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University of Alberta

Understanding the Relationships Between Resource Enforcement and Scarcity in Alberta Fisheries

By

Jordan Richard Walker

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

in

Conservation Biology

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Faculty of Graduate Studies and Research

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Understanding the Relationships Between Resource Enforcement and Scarcity in Alberta Fisheries** submitted by **Jordan Richard Walker** in partial fulfillment of the requirements for the degree of **Master of Science in Conservation Biology**.

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ABSTRACT

A critical concept in conservation biology is how people respond to resource scarcity. In some recreational fisheries, anglers may respond by illegally harvesting protected-length fish when they become scarce. I examined whether an enhanced enforcement strategy can deter anglers from violating regulations, what rationalizations anglers use for their behavior, and whether typical enforcement monitoring is a sufficient indicator of the illegal harvest problem. I concluded that enhanced enforcement did increase anglers' perception of detection and that officers were most efficient when they performed 12 patrols per lake or encountered 3% of anglers at lakes during Alberta's summer angling season. Strongly worded signs significantly increased anglers' perceptions of penalties. Illegal harvest rates decreased when deterrence (i.e. certainty and severity) was high. A large proportion of anglers (37.3%, 383/1026) reported that they had justifiable reasons to illegally keep a protected-size fish, but did not include resource scarcity as a justifiable reason. Typical enforcement monitoring using violation rate (i.e., the number of violations compared to the number of anglers) failed to gauge the actual illegal harvest rate. To break the scarcity-illegal harvest relationship, fisheries managers need to develop new ways to communicate biological knowledge to the public to reduce the consumptive nature of fishing in Alberta.

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CHAPTER 1 – INTRODUCTION

Anglers may respond to resource scarcity by harvesting illegally (Sullivan, 2002). In this thesis I describe how this scarcity relationship affects the enforcement of fisheries size-limit regulations, how it informs the interpretation of angler rationalizations for cheating, and how this relationship affects the type of monitoring enforcement officers must conduct to measure the illegal harvest problem. Illegal harvest refers the proportion of protected-length fish that have been illegally kept out of the total number of protected-length fish caught by recreational anglers (Sullivan, 2002). I use the word scarcity to refer to the low relative abundance of fish as measured by the catch-per-unit-effort (CPUE) of protected-size fish.

Length-based size-limits are widely used in North America to regulate recreational fishing harvests (Radomski, et al., 2001). While they have become popular and have largely replaced creel limits, they have been applied in an ad hoc way that has not led to experimentation about what has and has not worked to meet management objectives (Radomski, et al., 2001). In Alberta, length-limits have been applied in consistent provincial-wide plans for walleye (*Sander vitreus*) (Berry, 1995) and northern pike (*Esox lucius*) (Berry, 1999) that have allowed for monitoring and experimentation through adaptive management (Sullivan, 2003).

By large-scale experimentation, illegal harvest has been found to be a consequence of restrictive regulations in Alberta (Sullivan, 2002). This illegal harvest can negate the benefits of the regulations (Gigliotti and Taylor, 1990). In response to this finding, I have conducted field and modeling experiments to:

1) determine angler perceptions of enforcement techniques at lakes with and without enhanced levels of enforcement;
2) quantify perceptions of likelihood of detection and punishment to evaluate the deterrent effect of enhanced enforcement;
3) examine illegal harvest rates at lakes with and without enhanced enforcement;
4) identify angler attitudes towards illegal harvest and report the reasons why they believe they will or will not follow regulations;
5) evaluate with models and field study how angler response to fish scarcity affects the type of monitoring that is necessary to estimate the incidence of illegal harvest; and
6) offer recommendations to biologists and enforcement officers about how best to reduce illegal harvests.

There are three broad purposes for writing this thesis.

Firstly, fisheries management and enforcement management plans have previously been considered in exclusion of one another. I wanted to more closely integrate fisheries enforcement and management plans and to better explain how one affects the other. I believe enforcement officers and biologists need to work much more closely to achieve their common goals of resource conservation.

Secondly, the study of the human response to resource scarcity, through sociology, psychology, or economics has seldom been empirically linked to population ecology in the field of conservation biology. I have attempted to integrate social disciplines with fisheries enforcement and fisheries management.

Thirdly, I have modeled and empirically tested with field data the lack of relationship between the illegal harvest rate of walleye and the encounter rate of violations by conservation officers. I wanted to identify the implications of only monitoring violation encounter rates and to encourage other resource managers to investigate this phenomenon for other natural resources.

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CHAPTER 2 – EFFECTS OF ENHANCED FISHERIES ENFORCEMENT ON DETERRING ILLEGAL ANGLING HARVEST

2.0 INTRODUCTION

When managed sustainably, fisheries provide significant recreation and commercial opportunities and are important components of aquatic ecosystems that deliver essential ecological services (Pitcher, 2001). Many fisheries, however, are declining or overharvested as a result of high harvest pressure relative to productivity (Post et al., 2002). Rebuilding these fisheries requires effective and precautionary management relying upon restrictive regulations (Ludwig, Hilborn, and Walters, 1993; Richards and Maquire, 1998). Effective management implies a requirement for angler compliance (Gigliotti and Taylor, 1990), yet restrictive regulations are often socially unpopular and difficult to enforce.

Managers expect sufficient voluntary angler compliance with regulations (Novinger, 1984), but field studies conducted to investigate illegal harvest have reported rates between 18.7% and 67% (Sullivan, 2002; Glass and Maughan, 1984; Paragamian, 1982). These illegal harvest rates can make regulations ineffective. In simulations, illegal harvests that exceeded 5% (Sullivan, 2003) and 15% (Gigliotti and Taylor, 1990) negated the regulation benefits for the populations modeled. Enforcement is a logical management tool for agencies to apply to law-breaking behavior, but few size-limit violations are encountered by officers (Pierce and Tomcko, 1998; Van Vooren, 1991). Because the rate of violations encountered by conservation officers is low, typical large-scale enforcement is often considered inefficient and ineffective by managers (Sullivan, 2002; Van Vooren, 1991).

I studied whether an enhanced enforcement strategy designed by conservation officers could deter anglers from committing size-limit violations for walleye (*Sander vitreus*) and northern pike (*Esox lucius*), simultaneously. I investigated angler perceptions of two aspects of general deterrence theories (Liska and Messner, 1987; Pfohl, 1994): (1) the probability of detection by a conservation officer (certainty of punishment), and (2) the penalty for illegally harvesting one protected-size walleye or pike (severity of punishment). The purposes of the study were to (1) determine how component parts of an enhanced enforcement strategy affected these angler perceptions of detection and penalties, and (2) investigate how the deterrent effect of the enhanced enforcement strategy affected illegal harvest of pike and walleye.

2.1 METHODS

2.1.1 Study Design

This study included 14 investigations at 12 lakes ranging in size from 789 ha to 37,300 ha in northeastern Alberta, Canada (Table 2.1). A good physical description of the lakes and fisheries can be found in Mitchell and Prepas (1990) and Nelson and Paetz (1992).

I applied the enhanced strategy to treatment lakes and measured angler responses at treatment and control lakes using angler perception surveys and illegal harvest surveys during the summers of 2000 and 2001.

2.1.2 Enhanced Enforcement Strategy

To design the enhanced enforcement strategy, I met with experienced conservation officers at a workshop in May 2000. I discussed the management dilemma that was occurring as a result of high illegal harvests coupled with high angler-effort and depressed fisheries stocks. The officers agreed to design an enhanced enforcement strategy that they felt would be most effective at reducing the illegal harvest. I agreed to test the strategy as an experimental hypothesis. The enforcement strategy had to be applicable at any lake, quantifiable, and fit within existing budgets.

The enhanced enforcement strategy that the officers designed consisted of “saturation events”, increased patrol frequencies throughout the summer, and the use of signs and posters with “no-nonsense” educational messages. A saturation event consisted of officers concentrating their enforcement activities at a treatment lake for a weekend early in the angling season. The purpose of the saturation event was to raise angler awareness of officer presence at the lake. The officers attempted to contact all anglers at least once during the weekend using boat patrols, shore patrols, and road check-stops. I considered a patrol event as officers intercepting anglers to check for violations. If two or more officers worked independently during the same time frame at a lake, then two or more patrols were considered to have occurred.

Increased frequency of patrols was conducted at each treatment lake and applied throughout the summer. The decision about the number and type of patrols to be conducted at each lake was made by the local officers, who estimated the need for enforcement based upon their experience.

Large signs placed at boat launches, and posters placed in highly visible locations such as washrooms, fish cleaning stations, and campgrounds were used to clearly convey messages of no-tolerance for regulation violations and high penalties for violators caught at the lake (Appendix 1). These stark, no-tolerance messages were designed to educate the public about the consequences if caught with a protected-size fish. A key message on the sign was that violators had recently been assessed fines of up to $2500. Unlike most awareness programs, these signs did not focus just on broad education and conservation messages, appealing to anglers' sense of fairness and ethics. The broad education approach has been in place in Alberta since large regulation changes occurred in 1996 and 1999 for walleye and pike, respectively.

The field experiment was applied at a total of nine lakes from mid-May to mid-August in 2000 and 2001 (Table 2.2). Five control lakes were selected where typical patrol frequencies were maintained. No saturation events, enforcement signs, or posters were placed at these lakes. At all lakes, officers recorded the number and length of patrols (excluding travel to and from the lake), the number of anglers contacted and the number of size-limit violations encountered per angled fish species. An estimate of the percentage of anglers contacted by officers was calculated by dividing the number of angler contacts made by all officers at a lake by the estimated number of anglers in the sport-fishery. The number of anglers in the sport-fishery was estimated from the most recent creel survey performed at the lake. I assumed that the number of anglers using the lake did not change since the last survey. The creel survey program is a summer-season survey of anglers' catch and effort conducted using boat launch interviews with anglers returning from their fishing trips. These surveys have been conducted in previous years as part of an ongoing stock-monitoring program (Patterson and Sullivan, 2000).

2.1.3 Angler Perception Surveys

Surveys were conducted at each study lake, with individual anglers, throughout the summer during weekends and weekdays. I introduced myself as a student biologist conducting a survey of anglers for Alberta Fish and Wildlife and explained that the purpose of the survey was to gather a group of angler's opinions and observations about fisheries enforcement at the lake. I emphasized that I was not an enforcement officer and this distinction was repeated later in the interview. I dressed casually, did not wear a uniform, and drove a vehicle that would not be identified as a department enforcement vehicle. Anglers were told that the survey was completely voluntary, anonymous, and confidential, and that they may quit at any time. These surveys were conducted with anglers that had been fishing at the lake in the previous 24 hours. Less than 2% of anglers refused to participate.

Anglers contacted at each study lake were asked two questions. (1) *When you were fishing, what chance (in percent) do you think you had of being checked by an enforcement officer at this lake?* (2) *What do you think the penalty (in dollars) is for keeping one undersized (illegal) walleye or pike at this lake?* The perceptions of detection and penalties for each angler were scaled between zero and one by dividing each by the largest value recorded for all the lakes. I selected an interactive model for deterrence (Liska and Messner, 1999) which assumes that detection and penalties operate together to produce the deterrent effect. The scaled values were multiplied together and a mean deterrence was calculated for each lake. Sociologists may call this the "expected penalty", but I will refer to it as deterrence. These means were scaled (between zero and one) to the lake with the highest average (Pinehurst Lake). Because the detection and penalty responses were first scaled between zero and one before multiplication, I assumed each component had an equal weight in the determination of deterrence.

Because the detection, penalty and deterrence responses were non-normal for each lake, the responses of individual anglers were bootstrapped 2000 times and a mean was calculated for each simulation (Haddon, 2001). Confidence intervals at the 95th percentile were derived empirically from the likelihood profiles for each simulation.

2.1.4 Illegal Harvest Surveys

Illegal harvest for walleye and pike is the proportion of protected-size fish retained by anglers out of the estimated total number of protected-size fish caught by the anglers (Sullivan, 2002). These parameters were estimated at treatment lakes for walleye and pike with creel surveys and test-fisheries as described in Sullivan (2002). I did not conduct creel and test-fishery surveys at control lakes because the resulting sample size would be too small for analysis between perceptions of detection, penalties or deterrence at control and treatment lakes. I chose to survey treatment lakes and examine the response to the highly variable enforcement effort between lakes.

The number of protected-size fish caught by anglers was estimated by comparing the ratios of legal to protected-size fish in both the test fishery and the creel survey. These ratios would be equal if illegal harvest was 100%. These estimates represent a conservative, minimum value of illegal harvest, and exclude the fish concealed by anglers or eaten as shore-lunches. Confidence intervals (95^{th} percentile) were calculated around the estimate of the total catch of all sizes of fish in the sport fishery (N), by simulating a binomial maximum likelihood profile (Zar, 1999). Confidence limits for illegal harvest were calculated by dividing the number of protected-size fish retained by anglers in the creel survey by the upper and lower confidence intervals around N. Because a few anglers release legal-size fish, I assumed an arbitrary constant value of 10 % legal-size release and added this to the value of legal-size fish observed in the creel surveys.

2.2 RESULTS

Within treatment and control groups, a wide range of enforcement effort was applied. On average, officer patrols, patrol hours, and angler contacts at the treatment lakes were 3.2 times, 4.8 times and 6.0 times higher, respectively, than at the control lakes (Table 2.2).

Anglers' perceptions of detection were positively correlated with enforcement effort. The perception of detection at treatment lakes was significantly higher than at the control lakes (t = 3.04, df = 12, p = 0.01) (Figure 2.2, Table 2.3). At control lakes the perception of detection ranged from 23.7 % to 38.5% with a grand mean of 30.0 % (n = 5) (Table 2.3). The perception of detection at treatment lakes ranged from 31.3 % to 53.4 % with a grand mean of 42.5 % (n = 9)(Table 2.3)

The perception of penalties at treatment lakes was significantly higher than the control lakes (t = 7.4, df = 12, p <0.01) (Figure 2.2, Table 2.3). At control lakes, the mean perception of penalties ranged from $121 - $433 and had a grand mean of $239 (n = 5). The mean perceptions of penalties at treatment lakes ranged from $577 to $1402 with a grand mean of $1040 (n = 9). At control lakes, 6.1% of anglers thought the penalties were greater than $500 compared with 41.5% of anglers at treatment lakes. At control lakes, 34% of anglers remembered and reported the penalty amount of $2500 indicated on the signs.

I tested for a correlation between the mean perception of penalties and detection within treatment and control lakes to determine if these factors were independent of one another. I concluded that perception of detection and penalties were independent because I found no correlation between these factors at either control (r = 0.32, n = 5) or treatment lakes (r = 0.52, n = 9). Therefore, anglers did not report that they thought the penalties were high when they thought the chance of detection by an officer was high, or conversely.

