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Harbor Porpoise Bycatch Rates that Indicate Compliance with Pinger Regulations for the Northeast Gillnet Fishery

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List of Acronyms

GOM	=	Gulf of Maine
HPTRP	=	Harbor Porpoise Take Reduction Plan
HPTRT	=	Harbor Porpoise Take Reduction Team
NEFOP	=	Northeast Fisheries Observer Program
PBR	=	Potential Biological Removal
SAR	=	Stock Assessment Report
ZMRG	=	Zero Mortality Rate Goal

SUMMARY

This document provides additional analyses and documentation about some elements of the proposed revised Harbor Porpoise Take Reduction Plan (HPTRP). To improve compliance with the HPTRP, and to reduce and maintain harbor porpoise bycatch below the Potential Biological Removal (PBR) level, the Harbor Porpoise Take Reduction Team (HPTRT) proposed that a Consequence Closure Area be invoked if the observed 2-year average bycatch rate in an area exceeds the bycatch rate of pinger-compliant hauls observed between 1 January 1999 and 31 May 2007. Two Consequence Closures Areas were proposed.

This document presents the compliant bycatch rates, evaluates the effect on total bycatch when compliant bycatch rates are realized, defines how the 2-year average bycatch rate is to be calculated, and investigates the effect of an elevated bycatch rate in one year on the 2-year bycatch rate average.

Compliant Bycatch Rate

The compliant bycatch rate associated with the Coastal Gulf of Maine Consequence Closure Area is 0.031 harbor porpoises per metric tons of landings. The compliant bycatch rate associated with the Cape Cod South Extension and Eastern Cape Cod Consequence Closure Areas is 0.023 harbor porpoises per metric tons of landings.

Effect of the Compliant Bycatch Rates on the Total Bycatch

If observed bycatch rates during times and areas affected by the compliant bycatch rates were identical to the compliant bycatch rates, the estimated annual bycatch of harbor porpoises would be below PBR but above the Zero Mortality Rate Goal (ZMRG). The analysis assumed that effort was the average of that in 2005 and 2006, and that the Mid-Atlantic gillnet fleet complied with the HPTRP regulations applicable to the Mid-Atlantic management areas.

Average 2-year Bycatch Rate

The most appropriate 2-year average bycatch rate is a sample size weighted average bycatch rate, where the 'weight' is the number of observed hauls. This is because: (1) the amount of fishing effort observed (*i.e.*, number of observed hauls) in any two years will likely be different, and this difference should be accounted for; (2) a weighted average bycatch rate is already being used in time/areas where both pingered and non-pingered gillnets are fished; and (3) the bycatch rates used in deriving the annual bycatch estimates reported in the annual Stock Assessment Reports (SAR) can be used to calculate the 2-year averages.

Effect of 1 Year of an Elevated Bycatch Rate on the 2-year Average

During 2006, average bycatch rates observed in the Massachusetts Bay and Mid-Coast Management Areas were below the proposed compliant bycatch rate of 0.031 for the Coastal Gulf of Maine Consequence Closure Area. Even if the bycatch rate was double that observed in 2006, it is very feasible to obtain a bycatch rate during the second year that results in an 2-year average bycatch rate below the compliant bycatch rate. However, if the initial year bycatch rate was three times that observed in 2006, it may be possible to obtain a 2-year average bycatch rate lower than the compliant bycatch rate, depending on the observer coverage and actual bycatch rate.

INTRODUCTION

To improve compliance with the Harbor Porpoise Take Reduction Plan (HPTRP) and to reduce and maintain harbor porpoise bycatch below PBR, the Harbor Porpoise Take Reduction Team (HPTRT) proposed Consequence Closure Areas (Figure 1) be invoked during certain times of the year if the 2-year average bycatch rate[1] from corresponding areas exceeds the bycatch rate of observed hauls in these areas that complied with the HPTRP (*i.e.*, pinger-compliant hauls[2]). The Consequence Closure Areas are to be independent of one another. Compliant bycatch rates are to be calculated separately for each Consequence Closure Area using data from pinger-compliant hauls in the applicable management time/areas, where the data are from the Northeast Fisheries Observer program (NEFOP) from January 1999–May 2007 (after the HPTRP was implemented).

