheless, if we are to attempt to measure the response of fishermen to the effects of compliance control mechanisms and hence the 'cost-benefit' of compliance control activities some estimation, however general, would be a useful starting point. There may be two

approaches to this problem: the use of proxy estimates and direct estimation:

Proxy estimates:

In relation to the South Pacific tuna fisheries there might be a number of characteristics of individual fleets and nations that could be used as measures of honesty. These might include the following:

Reporting

- The relative proportion of compliance with reporting requirements such as the return of logsheets from licensed vessels.
- The ratio between catch statistics and landing statistics.
- Within each fleet it may be possible to determine a distribution of honesty across the fleet by looking at the reporting histories of individual vessels.

Fleet Characteristics

- The proportion of licensed vessels to overall fleet size known to be available to a particular fishery/geographic area, such as in the case of the Japanese zone licensing rules.
- The ratio of reported overall catches to known fleet capacity, either in terms of catch rates or carrying capacity.

Direct estimates:

The measurement of opinion (from market preference to risk assessment) can be subject to rigorous analytical method provided that the surveys are carefully designed. There is a particular characteristic of the current fishery management regime that can be used to good effect in any survey of opinion on risk and honesty. This is the almost complete compliance with the Terms and Conditions of Licensing exhibited by the US purse seine fleet operating within the Treaty Area. All vessels are licensed, they have no opportunity nor reason to be otherwise. All vessels comply with reporting requirements: they are also subject to US official control and have no reason to falsify their records since they are not subject to fee level variations based on the amount of catch, nor on catch restrictions or quotas. As such the US fleet would provide an ideal group to investigate a number of attributes of fishermen's behaviour.

In addition, such a 'control' group could be used as a base from which to measure the responses to the same survey by all groups within the fishery, by nationality or vessel type. These surveys, together with the results of any analyses of the data on the activities of fleets, would be useful in the determination of the risks fishermen perceive that they take when conducting fishing within any part of the zone.

Further Description of the Surveillance Function:

The surveillance function currently used describes a simple exponential curve in which the probability of capturing all illegal vessels tends to 1 as the surveillance cost tends to infinity. This surveillance function is plausible given that almost no matter how much effort is put into surveillance this will never be sufficient to capture all illegal fishing vessels.

However, the curve may not be that simple, particularly at medium to low levels of surveillance effort. The highest level of surveillance (and hence highest probability of capture for any one illegal vessel) assumes the ability to instantaneously capture all vessels as soon as they attempt an illegal activity. Effort must therefore be evenly distributed continuously. At lower levels of surveillance effort, when spatial and temporal distribution are not continuous, the application of that effort will not be random. The deployment of surveillance effort will take into account knowledge and experience and thus the probability of detection/surveillance curve may well be steeper at the lower levels than the current function describes.

Further research work needs to be undertaken on the factors that contribute to the probability of detection curve and to use such factors in the optimisation modelling.

Some approaches to the use of information in increasing the likelihood of encounters is further described in a later section on the expectation of fleet distributions.

FURTHER ANALYTICAL AND SIMULATION WORK:

The following outlines some ideas about how the data from the Japanese fishing fleets across all zones and the high seas might be analysed to provide different strategies for improving individual country returns either through regionally agreed management measures that fall just short of a multilateral arrangement, or a multilateral treaty itself.

It is clear that there could be added benefits from further regional cooperation, perhaps to the extent of tripling the fees to about 15% of catch value for longliners, 19% for pole and liners, if the marginal value of access is used. Or, in the event calculations based on the ability to pay are used, to a level of 8% for longliners and perhaps up to 16% for pole and liners because their profitability has improved in recent years (Geen, pers.comm.).

Nevertheless, while countries may remain satisfied at present with the rate of return, particularly with the 25% rise in overall income as the rate changed from 4% to 5% of catch value, there are still good reasons to undertake some analyses that might provide indications of future benefits under different management scenarios. Such analyses might assist countries by providing quantitative estimates and thus provide confidence in the contention - demonstrable in the case of the US but presently requiring a leap of faith in the case of the Japanese (although indicated by example by Geen) - that increased rates of return and overall incomes are achievable.

The approach to this might include a range of simulations using different management scenarios to test the expectation that present income foregone would be retrieved in later periods following improvement to the rate of return and income overall. The two principle management mechanisms that could be applied are zone closure and the limitation of effort. Both these pose problems to governments in that they have the potential to curtail gross income. In the case of zone closure to the Japanese there is the likely danger that cooperative projects and programmes under aid will also be jeopardised. *(Although this view of linkage between access and fisheries assistance remains there is evidence that attitudes within Japan are changing as fishing industry lobbying power declines - Japan's Fisheries Aid to the Pacific Island Countries - S Tarte, December 1993. Nevertheless such potential losses should also be taken into account. A sub-text of this linkage problem is that maintaining it can often be very advantageous (fisheries goods and services, infrastructure, equipment) directly to those institutions and officials which advise their governments on fisheries matters and provide technical support to fisheries negotiations).*

The effect of any one zone closure would probably lead to increasing effort in adjacent zones, similarly any limitation on effort where this might be less than the average effort. The control of such effort by the adjacent zones, in support of a zone closure, would be extremely difficult to handle. This is because the only mechanism for limiting effort available to countries at the

moment is through capping the number of licences. With the exception of Solomon Islands there are no total allowable catch limitations. Displaced vessels from the closed (or limited effort) zone would simply spend longer of their overall trip time in other zones. Nevertheless, with certain assumptions and other actions - such as also limiting 'days in zone' to previous averages in the open zones as part of the effort limitation exercise - it may well be possible to assess the economic losses both to Japan and the eventual economic gains to the region.

