Enforcement Program Optimisation Through Adaptive Management

John P. McKinlay

Department of Fisheries, Western Australian Marine Research Laboratories
PO Box 20, North Beach, WA, 6920, Australia. Email: jmckinlay@fish.wa.gov.au

Abstract. Western Australia operates a diverse enforcement and education program aimed at achieving high compliance in a wide range of commercial and recreational fisheries managed using a mix of input and output controls. Since enforcement resources are invariably insufficient to totally eliminate non-compliance with fishery rules, it is important to ensure that they are optimally allocated toward those areas or activities that pose the greatest compliance risks. While it is generally accepted that compliance with fishery rules by participants is fundamental to the success of any fisheries management plan, most management agencies collect very little data to enable estimates of non-compliance or take of illegal catch. The reasons for this are twofold: compliance information is notoriously difficult to accurately measure, and enforcement personnel often do not have the training or experience to design surveys or experiments. In this paper I explore the concepts of statistical sampling principles, experimental manipulation of enforcement effort, and adaptive management as tools for helping to target enforcement resources for best effect. The role of experimental design and statistics for the collection and analysis of fisheries biological and ecological data is well established. Western Australia has adopted the approach that collecting compliance related information should be undertaken with the same rigor as any of our biological sampling programs. To this end, fisheries officers routinely collect location-, activity-, and fishery-specific contact and infringement information. Analyses of these data help to direct future enforcement activity to specific areas of fisheries where compliance risks appear evident. Officers also take part in large-scale manipulative experiments varying the level of their enforcement activities. I outline the approach to compliance data collection and analysis adopted in Western Australia, drawing on examples of work undertaken in the western rock lobster fishery.

Keywords: Fisheries compliance, manipulative experiments, western rock lobster fishery.

1. INTRODUCTION

Fisheries monitoring, surveillance, and enforcement activities are an integral part of any well-managed fishery. Indeed, the failure of many fishery management programs in the United States has been ascribed to non-compliance with fisheries law (Sutinen *et al.* 1990). Around the world, demands on fisheries resources are increasing, requiring strict regulation to ensure that stakeholders use resources responsibly. Unfortunately, some people choose to disobey fisheries law, so that regulations in themselves are rarely sufficient to ensure responsible resource use. Measures must be undertaken to encourage an acceptable level of compliance with regulations, and most fisheries agencies provide a suite of enforcement and educative measures to achieve this aim. Services delivered within compliance programs may involve complex investigations, routine monitoring and inspection, intelligence gathering, and education activities. These activities are aimed at achieving maximum voluntary compliance and, where necessary, suitable deterrents to ensure that commercial and recreational fishing sectors abide by fisheries legislation.

The question of what constitutes an acceptable level of compliance does not have a straightforward answer, varying according to how particular rules affect management objectives in individual fisheries. Generally, "acceptable compliance" will relate to preserving resource sustainability, ensuring efficient economic returns from a fishery, and providing equitable access to all who may legitimately use the resource. An ideal level of compliance would, of course, be complete voluntary compliance with all fisheries regulations. In practice this is rarely achieved, although some fisheries have for periods approached this level through self-regulation (e.g. Maine lobster fishery (Houtman and Lignell 1996)). Normally, however, an acceptable level of compliance is determined by examining the trade-off between enforcement costs, requirements imposed by the current management strategy, and the effect particular levels of (non-) compliance might have on competing interest groups.

Since obtaining 100% compliance with fishery rules is arguably unachievable, the effective allocation of limited enforcement resources is a primary goal in most regulated fisheries (Fuss *et al.* 1980). Indeed, many compliance programs are complex, leading to significant costs depending on the jurisdiction and the fishery being managed. In Australia, costs are either recovered directly from an industry group for commercial fisheries, or by way of government contribution for recreational fisheries. Under the industry cost recovery process, compliance programs have come under increasing scrutiny of industry groups in terms of costs and details of programs. It is not uncommon, and perhaps understandable, for industry representatives to increasingly pose the question: if compliance with fishery rules is high, can enforcement effort (and therefore enforcement costs) be safely reduced? In order to answer such questions enforcement personnel must be able to provide information on the types of risks of non-compliance that exist in a fishery, compliance rates for particular breaches of fishery rules, and how rates might change under reduced enforcement effort strategies. Such information is not easy to obtain.