Notes:

1) It is not possible to determine for most observed hauls if the pingers on the nets were actually working. Hence, the compliant bycatch rates were derived from a combination of hauls, many of which had the required number of pingers and all pingers were operational, and some unknown percentage of hauls with the required number of pingers but an unknown number of non-functional pingers.
2) Because the proposed Consequence Closure Areas include areas that are currently managed under the current HPTRP and some areas that not managed, all observed pinger-compliant hauls were used to derive the compliant bycatch rate, even if such hauls were not in a current management area. However, nearly all pinger-compliant hauls (85% in the Gulf of Maine and 99% in the Southern New England [SNE] Management Area) occurred in the times and areas of a current HPTRP Managed Area. Hence, the compliant bycatch rates were derived from nearly all hauls accomplished in times and areas covered by the current HPTRP. These time periods are slightly different that the proposed pinger time periods, particularly in the proposed SNE Management Area.

GULF OF MAINE MANAGEMENT AREAS COMPLIANT BYCATCH RATE

In the Gulf of Maine (GOM), the Coastal GOM Consequence Closure Area is proposed to be closed if the overall average 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. (Note that the Massachusetts Bay Area used in this analysis was that defined in the current HPTRP, not the proposed slightly expanded Management Area).

Results

From January 1999–May 2007, no harbor porpoise takes occurred in pinger-compliant observed hauls in the Massachusetts Bay and Stellwagen Bank Management Areas (Table 1). In

[1] The bycatch rate is defined as the observed number of dead or seriously injured harbor porpoises per observed metric tons (mtons) of landings.
[2] The required number of pingers is defined as one more than the number of nets in the string. Thus, if there were 10 nets in a gillnet string, then 11 pingers were required.

the Mid-Coast Area during this period, the overall average annual bycatch rate of pinger-compliant gillnet hauls was 0.041 harbor porpoises/metric tons (mtons) landed, with annual bycatch rates ranging from 0.0 (in 2000, 2003, 2004, 2006, and 2007) to 0.094 (in 2001). The average annual bycatch rate over all three areas was 0.031, with annual values ranging between 0.00 and 0.071 (Table 1).

SOUTHERN NEW ENGLAND MANAGEMENT AREA COMPLIANT BYCATCH RATE

In the SNE area, the Cape Cod South Extension and Eastern Cape Cod Consequence Closure Areas are proposed to be closed from February through April if the bycatch rate within the SNE Management Area exceeds the compliant bycatch rate. The compliant bycatch rate was estimated from pinger-compliant hauls in the SNE Management Area that were observed from January 1999–May 2007.

Results

From January 1999–May 2007, no observed gillnet hauls east of Cape Cod used pingers as pingers were not required in this region. The compliant bycatch rate was therefore derived from pinger-compliant hauls accomplished in the region south of Cape Cod, where the average annual bycatch rate was estimated to be 0.023 harbor porpoises/mtons landed, and annual bycatch rates varied between 0.00 and 0.07 (Table 2). Almost all of the pinger-compliant observed hauls were in the Cape Cod South Management Area.

EFFECT OF THE COMPLIANT BYCATCH RATES ON THE TOTAL BYCATCH

The HPTRT proposed that an average bycatch rate from 2 years be compared to a compliant bycatch rate. The following analysis investigates what the estimated total harbor porpoise bycatch would have been if the compliant bycatch rates were realized.

Gillnet fishing effort data from 2005 and 2006 and the compliant rates were used to estimate what the harbor porpoise bycatch would have been in these years if the compliant bycatch rates had not been exceeded during the managed times and areas. Fishing effort in 2005 and 2006 was averaged to account for interannual variability.

A range of bycatch rates were used for the non-managed times and areas during 2005 and 2006. Under the worst case scenario, the largest observed bycatch rate within a specific time/area in either 2005 or 2006 was used. The realistic case used average conditions during both 2005 and 2006, and thus accounted for inter-annual variability.

To complete the predicted total bycatch estimate, bycatch in the Mid-Atlantic gillnet fishery was estimated from the bycatch rate derived from compliant hauls in the Mid-Atlantic fishery observed from January 1999–May 2007. Details of the calculations for the worst and realistic cases in all areas are provided in Table 3.

Results

In both cases, the estimated average annual harbor porpoise bycatch during 2005 and 2006 would have been below PBR (610 porpoises) and above ZMRG (10% of PBR or 61 porpoises; Table 4). Under the realistic case, the estimated annual bycatch would have been 333

animals, or about 31% of the actual average bycatch (1064 animals) in 2005 and 2006. Under the worst case, the estimated bycatch would have been 568 animals, or 53% of the actual average bycatch in 2005 and 2006.