A simulation exercise to assess the effects of zone closure and limited effort is suggested as a way to test the claim that improved economic benefits can be obtained in the future froma multilateral agreement with the Japanese. The simulation exercise would close different zones or groups of zones within the PNA. It could also test what might happen if certain sections of the fleet, say small longliners only or another group, were selectively excluded.

It is not suggested at all that zone closures or limited effort practices actually be put in place. It may be that the threat of such actions would stir the Japanese fleets to calculate their potential losses from being forced into acceptance rather than negotiate their way to an acceptable multilateral with higher (economically valid) rates of return to the region.

This needs no further elaboration here. If the idea to carry out some simulation studies is accepted then perhaps an immediate response would be to detail the nature of the above analytical and simulation work.

EXPECTATIONS OF FLEET DISTRIBUTION AND SURVEILLANCE:

The analysis of fleet distributions has been used in the past to anticipate their movements during the year to provide some means to assess when and where to target surveillance activities. To a large extent such analyses have failed to achieve such an objective. In most surveillance flights that have resulted in encounters there has been either prior information on the location of potential individual infractions or they have been discovered largely by chance.

With the gradual implementation of a Vessel Monitoring System the resulting real time position information of individual vessels and hence the different fleets will provide an improved key to surveillance targeting. The main assumption is that the 'target' individual vessels will almost always be in areas either at the periphery of the current fleet distribution or perhaps in some other area altogether. Fishing patterns also reveal that in a number of circumstances the distribution of vessels is almost random, that there may not be a real 'centre of gravity' to a fleet from which some zone of expected illegal fishing might be readily deduced.

Nonetheless, for certain fleets it may be possible to develop some idea about the changes to the 'centre of gravity' of activity and how this alters over time. With the VMS providing instantaneous assessments of compliant vessel positions and thus being able to generate a vessel track, it may be possible to take the fleet as a whole and produce a time series of 'centres of gravity' to develop what could be called a 'fleet trajectory'. Using such information and including the results of experience and search strategies (perhaps using military tactical planning methods) it may be possible to build up a surveillance model that could be used - instantaneously - with the actual VMS pattern to better target surveillance, both overflight and at sea.

Historical data - with all its problems of accuracy - could be used in a simulation exercise to test some of the assumptions made above, particularly whether in fact there is such a thing as a 'fleet trajectory' and whether it can be anticipated.

Unfortunately, the analyses of fishing patterns (FFA Report No. 89/26) over the years reveals very little change that might be followed in this way. For example, the mean (1983-1988) monthly patterns of effort for purse seine reveal simply that in the early part of the year the 'centre of gravity' of the whole fleet is in the northern PNG zone. The centre moves north across the high seas enclave between PNG and FSM becoming focussed on southwest FSM during June and July before moving back towards PNG during the later months. It may well be that this feature can be predicted and monitored by other means. Perhaps this movement is driven by ocean temperature or current fronts. A knowledge of where these 'hotspots' are at any one time might also be useful in anticipating fleet distribution.

For longliners the picture is even less clear, although the fishing patterns previously developed have not been disaggregated by vessel size. Whether in fact the distribution of fishing effort, even when largely known instantaneously, can be used in the determination of aerial and naval surveillance patterns is largely open to question.

RECOMMENDATIONS:

There are a number of specific recommendations that directly stem from the earlier work, its critical review and as a result of adaptive requirements as perceived.

1. INFRACTIONS

Complete listing of the infractions database as begun by the Legal Division at FFA and as partially completed during the conduct of this review. *(Examples of the work undertaken are attached.)*

Time Frame: Ongoing
Work to be carried out by: FFA

2. RISK PERCEPTIONS STUDY

Assessment of the 'honesty coefficient' as described in the earlier section through analysis using the proxy estimates. Assessment of perceived risk through the conduct of a survey of the attitudes of fishing masters in the fleets of the region. This would be undertaken initially with the US fleet

Time Frame: Immediate, with phased follow up during 1984 and early 1985. Initially, it is anticipated that the FMSP (MRAG) would commission the design of a survey by an expert, together with the necessary background documentation, which would be submitted to FFA for comment and input and then submitted to the US fleet through the annual consultations in March, or at another appropriate time. Analysis would follow, following which an assessment would be made about whether to extend the survey to other fleets in the fishery.
Work to be carried out by: MRAG and FFA

3. ADAPTATION OF THE CFF MANAGEMENT GAME MODEL

Following the concerns raised by and the inputs received from FFA, adapt the model to take into account the specific needs for the region as described in the foregoing sections, including the section on improvements to parameter estimations.

Time Frame: Ongoing, the next prototype to be completed by September 1994 and further work to be undertaken thereafter, finalising by March 1995.
Work to be carried out by: MRAG with input from FFA

4. SIMULATION STUDY

Conduct a specific simulation study on the lines summarised in the previous section.

Time Frame: Begin immediately, initially with a more detailed explanation of the nature of the study and a simulation using available statistics and the public domain information on the pre-1980s Japanese distribution data. Subject to agreement with FFA and obtaining more detailed information progressively improve the accuracy of the simulations and provide a detailed report on the consequences of various management strategies.
Work to be carried out by: MRAG with input from FFA and SPC.

5. ECONOMICS OF FISHERIES COMPLIANCE CONTROL STUDY

Prepare a detailed project proposal for the above study taking into account specific needs of the region but with the overall objective of generating a methodology for continuing assessment of fisheries surveillance and management economics, including operational aspects. *(The concept paper attached at Appendix 1 refers)*

Time Frame: Immediately prepare a project proposal for submission to interested partners, initially to the Programme Manager of the FMSP (at MRAG) and ODA, the concept for which might be submitted to FFC 1994.
Work to be carried out by: MRAG and FFA.