The deterrence at treatment lakes was, on average, 6.3 times higher than the control lakes (t = 4.9, df = 12, p <0.01) (Figure 2.2, Table 2.2) with a grand mean of 0.084 (n = 5) at control lakes and a grand mean of 0.53 (n = 9) at treatment lakes. The proportion of the deterrence due to detection or penalties was not different between treatment and control groups (t = 1.5, df = 12, p = 0.16). On average for all study lakes, detection made up 63% of deterrence and ranged from 47% to 77%. Conversely, the penalties made up 37% of the deterrence and ranged from 33% to 53%.

I observed no treatment effect of signs and saturation patrols (ANCOVA, F = 1.33, df = 1, p = 0.28) or lakes size (F = 0.58, df = 1, p = 0.46) on anglers' perception of detection. The percentage of anglers checked by officers (enforcement effort), however, was a significant factor explaining the increase in perception of detection at treatment lakes (F = 10.99, df = 1, p <0.01, r^2 = 0.73). This analysis was performed in SYSTAT 6.0.

Perception of detection was positively but not linearly correlated to enforcement effort (percentage of anglers checked, r = 0.91, p < 0.01; number of patrols, $r = 0.95$, $p < 0.01$; patrol hours excluding travel time, $r = 0.93$, $p < 0.01$) (Figure 2.3). As the percent of anglers checked by officers increased from 1% to 24%, the perception of detection increased from 23% to 54%. This relationship shows a diminishing return on the perception of detection for an increasing investment of enforcement effort. An asymptote in this relationship occurs when the percentage of anglers contacted by officers is approximately 3% and the mean perception of detection is 37%. Three percent of anglers contacted by officers corresponded to 27 patrol hours (excluding travel time to and from the lake), 12 patrols, or 150 angler-checks.

The estimates of illegal harvest rates for walleye at three treatment lakes were within the range of 20 estimates previously described for walleye populations in the study area when catch rate was considered (Figure 2.4) (Sullivan, 2002). Only routine enforcement was conducted during Sullivan's study. The catch rate of protected-size walleye strongly influenced the illegal harvest rates for walleye in Sullivan (2002) and appears also to have influenced the illegal harvest of walleye in this study. Unlike walleye, I did not observe a significant relationship between catch rate for protected-size pike and illegal harvest of pike ($r = 0.13$, $p = 0.37$)(Figure 2.4). Over the range of catch rates of protected-size pike I observed (0.061 to 0.33 pike/hr), illegal harvest rates of pike did not exceed 8.7%.

Although sample sizes are small, I observed within the treatment lakes a trend toward reduced illegal harvest rates at lakes with high deterrence ($r = 0.82$,

$p = 0.067$, n = 7) (Figure 2.5). The lowest pike illegal harvest rate of 0.7% (0.3% to 1.1%) occurred at Pinehurst Lake, which had the highest deterrence of 1.0. The highest pike illegal harvest rate of 8.7% (6.5% to 13.4%) occurred at Wabamun Lake, which had the lowest deterrence of 0.32.

2.3 DISCUSSION

2.3.1 Perception of Detection and Penalties

Theorists generally agree that certainty and severity of punishment are both important factors affecting general deterrence (Nagin, 1998; Paternoster, 1987). Recently, researchers have begun to study perceptions of these factors, arguing that people are not likely to accurately perceive the objective levels of these factors (Liska and Messner, 1999). In our study, anglers were able to perceive whether the probability of detection was high or low at the lake (Figures 2.1 and 2.2). They tended, however, to overestimate the actual chance of detection. In Figure 2.2, the percentage of anglers checked refers to the proportion of the summer anglers that were encountered by officers divided by the total number of anglers at the lake in the summer as estimated from creel surveys. The overestimation was highest when enforcement was very low (nearly 25 times the estimated actual chance of detection). The overestimation was lowest when the enforcement level was very high (nearly twice the estimated actual chance of detection). It appears that anglers can make a better assessment of the true probability of detection when they see officers at the lake more frequently. When the enforcement is very low, anglers may have a difficult time assessing the actual chance of being checked. This overestimation suggests that a lower perception threshold of about 22% may exist perhaps because anglers remember previous experiences from other lakes or other trips or because they may think that there is always a remote chance of being checked. Perception of detection may not have exceeded 55% because there were always new anglers entering the fishery from outside the local area who would be unfamiliar with the enforcement conditions at the lake. Perhaps a high patrol effort over several years would result in even higher perceptions of detection, as these less frequent anglers also became knowledgeable about the conditions.

Angler perception of detection increased quickly, from about 22% to nearly 40% when the percentage of anglers checked by officers increased from 1% to about 3%. This rapid human response would suggest that anglers may be sensitive to changes in enforcement conditions and communicate this information quickly. Information exchange is a necessary mechanism for general deterrence to work, as anglers communicate the risks and penalties for violating (Liska and Messner, 1999). The quick change in perception of detection also suggests that anglers may be sensitive to decreases in enforcement effort and that the general deterrent effect may be short-lived (although there is a possibility of a lag as anglers learn about the conditions). I speculate that this quick communication response may help to explain the overestimation of detection risk if anglers are telegraphing and exaggerating information. Multiple, compounded exaggerations by anglers may result in an overestimate as the information is passed from one angler to another. I speculate that the apparent interest in this information by anglers suggests perhaps a motivation to harvest illegally by some anglers when the risks are low. The implication to enforcement management is that even small increases in enforcement levels may considerably raise the perceptions of detection.

When there are many lakes in an officer's district, applying an enforcement effort that contacts more than 3% of the anglers over the season is inefficient. Enforcement effort applied beyond this asymptote has diminishing returns on perception of detection. Officers should apply an enforcement effort up to this asymptote and then switch lakes and apply effort elsewhere rather than continuing to conduct patrols at the original lake.

Because saturation patrols were not effective in raising the perception of detection, enforcement effort should be applied throughout the season, not over a short period of time. Anglers likely perceived the high enforcement effort for the saturation weekend, but statistically this effect did not carry through the summer season. This may have been because the turnover of anglers at the lake would not allow for this effect to be transmitted through the season and anglers' were able to perceive the reduced enforcement presence when the weekend was over; reassessing the low risk of detection. Repeated visits by officers were more effective in raising the perception of detection.

Lake-size was not a significant factor in determining perception of detection. Therefore, enforcement effort can be applied effectively by officers even for the largest lakes that I studied.

The use of signs and posters was effective in changing anglers' perception of the penalties for retaining a protected-size fish. The range in the perception of penalties within the treatment group was probably a result of how well the lakes were posted with signs. Big lakes with many access points were more difficult to post effectively than small lakes. At control lakes, four of 352 anglers reported that they thought the penalties for keeping a protected-size fish would be $2500 during the study (a direct value quoted from the warning signs posted at treatment lakes). This suggests there was very little intermixing of anglers from treatment and control lakes but that some anglers transfer knowledge from one lake to future experiences at another lake.

2.3.2 Illegal Harvest, Desirability, and Deterrence

The difference in illegal harvest between walleye and pike may be explained by the difference in the desirability of these species by anglers. This difference in desirability may be in part due to the relative scarcity between these two species (with northern pike being more abundant), but it also may be an intrinsic value due to other qualities such as palatability or preference in the type of angling experience. In either case, in Alberta, walleye are highly prized and, given the choice, most anglers would prefer to catch a walleye than pike (Berry, 1997). It seems when walleye become scarce (low catch rates), they become even more desired by anglers. At Seibert Lake, under enhanced enforcement conditions, anglers were willing to risk the potential punishment for the benefit of keeping a protected-size walleye when catch rates were low. At higher catch rates, protected-size walleye were less desirable (less scarce) and anglers were not willing to risk the potential punishment. Unlike walleye, when pike were scarce (low catch rates) anglers did not respond by increasing their illegal harvest. I speculate that small pike are not as desirable as a small walleye, and under these enhanced enforcement conditions most anglers are not willing to risk the punishments for the benefit of keeping a small pike, regardless of catch rate. Anglers often refer to small pike derogatorily as “hammer-handles not worth keeping anyway”. I have rarely heard similar phrases to describe small walleye.

Illegal harvests of walleye and pike occurred under all enforcement strategies. The lowest estimates of walleye and pike illegal harvests were 1.1% and 0.7%, respectively and the highest estimates were 51.0% and 8.7 %, respectively. I conclude that a small proportion of anglers will never be deterred from illegally harvesting protected-size fish, and that this must be considered in management strategies designed to recover stocks. Crane, Warner, and Kuchma (1999) determined a similar relationship in the reduction of illegal commercial fish harvests as a function of an increased rate of United States Coast Guard officer boardings on ocean vessels. Through increased enforcement, commercial violations decreased, but did not reach zero. They estimated that 1% of fishermen would not be deterred even at very high boarding rates. After interviews with wildlife poachers in Louisiana, Forsyth, Gramling and Wooddell, (1998) reported statements from some that indicated they would likely always remain poachers.

2.3.3 Model of Integrating Fisheries Management and Enforcement

To achieve more effective management, I propose an integrated approach to fisheries management and enforcement in Alberta that considers these human responses to enforcement and fishery conditions.

This descriptive precautionary model considers three relative harvest risk categories; low, medium and high, which depend on the stock status of the fish population (Figure 2.5). The approach requires that stock assessments be conducted and populations monitored and reclassified if stock conditions improve or decline.

Healthy populations have a low risk of immediate over-harvest and can afford a moderate harvest of fish. These populations can have more liberal size-limit regulations and be given a lower enforcement priority. These fisheries will attract large numbers of anglers, so there will be a tendency to direct higher enforcement resources toward these lakes because it is easy for officers to encounter anglers. This, however, is inefficient because illegal harvest rates at these fisheries will already be low because catch rates of fish are relatively high. These populations can afford the small illegal harvest rate and this can be compensated for in the initial design of the harvest regulations. Motivation and reward for enforcement personnel are often directed at maximizing the number of arrests or citations per time expended. My research calls for a different "currency" of motivation; maximizing beneficial biological impact on the resource. By maximizing deterrence effectiveness enforcement officers may be most efficient.

Moderately over-fished populations have a continued over-harvest risk. A long-term recovery might be achieved while sustaining a small harvest if restrictive size limits are used and illegal harvest remains small. Reduced catch rates, however, make these fish more attractive to anglers. These lakes should receive the enhanced enforcement, without saturation patrols, to deter these anglers. Inexpensive signs should be posted to emphasize the potential consequences for violations. Officers should apply an enforcement effort of approximately 12 patrols, 150 angler contacts, or 3% of anglers over the open water season. If stock monitoring shows the population recovering, then it should be reclassified to the low-risk category. If the population does not improve or continues to decline, the lake should receive the next higher category of protection.

Severely over-fished populations have an immediate, high risk for extirpation if a significant harvest is continued. These fisheries require the highest level of regulatory protection; a no-harvest regulation, which allows us to have a lower enforcement priority at these fisheries. From experience in Alberta, when no-harvest regulations are applied to lakes, angler effort drops to a small fraction of that observed at lakes with harvest regulations (Sullivan, 2002). At these lakes, officers find it difficult to encounter many anglers on patrols. Of the few anglers encountered, most have not caught a fish because the catch rates are very low (<1 fish per 10 hours). Enforcement patrols are inefficient under these circumstances. The very low angler effort means that the biological effect of the illegal harvest can be very small.

Officers and biologists working together to study the human dimensions of applied enforcement and biological regulations, are able to learn how to maximize the effect of their management plans. This collaborative adaptive approach to learning leads to innovative new strategies for conservation. By adopting a researched management strategy that ensures the desired biological regulation effect and the enforcement deterrent effect work in concert, agencies can be most efficient with their human and natural resources. When biologists and officers understand how each of their contributions work together to contribute to the maximum conservation at the fisheries, agencies will be effective resource stewards.

Table 2.1. Lake size (ha), angling regulations and treatment category for study lakes.

Lake and Year [a]	Area (ha)	Group[b]	Pike size limit[c] (cm)	Pike bag limit	Walleye size limit (cm)	Walleye bag limit
Pinehurst 2000	4070	T	63 min.	3	50 min.	3
Beaver 2000	3310	T	63 min.	3	50 min.	3
Cold 2000	37300	T	63 min.	1	50 min.	3
Moose 2000	4080	T	63 min.	1	50 min.	1
Seibert 2000	3790	T	100 min.	1	42 – 53 prot.slot	3
Lac Ste. Anne 2001	5450	T	63 min.	3	catch-and-release	0
North Buck 2001	1900	T	63 min.	3	catch-and-release	0
Baptiste 2001	981	T	63 min.	3	50 min.	3
Wabamun 2001	8180	T	63 min.	3	catch-and-release	0
North Buck 2000	1900	C	63 min.	3	catch-and-release	0
Baptiste 2000	981	C	63 min.	3	50 min.	3
Touchwood 2000	2900	C	63 min.	3	catch-and-release	0
Lac La Nonne 2001	1180	C	63 min.	3	50 min.	3
Long 2001	584	C	63 min.	3	catch-and-release	0

[a] Total length (maximum)

[b] Baptiste and North Buck lakes were included as controls in 2000 and as enhanced in 2001.

[c] T = Enhanced Enforcement Treatment; C = Control

Table 2.2. Enforcement effort applied by officers at study lakes in 2000 and 2001.

Lake	Group[a]	Saturation Patrol Dates	Total Patrols	Patrol Hours	Anglers Contacted
Pinehurst 2000	T	02, 03 June 2000	100	199	1250
Beaver 2000	T	23, 24 June 2000	50	69	896
Cold 2000	T	14, 15 July 2000	25	47	381
Moose 2000	T	14, 15 July 2000	23	79	945
Seibert 2000	T	04 June 2000	6	16	165
Lac Ste. Anne 2001	T	19, 21 May 2001	11	36	175
North Buck 2001	T	19, 21 May 2001	8	22	171
Baptiste 2001	T	07 July 2001	4	13	139
Wabamun 2001	T	19, 21 May 2001	30	125	460
North Buck 2000	C	N/A	14	17	79
Baptiste 2000	C	N/A	2	8	54
Touchwood 2000	C	N/A	6	7	23
Lac La Nonne 2001	C	N/A	8	24	190
Long 2001	C	N/A	14	13	81
Total			301	675	5009

[a] T = Enhanced Enforcement Treatment; C = Control

Table 2.3. Values and confidence intervals for anglers' perceptions of detection, penalties, and deterrence at study lakes.

