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White Paper

Alternative Estimates of the Compliance Bycatch Rate for Harbor Porpoise in the Northeast Management Area

1. Introduction

In the Gulf of Maine (GOM), the Coastal GOM Consequence Closure Area is proposed to be closed if the overall average Harbor Porpoise (HP) bycatch rate in the Mid-Coast, Massachusetts Bay, and Stellwagen Bank Management Areas exceeds the compliant bycatch rate. The compliant bycatch rate was derived from pinger-compliant hauls in these areas observed from January 1999–May 2007[1]. (Palka and Orphanide 2008). The compliance bycatch rate for this region is set at 0.031 harbor porpoises per metric tons (which is equivalent to 1 harbor porpoise taken per 71,117 lbs) landed after two consecutive management seasons. If this rate is exceeded, the Coastal Gulf of Maine Consequence Closure Area will be closed to gillnet fishing each year during the months of October and November. When this area is not closed, the current seasonal requirements of the HPTRP management areas remain in effect (US Department of Commerce 2012).

The problem with the current bycatch estimation methodology is that the methodology used to derive the compliance bycatch rate (Obs HP Takes / Observed Landed lbs.) acts as the standard for future fishermen to adhere to; even though it does not account for uncertainty in the fishery. By not accounting for uncertainty, confidence intervals cannot be derived and hence the compliance bycatch rate has very little statistical relevance beyond its own data set of January 1999-May 2007.

Fishermen's behavior, ecosystem dynamics, and the fisheries rules and regulations are extremely variable from year to year. To account for uncertainty, and to derive an estimated compliance bycatch rate more useful when applied outside its own data set, it is necessary to derive the bycatch rate via statistical methods like linear regression and maximum likelihood models. These methods account for a degree of uncertainty in the estimate—and hence provide an upper bound and lower bound on the compliance bycatch rate. Furthermore, these methods also rely on hypothesis testing, which can say what variables are most important in estimating the compliance bycatch rate based on their statistical significance.

[1] See Appendix 1 for data set used to derive the current estimate of Target Bycatch Ratio

My analysis will estimate the compliance bycatch rate for Harbor Porpoise based on the same data set used to derive the current rate; but will instead employ linear regression techniques to derive the estimate. Two models are shown. The first model uses "Observed Landings" as the independent variable to predict the dependent variable--Harbor Porpoise takes, and the second model uses "Observed Hauls" as the independent variable to predict Harbor Porpoise takes. The results show that both models are highly significant at greater than 99% certainty, AND, that the average compliance bycatch rate in both cases is lower than the current estimate.

In the rest of this paper, I will describe the major reasons for uncertainty regarding predicted HP takes, I will show the methods used to derive the two alternative estimates of compliance bycatch rate, I will show the results and the estimates of the two alternative compliance bycatch rates using confidence intervals, and finally I will compare these rates to the current compliance bycatch rate and discuss

2. Reasons for Uncertainty in Predicted Harbor Porpoise Takes

It is not straightforward to predict today's pinger compliance with a set of data that describes the dynamics of a fishery that no longer exists. The methods of deriving the current compliance bycatch rate assumes that the dynamics of the interactions between fishery, harbor porpoise and environment are constant from year to year—therefore, the current compliance bycatch rate is fixed and known with certainty.

Assuming that the current compliance bycatch rate is fixed and known with certainty means that it doesn't change over time. But the fishery has changed, dramatically. And the temporal and spatial distribution of observed HP takes has also changed. In New Hampshire, the most Harbor Porpoise observed takes are occurring in December, January and February—not September, October and November. This is due to the imposition of a new suite of rules, regulations, and management actions that have altered both fishing behavior and fishing location and effort choices.

Four primary reasons exist for why the compliance bycatch rate is likely not known with certainty, and for why this rate would likely change over time.

1) Uncertain Stock Size

- HP stock assessments are highly uncertain (Palka and Orphanides 2008). The last stock assessment was done in 2006 via airplane spotting.
- HP population growth is highly uncertain (Wade and Angliss 1997). It is considered a "stock of unkown status relative to the optimum".
- Possibly four separate populations of HP stocks in the western north Atlantic (Gaskin 1984, 1992).

2) Environmental Uncertainty

- Climate changes from year to year likely impact HP distribution and abundance
- Changes in habitat, especially for spawning, likely changes from year to year
- Changes in the abundance and distribution of bait fish likely change from year to year

3) Changes in Fishing Behavior and Fishing Regulations

- Fishermen often switch fisheries, gear type and areas fished from year to year
- Change to Sector Management has dramatically changed fishermen's behavior as effort controls were eliminated
- Change in fishery to Hard Tacs limits the total allowable landings and bycatch
- Change in at sea observer coverage from 4% to 31%

All of these changes have dramatically impacted the current landscape of the fishing industry. This provides a high degree of uncertainty about the true compliance bycatch rate from year to year. If it is necessary to use some type of compliance bycatch rate moving forward, two things should be changed: 1) the rate should be updated with new data from recent years, and 2) the rate should be predicted based on statistical methods that derive confidence intervals.

