NOAA Technical Memorandum NMFS-NE-212

Summary of Harbor Porpoise (*Phocoena phocoena*) Bycatch and Levels of Compliance in the Northeast and Mid–Atlantic Gillnet Fisheries after the Implementation of the Take Reduction Plan: 1 January 1999 – 31 May 2007

US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts
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Summary of Harbor Porpoise (*Phocoena phocoena*) Bycatch and Levels of Compliance in the Northeast and Mid–Atlantic Gillnet Fisheries after the Implementation of the Take Reduction Plan: 1 January 1999 – 31 May 2007

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EXECUTIVE SUMMARY

The Harbor Porpoise Take Reduction Plan (HPTRP), which went into effect on 1 January 1999, is a plan to reduce bycatch of harbor porpoises (*Phocoena phocoena*) in the Mid–Atlantic and Northeast gillnet fisheries. The plan requires a combination of time/area closures and gear modifications. The purpose of this paper is to document patterns of harbor porpoise bycatch, and levels of compliance to the HPTRP in the Mid-Atlantic fishery, divided into the southern mid–Atlantic and New Jersey regions and in the Northeast fishery, divided into the Cape Cod and Gulf of Maine regions. Data were collected by the Northeast Fisheries Observer Program (1 January 1999 – 31 May 2007). Bycatch rate patterns were explained in terms of gear characteristics, fishing practices, and environmental factors, as derived from regression models.

In the southern mid–Atlantic region, eight harbor porpoise takes were observed February – April in 1999–2007. Four of the takes were in the ocean–intercept American shad (*Alosa sapidissima*) and river herring (*Alosa chrysochloris*) fishery, which is no longer operational. The other four takes were in large mesh gillnets (7–18 in) that were out of compliance with the HPTRP requirements. About 65% of the observed small mesh (>5–<7 in) hauls and 21% of the observed large mesh hauls were in compliance with the HPTRP.

In the New Jersey region, 43 harbor porpoise takes were observed January – April in 1999–2007. They were in large mesh gillnets targeting monkfish (*Leptoscopus americanus*). About 77% of the observed small mesh gillnets and 40% of the observed large mesh gillnets were in compliance with the HPTRP. Bycatch rate patterns were best explained by a model that included (a) fixed environmental factors (bottom depth and distance to the 50 m depth contour) which indicate the location of the takes; (b) varying environmental factors (surface and bottom water temperatures and winter North Atlantic Oscillation [NAO] index values) which explain annual and monthly differences; and (c) fishing characteristics (ship's gross tonnage, anchor weight, number of anchors used, and time duration the gillnet was in the water [i.e., soak duration]).

In the Cape Cod region, 87 harbor porpoise takes were observed during December – May in 1999–2007, of which 63 were outside of the HPTRP's Cape Cod South management area. In this region during the time pingers were required, 45% used the required number of pingers, 40% did not use any pingers, and 15% used pingers but less than the required number of pingers. Bycatch rates of hauls that used pingers were about half that of hauls that did not use pingers: 0.053 versus 0.098 harbor porpoises per metric tons landed, respectively. Bycatch rate patterns in this region were best explained by a model that included fixed time and area characteristics (steam time, home state, and day of the year) and gear characteristics (twine size).

In the Gulf of Maine region, 104 harbor porpoise takes were observed during all months of the year in 1999–2007. The highest average bycatch rates were in February and November. Compliance with the seasonal HPTRP's pinger requirements was highest in 1999 (about 75%), dropped to a low in 2003 and 2004 (about 10%), and started rising again in the first quarter of 2007 (about 60%). Bycatch rate patterns were best explained by a model that included (a) fixed areas (Management Area); (b) environmental factors (sea surface temperature [SST], and NAO) which explain annual and monthly variations; and (c) gear characteristics (average mesh size and leadline total weight) which indicate types of gillnets with higher bycatch rates.