Lake	Group[a]	Perception of Detection (%) Mean[b] (95% CI)	n	Perception of Penalties ($) Mean[b] (95% CI)	n	Perception of Deterrence Mean[b] (95% CI)	n
Pinehurst 2000	T	53.5 (47.8 – 59.3)	82	1390 (1140 – 1645)	82	1.00 (0.80 – 1.22)	82
Beaver 2000	T	42 (34.4 – 46.6)	91	1028 (802 – 1278)	83	0.51 (0.36 – 0.68)	91
Cold 2000	T	43.3 (37.5 – 49.9)	86	919 (676 – 1155)	81	0.47 (0.33 – 0.65)	86
Moose 2000	T	51.0 (44.5 – 57.3)	85	1055 (820 – 1305)	84	0.60 (0.47 – 0.80)	85
Seibert 2000	T	41.1 (36.3 – 47.0)	74	1158 (866 – 1389)	74	0.54 (0.38 – 0.73)	74
Lac Ste. Anne 2001	T	34.2 (26.8 – 40.9)	68	1024 (787 – 1312)	68	0.42 (0.28 – 0.62)	68
North Buck 2001	T	40.4 (31.3 – 45.5)	78	1143 (901 – 1394)	76	0.45 (0.28 – 0.62)	78
Baptiste 2001	T	30.1 (24.3 – 37.9)	71	1177 (923 – 1455)	71	0.51 (0.33 – 0.66)	72
Wabamun 2001	T	48.8 (45.8 – 55.0)	60	605 (370 – 825)	60	0.32 (0.19 – 0.47)	60
	Mean T	42.5 (31.3 – 53.4)	695	1040 (577- 1402)	679	0.53 (0.32 – 1.00)	696
North Buck 2000	C	23.9 (18.1 – 29.6)	79	189 (150 – 246)	77	0.053 (0.019 – 0.095)	79
Baptiste 2000	C	25.8 (21.3 – 32)	82	108 (87 –160)	77	0.047 (0.029– 0.081)	82

Touchwood 2000	C	22.8 (17.7 – 31.1)	59	210 (105 – 313)	59	0.033 (0.020– 0.056)	59
Lac La Nonne 2001	C	40.0 (31.4 – 46.3)	61	400 (277 – 607)	56	0.21 (0.12 – 0.3)	61
Long 2001	C	37.1 (31.2 – 42.7)	84	232 (164 – 352)	83	0.080 (0.062 – 0.10)	84
	Mean C	30.0 (22.8 – 40.0)	365	239 (121 – 433)	352	0.084 (0.033 – 0.21)	365

[a] T = Enhanced Enforcement Treatment; C = Control

[b] These are pseudovalues from the maximum likelihood profiles of bootstrapped means. 95^{th} percentile confidence intervals were derived from the likelihood profiles for each data set.

Table 2.4. Summary of the parameters used to estimate illegal harvest at study lakes.
Prot. = numbers of protected-length fish. Legal = numbers of legal length walleye.
Illegal harvest is the number of protected length kept / protected-length caught.
Brackets indicate 95% confidence intervals.

Lake and Year of study[a]	Creel survey (from interviews)						Test Angling				Estimates			
	Anglers	Hours	Walleye kept		Pike kept		Walleye		Pike		Walleye		Pike	
			Prot.	Legal	Prot.	Legal	Prot.	Legal	Prot.	Legal	Prot. Caught	Illegal Harvest (%)	Prot. Caught	Illegal Harvest (%)
Pinehurst 2000	5128	6486	17	266	7	68	282	63	179	12	2069 (1622 – 2807)	1.32 (1.0 – 1.7)	1634 (1058 –3446)	0.68 (0.3 – 1.1)
Beaver 2000	8061	4005	10	29	4	20	264	8	70	4	1367 (843 – 3489)	1.1 (0.4 – 1.7)	334 (184 – 1564)	1.3 (0.3 – 2.4)
Cold 2000	6001	4035	–	–	2	59	–	–	97	34	–	–	259 (186 – 405)	1.0 (0.7 – 1.4)
Moose 2000	9957	2945	1	126	9	78	184	127	394	50	–	–	594 (459 – 831)	1.4 (1.0 – 1.8)
Seibert 2000	2910	3772	29	112	4	5	85	184	206	2	63 (48 - 82)	51.0 (39.1 - 67.0)	420 (222 – 3504)	1.1 (0.1– 2.0)
Lac Ste. Anne 2001	4864	14592	–	–	12	15	–	–	172	11	–	–	237 (151 – 527)	5.1 (2.3 – 8.0)
North Buck 1998[c]	5570	13230	–	–	–	–	–	–	–	–	–	–	–	–
Baptiste 1999[c]	4089	14738	–	–	–	–	–	–	–	–	–	–	–	–
Wabamun 2001	9464	27446	–	–	12	14	–	–	333	36	–	–	149 (110 – 222)	8.7 (5.8 – 11.7)
North Buck 1998[c]	5570	13230	–	–	–	–	–	–	–	–	–	–	–	–
Baptiste 1999[c]	4089	14738	–	–	–	–	–	–	–	–	–	–	–	–
Touchwood 1997[c]	8187	24045	–	–	–	–	–	–	–	–	–	–	–	–
Lac La Nonne 1997[c]	10698	30081	–	–	–	–	–	–	–	–	–	–	–	–
Long 1996[c]	1914	4357	–	–	–	–	–	–	–	–	–	–	–	–

[a] Baptiste and North Buck lakes were included as controls in 2000 and as treatment lakes in 2001
[b] T = Enhanced enforcement treatment; C = Control
[c] Estimates of anglers and hours are from creel surveys performed prior to this study; North Buck 1998, Baptiste 1999, Touchwood 1997, Lac La Nonne 1997, and Long 1996. No creel surveys were completed at these lakes during the study.

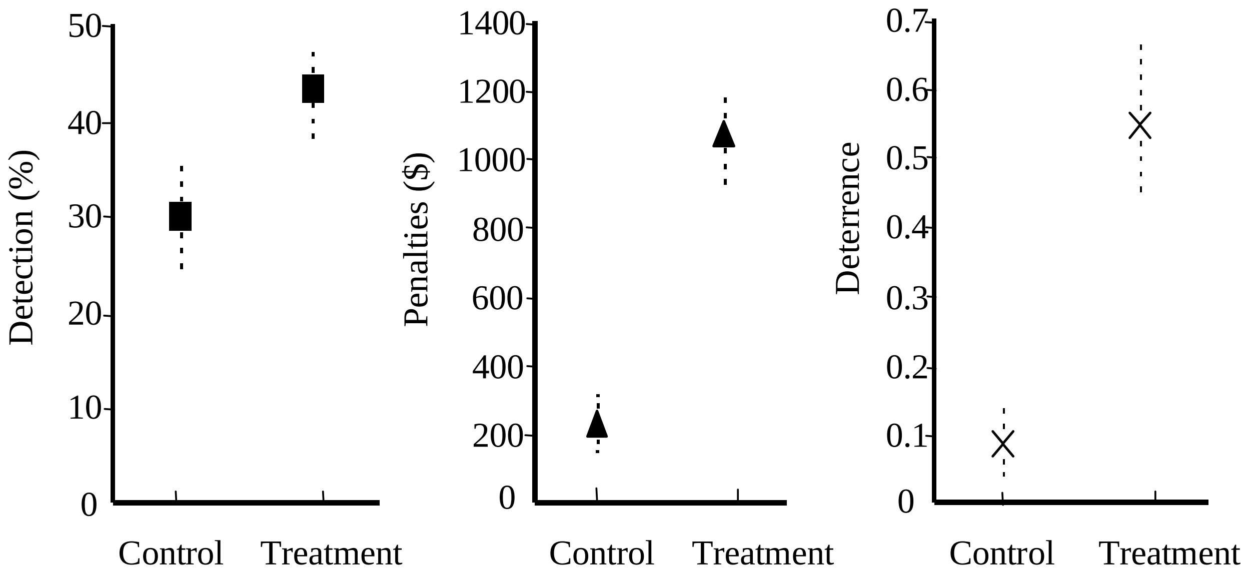

Figure 2.1. Grand means of the perception of detection (%), penalties ($), and deterrence between control lakes (n=5) and treatment lakes (n=9). Whiskers represent the empirical upper and lower 95th percentile confidence intervals of the likelihood profiles.

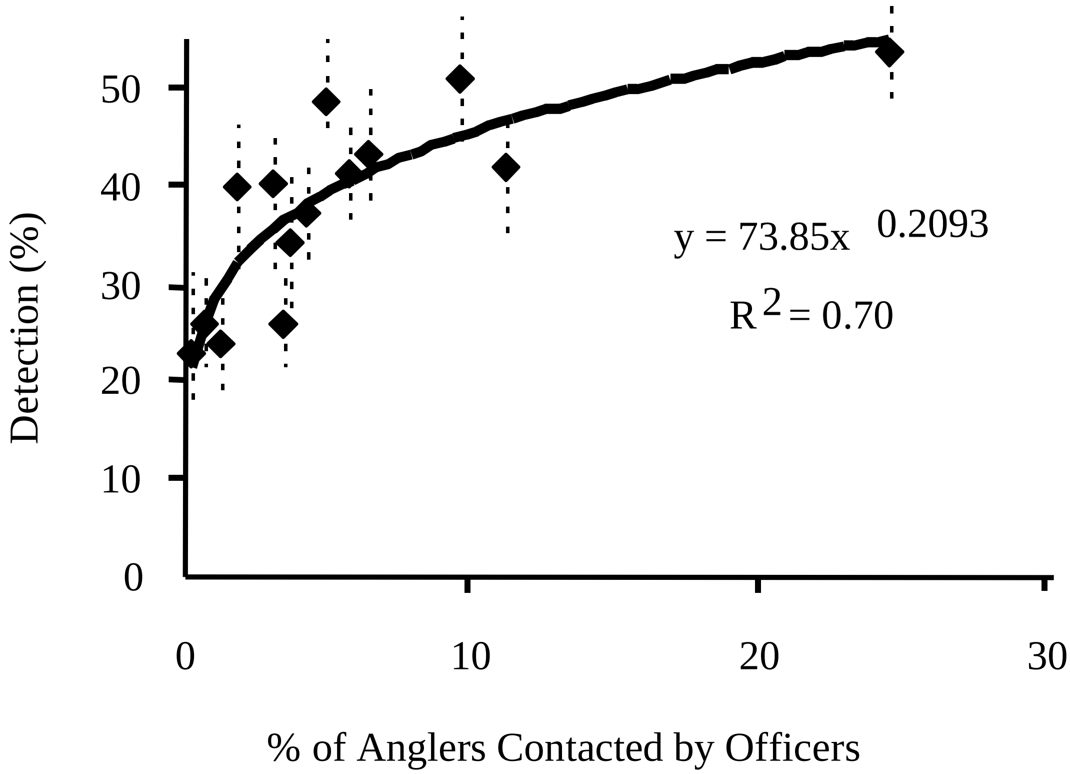

Figure 2.2. Non-linear correlation between the percent of anglers contacted by officers and the perception of detection (%) by anglers (n=14). The inflection was estimated visually to be at about 3% of anglers contacted and about 40% perception of detection.

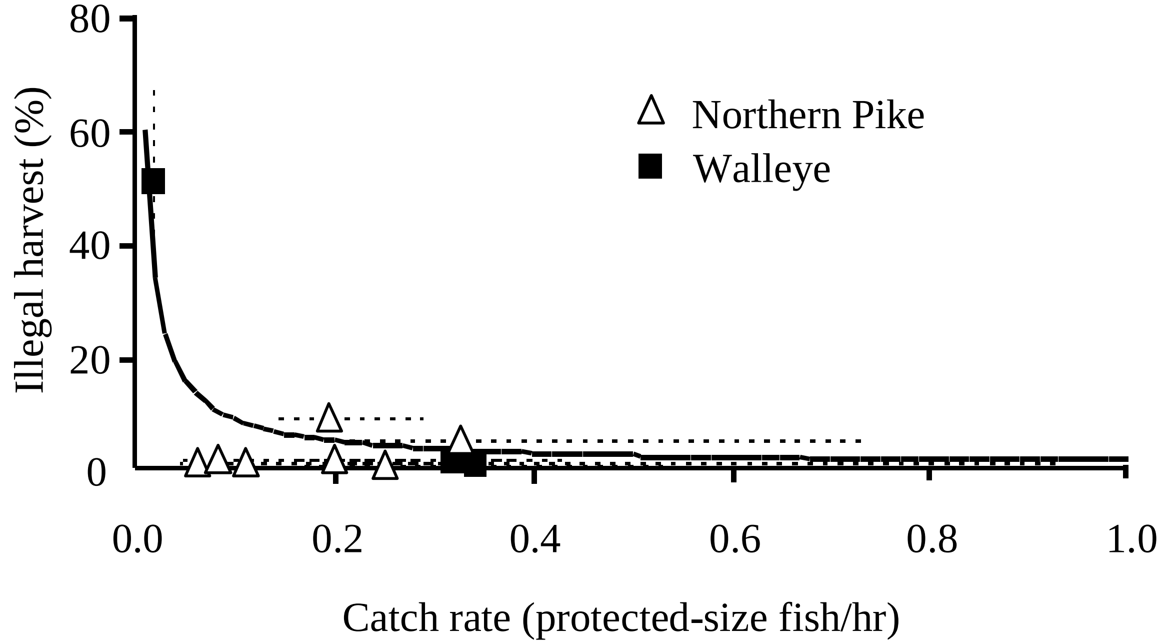

Figure 2.3. The illegal harvest of walleye and northern pike as a function of protected-size catch rate (fish per hr). The solid black line represents the functional relationship reported in Sullivan (2002) for walleye populations in our study area. Whiskers represent the empirical upper and lower 95th percentile confidence intervals of the likelihood profiles.

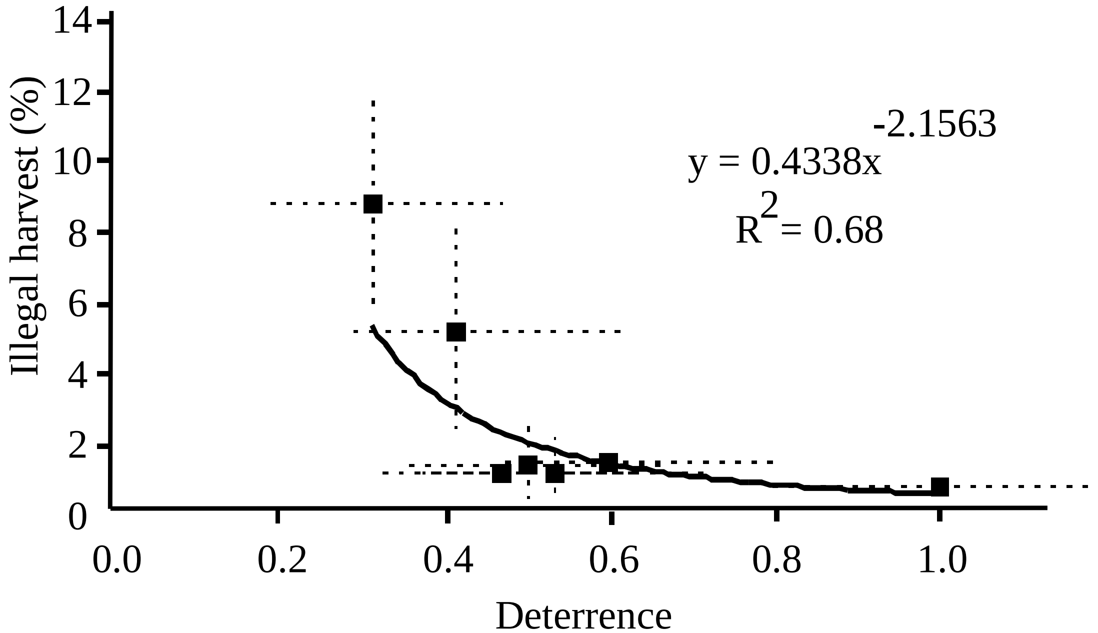

Figure 2.4. The correlation between deterrence and the illegal harvest of northern pike (%) at seven treatment lakes ($F_{0.05(2),6} = 5.51$, $P = 0.067$) when both axes are log10 transformed. The whiskers represent the empirical upper and lower 95th percentile confidence intervals of the likelihood profiles.