In Western Australia, risk assessment workshops are undertaken to identify compliance risks within fisheries. These typically involve representatives from the commercial and recreational sectors of a fishery, as well as management and enforcement personnel. Current and emerging risks are identified and prioritised as part of the process, however often only anecdotal evidence can be offered regarding the extent to which particular risks are a problem within a fishery. The imperative to provide hard evidence to justify enforcement programs has led to the adoption in Western Australia of a compliance research unit with the specific task of assessing levels of compliance, and how those levels might vary with the amount and type of enforcement effort. This work involves systematically measuring a broad range of enforcement activities and associated outcomes, applying the same rigor as can be found in sampling programs monitoring the biological or ecological status of a fishery. The approach taken is most suited to monitoring "routine" sea- and land-based enforcement activities, as might occur for recreational fisheries, non-audit related activities in ITQ managed commercial fisheries, or for individual transferable effort managed commercial fisheries (ITE, Rogers and Penn, 2000). Complex investigative activities are not easily measured, and these are not considered in this paper. Most work to date has, with broad industry support, occurred in the western rock lobster fishery, although the approach is currently being implemented for all commercial and recreational fisheries in Western Australia.

In this paper I examine how compliance-related data are collected and used to assist the Department of Fisheries, Western Australia, and industry improve the effectiveness and efficiency of enforcement programs. In this sense, improvement of enforcement programs can be defined as increasing compliance with fishery rules by stakeholders, and optimising enforcement and educative activities to achieve the best compliance outcomes within available resources. Such a definition encompasses many issues important to modern fisheries management, including fisher attitudes and perceptions toward fishery rules, stakeholder participation in management, and how the field activities of fisheries enforcement officers affect compliant behaviour. I focus on the last of these, showing that careful measurement of enforcement effort and outcomes can lead to meaningful measures of compliance. I also examine how adaptive management (Holling 1978; Walters 1986), through experimental manipulation of enforcement effort, can shed important light on the relationship between enforcement effort and compliance with fishing rules. I present results from the western rock lobster fishery as a case study, although many of the concepts discussed could equally apply to other fisheries.

2. MEASURING ENFORCEMENT EFFORT AND COMPLIANCE

This section discusses the rationale and methods used to measure enforcement effort and compliance in Western Australia. The first step should be to identify all points in the fishing process where fisher contacts are made, the types of activities Fisheries Officers undertake, and the nature of the contact or check. In Western Australia, Fisheries Officers currently record contact and offence rates across a range of compliance activities in all commercial and recreational fisheries. For example, Officers differentiate between random and targeted contacts for personal ("face-to-face") contacts, covert contacts (where they discretely observe fishers from a distance), unattended gear inspections, and contacts relating solely to advice, liaison and education. These contacts are differentiated across the range of field activities undertaken, including general land- and sea-based patrols, processor inspections, aerial surveillance, wholesale/retail inspections, and roadside checkpoints (Table 1). This information is available for all patrol-based work (including educational activities) at a number of predefined locations (10-30) within distinct regions of the state. Marine parks and marine protected areas are assigned their own specific location. A range of offence categories are recorded, and collection of this information has been designed to integrate with more detailed offence information held in the Department. Additional information is collected for commercial vessel checks, including fishery-specific licence, gear and catch checks.

Table 1. Compliance related data collected for the western rock lobster fishery. Symbols indicate that data are either collected (☑), not collected (☒), or infrequently/non-systematically collected (☐) for each cross-categorisation of infringement type and inspection point.

	Commercial and Recreational				Commercial		Recreational
Infringement Type	**Sea[1]**	**Air[2]**	**W/R[3]**	**Road[4]**	**Factory[5]**	**POL[6]**	**POL[6]**
Catch Restrictions							
Under-size	☒	☒	☑	☑	☑	☐	☑
Oversize (female)	☒	☒	☑	☑	☑	☐	☑
Setose *	☒	☒	☑	☑	☑	☐	☑
Tarspot *	☒	☒	☑	☑	☑	☐	☑
Out of season	☑	☑	☒	☐	☒	☑	☑
Gear Restrictions							
Number of pots	☑	☒	☒	☒	☒	☒	☑
Pot dimensions	☑	☒	☒	☒	☒	☒	☑
Escape gaps	☑	☒	☒	☒	☒	☒	☑
Pot identification	☑	☐	☒	☒	☒	☐	☑
Licence Restrictions							
Check licences	☑	☒	☑	☑	☒	☑	☑
Area restrictions	☑	☑	☒	☒	☒	☒	☒

1. **Sea:** checks undertaken by Fisheries Officers operating from agency patrol vessels.
2. **Air:** surveillance activities undertaken from low-flying small aircraft.
3. **W/R:** refers to inspections undertaken in the wholesale/retail sector, including any premises dealing in fish product.
4. **Road:** checks of vehicles involved in the transit of lobsters, including commercial rock lobster transit trucks and domestic vehicles.
5. **Factory:** inspections undertaken at rock lobster processing factories.
6. **POL:** checks made at point of landing. For recreational fishers this includes boat ramps and beaches, for commercial fishers this primarily refers to consignment depots or anchorages.