AVERAGE 2-YEAR BYCATCH RATES

The HPTRT proposed that an average bycatch rate from 2 years be compared to a compliant bycatch rate. However, two issues first needed to be resolved: (1) the exact method to calculate the average was not discussed by the HPTRT, and thus needed to be identified; and (2) concern was expressed that, if the bycatch rate for one of the two years (typically the first year) was above the compliant bycatch rate, it would be impossible to achieve an average 2-year bycatch rate at or below the compliant bycatch rate. These two issues are subsequently investigated in more detail.

Results

The most appropriate approach to calculating a 2-year average bycatch rate is a sample size weighted average bycatch rate, where sample size (in this case) is the number of observed hauls. Weighting is appropriate because observer coverage, *i.e.*, number of hauls observed, typically differs between years, and this should be taken into account, especially if the difference is large (Appendix A). A weighted average is already being used to estimate the bycatch rate in time/areas having both pingered and non-pingered strings. Furthermore, this type of average is practical because bycatch rates provided as components of the annual bycatch estimates reported in the annual SARs can easily be used in the 2-year average.

As an example, the observed annual bycatch rates in the area encompassing both the Mid-Coast and Massachusetts Bay Management Areas during the winter and fall seasons were 0.129 in 2005 and 0.022 in 2006, resulting in a 2-year weighted average of 0.097 (Table 5A and Appendix A). Note the observed bycatch rate in these two areas during 2006 was below the proposed compliant bycatch rate (0.031) for the GOM Management Areas.

To evaluate whether it was possible to achieve an average 2-year bycatch rate below the compliant bycatch rate when one of the two years had a bycatch rate higher than the compliant bycatch rate, the 2006 bycatch rate in the GOM was used as a benchmark and this rate was then doubled and tripled. A second year's bycatch rate was then calculated so as to generate a 2-year average bycatch rate that was lower than the compliant bycatch rate (0.031)

If the observed bycatch rate was twice that observed in 2006 (0.044 vs. 0.022), then it was still possible to obtain a 2-year average bycatch rate below the compliant bycatch rate when the number of observed hauls (the weighting factor) was like that documented in 2006 (Table 5B). This could be achieved without having zero observed bycatch in year 2 (in this case, the maximum second-year bycatch rate would be 0.014, assuming equal 'weighting' of the bycatch rates in the two years). However, under the assumption of equal number of hauls, *i.e.*, "equal weighting" of the bycatch rates in the two years, if the observed bycatch was triple that in 2006 (0.066 vs. 0.022), then it would not be possible for the 2-year bycatch average to be lower than the compliant rate, even if there was zero bycatch in the second year (Table 5C).

If observer coverage is too low, it could be impossible to observe one take and still have the observed bycatch rate below the compliant bycatch rate. However, given the present level of observer coverage, this does not seem to be a problem. For example, if the observed bycatch rate

in the first year was triple that observed in 2006 (0.006 vs 0.002) and the number of observed hauls during the second year was at a level intermediate between that documented in 2005 and 2006, then it is possible to achieve a 2-year weighted average that is below the compliant bycatch rate (Table 5D). Stated another way, given the observer coverage during 1999–2006 in the managed times in the Mid-Coast and Massachusetts Bay Management Areas, it was possible to obtain a bycatch rate that was below the compliant bycatch rate of 0.031 (Table 6). In fact, during most of these years (6 out of 8), if 0, 1 or 2 harbor porpoises had been observed, it was still possible to obtain a bycatch rate below the compliant rate.

APPENDIX A. WEIGHTED AVERAGE BYCATCH RATE CALCULATION METHOD

Taken from the online Wikipedia Encyclopedia (http://en.wikipedia.org/wiki/Weighted_mean)

The weighted mean, or weighted average, of a non-empty list of data [x_1, x_2, …, x_n], with weights [w_1, w_2, …, w_n] is the quantity calculated by:

$$\bar{x} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i} = \frac{w_1 x_1 + w_2 x_2 + \ldots + w_n x_n}{w_1 + w_2 + \ldots + w_n} \qquad (1)$$

Data elements with a high weight contribute more to the weighted mean than do elements with a low weight. The weights must not be negative. The weights may be zero, but not all of them (because division by zero is not allowed).

If all the weights are equal, then the weighted mean is the same as the arithmetic mean.