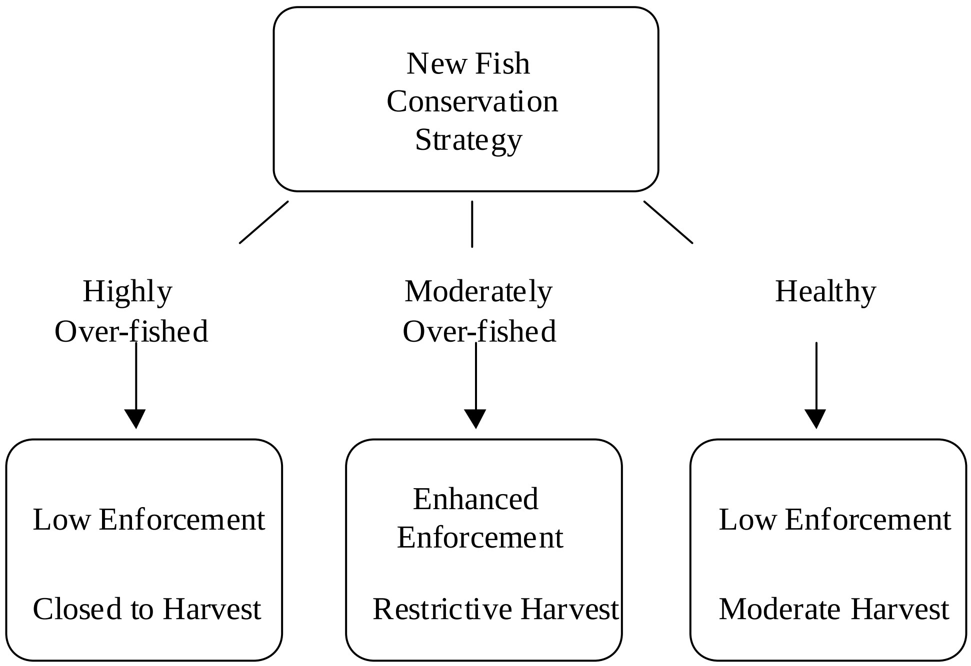

Figure 2.5. A proposed fish conservation strategy to bring enforcement and harvest regulations together for three different fish stock classifications.

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CHAPTER 3 – HUMAN DIMENSIONS OF ILLEGAL HARVEST BY ANGLERS

3.0 - INTRODUCTION

Rational actor enforcement models in fisheries management are relatively new, (Crane, Warner, and Kuchma, 1999; Sutinen, 1993; Sutinen and Hennessey, 1986) and have emphasized free choice by fishers about whether to violate management regulations. These largely economic models have assumed that fishers will choose whether to violate after comparing the expected economic benefit of violating with the certainty and severity of the penalty, if caught (Furlong, 1991). From this point-of-view, the reasons for deviant behavior are explained by internal causes, as individual fishers weigh the expected benefits and penalties, and then exercise free will to maximize their welfare. Through laws and enforcement actions, agencies attempt to deter fishers from violating by altering the certainty of apprehension and the severity of penalties.

A criticism of these models is that they do not account for moral, ethical or other social factors that may also play a role in the choice to illegally harvest. While fishers may consider the certainty and severity of penalties, normative theories of deviant behavior suggest that other social conditions will also influence the likelihood to violate. Recent models of illegal fishing have begun to identify and incorporate some social variables into traditional enforcement models (Furlong, 1991; Hatcher, Jaffry and Shabbar, 2000; Sutinen and Kuperan, 1999). The reasons for deviant behavior may be partially explained by external influences not strictly controlled by individuals, such as one's moral development, education, ethics, attitudes, peer group, and beliefs. Social scientists and management agencies are beginning to study these human dimensions of illegal harvesting of wildlife (Eliason, 1999; Boxall and Smith, 1987). Implicitly, managers expect to reduce illegal harvests by designing more strategic policies, education and enforcement programs to change these attitudes, beliefs and behaviors.

In this study, I investigated recreational anglers' attitudes and beliefs about whether they thought there were legitimate reasons to keep one protected-size walleye (*Sander vitreus*) or northern pike (*Esox lucius*). This type of illegal harvest is not motivated by commercial gain because the economic value of a single fish is small, and is generally regarded by society as a "folk crime". However, the cumulative impact to the fishery of many anglers keeping a protected-size fish has been reported to be a critical factor impeding the biological recovery of these species (Sullivan, 2002).

Our objectives were to (1) determine what proportion of anglers thought that there were justifiable reasons to keep a protected-size fish, and (2) determine what attitudes anglers reported as influencing their choice to keep a protected-size fish. By identifying and quantifying anglers' responses to these questions I expect to have a better understanding of the underlying social context affecting illegal harvests by recreational anglers in our area.

3.1 METHODS

I interviewed 1053 anglers at 12 lakes during the summers of 2000 and 2001 in northeast Alberta, Canada, (Table 3.1) and asked each angler: *"Is there any justifiable reason to keep a protected-size fish at this lake? Why or why not?"* Interviews were conducted at each study lake, with randomly selected anglers, throughout the summer during weekends and weekdays. I introduced myself as a student biologist conducting a survey of anglers for Alberta Fish and Wildlife and explained that the purpose of the survey was to gather a group of angler's opinions and observations about fisheries enforcement at the lake. I emphasized that I was not an enforcement officer and this distinction was repeated later in the interview. I dressed casually, did not wear a uniform, and drove a vehicle that would not be identified as a department enforcement vehicle. Anglers were told that the survey was completely voluntary, anonymous, and confidential, and that they may quit at any time.

In this observational study, I separated positive and negative angler responses into groups and then categorized their reasons into themes. Anglers often mentioned several reasons, but I categorized only their primary responses. Anglers were contacted during weekends and weekdays throughout the summer and at different times of the day to reduce sampling bias. The lakes I studied had large, restrictive minimum size limits of 50 cm and 63 cm for walleye and pike, respectively. These fish populations were classified as collapsed or recovering populations.

3.2 RESULTS

Of the 1053 anglers interviewed, 27 did not provide a reason why they would or would not keep a protected-size fish. It is important to note that there is likely a bias to anglers' responses. Few anglers would be expected to say there are justifiable reasons to keep an illegal fish and then, while fishing, decide to follow the regulation. Yet, some that reported no justifiable reasons to violate when interviewed would likely do so when the situation presented itself.

3.2.1 Would Not Keep a Protected-size Fish

The majority of anglers, 63.6 % (n = 643 of 1026), thought that there were no legitimate reasons to keep a protected-size fish (Figure 3.1). Five themes emerged from their responses.

3.2.1.1 Conservation and Recovery

Of those who responded negatively, 37.0% (n = 238) reported that their primary reason not to keep a fish was to conserve and promote the recovery of the fishery. Typical responses were, *"If we keep these fish, there won't be any fish left for next time." "Give the fish a chance to recover." "We're dwindling our resource away. Let's give them a chance to grow back." "We want the lake to recover."*

3.2.1.2 Fairness

Fairness was the second most common reason reported for not keeping a fish. 28.9% (n = 186) of anglers reported that to be fair, people should follow the rules. A typical response was: *“Rules are rules, and everyone should just follow them.”* Another example was*: “There’s no reason to keep a short fish whatsoever. Be fair, let someone else catch it.”*

Another 8.9% (n= 57) of respondents were concerned with inter-generational fairness. Anglers expressed comments such as: “*Let our kids catch fish in the future*” and “*We want our kids to know good fishing too.*” This altruism was expressed as a willingness to forego today’s catch for future generations of their family to catch fish.

3.2.1.3 Ethics

A few anglers, 13.1% (n = 84) stated that they thought it was unethical to keep fish. One angler reported: *"if you’re fishing to eat, then you've got it all wrong. It's a sport; catch and release".*

9.0% (n = 58) of anglers thought small fish should be released. For example an angler responded, “*it’s not right to keep a small fish, let them grow.*”

3.2.1.4 Good Fishing Conditions

A few anglers (1.9%, n = 12) thought the angling conditions at the lake did not warrant keeping a protected-size fish. Anglers reported that, *“There’re* *lots of fish out there; there's no reason to keep a short one"*, or *"if you fish long enough, you'll get a keeper."*

3.2.1.5 Risk

A few anglers expressed that risks for getting caught were not worth the benefits (1.2%, n = 8). One angler stated succinctly, *"It's not worth getting caught."*

3.2.2 Would Keep a Protected-size Fish

A large proportion of anglers, 36.4 % (n = 383), thought that there were legitimate reasons to keep a protected-size fish. Of those that responded positively, six themes were identified (Figure 3.2).

3.2.2.1 Hook Injured Fish

Of the anglers that responded positively, 45.2% (n = 171) thought that poorly hooked or injured fish should not be released for two reasons. They indicated that it was unethical to release an injured fish and that these fish should be humanely killed. For example, *"Fishing for jacks is murder for the fish. I'm seeing lots of hurt and dead fish. If it swallowed the hook, we should keep it. It's not right to let it go."* Other anglers could not agree with the management logic in releasing a fish that was obviously dead or, in their opinion, going to die. A typical response was, *"I hate to see the dead fish wasted*." A few anglers thought that they would have less impact on the fishery if they could just keep one and quit fishing. One angler stated, *"I have to catch all these little ones before I get a keeper. It's not right to kill so many with catch-and-release. I should just be able to keep one to eat.*" Others seemed to have a low regard for the fish and the regulation. *"If it's hooked in the gills and it's a nice hook, I will get it back."*

3.2.2.2 To Eat

To keep a fish to eat was an acceptable reason to retain a protected-size fish for 18.5% of anglers (n = 70). Of these, 21 respondents thought it would only be acceptable if the person was desperate or starving. For 49 anglers these conditions were not necessary. These anglers reported: *"If it's an inch short, it's O.K., especially if it's the last one for supper.*" *"We just keep one for a fish fry." "If someone keeps a fish and cooks it in his campsite, that's O.K. by me. Just no over-limits going home. One for supper is no crime."*

3.2.2.3 Unfairness

17.7 % of anglers (n = 69) claimed that unfairness was the reason why they thought they were justified to keep a protected-size fish. Anglers reported that it was unfair for commercial fishermen and First Nations fishermen to use nets to fish, while they could not keep fish. For example, "*It's the commercial nets that are catching all the big fish. If you let them fish, we should too." "Get the commercial fishery off the lakes!" "Natives can use nets and keep fish and I can't. I'm a native Albertan. It's my heritage too."* A few anglers thought they were justified to keep a protected-size fish because they reported ice fishermen and cabin owners were keeping too many fish.

Anglers thought that officers should give some leeway if the fish length was close to the size limit. They thought it was unfair of officers to enforce the length restrictions literally. For example, *"If someone's measuring board is a bit off, then they shouldn't be charged." "If it's within a half-inch there should be some leeway. It's hard to measure fish in a boat."*

3.2.2.4 Scientific Credibility

A belief that the biologists have the regulations all wrong, was reason to keep fish by 10.3% (n = 39) of anglers who responded "Yes". These anglers did not feel that the regulations were legitimate. For example, *"These regulations don't work. They should use Saskatchewan's regulations. You should leave the spawners and eat the small ones." "A reason to keep a fish is frustration with the regulations. These regulations are stupid. Surely we can eat just one fish and it won't matter." "I caught 59 pike and not 1 made the size. Should have changed the regulations years ago. It's too late now." "When you start catching as many as we are, there should be one we can keep. The rules are out-of-whack with the reality of the lake." "God-damned government biologists! You're just a bunch of asshole university students. You survey a lake and then you cut all the fishing out. I caught 15 today and couldn't keep one. You do all these studies but the biologists here and Saskatchewan come up with different answers. You don't know crap."*

3.2.2.5 Investment

5.6% of anglers who responded positively (n = 21) expressed that the money and time they invested entitled them to keep a fish. For example, *"If you fish all week and don't catch a fish, you deserve to keep one! I've spent $100,000 on my motorhome, $15,000 on my boat, $200 on gas, and another $120 for my campsite this week. To come this far and spend this much money; its my right to keep a fish. There's no way in hell, that we're putting the fish back. I don't care if I get a ticket."* Another angler expressed, *"If it's the only fish you've caught you should be able to keep it; especially if you've fished for days."*

3.2.2.6 Kids and Tradition

2.6% of anglers (n= 10) responded that they wanted their children or grandchildren to experience catching and keeping a fish, to pass along this tradition. For example, *"If a child catches a fish they should be able to keep it. They should give away children's tags." "I want to bring my grandchildren, but not if they won't be able to keep a fish." "I want more kids to go fishing. It's better if they can keep a fish".*

3.3 DISCUSSION

That 36.4% of anglers declared there were justifiable reasons to keep a protected-size fish implies a strong willingness among anglers to keep a protected-size fish, and may provide some evidence that the illegal harvest of these fish could be larger than the minimum estimates previously reported (Sullivan, 2002). I presume that some anglers in our study did not respond positively because their answers could be embarrassing or perceived as potentially self-incriminating.

Surprisingly, while individual anglers may have been evaluating the risks and rewards for violating, they rarely volunteered information on the probability of detection or the severity of penalties as the reason for or against cheating. I expected anglers to comment more frequently about their perceived risks for violating since most “rational actor” models assume that these factors affect illegal harvests. A study of these factors at these lakes showed that anglers perceived different probabilities of detection and different levels of penalties when these factors were manipulated (Chapter 2). Perhaps revealing their perceived level of risk in the context of these questions could have been considered potentially embarrassing or perceived as self-incriminating, or as an indication of a premeditated intention to act in an illegal way rather than to keep the discussion at theoretical and safe level. Anglers may have been uncomfortable reporting this to the interviewer. Another explanation may be that the assessment of risk was performed subconsciously and was therefore rarely reported.