* Setose and tarspot refer to particular stages of the female rock lobster breeding cycle.

Important considerations in developing the recording system included providing Fisheries Officers training and ongoing support to encourage accurate and timely data recording. This also helped to meet the essential requirement that measures of contact rates and infringements should be measured in a consistent way throughout the state and over time. Centralised validation of all data prior to entry into electronic format also contributes toward data integrity. Acceptance of the system by Fisheries Officers was a major concern when introducing the system, and to this end Officers were encouraged to take ownership of the data from the outset. For example, the system was designed in consultation with Officers, and reporting mechanisms were developed to assist Fisheries Officers in their day-to-day inspection duties. Additionally, a detailed procedures manual on how to correctly record data has been provided to Officers.

When collecting information on infringement activity it is important to distinguish between targeted and random inspections. A large proportion of checks undertaken by Fisheries Officers are random. Here I refer to inspections where an Officer has no preconceived idea that a fisher may be violating regulations prior to conducting a check. Data from random inspections allow estimation of the proportion of fishers engaging in non-compliant activity. Alternatively, Fisheries Officers often have lists of suspected or known offenders who they may check more regularly. These types of checks are considered targeted routine inspections (as distinct from specialised investigations into organised fisheries crime). If suspected offenders are checked more frequently, and they indeed break regulations more often than the "average" fisher, then not differentiating between targeted and random routine inspections will result in over-estimates of non-compliant activity in the fishery as a whole. Any inferences concerning non-compliance in the fishery should therefore be based upon randomly collected data.

The number of attempted or successful prosecutions is also a legitimate measure of illegal activity, although care must be taken when comparing between different time periods since seasonal biological or economic factors may affect non-compliant activity. It is especially important that any measure of enforcement activity be converted to reflect a standard unit of effort. In other words, it is important to record the number of fishers who do not break regulations, as well as those who do. The following hypothetical example helps to illustrate this point:

Interpretation of Infringement Rates – Hypothetical Example

In 1997, fisheries officers carry out 793 checks on vessels, find 121 infringements, decide to prosecute 87 of these, and successfully prosecute 56 cases. In 1998 there were 534 checks on vessels, 67 infringements were detected, prosecutions were initiated for 60 of these, and 52 cases were successfully prosecuted.

Comparing 1998 with the previous year, a naive interpretation of this scenario is that:

- The number of infringements went down by half (121 in 1997 compared with 67 in 1998).
- Attempted prosecutions fell substantially, from 87 in 1997 to 60 in 1998.
- The number of successful prosecutions didn't change very much (56 compared with 52).

It may not be uncommon in some fisheries agencies for the infringement data (point 1 above) to be presented along with the conclusion that compliance increased in 1998 compared with 1997.

A more realistic interpretation is given by standardising on levels of enforcement activity, thus converting absolute figures to rates:

- Infringement rates decreased slightly, but did not drop by half (121/793 = 15.3% in 1997 compared with 67/534 = 12.5% in 1998).
- The attempted prosecution rate rose dramatically, from 87/121 in 1997 to 60/67 in 1998.
- The rate of successful prosecution rose by 20% (56/87 in 1997 compared with 52/60 in 1998.

The correct conclusion is that infringement rates remained about the same between years, but the rates of attempted and successful prosecution rose. Since this result coincided with a decrease in the absolute number of infringements detected, one scenario that might account for such a change is that Fisheries Officers stopped issuing infringements for a rule breach that, perhaps due to technical difficulties, invariably resulted in a failed prosecution.

When considering attempted or successful prosecutions as measures of compliance it is worth remembering that it may be perfectly acceptable (in fact desirable) to have low levels of attempted prosecution provided compliance rates are high. Low levels of successful prosecution, on the other hand, indicate that the application of particular fisheries laws may not work in practice, and should possibly be reviewed. Hemming and Pierce (1997) note that many fisheries have in place some regulations that are difficult to enforce, won't hold up in court, or require resources which are simply not available for their effective enforcement.