EXAMPLE 1

Let's say we had two school classes, one with 20 students, and one with 30 students. The grades in each class on a particular test were:

Morning class = 62, 67, 71, 74, 76, 77, 78, 79, 79, 80, 80, 81, 81, 82, 83, 84, 86, 89, 93, 98

Afternoon class = 81, 82, 83, 84, 85, 86, 87, 87, 88, 88, 89, 89, 89, 90, 90, 90, 90, 91, 91, 91, 92, 92, 93, 93, 94, 95, 96, 97, 98, 99

The straight average for the morning class is 80% and the straight average of the afternoon class is 90%. If we were to find a straight average of 80% and 90%, we would get 85% for the mean of the two class averages. However, this is not the average of all the students' grades. To find that, you would need to total all the grades and divide by the total number of students:

$$\bar{x} = \frac{4300\%}{50} = 86\%$$

Or, you could find the weighted average of the two class means already calculated, using the number of students in each class as the weighting factor:

$$\bar{x} = \frac{(20)80\% + (30)90\%}{20 + 30} = 86\%$$

Note that if we no longer had the individual students' grades, but only had the class averages and the number of students in each class, we could still find the mean of all the student's grades by finding the weighted mean of the two class averages.

EXAMPLE 2

The implication of the above on the computation of an average harbor porpoise bycatch rate is the weights are the number of observed hauls.

As an example the weighted average bycatch rate from 2005 and 2006 are calculated for the managed times in the Massachusetts Bay and Mid-Coast Management Areas. Input data, below, are reported in Belden (2007) and Belden and Orphanides (2007).

Note some of the reported bycatch rates in the table below are already weighted bycatch rates, where the weight is the number of observed hauls with and without pingers.

year	season	Area	w = number of hauls observed	x = bycatch rate: harbp/mtons landed		w*x = $rate_{weighted}$	Average, weighted by number of hauls	Comment on average
2005	fall	Mass Bay	80	0.375		30.000	**0.129**	2005 annual average
		Mid-Coast	562	0.135		75.870		
	winter	Mass Bay	150	0.000		0.000		
		Mid-Coast	29	0.000		0.000		
2006	fall	Mass Bay	41	0.000		0.000	**0.022**	2006 annual average
		Mid-Coast	218	0.035		7.630		
	winter	Mass Bay	68	0.000		0.000		
		Mid-Coast	25	0.000		0.000		
Total			1173			113.500	**0.097**	2-year average bycatch rate

References

Belden D. 2007. Estimates of cetacean and pinniped bycatch in the 2005 northeast sink gillnet and mid-Atlantic coastal gillnet fisheries. US Dep Commer, Northeast Fish Sci Cent Ref Doc. 07-08; 16 p. Available at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0708/

Belden D, Orphanides CD. 2007. Estimates of cetacean and pinniped bycatch in the 2006 Northeast sink gillnet and Mid-Atlantic coastal gillnet fisheries. US Dep Commer, Northeast Fish Sci Cent Ref Doc. 07-20; 18 p. Available at: http://www.nefsc.noaa.gov/nefsc/publications/crd/crd0720/

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.

Table 2. For the region south of Cape Cod, the number of observed hauls (obs hauls), takes (obs 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.

	South of Cape Cod			
Year	**Obs hauls**	**Obs takes**	**Obs landings**	**Bycatch rate**
1999	190	1	20.98	0.0477
2000	101	0	18.94	0.0000
2001	52	0	9.78	0.0000
2002	93	2	28.63	0.0699
2003	21	0	7.50	0.0000
2004	78	0	17.49	0.0000
2005	53	0	8.27	0.0000
2006	49	0	3.38	0.0000
2007*	106	0	15.38	0.0000
TOTAL	**743**	**3**	**130.35**	**0.0230**

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

Table 3. Description of the two cases when calculating the predicted total bycatch if the compliant bycatch rates were realized.

