Landings: the unit of effort for bycatch rates in gillnet fishing gear

Chris Orphanides and Debi Palka
Northeast Fisheries Science Center
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The Take Reduction Teams for harbor porpoises and coastal bottlenose dolphins are dealing with bycatch in gillnet fisheries along the eastern coast of the US. These teams have requested exploration into a "more appropriate" measure of fishing effort (instead of landings). This documents some of these explorations.

When NEFSC staff estimate marine mammal mortality in any fishery, one of the first steps is to determine a measure of fishing effort that is appropriate for an accurate bycatch estimate. Statistical and practical issues must be considered when determining an appropriate measure of fishing effort. Statistically, an appropriate measure of fishing effort must have a positive relationship with takes, meaning it increases as the number of takes increases. Practically, the measure of fishing effort must also be available for both the observed sample used to estimate the bycatch rate, and for the entire fishery. The measure of effort must be present in both fisheries datasets in order to expand the bycatch rate of the sample to an estimate of bycatch for the entire fishery.

There are several variables that fulfill the needed statistical relation. However, only one of these variables, landings, fulfills the practical availability issue. As a result of such investigations we have concluded that, at this time, landings is the only measure of fishing effort for Atlantic gillnet fisheries that is both available and statistically. More details are discussed below.

Statistical issue

There are several variables that fulfill the needed statistical relation: as the number of takes increase, the amount of the fishing effort also increases. As an example, the data collected from January 1999 to April 2007 for gillnets that fished in waters off New Jersey and in the Mudhole are investigated. As the number of harbor porpoises taken per haul increase from 0 to 4, average landings (in metric tons) increased (Figure 1A) as does another potential unit of effort, the product of string length and soak duration (in feet*hrs) (Figure 1B). Though the slope using the string length*soak duration is steeper, there is a predictable slope between number of takes and landings. Thus, landings is an acceptable variable to be used for the unit of effort.

Practical issue

There are various measures of effort for the Atlantic gillnet fishery that are available for parts of the fishery, but not for the entire fishery. In particular, the data collected by the Northeast Fisheries Observer Program and data collected by the state of Virginia include several measures of effort other than landings (hours fished, amount of gear, and gear length), however, the other states presently do not collect these types of data.

Another available database is the Northeast Vessel Trip Report (VTR) dataset which contains effort data from trips that landed federally regulated species. In the Mid-Atlantic region, there are several fisheries not federally managed (primarily in the more southern states of Virginia and North Carolina). As a result, not all gillnet effort is captured in the VTR.

In addition, some aspects of the gillnet data that are in the VTR database do not appear to accurately reflect the fishery. For example, in the 1999-2005 VTR gillnet data 47% of the trips consist of only one haul, while the observer data from the same time period and area recorded only 7% of the trips consist of only one haul. It might be assumed that those VTR trips that recorded one haul misinterpreted the meaning of the field, but that the total effort recorded for the trip was correct. For example, what was recorded as one haul with 30 nets in the VTR data could equate to three hauls of 10 nets each in the observer data, resulting in the same amount of overall effort if the effort was measured as hauls x nets. To investigate this possibility, the following measures were compared for trips that were observed and matched to its corresponding VTR trip: total number of nets (number of hauls x number of nets), total amount of gear (number of hauls x number of nets x net length), and total amount of gear soaked (number of hauls x number of nets x net length x soak duration). Unfortunately, the VTR recording errors were not consistent enough to allow the use of these total effort measures as a unit of effort for calculating bycatch estimates. Even when measured three different ways, total effort recorded in the VTR database did not reflect effort as recorded by the independent observers on the same trips (Table 1).

Southeast Regional Office staff members are currently investigating other databases that might provide additional effort information. Perhaps in the future we will be able to use a unit of effort for the bycatch rate other than landings.