DGR Consulting (1996) summarise a range of performance indicators for assessing the efficacy of fisheries enforcement programs, some of which I have discussed. Many of these indicators provide useful clues to designing ways in which to measure non-compliance. For example, Western Australia coordinates a Fishwatch program, a state-wide toll-free telephone service set up to receive public information about illegal fishing activity. Monitoring the percent change over time of telephone calls to Fishwatch might give an indication of trends in non-compliance (although by no means unambiguously – a rise in the number of reported incidents could also result from increased community awareness).

The object of targeting enforcement activities is to optimally direct limited resources to those areas thought to be high-risk for non-compliant activity. Targeting resources shifts the enforcement paradigm from one of reactive catch-up policing to a pro-active, forward-looking approach. This may require the effective collection and use of a variety of information, including catch and effort data, biological research data, attitudinal and demographic data, and intelligence from fishers, fisheries officers and the wider public. While enforcement effort allocation within a fishery will largely depend on the management objectives and identified risks to those objectives, in any specific fishery it is useful to consider the following points:

a) Fisher contacts – is there an acceptable number of contacts a fisher should have with enforcement personnel each year or season? Should there be a fixed probability of contact, or are different probabilities of contact desirable for different regulations?
b) Air vs sea vs land based inspecting – what is the optimal allocation of effort between air, sea and land based enforcement activities? What types of regulations are best policed by each of these approaches? In many fisheries it may be useful to target particular points in the fishing process in order to optimise the use of enforcement resources and encourage compliance. In the commercial sector of the western rock lobster fishery, for example, one of the focus points for inspection is catch consigned to rock lobster processing factories. Since most of the commercial catch is sold overseas, and lobsters must be processed through a licensed factory prior to export, factories provide an ideal "bottleneck" through which almost all catch passes. As long as export prices remain high, lobster-processing factories will provide a convenient point of inspection for the commercial catch.

c) Types of infringement – are some regulations more important than others in achieving management goals, and should these be afforded more attention than others? How should enforcement effort be allocated between infringement types?
d) Temporal and spatial considerations – most fisheries management agencies collect a range of data that may be potentially useful for determining spatial or temporal "hot-spots" where illegal activity may be taking place. For example, there may be certain times of the year when non-legal fish are more abundant, or when prices for fish are particularly high – both these instances may result in higher than normal illegal fishing. Data on contact and infringement rates may be analysed to empirically determine where and when the highest detected infringement activity is occurring. In particular, analyses have the potential to highlight regional differences in compliance that may not be otherwise apparent to fisheries staff dispersed over wide geographic areas.
e) Utilise other information – is there other information to suggest that enforcement effort should be targeted in particular ways? Fisheries agencies often collect economic, licensing, biological and catch/effort data, but rarely is this data considered in the context of optimising enforcement activities. This is unfortunate, since carefully examining existing information already available to an agency is perhaps the least expensive method of helping determine where enforcement activities should be targeted.

3. DETERMINING ENFORCEMENT/COMPLIANCE RELATIONSHIPS

Having determined appropriate measures of enforcement effort and compliance, this information can be used to weight enforcement resources toward those points in the fishing process where there appears a high risk of non-compliant activity. Intuitively, areas where compliance is high might usefully have the amount of enforcement effort reduced – or can they? This is in fact the nub of the problem concerning allocation of enforcement effort: if compliance is high, will reducing enforcement effort cause non-compliance to increase, over what time-scale, and how might this effect best be measured?

Determining and quantifying the relationship between levels of enforcement and observed levels of compliance is a difficult, but increasingly important, task for fisheries management agencies. Faced with increasing pressure from industry participants to demonstrate that enforcement resources are usefully expended, compliance managers must be able to show the linkages between enforcement effort and compliant behaviour. Consider, for example, reducing enforcement expenditure by 50% in a particular fishery. If under this scenario non-compliance with fishery rules increases by a once-only jump of 10%, and the increase does not threaten the sustainability of the stock, it might be reasonable to argue that the fishery was originally over-serviced. If, however, the observed increase was an additional 10% non-compliance *per year*, and such increases would soon put the stock at risk of future collapse, then the resources needed to secure the original level of compliant behaviour might well be justified.

This leads to the question of how compliance-enforcement relationships might be measured in an experimental sense. One approach is to apply different numbers of standardised units of enforcement effort to treatment and control groups. Traditional repeated measures sampling designs are useful in this regard, and the important components in such studies can be summarised:

- Treatment and control groups should be used to unambiguously identify changes in compliance with changes in enforcement effort.
- Measurements should be taken before and after treatment effects are applied.
- Possible time lags between changes in enforcement effort and changes in compliance should be considered.
- Enforcement effort should be quantified and standardised over the period of the experiment.

