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Development of a Process for the Long-term Monitoring of MMPA Category I and II Commercial Fisheries

Proceedings of a Workshop held in
Silver Spring, Maryland, 15–16 June 1998

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NOAA Technical Memorandum
NMFS-OPR-14
September 1999

U.S. Department of Commerce
William M. Daley, Secretary

National Oceanic and Atmospheric Administration
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National Marine Fisheries Service
Penelope D. Dalton, Assistant Administrator for Fisheries

Submitted in partial fulfillment of the requirements of NOAA contract 40AANF802291.

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This document should be cited as follows:

Didier, A. J., Jr., and V. R. Cornish (eds.). 1999. Development of a process for the long-term monitoring of MMPA Category I and II commercial fisheries. Proceedings of a workshop held in Silver Spring, Maryland, 15–16 June 1998. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-14, 46 p.

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Planning observer coverage by calculating the expected number of observed mortalities
Paul Wade, NMFS Alaska Fisheries Science Center (paper submitted to workshop)

Planning the amount of observer coverage to allocate to observing a fishery should be based on achieving management goals. Simple "rules of thumb" such as targeting 5 or 10% observer coverage are not sufficient for planning. Five percent observer coverage may be sufficient for a very large fishery, but may be grossly inadequate for a smaller fishery. Targeting achieving a specified coefficient of variation of the mortality estimate, such as 0.3, is a better planning method.

However, another way to investigate whether an observer program has an adequate sample size is to examine the expected number of observed mortalities for a given true mortality rate. Particularly for fisheries being observed for the first time, it may be most appropriate to use a planning method that is more specifically aimed at documenting takes, if takes are occurring. In other words, a first-time observer program for a fishery should make the probability of observing zero takes very small if the true number of takes is great enough to be of concern (i.e., on the order of the PBR, or some other similar measure).

The are several reasons for taking this approach. First, with limited resources, it may not be possible to allocate enough observer coverage to a fishery to immediately produce a mortality estimate with a low CV. Second, observing no takes (when real takes are important) in a first-time observer program could be problematic, as it might lead to the false conclusion that takes are not a problem, when they are. A one-time observer program should be considered to have a flawed design if the probability of observing zero takes is too high, under the assumption that takes are truly great enough to be of concern.

One simple way of making such calculations is to use a binomial distribution, where the mortality rate is the binomial parameter (the mean), and the number of observations is the intended sample size, in some unit of fishing effort (such as sea-days, trips, or whatever unit of effort is the basis for planning observer coverage). I do not intend to take credit for inventing this approach (for example, such a method was used by DeMaster and others in planning the Alaska Category II observer program), I simply wanted to describe the approach in simple terms for those who are not familiar with it.

The steps needed to perform this calculation can be described this way:
(1) Select an expected amount of effort (E) for the fishery. This would most logically be based on the amount of effort seen in the fishery in the most recent year for which this information is available. The effort should be in a unit, such as sea-days or trips, that is related to how effort will be allocated.
(2) Select a level of mortality (M) that is considered to be of concern, in numbers of animals. This could logically be based on the PBR of a stock of concern, or on other information, such as a level of takes predicted from strandings data, for example.
(3) Calculated the binomial parameter p=M/E, which is the expected mortality per unit of effort, if M animals are being killed per year.

(4) Select a proposed amount of observer coverage (*n*), in the same unit of effort of E in 1. This is the proposed sample size.
(5) Calculate the probability of observing x=1,2,3,4,...10 mortalities using the binomial distribution *b(x; n, p)*.

Making calculations in this way carries an assumption that marine mammal mortalities have a binomial distribution, meaning the expected rate of bycatch is constant for unit of effort such as a sea-day. This may not be strictly true, as bycatches may sometimes be clumped in distribution for a variety of reasons. However, this provides a reasonable starting point for designing an observer program.