3. Alternative Methods for Estimating HP Compliance Bycatch Rate

The same data set used to calculate the compliance discard ratio of .031 HP per metric ton of landed lbs. (January 1999- May 2007) was used in this analysis to show that two variables, "Observed Landings", and "Observed Hauls" were both statistically significant as independent variables for predicting HP observed takes.

Appendix 1 shows the January 1999 – May 2007 data set used to derive the compliance bycatch rate. It was generated by region and over all three Gulf of Maine management areas. The number of observed hauls, observed landings, and the resulting bycatch rate (number of harbor porpoise takes/mton of landings) are shown in the tables. These hauls were made on nets that were fully pinger compliant.

Linear regression models take the form:

$Yi = Xi\beta + \mu$,

where Yi is the dependent variable that consists of 28 observations about HP takes. Xi is the independent variable, like "Observed Landings" and "Observed Hauls". μ is the stochastic elements (to account for uncertainty). Two models are estimated using this approach, one model for each independent variable. This is done because "Observed Landings" and "Observed Hauls" are collinear functions of one another and therefore, can't be estimated in the same model or biased results arise.

4. Results

Model 1: “Observed Landings”

Regression Statistics	
Multiple R	0.8788
R Square	0.7724
Adjusted R Square	0.7353
Standard Error	0.3896
Observations	28.000 0

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1.0000	13.9025	13.902	91.610	0.0000
Residual	27.000 0	4.0975	0.1518		
Total	28.000 0	18.0000			

	β	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0.0000	#N/A	#N/A	#N/A	#N/A	#N/A
Observed Landings	0.0424	0.0044	9.5713	0.0000	0.0333	0.0515

The intercept for this model was assumed to be zero, which implies that with zero landings, there would be zero HP takes. The model is highly significant, with and F-stat of 91.6 and and R-squared value of .77. This implies the 77% of the variation in the dependent variable, “Observed HP takes”, can be explained by variation in the independent variable, “Observed Landings”. The coefficient (*β*)for the variable, “Observed Landings” is highly significant with a t-stat of 9.57.

The estimate of the coefficient, .0424, is the estimated population parameter for the true compliance bycatch rate. This rate implies a population parameter of .0424 HP observed takes per 1 metric ton of landings, or 1 HP per every 52,028 lbs of observed landings. The model also derives a 95% confidence interval, which says that the true estimate of the compliance bycatch rate population parameter falls somewhere between .0333 and .0515 HP takes per 1 metric ton of landings.

Model 2: “Observed Hauls”

Regression Statistics	
Multiple R	0.7160
R Square	0.5127
Adjusted R Square	0.4757
Standard Error	0.5699
Observations	28

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	9.2295	9.229	28.413	1.41E-05
Residual	27	8.7704	0.324		
Total	28	18			

	β	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A
Observed Hauls	0.0063	0.0011	5.3304	0.0000	0.0039	0.0088

An alternative to using Observed Landed lbs as the variable to predict Observed HP takes, the variable, “Observed Hauls” can be used instead. The intercept for this model was also assumed to be zero, which implies that with zero hauls, there would be zero HP takes. This model is also highly significant, with and F-stat of 28.41 and and R-squared value of .51. The coefficient (*β*) for the variable, “Observed Hauls” is also highly significant with a t-stat of 5.33. This model shows that using the variable “Observed Hauls” to predict HP Observed takes is just as statistically appropriate as using “Observed Landings”.

The estimate of the coefficient, .006, is the estimated population parameter for the true compliance bycatch rate (using Observed Hauls). This rate implies a population parameter of 6 HP observed takes per every 1,000 hauls. The model also derives a 95% confidence interval, which says that the true estimate of the compliance bycatch rate population parameter falls somewhere between 4 and 9 HP takes per 1,000 hauls.

Table 1. Comparison of Compliance Bycatch Rates

	Lower Bound Estimate (95%)	***B***	**Upper Bound Estimate (95%)**
Current Compliance Bycatch rate		1 HP in 71,113 landed lbs	
Alternate Compliance Bycatch Rate (Model 1)	1 HP in 42,843 landed lbs	1 HP in 52,028 landed lbs	1 HP in 66,225 landed lbs
Alternate Compliance Bycatch Rate (Model 2)	4 HP in 1,000 hauls	6 HP in 1,000 hauls	9 HP in 1,000 hauls

Table 1 shows a comparison of all three estimated compliance bycatch rates, all derived using the same set of data. The major difference between the two estimates based on landed lbs is that the current compliance bycatch rate was not derived with confidence intervals. In fact, the estimate for the current bycatch compliance rate (71,113) falls outside the 95% upper bound confidence interval for landed lbs (66,225).

The model based on Observed Hauls (Model 2) predicts HP Observed Takes based on a completely different metric of effort. However, using "Observed Hauls" as the metric may in fact be more appropriate to count for the changes in the fishery and its dynamics since the study period. Number of hauls is a more complete definition of fishery effort. Far less fishermen fish now and those who do fish are doing so with different and less abundant gear. Information about # of hauls is readily available via VTRs and observer data (which now spans 30% of the fleet's trips).