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1. GENERAL OVERVIEW AND METHODS

1.1 Introduction

The Harbor Porpoise Take Reduction Plan (HPTRP) went into effect on 1 January 1999 (63 FR 66464, 2 December 1998). The purpose of this plan is to reduce the serious injury and mortality of the Gulf of Maine/Bay of Fundy harbor porpoises (*Phocoena phocoena*) from incidental interactions with the Mid–Atlantic and Northeast gillnet fisheries, where these two fisheries were defined in the List of Fisheries (72 FR 66048, 27 November 2007).

For the Mid–Atlantic gillnet fishery, which operates to the west of the 72°30'W longitude line and south of Long Island, NY, the HPTRP defines three management areas (MA): the southern mid–Atlantic MA, Mudhole MA, and Waters off New Jersey (excluding the Mudhole) MA (Figure 1). The HPTRP has different regulations for gillnets made with "large mesh" (7–18 in) and "small mesh" (>5–<7 in). Gillnets using other mesh sizes are not managed under the HPTRP. The HPTRP regulations include complete closures to all gillnets in some times and areas, and they include restrictions in gillnet string lengths, twine sizes and tie downs in other times and areas (Table 1).

For the Northeast gillnet fishery, which operates to the north and east of the 72°30'W longitude line, the HPTRP defines six management areas: the Cape Cod South MA, Massachusetts Bay MA, Mid–Coast MA, Northeast MA, Offshore MA, and Cashes Ledge MA (Figure 1). These management areas, for specified time periods, are either completely closed to all gillnets or closed to all gillnets that do not use pingers[1] (Table 2). Two other areas of interest relative to the bycatch of harbor porpoises include: (1) the Western Gulf of Maine Closure Area (WGOM CA), which is a multispecies fishery management area implemented 1 May 1998 that is closed year round to all fishing gear types (63 FR 15326, 31 March 1998[2]); and (2) an area discussed by the Harbor Porpoise Take Reduction Team (HPTRT) for potential future management under a revised HPTRP, which will be referred to as the Stellwagen Bank Area. Note, in this manuscript, the terms "closure area" and "CA" indicate an area that is closed year round to fishing; the terms "management area" and "MA" indicate an area defined in the HPTRP which requires bycatch mitigation measures to reduce harbor porpoise bycatch, and the term "area" is a more general term which can indicate a closed area, a management area, or an area that is not managed.

This paper investigates harbor porpoise bycatch in the Mid–Atlantic and Northeast gillnet fisheries after the HPTRP was implemented. To aid in describing bycatch patterns and because of differences in fishing practices and harbor porpoise habitat usage, the two fisheries were divided into two regions (Figure 1). The Mid–Atlantic gillnet fishery was divided into the southern Mid–Atlantic and New Jersey regions. The Northeast gillnet fishery was divided into the Cape Cod and Gulf of Maine regions. Data collected from 1 January 1999 – 31 May 2007 by the Northeast Fisheries Observer Program (NEFOP) were used to describe, within each region, the general patterns in harbor porpoise bycatch; levels of compliance with the HPTRP

[1] A pinger is defined as an acoustic deterrent device which, when immersed in water, broadcasts a 10 kHz (± 2 kHz) sound at 132 dB (± 4 dB) re 1 micropascal at 1 m, lasting 300 milliseconds (± 15 milliseconds) and repeating every 4 seconds (± 2 seconds).

[2] This multispecies fishery management action also implemented other closure areas, but only the WGOM Closure Area was discussed by the harbor porpoise take reduction team.

mitigation measures; and bycatch rate patterns as related to space and time, gear characteristics, fishing practices, and environmental factors.

1.2 Data

Observers from NEFOP collect data on characteristics of the trip, haul, gear, economic factors, catch, and incidental bycatch (NEFSC 2008). Only bycatch of dead harbor porpoises and only observed hauls that have complete location information were used. The factors collected by NEFOP that were used in these investigations are described in the appendix. Annual percent observer coverage (in terms of metric tons (mtons) landed) for the Mid–Atlantic gillnet fishery has been 1–5%, which is generally lower than the coverage in the Northeast gillnet fishery, 1-7% (Figure 2).

