AN ANALYSIS OF NATION-WIDE WILDLIFE LAW ENFORCEMENT DATA

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Abstract: Data gathered by Morse in 1968, 1972, and 1976 surveys of state enforcement divisions were subjected to correlation and multiple regression analysis. Correlation analysis resulted in 75 significant ($P \leq 0.05$) correlations between pairs of enforcement variables. Man-years of fisheries and wildlife law enforcement was the most frequently occurring variable in the 75 bivariate correlations. Multiple regression analysis was used to gain insight into the relative strength of the relationships between proposed independent variables and a dependent variable (either arrests or arrests per 1,000 licenses) in 6 regression models. A Uniform Recording and Reporting System and an annual survey of law enforcement divisions would make law enforcement data more amenable to statistical analysis.

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Morse (1968, 1972, 1976) conducted a nation-wide data-gathering questionnaire survey of state wildlife law enforcement divisions in each of the years 1968, 1972, and 1976. He attained very high questionnaire response rates from the states in each of the 3 surveys and has gathered volumes of wildlife law enforcement data.

Few significant relationships among wildlife law enforcement variables have been documented. Variables common to all state wildlife law enforcement divisions (e.g. arrests, convictions, number of agents, man-years of enforcement) often assume widely divergent numerical values. The purpose of this report is to present some of the data collected by Morse in a different format, present significant statistical relationships between and among wildlife law enforcement variables, and suggest future modifications for collecting and analyzing nation-wide and individual-division wildlife law enforcement data.

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PRESENTATION AND DESCRIPTION OF VARIABLES

Morse conducted questionnaire surveys in each of the years 1968, 1972, and 1976 but data gathered did not correspond to the year the survey was conducted because states are on different reporting schedules. For each of the survey years the data received correspond to either the calendar year preceding the survey year or the most recently completed fiscal year (e.g. for the 1968 survey the data are either for the period 1 January 1967 to 31 December 1967 or 1 July 1966 to 30 June 1967).

Variables that were used for analysis of 1968, 1972, and 1976 survey data are shown in Tables 1, 2, and 3, respectively. Variables have been assigned a name to facilitate their

Table 1. Variables used for analysis of 1968 survey data.

Variable Name	*Number of Observations*	*Mean*	*Standard Deviation*	*Minimum Value*	*Maximum Value*
ARRCO1	42	34	17	4	69
PERCO1	41	96	3	82	99
ARRXL1	42	5.56	3.09	1.40	13.60
SPOCO1	48	7,005	2,686	459	12,369
PTSIZ1	46	781	816	45	3,476
COCOS1	43	31	31	4	131
COTIM1	41	59	19	20	95
MANYR1	41	60.9	45.7	3.5	212.5
ENRES1	41	0.27	0.25	0.03	1.23
ENSPO1	41	0.13	0.25	0.02	1.63
SPORT1	41	726,259	592,112	10,552	2,656,250
COSOF1	41	101	68	7	295
ARRST1	41	3,839	349	91	15,967

Table 2. Variables used for analysis of 1972 survey data.

Variable Name	*Number of Observations*	*Mean*	*Standard Deviation*	*Minimum Value*	*Maximum Value*
ARRCO2	46	42	18	8	71
PERCO2	41	95	5	76	100
ARRXL2	46	6.95	4.99	1.90	29.7
SPOCO2	47	7,416	3,179	574	14,451
PTSIZ2	45	753	835	37	3,925
PERST2	45	35.7	12.2	16.5	67.6
PERBU2	43	28.6	9.5	11.1	50.2
COCOS2	47	25	25	4	129
COTIM2	43	59	18	20	89
MANYR2	42	65.2	54.9	7.8	248.3
ENRES2	42	0.28	0.29	0.02	1.58
ENSPO2	42	0.13	0.21	0.03	1.39
SPORT2	42	791,325	634,261	15,540	3,103,750
COSOF2	42	105	70	14	306
ARRST2	41	4,890	4,659	263	21,420

Table 3. Variables used for analysis of 1976 survey data.