Discussion:

The estimated bycatch rate for the fleet over the first year of sector management was .078, which exceeds the current compliance bycatch rate of .031 to the degree where zero observed takes over the next year would not be enough to meet the compliance bycatch rate.

But what if a different estimate for the compliance bycatch rate were used? If Model 1 were used, the estimated bycatch rate for the fleet over the first year of sector management of .078 would still exceed the mean estimate of .043. However, I zero observed takes occurred in the second year, the fleet would still be in compliance. If the upper bound estimate of .0515 were used, the fleet could have an estimated bycatch rate of .025 in year 2 and still be in compliance.

If Model 2 were used, it is likely that different estimates of compliance would also result. It would be necessary to go back to the VTRs and observer data to estimate the bycatch rate for the first two years and then compare this estimate to the values presented above. Given the dramatic impacts of implementing a consequence closure during the most profitable time of the fishing season; it seems warranted to take the time to explore all possible options of predicting compliance.

Works Cited

Palka, D. C. Orpandides. (2008). *Harbor Porpoise Bycatch Rates that Indicate Compliance with Pinger Regulations for the Northeast Gillnet Fishery*. U.S. DEPARTMENT OF COMMERCE**,** Northeast Fisheries Science Center Woods Hole, Massachusetts.

Orphanides, C. 2007. Gillnet Harbor Porpoise Bycatch Estimates and Factors influencing Bycatch. U.S. DEPARTMENT OF COMMERCE**,** Northeast Fisheries Science Center Woods Hole, Massachusetts. PPT. Presentation. www.nero.noaa.gov/prot_res/.../doc/.../Est_**Bycatch**_Presentation.pdf

Wade, P.R. and R.P. Angliss. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 pp.

US Department of Commerce. 1998. Taking of Marine Mammals Incidental to Commercial Fishing Operations; Harbor Porpoise Take Reduction Plan Regulations. Final Rule. National Oceanic and Atmospheric Administration 50 CFR Part 229 [Docket No. 970129015–8287–08; I.D. 042597B] RIN 0648–AI84.

Gaskin, D.E. 1984. The harbor porpoise *Phocoena phocoena* (L.): Regional populations, status, and information on direct and indirect catches. Rep. int Whal. Commn 34:569-586.

Gaskin, D.E. 1992. The status of the harbour porpoise. Can. Fld. Nat. 106:36-54

Rosel, P.E., S.C. France, J.Y. Wang, and T.D. Kocher. 1999a. Genetic structure of harbour porpoise *Phocoena* populations in the northwest Atlantic based on mitochondrial and nuclear markers. MolecularEcology 8: S41-S54.

Rosel, P.E., R. Tiedemann, and M. Walton. 1999b. Genetic evidence for limited trans-Atlantic movements of the harbor porpoise *Phocoena phocoena*. Marine Biology 133: 583-591.

Palka, D. 2007. Effect of Pingers on Harbor Porpoise and Seal Bycatch. U.S. DEPARTMENT OF COMMERCE**,** Northeast Fisheries Science Center Woods Hole, Massachusetts.

Appendix 1

Table 1. By region and over all three Gulf of Maine management areas, the number of observed hauls, takes and landings (obs landings) and the resulting bycatch rate (number of harbor porpoise takes/mton of landings) of hauls that had all of the required number of pingers and were observed from 1 January 1999–31 May 2007.

	Massachusetts Bay				MidCoast			
Year	Number of hauls	Number of takes	Obs landings	Bycatch rate	Number of hauls	Number of takes	Obs landings	Bycatch rate
1999	59	0	5.35	0	232	3	65.50	0.046
2000	115	0	16.77	0	198	0	15.88	0.000
2001	74	0	7.00	0	109	2	21.29	0.094
2002	8	0	0.62	0	199	2	30.15	0.066
2003	8	0	0.94	0	40	0	4.46	0.000
2004	3	0	0.23	0	49	0	11.33	0.000
2005	4	0	4.59	0	134	1	29.30	0.034
2006	29	0	5.70	0	87	0	17.77	0.000
2007*	53	0	5.70	0	9	0	0.29	0.000
TOTAL	**353**	**0**	**46.90**	**0**	**1057**	**8**	**195.97**	**0.041**

	Stellwagen Bank				ALL			
Year	Number of hauls	Number of takes	Obs landings	Bycatch rate	Number of hauls	Number of takes	Obs landings	Bycatch rate
1999	10	0	0.56	0	301	3	71.41	0.042
2000	1	0	0.04	0	314	0	32.69	0.000
2001	1	0	0.02	0	184	2	28.31	0.071
2002	1	0	0.38	0	208	2	31.15	0.064
2003	1	0	0.10	0	49	0	5.50	0.000
2004	6	0	0.95	0	58	0	12.51	0.000
2005	10	0	2.83	0	148	1	36.72	0.027
2006	9	0	2.16	0	125	0	25.63	0.000
2007*	79	0	7.38	0	141	0	13.37	0.000
TOTAL	**118**	**0**	**14.42**	**0**	**1528**	**8**	**257.29**	**0.031**

* Data in this row only from 1 January through 31 May 2007.