Region	Time period	Assumptions made when calculating the predicted total bycatch			
		Worst case		Most realistic case	
		Bycatch rate (number of harbor porpoise/mtons landed)	**Effort (mtons landed)**	**Bycatch rate (number of harbor porpoise/mtons landed)**	**Effort (mtons landed)**
Southern Mid-Atlantic	all year	0	average annual mtons landed	0	average annual mtons landed
New Jersey	Jan-Apr	highest annual rate of hauls that complied with the gear requirements (0.3074)	average annual mtons landed	average of annual rates of hauls that complied with the gear requirements (0.1537)	average annual mtons landed
New Jersey	May-Dec	0	average annual mtons landed	0	average annual mtons landed
Northeast proposed Management Areas during the times managed	winter and fall	0.031 for GOM and 0.023 for Southern NE	average annual mtons landed	0.031 for GOM and 0.023 for Southern NE only for years where the managed times and areas had an observed bycatch. Zero bycatch rate for managed times and areas where there were no observed bycatch. Then the average of the two years within each managed time and area was used.	average annual mtons landed
Northeast times and areas not in proposed times and areas of the Management Areas	all year	highest bycatch rate from 2005 or 2006 for each time/area	average annual mtons landed	average bycatch rate from 2005 and 2006 for each time/area	average annual mtons landed

Table 4. Predicted bycatch estimates if the proposed revised HPTRP had been in place during 2005 and 2006 (Predicted), as compared to the average bycatch estimate actually reported for those years (Actual), and the percent decrease between these two numbers. As a reference, PBR is 610 and ZMRG is 61. Note, a negative percent decrease means the predicted bycatch is greater than the actual average bycatch.

Actual Average of 2005/06 Bycatch			**Predicted total bycatch**			
			Worst case		**Realistic case**	
Area	Season	Actual	Predicted	% Decrease	Predicted	% Decrease
Northeast	Jan-May	363	201	45	136	63
	Jun-Aug	45	79	-76	45	0
	Sep-Dec	165	95	42	55	67
	All year	**573**	**375**	**35**	**236**	**59**
New Jersey	Jan-Apr	491	193	61	97	80
GRAND TOTAL	**GRAND TOTAL**	**1064**	**568**	**47**	**333**	**69**

Table 5. Bycatch rates from the Mid-Coast and Massachusetts Bay Management Areas during the winter (January–May) and fall (September–December) under four different situations. The highlighted and bold total bycatch rate is the 2-year average bycatch rate weighted by the number of observed hauls.

A. Data actually observed during 2005 and 2006.

B. Assume year A has a bycatch rate that is two (2) times that observed in 2006. Bycatch rate in year B is calculated assuming the number of observed hauls ("weighting") is like that documented in 2006 and there is one observed take.

C. Assume year A has a bycatch rate that is three (3) times that observed in 2006. Bycatch rate in year B is calculated assuming the number of observed hauls ("weighting") is like that documented in 2006 and there are no observed takes.

D. Assume year A has a bycatch rate that is three (3) times that observed in 2006. Bycatch rate in year B is calculated assuming the number of observed hauls ("weighting") is intermediate between that documented in 2005 and 2006 and there is one observed take.

As a reference point, the compliant bycatch rate value for these areas is 0.031.

A. Actual data from 2005 and 2006

Year	Observed number of hauls	Observed harbor porpoise takes	Bycatch rate: harbp/mtons landed
2005	821	13	0.129
2006	352	2	0.022
Total	1173	15	**0.097**

B. Year A: Assume 2 times 2006 bycatch

Year	Observed number of hauls	Observed harbor porpoise takes	Bycatch rate: harbp/mtons landed
A	352	3	0.044
B	352	1	0.014
Total	704	4	**0.029**

C. Year A: Assume 3 times 2006 bycatch

Year	Observed number of hauls	Observed harbor porpoise takes	Bycatch rate: harbp/mtons landed
A	352	4.5	0.066
B	352	0	0.000
Total	704	4.5	**0.033**