Notwithstanding these considerations, experiments measuring human behaviour, especially illegal human behaviour, are difficult and can be subject to severe practical limitations. In a manner analogous to the Heisenberg uncertainty principle in quantum mechanics, measuring illegal human behaviour can have the effect of actually modifying the behaviour of the subjects being observed, such that observations may not represent reality in the absence of the observer. For example, if fishers were to suspect a shift in normal enforcement practices had been planned, they might modify their behaviour and in fact become more compliant even with reduced amounts of enforcement effort. This effect is thought likely to have occurred in an experimental reduction of enforcement effort in processing factories in the western rock lobster fishery, when, despite best efforts to ameliorate factors that might affect fishers' normal behaviour, compliance rates improved in both treatment and control groups compared with pre-treatment monitoring.

In the event that traditional experimental approaches prove impractical or cannot be sufficiently disguised from fishers, then an adaptive management approach might be considered. When managing complex systems, such as fisheries enforcement programs, it is often difficult to predict outcomes that may arise from the introduction of different management strategies. Holling (1978) and Walters (1986) recognised this in terms of natural resource management, and introduced the concept of adaptive management as a method to try to reduce uncertainties associated with managing such systems. The principal tenet of adaptive management is that perturbing systems through changes in the management regime, and observing outcomes, can lead to a greater understanding of how the system works compared with small, incremental changes.

Hilborn and Walters (1992) distinguish between active and passive adaptive management. The former involves the experimental manipulation of a management system to test a range of alternate hypotheses in order to determine an optimum management model. In contrast, passive adaptive management relies on the choice of a single "best guess" management regime, and consequent changes to this system only occur if future assessments reveal deficiencies. Enforcement program management in Western Australia utilises an active adaptive management approach, systematically varying the frequency of inspection at different stages in the fishing process and using standardised measures of effort and compliance (described in Section 2) to assess the effects of different strategies. Section 4 describes an example of this approach adopted in monitoring commercial catches of western rock lobster.

Finally, the possibility of natural experiments should not be ignored. Natural experiments are unplanned situations that may provide useful insight into the relationship between compliance and enforcement. For example, an area may not be checked (or checked less frequently than usual) for a period of time because of staff shortages or vessel maintenance. When inspections recommence it is desirable that they recommence with approximately the same level of enforcement effort as when inspections ceased. In this way it is possible to compare the "usual" level of compliance with the level that occurs after a prolonged absence of enforcement activity.

4. CASE STUDY: COMPLIANCE IN COMMERCIALLY CONSIGNED ROCK LOBSTER CATCH

4.1 Fishery Overview

The fishery for western rock lobster, *Panulirus cygnus*, is Australia's most valuable single-species fishery, with annual commercial catches in the 1990's ranging between 9,000 and 13,000 tonnes for a value (ex vessel) of between $200 and $300 million AUD. In 1997/1998 this corresponded to around 39% of the total value of Western Australian fisheries production, and approximately 11% of the total value of national fisheries production (ABARE 1998). Market values for individual fishing operations are typically between $2 and $3 million AUD, and the fishery is estimated to have a total capitalisation of $2 billion AUD. Substantial live export markets to Japan, Taiwan, and China account for the majority of the value of the commercial catch (Marec 1997). The fishery also supports a substantial recreational sector of around 37,000 participants, with catches over the last 10 years of between 3-5% of total commercial landings (Melville-Smith *et al.* 2001).

Geographically, the fishery operates over a wide area along the Western Australia coastline, ranging between latitudes 21°44'S and 34°24'S (Figure 1). In the 2000/2001 season there were around 600 licensed commercial vessels fishing a total of 56,800 pots over 1200 km of coastline, and a recreational sector of approximately 37,000 licensed participants. There is some degree of spatial separation between the commercial and recreational sectors (fishing generally occurs for these groups within 60 and 2 nautical miles of the coast, respectively), but high inshore catches during seasonal lobster migrations presents the opportunity for competition for catch between the groups. Commercial fishers are restricted by license to operate within designated zones, including a highly productive off-shore island region, the Abrolhos Islands. Recreational fishers are generally not restricted in where they may fish, the exception being restrictions against fishing in certain marine protected areas that apply equally to the commercial sector.