Variable Name	*Number of Observations*	*Mean*	*Standard Deviation*	*Minimum Value*	*Maximum Value*
ARRCO3	46	50	22	15	94
PERCO3	44	94	6	68	100
ARRXL3	46	8.27	5.09	2.70	27.00
SPOCO3	47	7,359	3,454	560	14,853
COTIM3	38	63	16	30	95
MANYR3	37	80.9	64.8	12.0	291.0
ENSPO3	37	0.14	0.21	0.03	1.25
PERST3	42	35.4	12.7	13.9	57.5
PERBU3	41	31.0	11.3	13.5	50.8
ARRST3	46	6,244	5,225	515	23,860
COSOF3	47	119	82	19	428
SPORT3	37	903,891	733,823	19,040	3,177,500

presentation with corresponding values. A "1", "2", or "3" at the end of a variable name denotes the survey year corresponding to the variable (i.e. a "1" at the end of a variable name signifies that the variable was for the 1968 survey year, a "2" corresponds to the 1972 survey year, and a "3" corresponds to the 1976 survey year). Tables 1, 2, and 3 also include the number of individual enforcement divisions for which data were available, the arithmetic mean, standard deviation, minimum value, and maximum value of the variable. Data for the Pennsylvania Game Commission, Pennsylvania Fish Commission, Washington Department of Game, and Washington Department of Fisheries were not analyzed because the functions of each department are probably not mutually exclusive. It would therefore be inappropriate to combine data from both departments. Certain variables for the Oregon Wildlife Commission were eliminated because of the combined wildlife and police law enforcement functions of Oregon agents. The number of individual state divisions for which data were available for a variable will vary because some states either did not respond to Morse's 1968, 1972, and/or 1976 questionnaire, did not provide data for some of the questions, and/or provided data that could not be compared with data provided by the states as a whole.

Following is a description of each variable and the manner in which it was derived. An asterik (*) following a variable name signifies that values for the variable were taken directly from Morse's (1968, 1972, 1976) reports.

ARRCO (1) (2) (3)* - Mean number of arrests per conservation officer.

PERCO (1) (2) (3)* - Mean percent conviction of arrests.

ARRXL (1) (2) (3)* - Mean number of arrests per 1,000 fishing and hunting licenses sold.

SPOCO (1) (2) (3)* - Mean number of hunters and fishermen per conservation officer.

PTSIZ (1) (2)* - Average patrol district size in square miles.

COCOS (1) (2)* - Average number of conservation officers per conservation officer supervisor.

COTIM (1) (2) (3)* - Average percentage of conservation officer time spent on fisheries and wildlife law enforcement.

MANYR (1) (2) (3) - Number of man-years of fish and wildlife enforcement. This value is calculated for each state by multiplying the number of conservation officers by the average percent of officer time spent on fisheries and wildlife law enforcement. In most cases, values of this variable will be an underestimate because of field law enforcement of supervisors, deputy wardens, special wardens, trainees, and undercover agents.

ENRES (1) (2) - Number of man-years spent on fisheries and wildlife law enforcement per 10,000 resident population. This number is calculated for each state by dividing the number of man-years of fisheries and wildlife enforcement by the resident population of the state in 10,000's on 1 July 1967 or 1 July 1971.

ENSPO (1) (2) (3) - Number of man-years spent on fisheries and wildlife law enforcement per 1000 sportsmen. Values are calculated for each state by dividing the number of man-years of fisheries and wildlife enforcement by the number of paid hunting and fishing license holders in thousands in fiscal year 1967 or 1971. Morse's data were adjusted to calculate the variable value for 1976.

COSOF (1) (2) (3)* - Number of conservation officers.

ARRST (1) (2) (3)* - Number of arrests (includes arrest data for non-fish and wildlife law violations).

SPORT (1) (2) (3) - Number of paid fishing and hunting license holders.

PERBU (2) (3)* - Percentage of total agency budget allocated for enforcement.

PERST (2) (3)* - Percentage of total agency staff in enforcement.

RESULTS

Statistical Analyses

Variables and combinations of variables were analyzed using Pearson product-moment correlation analysis and forward selection multiple regression analysis. Correlation and regression analysis was performed using the Statistical Analysis System of Barr et al. (1976).

Pearson correlation coefficients were computed for all possible combinations of pairs of variables in each of the years 1968, 1972, and 1976. The results of the correlation analysis of 1968, 1972, and 1976 variables are shown in Tables 4, 5, and 6, respectively.

Table 4. Pearson correlation analysis of 1978 variables.