I was also surprised that anglers did not openly state that the reason they would keep a fish was because of the scarcity of the resource itself. Sullivan (2002) showed that the illegal harvest rate of anglers in my study area was negatively exponentially correlated to the catch rate of protected-size fish. Again, anglers may have thought that this answer would be potentially incriminating or embarrassing. Perhaps they were not consciously aware that they would make harvest decisions based upon the perception of the scarcity of fish.

I can think of two theories about this unexpected result. Potentially, these rationalizations are simply excuses for illegal activities that people consciously know they should not be doing. That would imply that caution should be applied in using their rationalizations to explain any part of the illegal behavior. This assumes that Sullivan's scarcity relationship was unaffected by these human dimensions.

A second theory may be that these human rationalizations may play a role in choosing to illegally harvest. People will respond to scarcity as shown by Sullivan, (2002), but I speculate this scarcity relationship may be exacerbated by the human responses anglers reported for why they feel justified to illegally harvest; fairness, scientific credibility, hook-injured fish, and tradition. These human dimensions may be a part of the relationship observed in Sullivan, (2002). The implications of this are that if these human dimensions are also acting in concert with scarcity then finding ways through education, choice of regulations, policy changes, and community participation to reduce the frustration may also reduce the slope of the scarcity relationship. I am drawn to this second theory perhaps through optimism, but I believe this should be tested through experimentation. This would be an excellent opportunity for collaboration of social and biological sciences.

Anglers who responded positively used neutralization techniques to rationalize their responses (Eliason, 1999). Neutralization is, “a method whereby a person renders behavioral norms inoperative, thereby freeing himself to engage in behavior which would otherwise be considered deviant” (Rogers and Buffalo, 1974). Eliason and Dodder (1999) described four types of neutralizations used by deer poachers to justify their behaviors: (1) *denial of responsibility* (they did not mean to, it was an accident), (2) *metaphor of the ledger* (all of their good qualities made up for the one time they harvested illegally), (3) *defense of necessity* (they needed the meat), and (4) *condemnation of the condemners* (change the focus from their activities to the behavior of the conservation officers). In this study, the “unfairness” and “hook injured” themes reported by anglers were similar to the *denial of responsibility* claimed by deer hunters. Some anglers who incorrectly measured their fish claimed it was difficult to measure the fish in the boat and that they did not mean to keep a protected-size fish. They blamed the officers for enforcing the regulations literally rather than themselves, for keeping a fish that they were unsure would be legal. Others claimed that they accidentally injured or killed the fish while recovering their hooks. They thought the responsibility lay with the regulations. Some anglers found fault with the regulations because they thought the regulations encouraged anglers to hook and release (and injure) many small fish before they could keep a legal one. In all cases, they did not think it was their fault for keeping a protected fish. *Defense of necessity* was given as a reason by 5.5% of those who responded positively and it was usually stated as, “Yes, if someone’s starving.” However, for the rest of those angler’s responses categorized in the “to eat” theme, necessity was not a requirement. Just wanting one to eat was reason enough for these anglers. A perceived lack of “scientific credibility” seemed to be the root of the condemnation of the biologists and the regulations. This was similar to the category of *condemnation of the condemners*. However, while the deer hunters condemned the wardens, the anglers tried to change the focus to their perceived illegitimacy of the regulations or to the credibility of the biologists. “Kids and tradition”, “investment” and the “unfairness” of the allocations between user groups were all important neutralizations that were unlike the deer hunters. Anglers did not report the *metaphor of the ledger* neutralization.

Muth and Bowe (1998) examined the illegal harvest literature for renewable resources in North America and developed a 10-part typology for poachers’ motivations. In our study, anglers did not report commercial gain, trophy poaching, thrill killing, protection of self and property, or gamesmanship as reasons to keep a protected size fish. Anglers who responded positively did not see their actions as “poaching” and often commented that, “the officers should be out catching the real poachers”; referencing people keeping over-limits or using nets. One illegal fish was seen as a folk crime and less serious than the crimes committed by others (Forsyth, Gramling and Wooddell, 1997). Household consumption, recreational satisfactions, poaching as rebellion, poaching as traditional right and disagreement with the regulations were clearly evident in the anglers' responses.

3.3.1 Misunderstanding Management

Many of the reasons anglers offered for why they felt justified keeping a protected-size fish may be a result of the misunderstandings anglers have about the management of these populations of fish. However, these misunderstandings may go deeper than the scientific illiteracy of anglers. Weeks and Packard (1997) propose that a constellation of social factors determine the extent to which the public accepts the scientific basis of policy and regulations regardless of the soundness of the management science. They report how non-scientists use their own criteria to determine the credibility of scientific information upon which regulations are based. The range of responses I received in this study would tend to support this theory. Many anglers were poorly informed about the management rationale and had their own personal criteria for evaluating the regulations, allocations, stock status, fishing pressure, and basic ecology of these species. Many were uninformed about, or did not believe the results of, how the fisheries are monitored, how stocks are assessed, how regulations are determined, or how their individual actions could have an effect on a fishery. These misconceptions identify a discontinuity between the empirical ecological knowledge used by management scientists and the local knowledge of anglers. Many anglers mistook their excellent site-specific, local knowledge of fishing for the broad, empirical population ecology and harvest information that fisheries scientists are using to determine regulations, set allocations, and monitor the fisheries. For example, from the biologist's perspective, large minimum size-limits are necessary to reduce the harvest while still maintaining a rare opportunity for anglers to catch a fish to eat. A portion of the released fish are injured due to hooking or handling, but must be released to provide them with an opportunity for survival and to not provide anglers with an excuse to keep healthy fish. From some angler's perspectives, releasing hurt or dead fish is considered unethical or wasteful. Based upon their personal criteria, a regulation that requires these fish to be released is illegitimate and less likely to be followed.

The stage may be set to see the discontinuity between anglers and management scientists continue to grow and this will continue to influence illegal harvest. The rate at which biologists are learning about the scientific information needed to manage these fisheries, may be exceeding the rate at which the public can culturally adopt new evaluation criteria. A rapid proliferation of information resulting from long-term population data, computer modeling advances, and a move to adaptive management strategies are seriously challenging the rate that these scientifically based criteria can become accepted and attitudes toward the fishery can change. This is most clearly seen in the angler responses of perceived illegitimacy, poor scientific credibility and unfairness of the regulations which anglers reported as reasons why they would keep protected-sized fish. As I examine this extremely complex and "wicked" (Ludwig, Mangel and Haddad,

2001) biological and social problem, it becomes clear that, "cultural evolution is required in both the scientific community and the public at large, to improve significantly the now inadequate response of society to the human predicament" (Ehrlich, 2002). To bridge this gap, one part of the solution may be to improve communication and education programs for anglers. If this is the case, illegal harvest rates may be elevated during this period of transition and relearning. Illegal harvest may be reduced as a new comfort level is reached with the era of scientific management.

Innovative approaches to public education that focus on the most prevalent themes identified by the anglers may help us to change anglers' criteria that they are using to evaluate the policies and regulations. Novel approaches to educate the next generation of anglers such as interactive Internet learning tools and new classroom curricula might be useful to provide young anglers with more scientific criteria to judge our management regulations. Traditional curricula that focus on fish identification, the principles of fairness, and the intrinsic value of healthy fisheries are not likely enough. I suggest a greater emphasis be placed upon the basic principles of population ecology, cumulative effects of fishing mortality, and allocation rules to counter the most prevalent themes reported by the anglers; however, I concede that some anglers' attitudes are unlikely to be changed. Studies designed to evaluate the effectiveness of public education in changing the attitudes and behaviors of anglers may also be prudent.

While education programs for anglers seem to offer a part of the solution to bridge the gap, they may not be successful if trust between anglers and the management agency is low (Weeks and Packard, 1997). Simply providing anglers with the scientific arguments upon which regulations or policy are based, may not be enough to change their actions if they are distrustful of the agency or managers. In the absence of sufficient trust, they may continue to use only their own ethical, moral, or other criteria to judge the merit of scientific based management policy. To improve trust I offer several ideas.

1) Develop tools to improve the communication between anglers and the agency. Develop new strategies to impart ecological messages to the anglers.
2) Improve the transparency of management decisions to anglers by being clear about what scientific criteria and timelines are being used to make management decisions, set regulations, and monitor populations and by including angler groups in the development of new strategies.
3) Try to find ways for anglers' beliefs to be reflected in management policy, however, not at the expense of good science-based management.
4) Develop policies to keep the same biologists in the field offices to build trust with their local constituents (Weeks and Packard, 1997). Ensure upper management support for these biologists so those local

groups know these biologists have the trust and support of their superiors in implementing departmental policy.

5) Develop policies to ensure consistent management strategies for similar species between districts and regions in the province.
6) Develop internal agency policies to ensure consistent messages to the public; particularly between upper management and local regional managers.
7) Increase communication between biologists and enforcement officers. The fishing public sees both as policy spokespersons. They should be telling the same story.

Without sufficient trust, anglers' beliefs about the legitimacy, fairness and credibility of the regulations may act as depensatory mechanisms when fisheries populations decline to a point where recovery is necessary. Examples that reflect these attitudes are, "*Why bother, it's too late now, you should have changed the regulations years ago*" or "*I've spent a lot of money and time to catch a fish, there's no way I'm letting it go*". Perceptions about the unfairness of the allocation between groups are likely to exacerbate the depensatory response when fish become rare and restrictive regulations are imposed.

Similarly, it appears from anglers' responses that the credibility of the biologists declines as the fishery declines. If the biologist's credibility declines so does the legitimacy of the regulations implemented to improve the fishery. I suggest that it is better to implement the regulations early in a decline and see a quick recovery than to wait until the stock has nearly collapsed, lose credibility, and add another depensatory mechanism that impedes recovery.

In addition to communication, education, trust, and the timeliness of regulation changes, efficient enforcement integrated with management regulations to deter illegal behavior will also be important (Chapter 3). Focused enforcement can act quickly and narrowly to reduce illegal harvests tactically, while education, trust, and timely management, if they operate at all, will operate more strategically, broadly and long-term.

Through this paper I have illustrated the human dimensions surrounding the illegal harvest of walleye and pike. By illustrating the reasons anglers say they do not follow the regulations I hope that managers can be more informed about the social context when designing regulations and developing educational and enforcement policies.

Table 3.1 Number of yes and no responses to whether anglers thought there were justifiable or ethical reasons to keep a protected-size fish (n = 1053).

Lake	Year	Number of Interviews	% Yes	% No
Baptiste	2000	82	26.8	73.2
Beaver	2000	91	40.0	60.0
Cold	2000	86	39.6	60.4
Moose	2000	85	36.0	64.0
North Buck	2000	79	23.0	77.0
Pinehurst	2000	82	38.2	61.8
Seibert	2000	74	21.5	78.5
Touchwood	2000	59	44.7	55.3
Baptiste	2001	70	40.5	59.5
Lac La Nonne	2001	61	47.4	52.6
Lac Ste. Anne	2001	68	36.6	63.4
Long Lake	2001	79	44.6	55.4
North Buck	2001	78	22.0	78.0
Wabamun	2001	59	18.6	81.4

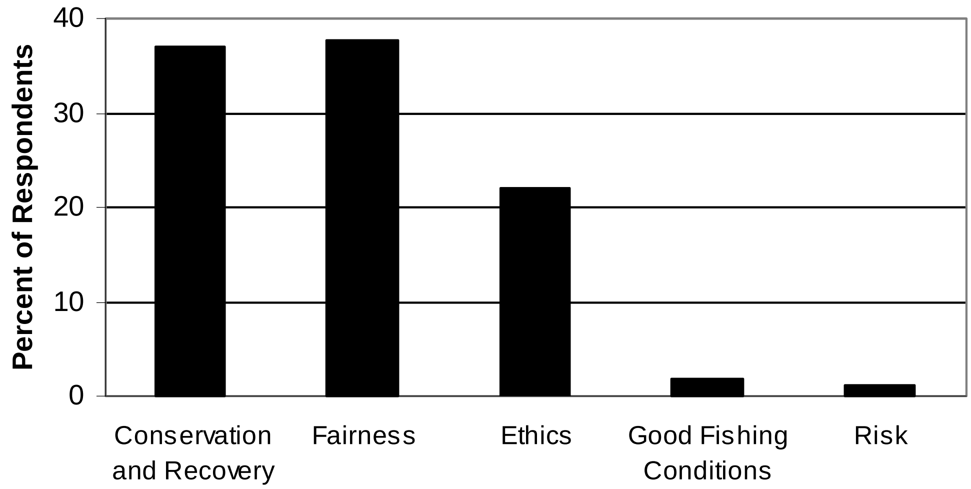

Figure 3.1. Five themes for why anglers thought they would not keep a protected-size fish (n = 643). Anglers primary responses were categorized.

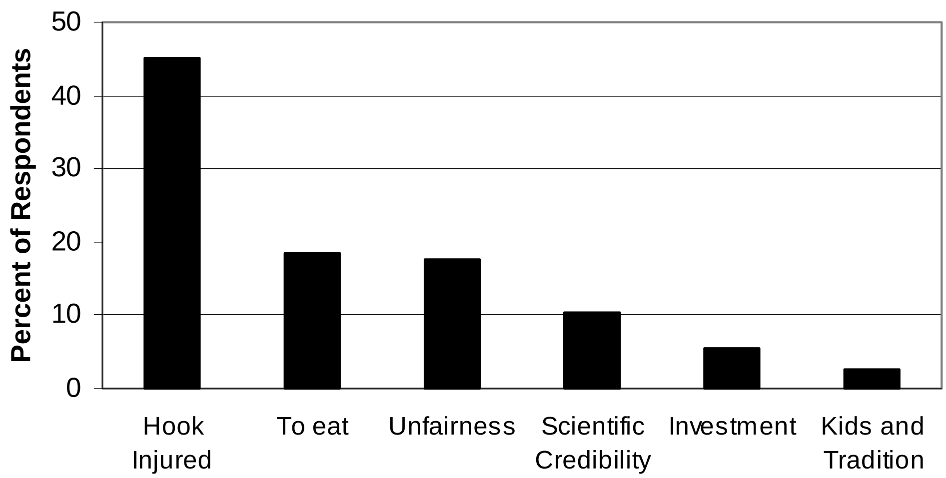

Figure 3.2. Six themes for why anglers thought they would keep a protected-size fish (n = 383). Anglers primary responses were categorized.

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CHAPTER 4 –DETECTION OF WALLEYE SIZE-LIMIT REGULATION VIOLATIONS BY CONSERVATION OFFICERS

4.0 INTRODUCTION

Previous enforcement models have not explicitly considered the potential interaction between illegal fishing behavior and the biological condition of the fishery. However, evidence from different disciplines strongly suggests that as a resource becomes scarce, it becomes valuable and desirable (Loomis and Fix, 1998; Brock 1968). For highly desired recreational fish, the illegal harvest rate has been shown to increase sharply when anglers perceive fish to be rare. (Sullivan, 2002). This potential interaction between fishery quality and illegal harvest rate is important to explore because of the influence I hypothesize it will have on violation detection by conservation officers.