Management is by TAE/ITE system, but includes closed seasons, spatial closures, gear restrictions, size-limits on lobster, juvenile and breeding-stock protection, and bag-limits for recreational fishers. Entry to the commercial fishery has been limited since 1963, and current management arrangements centre around a system of limited-entry individual transferable effort; that is, individuals control rights to use a certain number of lobster pots, and these may be bought and sold among existing fishery participants. There are currently no direct output controls in the form of an annual TAC, the management instead controlling the exploitation rate by setting a total

allowable effort (TAE) in order to ensure the escapement of animals to the breeding stock. Entry to the recreational sector is not limited, with catches between 3-5% of the total commercial catch over the period 1987-1999 (Melville-Smith and Anderton 2000).

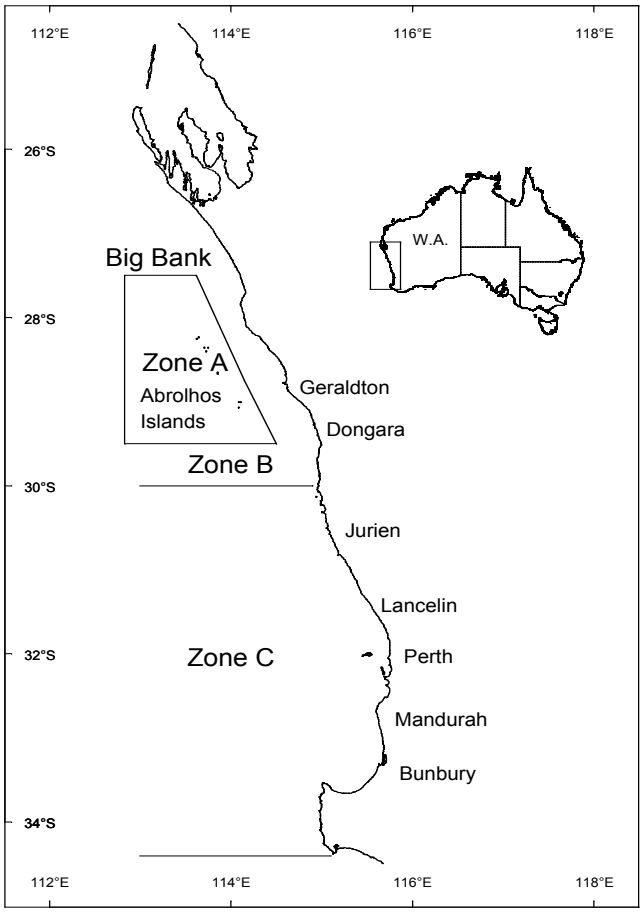

Figure 1. Western Australia coastline showing zones of the commercial rock lobster fishery.

4.2 Enforcement and Compliance

As demands on fishery resources increase, effective regulation and a high level of compliance become vital. Enforcement effort in the western rock lobster fishery is designed to maximise the potential for fishers to voluntarily comply with fishery rules, while at the same time providing a reasonable threat of detection, successful prosecution, and significant penalties for those who do not. This is achieved by effective monitoring and surveillance, appropriately trained enforcement staff, suitable deterrents in the form of fines and administrative penalties, and targeted educative campaigns. The Department of Fisheries WA employs approximately 45 Fisheries Officers involved in rock lobster compliance monitoring around the state each season. Most Officers are permanently located in the population centres of Perth and Geraldton, however there is a permanent presence maintained in six smaller regional towns. Four Officers are specifically employed to undertake mobile patrols along the length of the fishery. These Officers are able to conduct "surprise" inspections, an activity that is particularly important in smaller towns where fishers can quite easily learn the movement patterns of local Officers. Fisheries Officers access the rock lobster fishery at sea by three large patrol vessels (greater than 20 m), 8 small patrol vessels (up to 8 m), and trips aboard commercial fishing vessels.

In 1995/1996 the commercial rock lobster fishery began operating on the basis of partial cost recovery from license fees, with full cost-recovery implemented in the 2001/2002 season. The compliance budget for 2001/2002 was around $3.5 million AUD, approximately 2-3% of the total value of production from the fishery, which compares favourably with many other national and international fisheries compliance expenditures.

Stakeholder participation, and in particular fisher input to risk assessment processes, plays an important role in ensuring that enforcement resources are targeted to best affect among competing compliance activities.