Correlated Variables	*Correlation (r)*	*Significance ($H_0 : r = 0$)*	*Number of Observations*
MANYR1*COSOF1	0.858	0.0001	41
MANYR1*ARRST1	0.842	0.0001	41
MANYR1*SPORT1	0.770	0.0001	41
ARRCO1*ARRST1	0.648	0.0001	41
ARRXL1*ARRCO1	0.578	0.0001	42
SPOCO1*SPORT1	0.571	0.0001	41
ENRES1*COTIM1	0.435	0.0045	41
ARRXL1*ARRST1	0.433	0.0047	41
COCOS1*COSOF1	0.423	0.0059	41
MANYR1*COTIM1	0.418	0.0065	41
MANYR1*ARRCO1	0.347	0.0261	41
COCOS1*ARRST1	0.335	0.0320	41
SPOCO1*ARRCO1	0.312	0.0441	42
ENRES1*SPORT1	-0.308	0.0497	41
PTSIZ1*ARRST1	-0.362	0.0431	39
PTSIZ1*COSOF1	-0.370	0.0203	39
MANYR1*PTSIZ1	-0.424	0.0071	39
COTIM1*PTSIZ1	-0.447	0.0043	39
SPOCO1*ARRXL1	-0.507	0.0006	42
ENSPO1*SPOCO1	-0.553	0.0002	41

Table 5. Pearson correlation analysis of 1972 variables.

Correlated Variables	*Correlation (r)*	*Significance ($H_0 : r = 0$)*	*Number of Observations*
MANYR2*COSOF2	0.940	0.0001	42
MANYR2*ARRST2	0.900	0.0001	41
MANYR2*SPORT2	0.801	0.0001	42
ENSPO2*ARRXL2	0.750	0.0001	41
PERBU2*PERST2	0.722	0.0001	41
ARRCO2*ARRST2	0.708	0.0001	41
MANYR2*COTIM2	0.521	0.0004	42
SPOCO2*SPORT2	0.518	0.0004	42
ARRCO2*SPORT2	0.506	0.0007	41
ARRCO2*COSOF2	0.482	0.0014	41
MANYR2*PERBU2	0.479	0.0023	38
SPOCO2*ARRCO2	0.473	0.0009	46
PERBU2*COSOF2	0.469	0.0030	38
MANYR2*ARRCO2	0.466	0.0022	41
PERBU2 *ARRST2	0.426	0.0086	37
COCOS2*ARRST2	0.376	0.0154	41
PERST2*ARRXL2	0.374	0.0125	44
ENRES2*COTIM2	0.367	0.0170	42
COCOS2*ARRCO2	0.363	0.0131	46
ENSPO2*COTIM2	0.357	0.0203	42
COCOS2*COSOF2	0.323	0.0367	42
COTIM2*ARRXL2	0.320	0.0390	42
PERBU2*ARRXL2	0.319	0.0394	42
MANYR2*COSOS2	0.305	0.0494	42
PTSIZ2*COSOF2	-0.335	0.0344	40
COTIM2*PTSIZ2	-0.338	0.0307	41
MANYR2*PTSIZ2	-0.337	0.0334	40
ENRES2*SPOCO2	-0.343	0.0263	42
PERST2*PERCO2	-0.371	0.0169	41
ENSPO2*PTSIZ2	-0.395	0.0116	40
PERST2*SPOCO2	-0.442	0.0024	45
PERBU2*PTSIZ2	-0.446	0.0021	41
SPOCO2*ARRXL2	-0.540	0.0001	46
ENSPO2*SPOCO2	-0.587	0.0001	42

Table 6. Pearson correlation analysis of 1976 variables.