I hypothesize that the typical illegal harvest monitoring of fisheries size-limit regulations by agencies is not sensitive and underestimates the illegal harvest problem when stocks decline. Management agencies adjust their enforcement effort based upon their perception of the illegal harvest problem. However, currently these perceptions depend upon the rate of violations encountered by conservation officers during their patrols (Van Vooren, 1991). Therefore, I investigated how the fish scarcity-illegal harvest relationship (Sullivan, 2002) may influence officers’ violation detection and hence their perception of the magnitude of illegal harvest.

In this paper, I use the term violation rate (V_t) to describe the number of walleye (*Sander vitreus*) size-limit violations that are encountered by conservation officers per 100 anglers contacted during their patrols. I use the term illegal harvest rate (Y_t) to describe the number of sub-legal walleye kept by anglers divided by the total number of sub-legal walleye caught by anglers multiplied by one hundred (Sullivan, 2002). Subscript t refers to time. I describe the relationship for walleye where Y_t increased exponentially as the catch-per-unit-effort (CPUE) of sub-legal fish declines as Sullivan's relationship (Sullivan, 2002). I define b (Sullivan, 2002) as the effect of CPUE on Y_t and the term a (Sullivan, 2002), as the Y_t that will occur regardless of the influence of the CPUE, when $b = 0$. CPUE will only refer to the CPUE of sub-legal fish in this paper.

Under declining population conditions, I hypothesize that the V_t encountered by officers is not correlated to the *Yt* at the fishery. The CPUE will determine the number of people who have the opportunity to break the law and therefore the number of people officers can find with violations, but the CPUE will also determine *Yt* of the anglers (Sullivan's relationship). The consequences are that at low CPUE's, officer patrols are inefficient because most anglers have not caught a fish. However, of those who have caught a sub-legal fish, many will choose to keep the fish. Therefore, Y_t is high, and officers will not see this problem with their traditional sampling methods. Also, at a high CPUE fishery, Sullivan's relationship predicts a low *Yt*. Officers will encounter many people who have caught fish, but few who have kept an illegal fish. The consequences are that the officer patrols are also inefficient under these circumstances as officers encounter many people but few violations.

In this paper, I simulated the theoretical relationships V_t and *Yt* of walleye at lakes regulated with minimum-size limits in Alberta under three scenarios:

1) no relationship between CPUE and Y_t
2) Sullivan's relationship,
3) a positive exponential relationship between CPUE and Y_t.

In scenario 1, I observed that there was no relationship between Y_t and V_t. Y_t was determined by *a*. V_t increased with CPUE as determined by *a*, and trip length (*d*). In scenario 2, I observed that there was no relationship between Y_t and V_t. V_t remained constant over the range of CPUEs but was determined by *a* and *d*. In scenario 3, I observed a positive exponential relationship between Y_t and V_t. I compared the simulation results to field observations.

4.1 METHODS

4.1.1 Simulations

I re-wrote Sullivan's relationship as:

$$Y_t = a(C_t / E_t)^b \tag{1}$$

where C_t is catch of sub-legal fish and E_t is angler-effort (hours). Using Schaefer's (1954) classic dynamic fishery model, and substituting biomass (B_t) with the population size of protected-size fish (N_t) and C_t with illegal harvest (IH_t) results in equation 2. *K* is the carrying capacity.

$$N_{t+1} = N_t + rN_t\left(1 - \frac{N_t}{K}\right) - IH_t$$

(2)

IH_t can be further expressed as the product of the Y_t and C_t (Eq. 3) divided by 100.

$$N_{t+1} = N_t + rN_t\left(1 - \frac{N_t}{K}\right) - \frac{Y_t C_t}{100} \quad (3)$$

Substituting equation 1 for Y_t results in equation 4.

$$N_{t+1} = N_t + rN_t\left(1 - \frac{N_t}{K}\right) - \frac{a(C_t / E_t)^b (C_t)}{100} \quad (4)$$

Substituting C_t, using Ricker's (1958) definition where $C_t = N_t E_t q$ (and q is the catchability coefficient), results in equation 5.

$$N_{t+1} = N_t + rN_t\left(1 - \frac{N_t}{K}\right) - \frac{aE_t(N_t q)^{b+1}}{100} \quad (5)$$

The q is the proportion of the fish population caught with one unit of angler-effort for the area occupied by the population (Hansen et al, 2000). The modeled lake area was 8000 ha.

V_t was calculated by dividing IH_t by the E_t and multiplying by d (equation 6). I assumed that no angler cheats by more than one fish. I feel this is valid because, during 317 field patrols, officers wrote 2 or more tickets during a patrol only 5 times. Of these, only one person received more than one ticket. Officers in Alberta issued one ticket for each fish over the limit.

$$V_t = ad(N_t q)^{b+1} \quad (6)$$

I assumed that officers would encounter anglers randomly during their enforcement patrols. I did not divide V_t by 2 to account for incomplete trips, because officer field patrols consisted of both complete and incomplete checks. Officers in our field study performed shore, boat and roadside checks. Boat checks were largely incomplete trips, but the majority of shore checks and roadside checks tended to be conducted upon trip completion at the boat launches or on roadsides.

I simulated a population of walleye in Excel 97 with characteristics similar to observed Alberta lakes. The simulated population had an initial size (N_0) of 5000 protected-size fish, r = 0.2 and K = 300 000 protected-size fish. The modeled lake area was 8000 ha and the CPUE varied from 0.005 protected-size fish per angler-hour to 2.2 protected-size fish per angler-hour. Catchability, (q) was a constant of 0.03 (Hansen, et al., 2000). To examine the relative effects of a and b on relationships between CPUE, Y_t and V_t, a was modeled with 1%, 1.25%, 10%, and 20%, and b was modeled with –1, –0.84, 0, and 5. To compare results with field data initial values for a and b were taken from Sullivan (2002), and were 1.25 and -0.84, respectively. An average d of 2.8 hours was calculated from data in Sullivan (2002) and held constant for all simulations. From these data I calculated a CPUE over a range of population sizes and examined V_t by officers, over a range of CPUEs and Y_t.

4.1.2 Field Observations

Illegal harvest data from twenty walleye populations reported in Sullivan (2002) were combined with 3 surveys completed in the same study area in 2000 – 2001 following the same methods (this study).

In brief, creel survey clerks tallied protected-size walleye illegally kept by anglers. Test fisheries were used to determine the total number of protected-size fish caught. Combining these values allowed an illegal harvest rate to be estimated.

The V_t was calculated by dividing the total number of protected-size fish observed by the technicians by the total number of anglers observed visiting the lake during the survey period for each lake. Because anglers would not have shown technicians all protected-size fish, the V_t represents a minimum probability of encountering a size-limit violation per angler.

4.2 RESULTS

4.2.1 Simulation: b=0 (No Influence of CPUE on Illegal Harvest Rate)

Parameter *a* determined Y_t (Figure 4.1a). Y_t remained constant and equal to *a* (Figure 4.1a), regardless of CPUE. There was no relationship between Y_t and V_t (Figure 4.1b). However, the variance around V_t was low when *Yt* was low. The V_t was influenced proportionally by *a*, *d*, and CPUE. (Figure 4.1c). When CPUE was highest, V_t was also highest. When *a* was highest, V_t was also highest. Although not the focus of this model, I observed a small and proportional influence of *d* on the results over the range of *d*s that I observed in our study area. Therefore, I held *d* constant between scenarios.

4.2.2 Simulation: b=-1 (Illegal Harvest Rate Increases with Decreasing CPUE)

When Yt increases as CPUE decreases (Figure 4.2a), there was no relationship between Y_t and V_t (Figure 4.2b). The V_t remains constant regardless of CPUE (Figure 4.2c). As the CPUE decreased, larger proportions of the protected-size fish were kept, however fewer anglers were catching and keeping protected-size fish. At b=-1, there is a balance between these two factors and the result is a constant V_t. Parameter *a* increased the magnitude of these relationships.

4.2.3 Simulation : b=5 (Illegal Harvest Rate Increases with Increasing CPUE)

When the illegal harvest rate increases with increasing CPUE (4.3a), Y_t increases exponentially with V_t (Figure 4.3b). V_t increases exponentially with CPUE. (Figure 4.3c). The proportion of harvest that anglers keep illegally increases with CPUE yielding a high V_t. However, the Y_t does not increase as quickly as V_t. This is because the influence of the N_t on Y_t is high when the population is larger resulting in a V_t that increases faster than the Y_t.

4.2.4 Comparing the Predicted Model to Field Data

The predicted model using parameters from Sullivan, (2002) (*a* = 1.25 %, *b* = -0.85) had a good relationship with the field data (r^2 = 0.85, n = 23). Neither the field data ($F_{0.05(1), 1, 21}$= 0.46, *P*=0.51, r^2 = 0.021) nor the model ($F_{0.05(1), 1, 21}$= 1.11, *P*=0.30, r^2 = 0.050) showed a significant relationship between Y_t and V_t (Fig.4.4).

The *b* in the model was –0.85 (Sullivan, 2002) which was close to –1, the point where the V_t is balanced between the proportion of protected-size fish being kept and the opportunity by anglers to catch a protected-size fish. The average model V_t of anglers was 2.6% (*SE* = 0.18, n = 23), while the average field V_t was 3.7% (*SE* = 0.98, *n* = 23). The field V_t was skewed by one population, which had a V_t of 21.1% (Iosegun Lake). Excluding this point, the average field V_t was 2.9% (*SE* = 0.60, *n* = 22).

4.3 DISCUSSION

The V_t of anglers is an insensitive monitoring tool for managers to monitor the Y_t of anglers conditions and may provide false information about the potential risk to the stock from this kind of illegal harvesting activities. For Alberta, conservation officers monitoring the V_t among anglers may not provide an accurate measure of the magnitude of the illegal harvest problem for a fish population if the Y_t is biased either positively or negatively as a result of angler's perceptions of the quality of the fishery. The average V_t that I encountered in my field studies was 3.7% while the Y_t exceeded 60 % at very low catch rates. At Y_t greater than 20%, populations of walleye in Alberta have collapsed or ceased to recover (Sullivan, 2003). Traditional enforcement monitoring will fail to identify this illegal harvest problem. To effectively monitor the illegal harvest, managers will need to directly measure the Y_t, not imply it from the V_t.

A positive *b* may occur if stocks increase and anglers do not feel ethically-bound by restrictive regulations. If a stock has been collapsed for many years, anglers may also have changed their internal benchmarks for what a "good" CPUE is for the species and be more satisfied with a lower CPUE than historically (Pauly's Rachet)(Pitcher, 2001). Anglers may use different or incomplete criteria to evaluate the recovering fishery and not believe that the restrictive regulations are necessary (Weeks and Packard, 1997). Some anglers may not consider the regulations legitimate and question the science upon which the regulations are based, and I speculate that this misunderstanding may result in a Y_t that has a positive bias ($b > 1$) with CPUE. Further, anglers may lose faith in the credibility of the management and decide to harvest illegally. Managers often do not have the resources or tools necessary to adequately reach their anglers with the information they need to evaluate the risks of increased harvest of the fishery. Anglers that are reached may distrust the information provided to them by managers.

I believe this scenario occurred at Iosegun Lake, which had a low Y_t (3.5%), but a high (21.1%) V_t. This fishery had a large minimum size-limit restriction (50 cm), and a size-class structure that yielded almost no fish over the size-limit. However, the CPUE of protected-size fish was relatively high (CPUE >1). The model also explains this data point when a = 5% and b = 5. The V_t likely exceeded the Y_t because many anglers chose to harvest illegally. The illegal harvest rate remained low because the population of fish was also larger at the high CPUE and the proportion of illegal fish kept increased more slowly than the V_t. I speculate that a may also increase under these conditions, as more anglers believe the regulations are unnecessary. The increasing number of violations observed by officers may have led managers to conclude that the illegal harvest problem was greater than it actually was and, therefore, to apply an inappropriate amount of enforcement effort at the lake to reduce the biologically inconsequential illegal harvest.

This example highlights the importance of viewing the problem of illegal harvest in relation to the population size being protected. The Y_t takes this into consideration while the V_t does not. It is also important for managers to understand whether the Y_t has a positive or negative bias with stock abundance, possibly as a result of the human perception of resource abundance.

I hypothesize that other social and physical attributes, such as remoteness of the population, perception of penalties and detection by officers, or fairness will may affect (a) and (b) (Table 4.1). Many of these factors have previously been qualitatively studied in relation to poaching or illegal harvest activities (Eliason, 1999; Forsyth, et al., 1998; Hatcher, et al., 2000). Quantifying the effect of these social factors on the influence of *a* and *b* may be valuable for future research. Research into the different *b's* of species may provide information about the relative vulnerability of different species in the enforcement of mixed-species fisheries.

4.3.1 Design Considerations for Enforcement and Management

Through the examination of the relationships between resource abundance (CPUE), illegal harvest rate, and violation rate, I suggest that there are some important considerations in the design of more effective enforcement strategies for recreational fisheries.

- Managers should apply enforcement effort based upon the illegal harvest rate for the stock, the vulnerability of the stock and the deterrence effectiveness of the enforcement effort rather than the number of violations officers are encountering.
- Understanding what influences the shape of the illegal harvest rate vs. resource abundance curve, is a key to the design of meaningful enforcement strategies.
- Enforcement officers, biologists, and sociologists need to work more closely together to understand how social pressure and biological requirements can best be integrated in the design of efficient enforcement strategies. We ultimately must believe that most anglers will behave in a sustainable manner either through enlightenment or coercion.

Table 4.1. Potential attributes that may affect a and b. Parameter a is the portion of the illegal harvest rate (Y_t) that will occur regardless of the influence of the catch-per-unit-effort (CPUE). Parameter b is the effect of CPUE on illegal harvest rate (Yt).