D. Year A: Assume 3 times 2006 bycatch

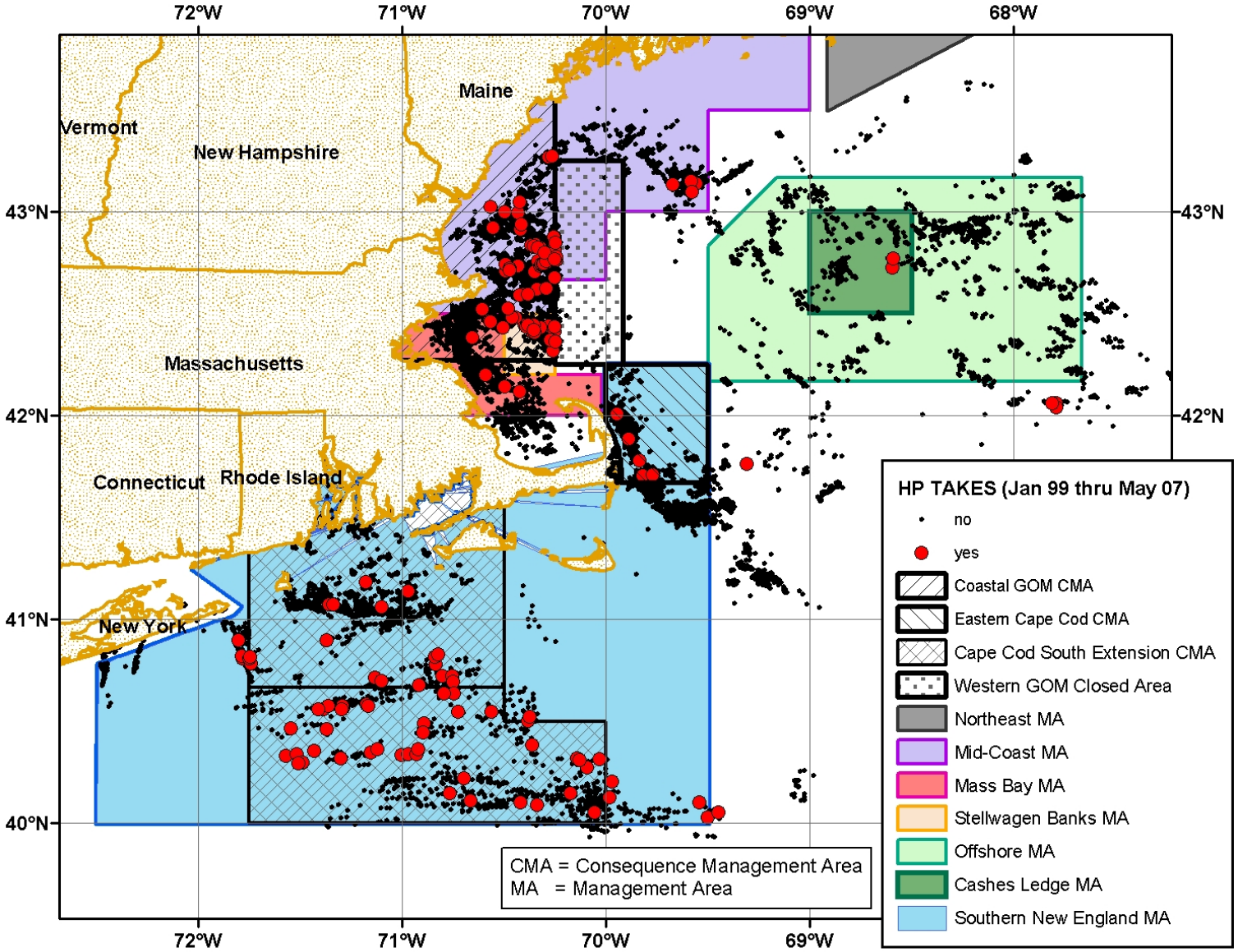
Year	Observed number of hauls	Observed harbor porpoise takes	Bycatch rate: harbp/mtons landed
A	352	4.5	0.066
B	600	1	0.008
Total	952	5.5	**0.030**

Table 6. For the time periods within each year that were managed in the Mid-Coast and Massachusetts Bay Management Areas during 1 January 1999–31 May 2007, the number of harbor porpoises (HP) that would have been observed if the bycatch rate was exactly at the compliant rate of 0.031 observed harbor porpoises per observed mtons landed.

Thus, the way to interpret this table is: in 1999 if there had been observed 0, 1, 2, or 3 harbor porpoises (whole numbers below the value in the last column) then the resulting bycatch rate would have been below the compliant bycatch rate, 0.031.

Year	Observed number of hauls	Observed mtons landed	Number of HP that needed to be observed to obtain a 0.031 bycatch rate
1999	429	107.21	3.3
2000	495	71.12	2.2
2001	349	50.96	1.6
2002	430	66.89	2.1
2003	432	73.81	2.3
2004	963	183.18	5.7
2005	806	155.38	4.8
2006	332	58.30	1.8

Figure 1. Location of hauls with (red circles) and without (small black circles) harbor porpoise (HP) takes observed from 1 January 1999–31 May 2007 as related to the management areas (MA) in the Take Reduction Plan and the proposed Consequence Closure Areas.



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