Correlated Variables	*Correlation (r)*	*Significance ($H_0 : r = 0$)*	*Number of Observations*
COSOF3*MANYR3	0.935	0.0001	37
COSOF3*ARRST3	0.877	0.0001	46
ARRST3*MANYR3	0.876	0.0001	37
SPORT3*ARRST3	0.855	0.0001	37
SPORT3*COSOF3	0.795	0.0001	37
ENSPO3*ARRXL3	0.750	0.0001	37
PERBU3*PERST3	0.689	0.0001	39
SPORT3*MANYR3	0.721	0.0001	37
SPOCO3*ARRCO3	0.555	0.0001	46
ARRST3*ARRCO3	0.534	0.0001	46
PERST3*ARRXL3	0.440	0.0040	41
SPORT3*SPOCO3	0.431	0.0077	37
ARRST3*PERBU3	0.388	0.0135	40
MANYR3*COTIM3	0.387	0.0181	37
ARRCO3*SPORT3	0.380	0.0203	37
PERBU3*MANYR3	0.362	0.0357	34
COSOF3*PERBU3	0.359	0.0212	41
PERST3*SPOCO3	-0.379	0.0134	42
ENSPO3*ARRCO3	-0.388	0.0177	37
ENSPO2*SPOCO3	-0.571	0.0003	37
SPOCO3*ARRXL3	-0.636	0.0001	46

Each table includes the pair of numeric variables for which a correlation coefficient was computed, the magnitude and direction of the relationship, the significance probability of the correlation coefficient (i.e. the probability that a value of the correlation coefficient as large or larger in value could have arisen by chance were the 2 random variables truly uncorrelated, and the number of observations (divisions) contributing to the correlation coefficient. Only those correlation coefficients whose significance probability was 0.05 are listed.

For the purpose of this paper, a correlation coefficient between 2 variables of between ±0.30 and ±0.50 will be classified as "weak," a coefficient between ±0.51 and ±0.75 will be classified as "moderate," and a coefficient between ±0.76 and ±1.00 will be classified as "high." The coefficient classifications are contrived but in general are reflective of social science descriptions of correlational relationships.

The variable MANYR (man-years of fisheries and wildlife law enforcement) was the most frequently occurring variable in the 75 significant correlations (it was one of a pair of correlated variables in 19 of the 75 correlations). MANYR was followed, in decreasing frequency of occurrence, by ARRST (15), SPOCO (14), ARRCO (13), COSOF (12) , SPORT (11) and ARRXL (10) (Table 7). Table 7 also includes an intercorrelation index

Table 7. Frequency of occurrence and intercorrelation index of enforcement variables in 75 correlations.[a]

Variable	*Number of correlations in which the variable was one of a pair of correlated variables*	*Intercorrelation index (Number of variables with which the variable was correlated)*
MANYR	19	8
ARRST	15	8
SPOCO	14	6
ARRCO	13	9
COSOF	12	7
SPORT	11	6
ARRXL	10	6
PERBU [b]	10	6
PTSIZ [b]	9	6
COTIM	9	5
ENSPO	8	5
PERST [b]	7	4
jCOCOS [b]	6	4
ENRES [b]	4	3
PERCO	1	1

[a] 1968, 1972, and 1976 survey data and variables combined.

[b] Variable was used in correlation analysis for 2 of the 3 survey years.

for each variable (i.e. the number of *different* variables with which a variable was correlated for the 1968, 1972, and 1976 combined variables). A Spearman rank-order correlation coefficient was calculated in order to examine the time a variable was one of only a *pair* of correlated variables and was correlated to a set of *different* variables. The calculated rho of 0.93 ($P \leq 0.001$) indicates a highly significant relationship between frequency of occurrence of a variable in correlations and the number of variables with which a variable was correlated.

The variable MANYR had the highest frequency of occurrence in the 12 highl-correlation situations (occurred 8 times) and was followed by ARRST (6), COSOF (5), SPORT (4), ENSPO (2), ARRXL (1), PERBU (1), and PERST (1). Forty-six (61%) of the 75 correlations were classified as weak, 17 (23%) as moderate, and 12 (16%) as high. The direction of the relationship was positive in 54 (72%) of the correlations and negative in 21 (28%) of the correlations.

Most of the correlations presented in Tables 4-6 are intuitive and probably are important from the standpoint of documenting relationships between and among variables. For example, man-years of enforcement appeared to be highly and positively correlated with numbers of sportsmen in 1968 and 1972 and moderately correlated in 1976. The mean number of sportsmen per conservation officer was moderately and negatively correlated with mean number of arrests per 1000 licenses in each of the survey years. Thus, as the number of sportsmen per officer increases, arrests per 1000 licenses appears to decrease.

Other apparent relationships are not as stable over the 8-yr period. Man-years of enforcement per 1000 sportsmen were moderately to highly correlated in a positive direction with arrests per 1000 licenses in 1972 and 1976 but they were not significantly ($P \leq 0.05$) related in 1968. The mean number of sportsmen per conservation officer was moderately and positively correlated with numbers of sportsmen in 1968 and 1972 but only weakly correlated in 1976.