4.3 Adaptive Management to Assess Enforcement-Compliance Relationships in Factory Consigned Commercial Rock Lobster Catch

Inspections by Fisheries Officers of catch consigned by commercial fishers to licensed processing facilities (factories) provide the primary mechanism for determining compliance with many of the catch-related rules in the commercial western rock lobster fishery. While individual commercial fishers maintain a right under licence conditions to sell catch directly to the public, most do not. The reasons for this are twofold; the domestic market for rock lobster in Western Australia is small compared with the volume of the total catch, and processors (who export a large proportion of the catch live to lucrative overseas markets) generally pay higher catch prices than can be obtained through sales direct to the domestic market. This has meant that over 95% of the commercial catch in the last 10 years has been consigned to a limited number of processing factories, providing a convenient "bottleneck" for Fisheries Officers to relatively easily check a known proportion of the catch.

Discussions with commercial fishers and Fisheries Officers reveal three scenarios that might lead to illegal catch being consigned to processing factories. First, small amounts of illegal catch may occasionally be consigned by accident along with legal catch. This can happen due to omission or measurement errors that might arise when skippers are training new crew. Second, fishers are aware that only a relatively small proportion of the catch is inspected by Fisheries Officers (typically less than 5%), and for some fishers there exists the temptation to habitually consign small numbers of illegal animals amongst legal catch. Penalties for detection of small numbers of illegal animals are relatively minor, and, although more severe penalties are imposed on fishers repeatedly making minor transgressions, commercial operators are aware that small, continuing profits can be made in this manner. Finally, some fishers consign large numbers of illegal animals in a single consignment in the hope that their catch will successfully "run the gauntlet" and not be inspected. Although the probability of detection is relatively low, penalties received for large illegal consignments can be severe, in some instances leading to suspension or loss of license.

Working in pairs, Fisheries Officers record information on the catch they inspect in a systematic manner on predetermined data recording sheets, including the date and time the inspection takes place, the fishing vessel that consigned the catch, the number of baskets inspected, and the numbers of illegal animals detected in various categories. During a check Officers will pull aside one or more baskets of catch from an individual fisher. Officers usually check a subset of the total catch consigned by a fisher during an inspection, but may check all of a fisher's catch if there is only a small amount, if they detect breaches in the catch they have checked, or if they suspect a fisher to be breaking fishing regulations. Inspections purposefully directed at particular fishers because of prior information are recorded as targeted, and are treated separately from random inspection in estimating compliance rates.

Examination of this data has shown that compliance in factory consigned catch is excellent. In the 1998/1999 season, Fisheries Officers conducted almost 10,000 catch inspections, individually examining around 1.3 million lobsters, or approximately 5% of the total commercial catch. Most vessels had catch inspected 9-20 times (inter-quartile range). Over 90% of these inspections detected no illegal product, and around 75% of those inspections where illegal product was found detected 2 or fewer illegal animals. Pooling over all infringement categories (the majority of illegal animals were undersize), this equates to around 1.2 illegal animals in every 1,000 lobsters checked. Under certain assumptions about the average size of an illegal lobster, and utilising the known total commercial catch as determined from processing factory records, it is possible to estimate that around 16.4 tonnes of illegal lobster were consigned during the season. In the context of a total commercial catch of 13,000 tonnes, this result is commendable by any standard.

In 1999/2000 the inspection level in factories was purposefully reduced by 80% compared with the previous season, with Fisheries Officers inspecting around 1% of the total commercial catch. This was done to examine if high levels of compliance could be maintained with reduced levels of factory enforcement, allowing Fisheries Officers to be diverted to other points in the fishing process for that season. If high compliance rates could be maintained, then a strong argument could be mounted for reducing the continuing importance of factory inspections in the rock lobster compliance program.

Pooled over all infringement categories, results indicated that infringement rates more than doubled compared with the previous season, to around 2.8 illegal lobsters in every 1,000 animals checked. Extending this rate to the 99% of catch that Fisheries Officers did not check, it is estimated that fishers consigned around 41 tonnes of

illegal product during the 1999/2000 fishing season. Despite the jump in non-compliance, this is still an excellent result considering the total catch for the season was 14,437 tonnes.