Attribute	*a*	*b*
Remoteness increasing	increases	decreases
Perception of detection increasing	decreases	increases
Perception of penalties increasing	decreases	increases
Information and education increases	decreases	increases
High tradition of poaching or eating	increases	decreases
Perception of legitimacy at low CPUE fishery	increases	decreases
Perception of fairness increases	increases	decreases
Angler investment ($) increases	increases	decreases
Size-structure of fish decreases	increases	decreases
Peer pressure to cheat increases	increases	decreases
Few alternate species of fish present	increases	decreases
More desirable species of fish	increases	decreases

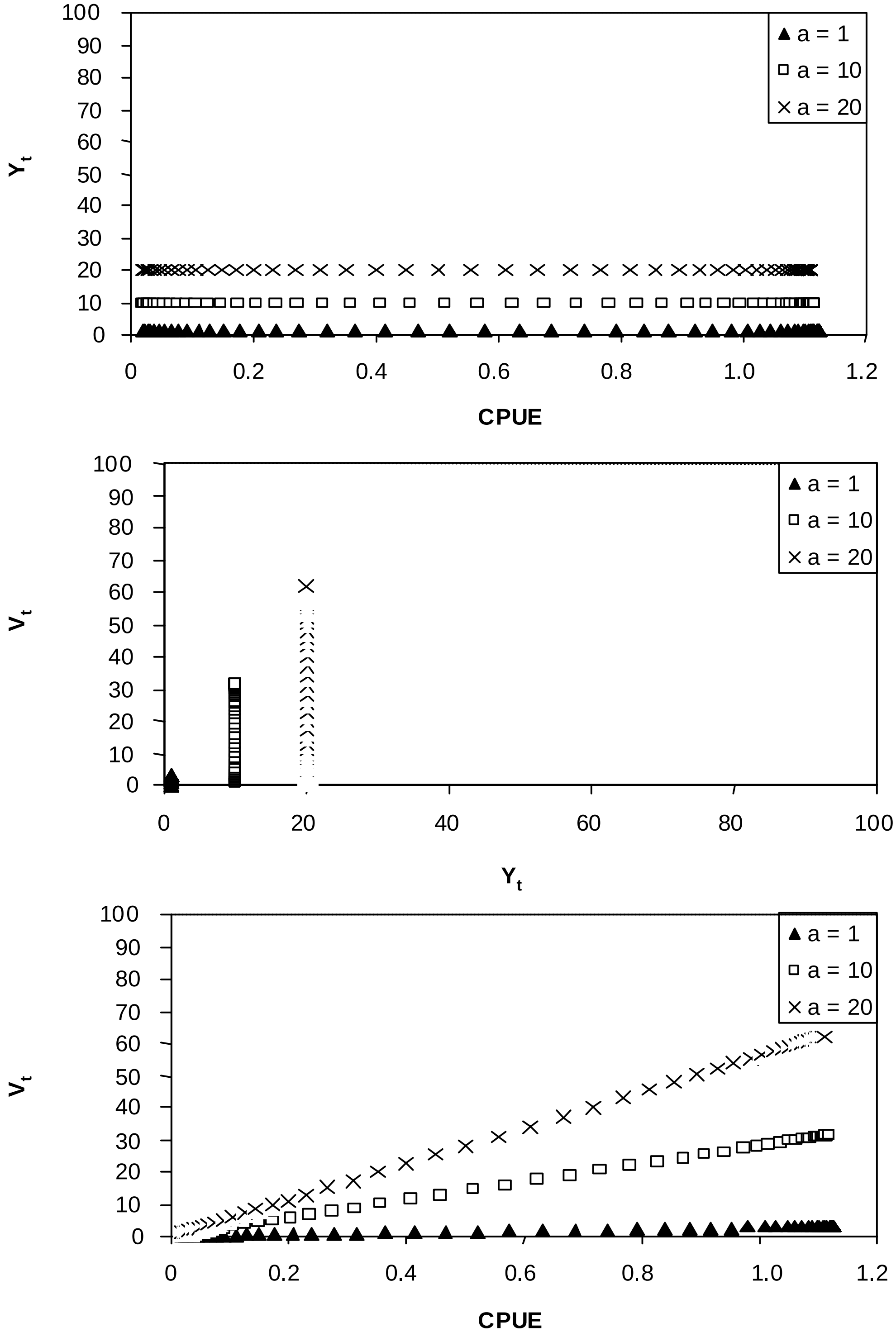

Figure 4.1. The relationships between protected-size catch-per-unit-effort (CPUE), illegal harvest rate (Y_t), and violation rate (V_t) when b = 0 and a = 1, 10, and 20 %.

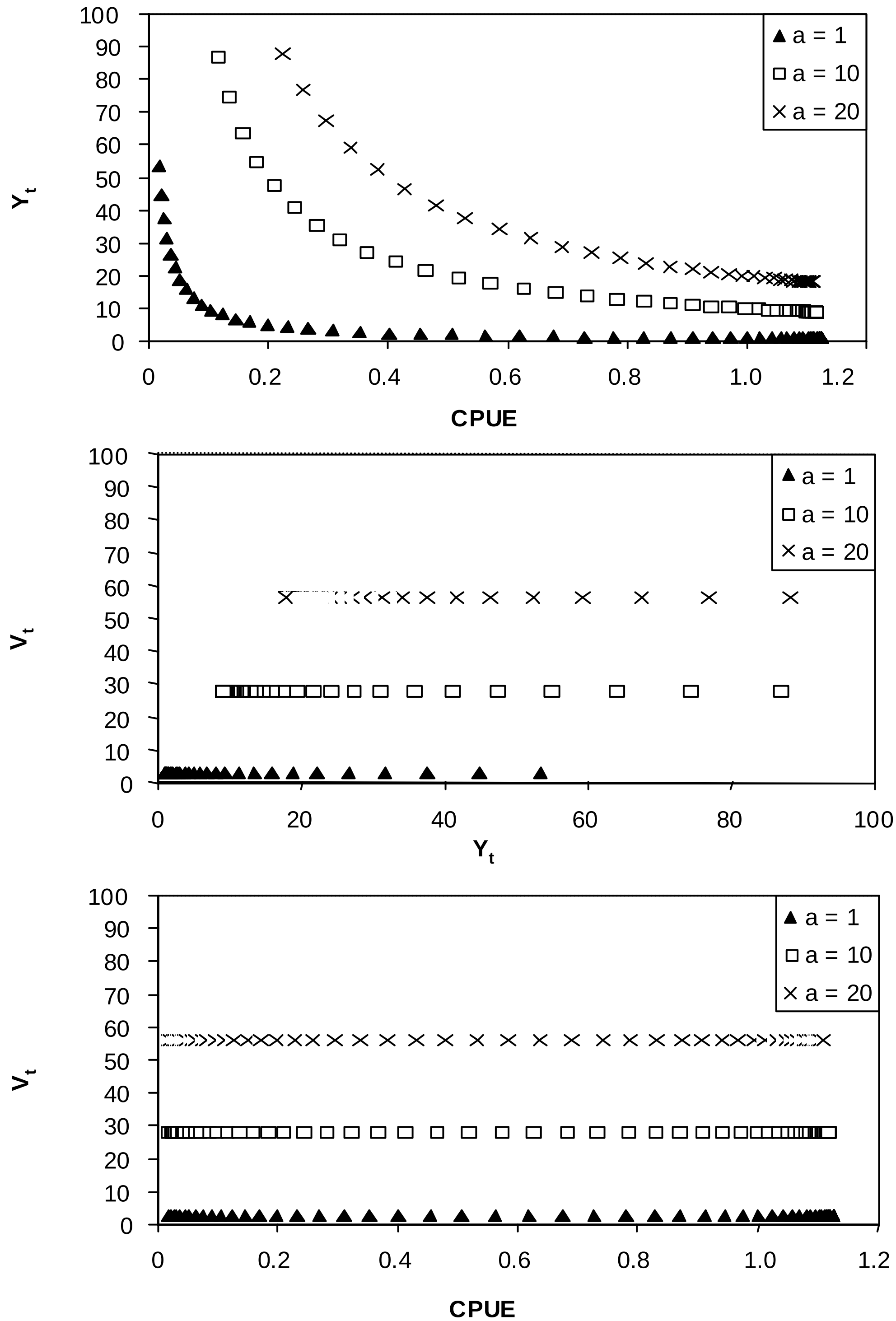

Figure 4.2. The relationships between catch-per-unit-effort (CPUE), illegal harvest rate (Y_t), and violation rate (V_t) when b = -1 and a = 1, 10, and 20 %.

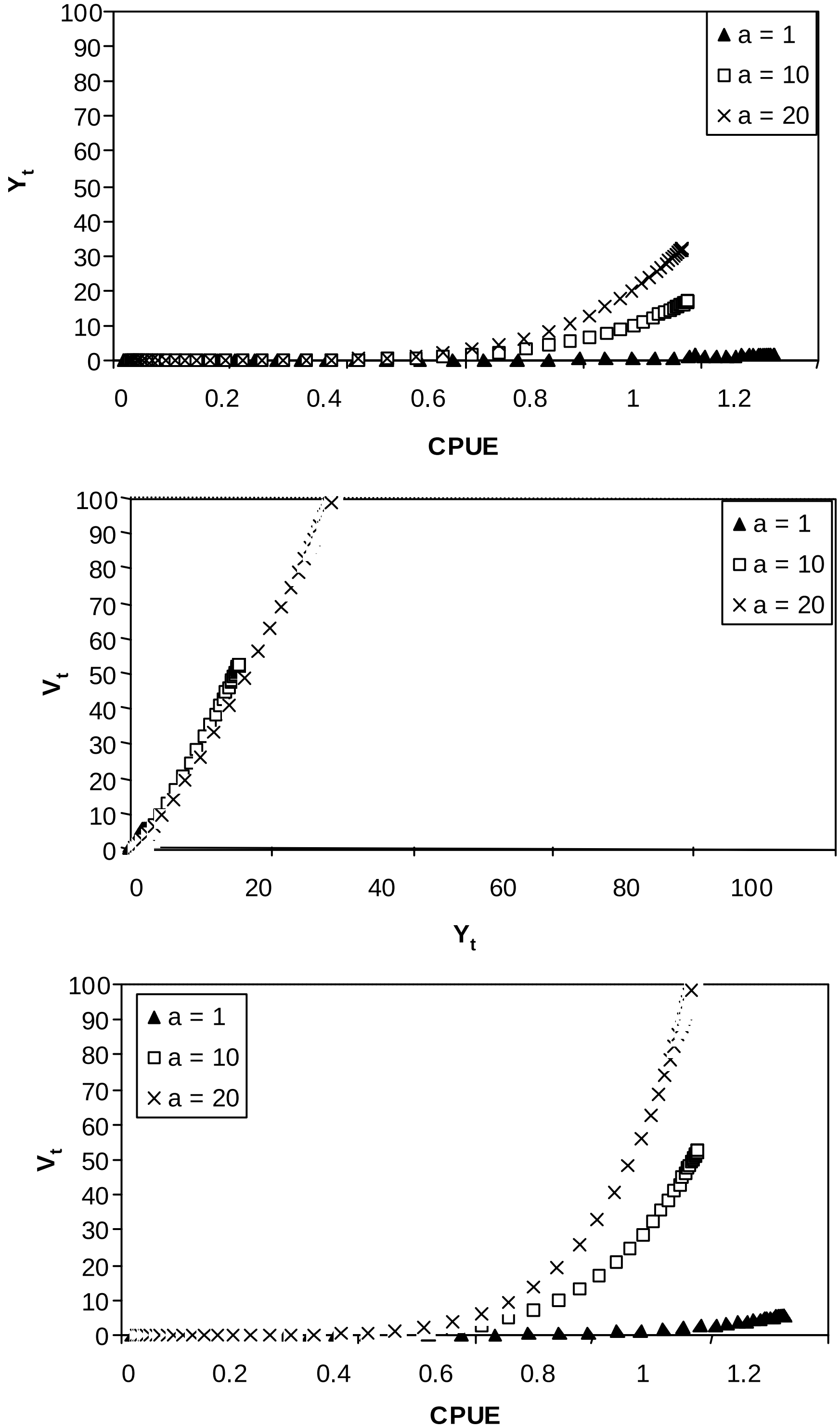

Figure 4.3. The relationships between catch-per-unit-effort (CPUE), illegal harvest rate (Y_t), and violation rate (V_t) when b = 5 and a = 1, 10, and 20 %.

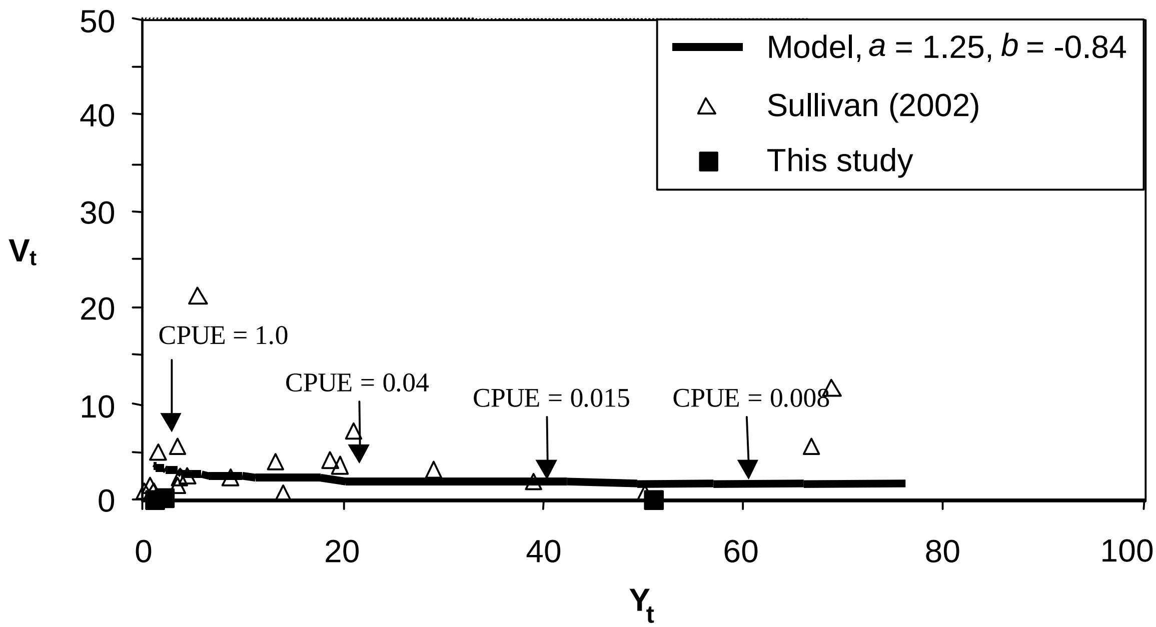

Figure 4.4. The comparison between the model and field data (n = 23 lakes) for the relationship between illegal harvest rate (Y_t) and violation rate (V_t.). The model values for *a* and *b* were 1.25 and -0.84, respectively and selected from Sullivan, (2002). Field data were collected from walleye fisheries in northeastern Alberta from 1991 - 2002 (Sullivan, 2002 and this study).

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CHAPTER 5 – CONCLUSIONS

Illegal harvest of vulnerable species can be a threat to their survival (Muth and Bowe, 1998; Eliason, 1999). For fisheries this illegal response to scarcity can act as a depensatory mechanism to make fisheries recovery uncertain (Post, et al., 2002). My thesis is that this scarcity relationship should affect conservation officers' strategies to deter illegal harvest, our interpretation of anglers' rationalizations for cheating, and the type of monitoring that managers must conduct to gauge illegal harvest.