We have not provided an in-depth interpretation of correlational relationships between and among variables because of the generally-accepted disrepute of *"ex post facto"* hypothesizing. All hypotheses must be subjected to disconfirmation and, it is reasoned, once the researcher has *observed* a relationship between 2 variables, any hypothesis regarding that relationship cannot be disproved. This line of reasoning is generally directed toward the researcher "who does nothing more than dress up his empirical observations with deceptive hypotheses after the fact" (Babbie 1973:925). This does not imply that one should not hypothesize "after the fact." Lazarsfeld developed an elaboration paradigm for testing *"ex post facto"* hypotheses within the same body of data (see Rosenberg 1968).

We have been unwilling or unable to extend our analyses of the data because some significant ($P \leq 0.05$) relationships may be biased because of missing observations (i.e. up to 10 agencies may not have been included in correlation analysis of pairs of variables). Thus, correlation statistics presented in Tables 4, 5, and 6 would have to be adjusted for missing observations to improve their reliability.

Other limitations we observed were that many of the correlations are probably spurious and interactive because of the potential influence of one or more variables on 2 correlated variables. Partial correlations were not used to "partial out" or control the influence of possible confounding variables because of (1) nonrandom measurement errors known to be associated with certain variables studied here, (2) probable distortions produced by outside confounding influences for which information was not available, and (3) the complexity of numerous intercorrelations among variables.

Multiple Regression Analysis

Forward selection multiple regression analysis was used to gain insight into the relative strength of the relationships between proposed independent variables and a dependent variable in 6 regression models. The forward selection technique (Barr et al. 1976:251) first identifies a single-variable model which produces the largest R^2 statistic. R^2 is the coefficient of multiple determination (or the square of the multiple correlation coefficient) and measures the proportion of total variation about the mean of the dependent variable explained by regression. The significance level for entry of an independent variable into a regression model was $P \leq 0.05$ (tested by a partial F-test). Independent variables which produced the largest F-statistic having a significance probability greater than the specified significance level for entry were entered sequentially into the regression model. When possible, independent variables were added one by one to a model until no variable produced a significant F-statistic.

The dependent variables considered in the 6 regression equations were ARRXL1, ARRXL2, ARRXL3, ARRST1, ARRST2, and ARRST3 (arrests per 1,000 licenses in 1968, 1972, 1976 and arrests in 1968, 1972, and 1976, respectively). Independent variables considered for inclusion in a regression model are listed in Table 8. Following are the 6

Table 8. Dependent and independent variables considered in six regression models.

Regression Number [a]	*Dependent Variable*	*Independent Variables*
1	ARRXL1	PERCO1, SPOCO1, PTSIZ1, COTIM1, MANYR1, ENRES1, ENSPO1
2	ARRXL2	PERCO2, SPOCO2, POTSIZ2, PERST2, PERBU2, COTIM2, MANYR2, ENRES2, ENSPO2
3	ARRXL3	PERCO3, SPOCO3, COTIM3, MANYR3, ENSPO3, PERST3, PERBU3
4	ARRST1	PERCO1, SPOCO1, PTSIZ1, COTIM1, MANYR1, ENRES1, ENSPO1, SPORT1, COSOF1
5	ARRST2	PERCO2, SPOCO2, PTSIZ2, PERST2, PERBU2, COTIM2, MANYR2, ENRES2, ENSPO2, SPORT2, COSOF2
6	ARRST3	PERCO3, SPOCO3, COTIM3, MANYR3, ENSPO3, PERST3, PERBU3, SPORT3, COSOF3

[a] 11, 15, 19, 11, 15, and 19 observations (agencies) deleted due to missing values in regression number 1, 2, 3, 4, 5, and 6, respectively.

regression equations that were developed. All regression equations and partial regression coefficients of independent variables were significant at $P \leq 0.05$.