I have written a simple computer program (SEADAYS) that can make these calculations. An example of its use is given here:
(1) Most recent number of sea-days of effort from a target fishery was E=5668. It is assumed that the fishery will have a similar number of sea-days of effort in the year it is observed.
(2) Strandings data have led to an estimate of M=39 mortalities from fishery interactions, which cannot be definitively attributed to a specific fishery. An observer program is started for the fishery suspected of causing the mortalities.
(3) If it is assumed that the true mortality is 39, then the expected mortality rate $p = 39/5668 = 0.0069$.
(4) Proposed sample sizes for the number of observer sea-days are *n*=200, 300, 400, or 500 sea-days.
(5) The expected probability of observing a given number of mortalities can be calculated from a b(x; 200, 0.0069), etc. The calculations in Table 5 are output from SEADAYS.

Table 5. Outputs from the computer program SEADAYS, June 1, 1998.

BINOMIAL PROBABILITIES FOR SAMPLE SIZE N=100 AND P=0.006900

Pr of obs number	Cumulative Pr of obs that number or more
Pr(x= 0)=0.5004	Pr(x>= 0)=1.0000
Pr(x= 1)=0.3477	Pr(x>= 1)=0.4996
Pr(x= 2)=0.1196	Pr(x>= 2)=0.1520
Pr(x= 3)=0.0271	Pr(x>= 3)=0.0324
Pr(x= 4)=0.0046	Pr(x>= 4)=0.0053
Pr(x= 5)=0.0006	Pr(x>= 5)=0.0007
Pr(x= 6)=0.0001	Pr(x>= 6)=0.0001

Probability of observing 1 or more takes: 0.500
Most likely # of observed mortalities: 0

BINOMIAL PROBABILITIES FOR SAMPLE SIZE N=200 AND P=0.006900

Pr of obs number	Cumulative Pr of obs that number or more
Pr(x= 0)=0.2504	Pr(x>= 0)=1.0000
Pr(x= 1)=0.3479	Pr(x>= 1)=0.7496
Pr(x= 2)=0.2405	Pr(x>= 2)=0.4017
Pr(x= 3)=0.1103	Pr(x>= 3)=0.1612
Pr(x= 4)=0.0377	Pr(x>= 4)=0.0509
Pr(x= 5)=0.0103	Pr(x>= 5)=0.0131
Pr(x= 6)=0.0023	Pr(x>= 6)=0.0029

Probability of observing 1 or more takes: 0.750
Most likely # of observed mortalities: 1

BINOMIAL PROBABILITIES FOR SAMPLE SIZE N=300 AND P=0.006900

Pr of obs number	Cumulative Pr of obs that number or more
Pr(x= 0)=0.1253	Pr(x>= 0)=1.0000
Pr(x= 1)=0.2611	Pr(x>= 1)=0.8747
Pr(x= 2)=0.2712	Pr(x>= 2)=0.6136
Pr(x= 3)=0.1872	Pr(x>= 3)=0.3423
Pr(x= 4)=0.0966	Pr(x>= 4)=0.1551
Pr(x= 5)=0.0397	Pr(x>= 5)=0.0585
Pr(x= 6)=0.0136	Pr(x>= 6)=0.0188

Probability of observing 1 or more takes: 0.875
Most likely # of observed mortalities: 2

BINOMIAL PROBABILITIES FOR SAMPLE SIZE N=400 AND P=0.006900

Pr of obs number	Cumulative Pr of obs that number or more
Pr(x= 0)=0.0627	Pr(x>= 0)=1.0000
Pr(x= 1)=0.1742	Pr(x>= 1)=0.9373
Pr(x= 2)=0.2415	Pr(x>= 2)=0.7631
Pr(x= 3)=0.2226	Pr(x>= 3)=0.5216
Pr(x= 4)=0.1535	Pr(x>= 4)=0.2990
Pr(x= 5)=0.0845	Pr(x>= 5)=0.1455
Pr(x= 6)=0.0386	Pr(x>= 6)=0.0610

Probability of observing 1 or more takes: 0.937
Most likely # of observed mortalities: 2

In this example, it can be seen that with only 100 observer sea-days, the most likely observation will be of zero takes, with only a 50% chance of observing takes. A sample size of 200 increases the probability of observing takes to 75%. A sample size of 400 sea-days increases this probability to 94%.