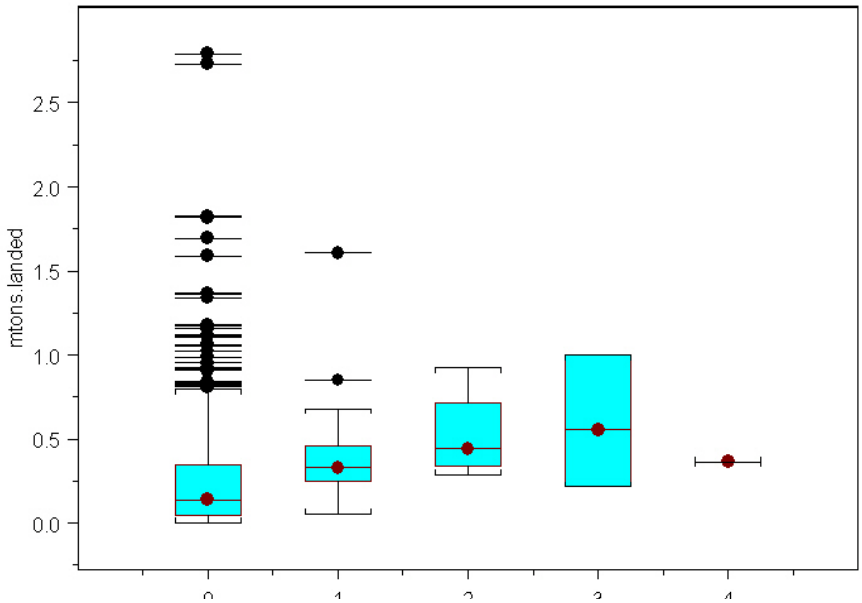
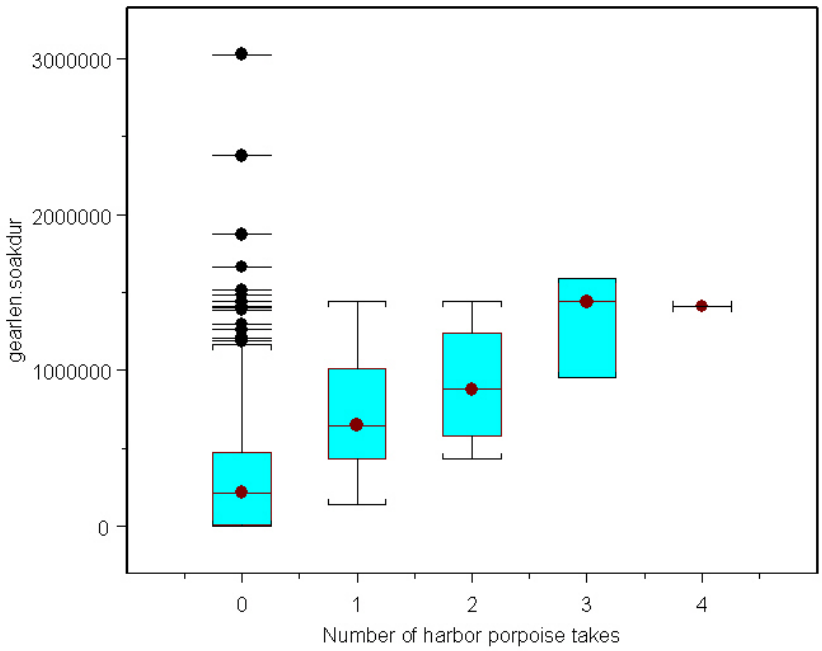
Table 1. Statistical distribution of one-to-one match between corresponding variables in **Observer (in red and shaded)** and **VTR (in blue)** data. Trips that contained a value of missing or zero for a variable were not included in the comparison. Additional variables include: for the same trip, the difference between the values recorded in the Observer and VTR databases (variable*diff* = variable*Obs* - variable*VTR*), and the corresponding percent difference (variable*perc* = (variable*diff*-variable*Obs*)*100). The distribution of each variable is described by the mean, median, standard deviation, minimum and maximum.