5.0 THE HUMAN RESPONSE TO RESOURCE SCARCITY

People may respond to resource scarcity, in part, by harvesting illegally. The overriding desire to harvest illegally in response to scarcity may be an intrinsic human behavior and applicable to many valued resources. This is a fundamental idea for conservation biology, because if it operates widely, then some conclusions from this thesis may be applicable to the management of other natural resources. For fisheries conservation, the basis for the idea can be found in the disciplines of ecology, psychology, sociology and economics.

From ecology, an analogue to this relationship might be the "functional response" of an individual predator's rate of food consumption to the prey density (Holling, 1966)(Figure 5.1). I speculate that the harvest by anglers in response to fish density is similar to a Type II functional response curve of a predator. When prey are abundant enough and regulations liberal enough to allow one fish per trip, anglers can probably be satiated. At lower prey densities the harvest rate will decrease because the capture time increases and success rates drop. At lower densities, anglers will not catch one fish per trip and this will not likely satiate them.

I speculate that in the absence of regulations, alternate prey, other lakes, or changes in attitudes, anglers, as predators, would probably follow A (Figure 5.1). Under restrictive size-limit regulations and no illegal harvest, anglers' predation may follow B as regulations restrict harvest. More realistically, however, under restrictive size-limit regulations anglers will harvest some fish illegally and their predation rate may follow C. The shaded area between B and C represents the illegal harvest. Both the slope of Sullivan's scarcity relationship for walleye, and the catch-per-unit-effort (CPUE), will determine the slope and shape of C. The value and desire for the resource will affect the shape of this curve for different resources.

From psychology, motivational theory suggests that as catch rates decrease, the importance of catching a fish by an angler will increase (Finn and Loomis, 2001). "Satiation-deprivation" theory implies that if a reward (catching a fish) is received infrequently that this results in deprivation and a higher valuation of the reward. Loomis and Fix (1998) suggest that there is diminishing value placed on each additional fish caught in a trip by an angler. This implies the first fish that can be kept legally is of high importance. This desire may help to explain the willingness to keep a protected-size fish especially when the fish caught is likely to be the first and last fish caught.

The economist Adam Smith (1937) wrote "*the merit of an object, which is in any degree either useful or beautiful, is greatly enhanced by its scarcity, or by the great labor which it requires to collect any considerable quantity of it…*". Similarly, commodity theory states that something desired will be valued to the extent of it's availability, scarcity, restrictions or delays (Brock, 1968). Therefore, the marginal value of a fish is not constant but may be in part determined by the perceived relative abundance by anglers (relative to its desired abundance). Economic theories about the exhaustion of non-renewable resources describe this as a nonlinear demand curve, or an isoelastic curve (Hartwick and Olewiler, 1986), and common to situations where there is no alternative good that people will switch to when the costs become too high. Declining catch rates increase the value of a fish as a result of the increasing scarcity of the resource. Restrictive regulations in place to decrease harvests will increase the scarcity of the legal-size fish to the angler and may increase the value of any sized fish.

Possession of a scarce resource may itself provide an increased source of status or a basis for negative comparison with others who do not possess these resources (Lynn, 1992). If the restrictive regulations are not believed to be legitimate by the group, then the desirability of the fish may be increased as anglers are motivated to re-establish foregone freedoms (Brehm et al, 1966; Lynn, 1992) and gain this social reward. Further, people are physiologically motivated by barriers to the possession of objects and this increases the desire for these objects (Wright, 1992, Lynn, 1992). Therefore, for some anglers there may be a lower threshold of declining catch rates before they choose to harvest illegally. Potentially, different groups of angler may respond differently to scarcity. Therefore, the violation rate may be different among groups of anglers. This may be an area for additional study by sociologists.

Sociologists may describe the increased illegal harvest rate as resources decline, as an example of the failure of rules to maintain an open-access, common-pool resource resulting in a "tragedy of the commons" (Hardin, 1968). "*When the resource units produced by a common-pool resource have a high value and institutional constraints do not restrict the way resource units are appropriated, individuals face strong incentives to appropriate more and more resource units, leading to congestion, overuse or even the destruction of the resource itself*" (Ostrom, 1999). Anglers following the regulations set by the state or community, is an example of cooperation among users. Breakdown in the cooperation as a result of resource scarcity is common (Ternstrom, 2001). Ostrom (1990) provides examples of water scarcity among irrigators and the increased temptation to cheat when water is limited.

I speculate that other examples that might produce similar human responses to those observed for walleye scarcity might be water poaching for irrigation, moose hunting, wild turkey conservation, the Newfoundland blueberry season, or wild mushroom picking conflicts in British Columbia. In fisheries, examples might be lake trout (*Salvelinus namaycush*) in Ontario, rainbow trout (*Oncorhynchus mykiss*) in British Columbia, (Post, et al., 2002) or striped bass (*Morone saxatilis*) in Chesapeake Bay, U.S.A. In each of these examples, if resource scarcity increases the illegal harvest rate exponentially, as was found in walleye in Alberta, then some of the conclusions from this study may be analogous. For each of these resources, observing the violation rate through enforcement may fail to detect an illegal harvest problem. Managers of other natural resources may want to investigate whether typical violation rate monitoring will be an accurate index of illegal harvest for their resource by first looking for a relationship between illegal harvest rate and resource scarcity. This would likely involve calculating this relationship empirically from field study.

6.1 INFLUENCE OF ENFORCEMENT STRATEGIES TO REDUCE THE ILLEGAL RESPONSE TO SCARCITY

To curb this illegal harvest response, I investigated changing anglers' perceptions of detection and penalties (i.e. deterrence) by applying an enhanced enforcement effort. My results showed a trend towards reduced illegal harvest for northern pike when deterrence was high. Anglers overestimated the risk of detection and there was a diminishing return on perception of detection for increased enforcement investment beyond 12 patrols, 27 patrol hours, or 3% of anglers contacted over the Alberta summer angling season. This information allows conservation officers to efficiently distribute their effort between lakes to maximize their deterrent effect. To achieve this deterrent effect, officers should conduct their patrols throughout the angling season. I observed no effect of signs or repeated early season patrols (saturation patrols) on raising the longer term perception of detection.

Anglers read and retained the information about potential penalties from signs posted at the lakes more often than I anticipated. Anglers (34%) reported the penalty amount from the signs at posted lakes. Signs appear to be a very efficient and inexpensive way to inform anglers about the potential penalties for violation. Signs should contain direct messages about potential personal consequences to harvesting illegally if they are to maximize the deterrent effect.

I conclude that enhanced enforcement will likely be a short-term, tactical tool for managers to reduce illegal harvest for a population. It may have limited effectiveness for highly desirable species such as walleye and be more effective for less desirable species such as northern pike. Public education to inform anglers about the consequences of overharvest and to change angler attitudes and beliefs about the resource, may have long-term benefits. Studies to determine the benefits of education to reduce illegal harvest may be an informative next step.

6.2 ANGLERS' RATIONALIZATIONS OF THE HUMAN RESPONSE TO SCARCITY

Understanding the scarcity effect on illegal harvest allows managers to put into context anglers' rationalizations for cheating. Very few anglers reported the potential consequences or risks of getting caught as reasons why they did not feel justified in cheating, yet by asking directly we know that they were assessing this information. I believe that these rationalizations are excuses for behavior anglers understand are not legal. The fact that so many people chose to respond “yes” to whether they felt justified in cheating, strongly suggests that there is a large component of anglers who believe that the current regulations have low legitimacy. From anglers’ responses I conclude there is a misunderstanding between anglers and biologists that goes deeper than the scientific illiteracy of anglers. Anglers use their own personal criteria for evaluating regulations, allocations, stock status and fishing pressure that does not often include the empirically-based, scientific measures of biologists. This discontinuity between biologists and anglers affects the perceived credibility of the regulations and therefore the acceptance of the regulations by many anglers. I believe that these social reasons may influence the decision of anglers to illegally harvest and amplify the scarcity-illegal harvest relationship.

These misunderstandings represent important areas for public education to make progress in changing attitudes towards the fishery and reducing tensions between users. However, biologists and officers must inform the public with consistent messages and work with the public to effectively manage public resources.

6.3 HOW SCARCITY AFFECTS ENFORCEMENT MONITORING OF ILLEGAL HARVEST

The scarcity effect does not allow for traditional monitoring using enforcement violation encounter rates to estimate the illegal harvest problem at declining fisheries. We observed this in both our model and in the field studies that were conducted. When the catch rate (CPUE) declined, few people caught sub-legal fish, yielding a low violation rate among anglers for officers to encounter. But of those that did catch sub-legal fish, many chose to keep them resulting in a high illegal harvest rate (scarcity effect on illegal harvest; $b<0$). Under these conditions typical enforcement monitoring will fail to detect an illegal harvest problem. I suggest that the illegal harvest rate be measured directly, inferred from the catch rate of sub-legal walleye, but not inferred from enforcement violation encounter rates.

The model also predicts that if there is a positive relationship between abundance and illegal harvest ($b>0$), which I believe can occur under conditions of recovering fisheries and restrictive harvest limits, that the violation rate will overestimate the illegal harvest rate for the fishery. This may become more relevant as fisheries continue to recover in Alberta.

I speculate that the bias in the illegal harvest rate will depend upon a number of social factors that include species of fish, presence of alternate species, perception of detection, perception of penalties, education, tradition for poaching, legitimacy of regulations and angler investment. Research in many disciplines about how these factors may affect this bias may be useful in reducing illegal harvest.

5.4 BREAKING THE SCARCITY RELATIONSHIP

I think it is important to consider two ways managers might minimize or break this scarcity and illegal harvest relationship. Firstly, managers can try to make previously harvested resources non-harvestable by changing attitudes towards the use of the resource. For fisheries management, this could include long-term education programs to shift angler attitudes and beliefs from consuming fish to catch-and-release.

Secondly, managers can, through the choice of regulations, change individual anglers' perceptions about the scarcity of the resource. Managers can move away from size-limit regulations where anglers are playing a lottery to catch a fish they can keep, and move toward quota systems where the lottery occurs on land long before the fishing begins. Therefore, successful applicants are already relatively assured of getting to keep a fish before they go on the water; thus removing the perception of scarcity and reducing the propensity to cheat. Study of the best ways to break this scarcity-illegal harvest relationship may be an excellent area for future sociological investigation and should inform fisheries managers of the best ways to avoid the problem.

Finally, I believe that to break the scarcity relationship, fisheries managers in Alberta need to develop new ways to communicate biological knowledge to the public to reduce the consumptive nature of fishing. Only through sustained, reduced harvests will stocks recover. Anglers will need to interact differently with the resource than in the past and they must understand why biologists are concerned. I urge managers to consider the benefits that come from integrating disciplines such as sociology, education, economics, or psychology with traditional ecologically based management. I believe that without doing so, the empirically correct management plans will be ignored by politicians, bureaucrats, and anglers, further frustrating biologists and officers. I also urge enforcement officers and biologists to work more closely together by integrating their management plans to achieve the common goal of reduced illegal harvests.

The integration of human dimensions with traditional ecological management is rare, yet considered by some to be critical to fisheries and wildlife management, and conservation in the 21st century (Riley, et al, 2002; Radomski, 2001; Fedler, 1994). I believe that the integration of these human dimensions is critical to breaking this scarcity relationship.

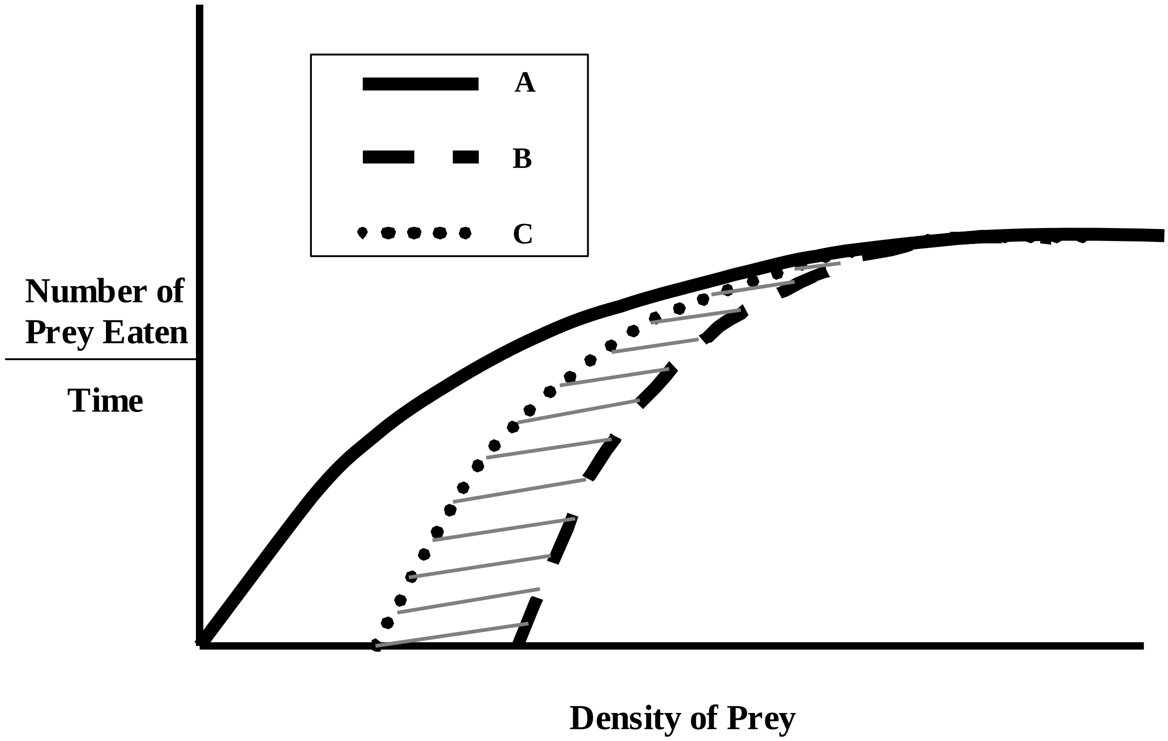

Figure 5.1. Line A is Holling's (1966) Type II functional response of predators to prey density. I speculate that anglers, as predators, may follow A. Under restrictive size-limit regulations and no illegal harvest, anglers' predation may follow B. But under restrictive size-limit regulations anglers will harvest some fish illegally and so anglers' predation rate may follow C. The shaded area between B and C accounts for the illegal harvest. The slope of Sullivan's relationship (2002) for a species, in part, determines the slope and shape of C. The slope of C affects the violation rate (V_t) encountered by enforcement officers.

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Appendix A: Signs used to convey consequential messages to anglers at enhanced enforcement lakes.