ARRXL1 = 2.79 + 28.96ENSPO1 (R^2 = 0.27,df = 36)
ARRXL2 = 12.37 - 0.0008SPOCO2 (R^2 = 0.27,df = 32)
ARRXL3 = 2.40 + 16.06ENSPO3 + .11PERST3
(Adjusted R^2 = 0.65,df = **28)**
ARRST = 13.00 + 64.24MANYR1 (R^2 = 0.71,df = 40)
ARRST2 = 120.92 + 75.90MANYR2 (R^2 = 0.84,df = 32)
ARRST3 = 3152.03 + 0.0056SPORT3 + 145.34PERBU3
(Adjusted R^2 = 0.81,df = 28)

One of a combination of significantly (0.10) correlated independent variables was removed from several of the regression equations to offset problems of multicolinearity. The variable COTIM2 was removed from the equation for ARRST2 because it was substantially correlated with MANYR2 (r = 0.52,$P \leq 0.0005$). The variable MANYR3 was removed from the regression equation for ARRST3 because it was moderately correlated with SPORT3 (R = 0.62,$P \leq 0.0001$) and significantly correlated with PERBU3 (R = 0.36,P 0.0357).

The proportion of total variation about the mean of the ARRST variable (R^2) explained by regression was much greater than the variation explained for the ARRXL variable (mean number of arrests per 1000 fishing and hunting licenses sold). This may have been due to the ARRST variable being a naturally-occurring variable whereas ARRXL is a contrived variable created from both arrests and number of sportsmen. Three of the 6 regression equations contain either man-years of enforcement or man-years of enforcement per 1000 sportsmen as the only independent variable. As was previously stated, man-years of enforcement was calculated by multiplying the number of conservation officers by the average percentage of officer time spent on fisheries and wildlife law enforcement. Morse (1976:128), in his publication of 1976 survey results, stated "... the data showing how the conservation officer spends his time is largely based on estimates made by the agency official answering the questionnaire. Since personnel and conditions change, there is little validity or continuity in these estimates. . ." Ordinary regression analysis is usually based upon the assumption that there may be errors of measurement with respect to the dependent variable but that all of the independent variables have been measured without error. Thus, 4 of the 6 regression equations (ARRXL1, ARRXL3, ARRST1, ARRST2) would be unreliable to the degree that figures for the average percentage of officer time spent on fisheries and wildlife law enforcement do not correspond to the "true" percentages.

One possible explanation for the inability to explain a greater percentage of variation in the dependent variables might be that arrests between different states do not cover the same range of behaviors. Comparable numbers of officers working a similar percentage of time in enforcement in 2 states, 1 with and 1 without police powers (expanded arrest authority), may make different average numbers of arrests per officer, partly because of the police powers. Thus, the regression equations may be misleading because the dependent variables do not cover the same range of behaviors. The regression equations would also be misleading to the extent that values for missing observations (i.e. states not included) were divergent from the pattern of values used in the regression analysis.

CONCLUSIONS

Several problems became apparent when analyzing state wildlife law enforcement data on a national basis for 3 1-yr. periods. Several agencies were unable to supply data for certain questions in Morse's questionnaire. Other agencies supplied "estimates" of variable paramenters. Most agencies supplied exacting data for the number of arrests but the arrest variable may not have covered a common range of behaviors. Several of the questions in Morse's questionnaire provide "interesting" information (fines, number of cases appealed) but may be of low relevance in trying to document significant and important relationships among law enforcement variables.

Individual wildlife law enforcement divisions should take a close look at the data they are collecting. The types of data to collect will be dictated, to a great extent, by the objectives of the enforcement division. Once the division has firmly established explicit objectives and has reached agreement on the methods to be used to achieve objectives, numerical measures of the methods and their degree of achievement will supply data needed for evaluation of attainment of objectives.

A Uniform Recording and Reporting System is greatly needed to achieve comparability of data between enforcement divisions. Task forces composed of members of regional fish and wildlife associations would seem to be suited to recommending components of a Uniform Recording and Reporting System.

Morse has provided an excellent service to the states with his quadrennial law enforcement survey. However, to present an analogy, it would appear difficult to manage the nation's waterfowl for consumptive use if harvest data, age and sex structure data, population estimates, range extensions, etc., were available at only 4 year intervals. National wildlife law enforcement data would be more amenable to statistical analysis and evaluation if states achieved continuity and uniformity in their data collection procedures and if the data were analyzed annually on a national basis. Individual enforcement divisions, collections of divisions, regional enforcement sections and/or wildlife law enforcement officer associations should consider taking the initiative in developing such a program.

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