The difference between seasons in individual vessel compliance rates is worthy of comment. Figure 2 shows, for each season, individual vessels according to their recorded infringement rate. The dotted line appearing at 0.1 indicates twice the average infringement rate detected in the 1998/1999 season; this figure is chosen arbitrarily to facilitate comparison between seasons. Note that nine vessels with infringement rates greater than two illegal animals per basket in 1999/2000 have not been plotted in order that axes are not unduly stretched. This result shows that the vast majority of commercial vessels in both seasons consigned less than one illegal lobster in every 10 baskets of catch, and that most of these vessels consign no illegal catch whatsoever. The percentage of the fleet consigning greater than one illegal lobster in every 10 baskets remained fairly consistent between seasons (15% in 1998/1999 compared with 18% in 1999/2000). This indicates that the number of fishers breaking rules under conditions of a reduced factory enforcement presence did not change appreciably, but rather that those fishers choosing to break fishing rules did so to a greater extent.

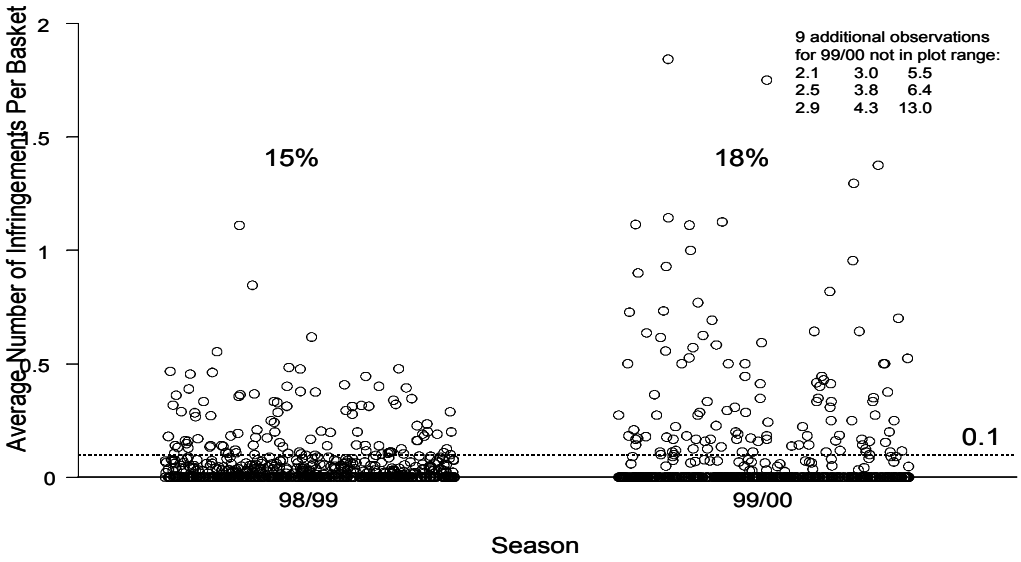

Figure 2. Individual vessel non-compliance rates expressed as the average number of illegal lobster detected per consigned basket of catch. The reference line at 0.1 indicates twice the average rate detected in the 1998/1999 fishing season.

Of particular interest was the reaction of the commercial rock lobster industry to these results. Most observers had anticipated that commercial fishers would judge an inspection rate of 1% of the total catch to be adequate, providing that observed non-compliance rates of around three illegal lobster in every 1,000 checked did not increase in subsequent years. This was not the case, however. Fishers instead expressed the wish that factory inspection levels should be lifted to 3-5% of the total catch. The reasons for this are twofold. First, as evident in Figure 2, most participants in the fishery approach 100% compliance with catch consignment regulations. Most are proud of this fact, and are willing to pay (through the cost-recovery process) to ensure that their competitors have a reasonable chance of detection if they cheat. The second reason is that the infringement notice system for small breaches (akin to traffic tickets) in place in Western Australia acts as a form of process control for skippers and licence holders. By receiving a warning or small fine, fishing operators are alerted to problems in their catch as they occur, rather than being breached for a major offence once a problem becomes established. For example, crew members who are paid as a proportion of the catch may be tempted to place illegal animals in with legitimate catch. If undetected by the skipper, and left unchecked by a low level of factory inspections, the practice may increase until finally a major breach is detected. Many license holders therefore view a rigorous factory inspection program as essential.

5. CONCLUSIONS

Careful collection and analysis of contact and infringement rate data is a priority in all Western Australian fisheries. With increased interest group participation in the management process has come the need to accurately report on enforcement activities, and how these promote and maintain compliance in fisheries. Aside from reporting purposes, such information is vital in helping identify areas at risk of non-compliance, and in directing enforcement resources to best effect. Determining how enforcement effort affects compliance outcomes can be problematic, and careful consideration needs to be given to designing sampling schemes to do this. In particular, time-lags between shifts in enforcement effort and changes in compliance behaviour may initially be unknown and are likely to be non-stationary, requiring continued monitoring through time.

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