Variable[1]	N	Mean	Median	Std Dev	Minimum	Maximum
NumHauls-obs	**4714**	**4.39**	**4.00**	**2.56**	**1.00**	**34.00**
NumHauls-vtr	**4685**	**3.66**	**2.00**	**5.70**	**1.00**	**70.00**
NumHauls-diff	4685	0.73	1.00	5.89	-64.00	30.00
NumHauls-perc	4685	-0.26	25.00	158.80	-1233.33	92.86
TotNets_obs	**4714**	**47.90**	**40.00**	**51.43**	**1.00**	**947.00**
TotNets_vtr	**4684**	**120.80**	**50.00**	**268.15**	**1.00**	**4900.00**
TotNets-diff	4684	-72.86	-1.00	258.61	-4858.00	467.00
TotNets-perc	4684	-177.33	-1.45	604.47	-14275.00	99.32
AvgSoak-obs	**4685**	**51.51**	**39.83**	**44.92**	**0.03**	**632.00**
AvgSoak-vtr	**4547**	**44.33**	**24.00**	**37.31**	**0.25**	**528.00**
AvgSoak-diff	4518	8.90	0.00	30.87	-472.00	584.00
AvgSoak-perc	4518	-20.15	0.00	505.63	-23900.00	99.17
AvgNumNets-obs	**4714**	**10.69**	**10.00**	**5.16**	**1.00**	**42.63**
AvgNumNets-vtr	**4710**	**36.34**	**30.00**	**44.58**	**1.00**	**2300.00**
AvgNumNets-diff	4710	-25.66	-20.00	43.19	-2296.00	24.00
AvgNumNet-perc	4710	-248.17	-200.00	873.90	-57400.00	96.00
AvgNetLen-obs	**4714**	**312.38**	**300.00**	**81.98**	**50.00**	**1542.86**
AvgNetLen-vtr	**4699**	**371.49**	**300.00**	**456.58**	**7.00**	**12000.00**
AvgNetLen-diff	4699	-59.08	0.00	448.03	-11700.00	1242.86
AvgNetLen-perc	4699	-18.99	0.00	140.94	-3900.00	97.67
GearAmt_obs	**4714**	**14507.68**	**12000.00**	**15380.34**	**300.00**	**284100.00**
GearAmt_vtr	**4674**	**37682.65**	**15000.00**	**92356.39**	**30.00**	**3000000.00**
GearAmt-diff	4674	-23166.41	-300.00	89835.20	-2970000.00	140100.00
GearAmt-perc	4674	-186.88	-3.98	627.21	-16281.77	99.32
SoakEffort_obs	**4685**	**833235.18**	**432000.00**	**1151950.23**	**45.00**	**18960000.00**
SoakEffort_vtr	**4515**	**1910552.42**	**576000.00**	**5965158.62**	**300.00**	**216000000.00**
SoakEffort-diff	4486	-1059705.58	-9045.00	5745500.44	-213840000.00	14352000.00
SoakEffort-perc	4486	-342.11	-6.36	6020.52	-287900.00	99.93

[1] NumHauls: Number of hauls per trip
TotNets: Total number of nets per trip (NumHauls · Number of nets)
AvgSoak: Average soak duration of all hauls on the trip (in hours)
AvgNumNets: Average number of nets per trip
AvgNetLen: Average length of a net within a string (in feet)
GearAmt: Total amount of gear (NumHauls · number of nets · net length)
SoakEffort: Amount of gear-hours (GearAmt · AvgSoak)

Figure 1. Box plots displaying the relationship between two units of effort and the number of harbor porpoises observed taken in gillnets off of New Jersey (including the Mudhole) during January to April, 1999 to 2007. The unit of effort is (A) landings (in metric tons) and (B) string length*soak duration (in ft*hrs). The dot on each box plot indicates the average value of the variable on the y-axis, the horizontal bar in the blue box indicates the median. The blue box indicates the range between the 1st and 3rd quartiles. The notched bars indicate the 95% confidence limit. The individual dots outside of the notched bars indicates extreme values.

(A) Landings



(B) String length*soak duration