Environmental factors associated with the location and date of the observed haul were added to the data collected through 2006: bottom depth and slope, distance between the location of the haul and the coastline and various depth contours, sea surface and bottom water temperatures, North Atlantic oscillation (NAO) index value, chlorophyll α concentration, and sediment type (Appendix). Data from 2007 were still preliminary and had not been processed as completely as the older data. For details on the processing and inclusion of environmental data see Warden and Orphanides (2008).

For many factors collected before January 2007 (flagged in appendix), missing values were filled in with the next best available value. Most of these factors had less than 4% missing values, many less than 1%. For those values that were missing, a hierarchy of replacement strata was established, varying to some degree on the factor in question. Generally, missing values were filled in with a value from the same trip, if available. If not available, then a stratified median value based on a combination of vessel, gear type, month, and year was used to fill in the missing values. For missing depth and water temperature values collected by the observers, depth and sea surface temperature (SST) sampled from GIS datasets were used as replacement values, followed by stratified medians. For more details on the imputation of missing values, see Warden and Orphanides (2008).

The above process left most factors with less than 0.5% missing values. For factors that were not filled in or were collected in 2007, the S–PLUS function *na.gam.replace* was used to fill in the missing value. That is, within each region's data, missing values for continuous factors were replaced with the mean of the factor's values that were not missing, and for categorical factors, an additional missing value level of the factor was created.

1.3 Analysis Methods

1.3.1 Observer coverage

For each region, the number of observed hauls, trips, and vessels were documented from 1 January 1999 – 31 May 2007. In addition for each region, further analyses were performed only on data collected during the months when harbor porpoises are typically in the region, which usually corresponded to the months with documented takes.

1.3.2 General patterns

For each region, the following was described: general patterns of where and when the fishery was observed; general spatial–temporal patterns of the harbor porpoise bycatch; and bycatch rates for various levels of gear characteristics, fishing practices, and environmental factors.

1.3.3 Compliance

For each region, the percent of hauls that were compliant with each individual mitigation measure and the percent of hauls that were completely in compliance were calculated.

1.3.4 Correlated factors

For each region, a model was developed to identify which location factors, gear characteristics, fishing practices, and environmental factors were most highly correlated to the bycatch rate. These factors were regressed against the bycatch rate by using generalized additive models (if the factor was continuous) or by using generalized linear models (if the factor was categorical), assuming a quasi–Poisson distribution[3], using S–PLUS version 7.0 for Microsoft Windows. The bycatch rate was defined as the total observed number of dead harbor porpoises per total amount of observed landings, where landings were reported in metric tons[4] + 0.001[5].

Generalized additive models allow a nonlinear relationship between the factor and bycatch rate, if the data support a nonlinear relationship. A forward stepwise selection method was employed, using the Akaike Information Criterion (AIC) as the selection criterion, where a model with a smaller AIC fits the data better than a model with a larger AIC. The forward stepwise selection method was as follows. First, all factors were individually regressed against the bycatch rate. The most highly significant factor identified was used to create a 1–factor model. Then all other factors were individually added to the 1–factor model to identify the next most significant factor, which was then added to the 1–factor model to create a 2–factor model. This process continued until the AIC did not decrease by at least 2%, thus resulting in the best fitting model.

[3] A Poisson distribution was used because the numbers of observed takes were counts ranging from 1 – 4 animals per observed haul. This distribution assumes equal–dispersion; that is, the variance of the bycatch rate is equal to the mean of the bycatch rate. Because this assumption may not always be valid, a quasi–Poisson distribution was used to properly account for over– or under–dispersion, if it was needed.

[4] The factor metric tons landed is the only factor available that can be used as a unit of effort to expand a bycatch rate from an observed sample of the gillnet fishery into a bycatch estimate for the entire gillnet fishery.

[5] For each haul 0.001 metric tons of landings was added to the recorded landings to ensure the amount of landings for each haul was greater than zero.

Table 1. Management measures for large and small mesh gillnets in the Mid–Atlantic gillnet fishery, which includes three harbor porpoise take reduction plan's management areas (MA).

LARGE MESH FISHERY (7–18 in)	
Floatline length:	
Mudhole MA and southern mid–Atlantic MA	≤ 3,900 ft
Waters off New Jersey (excluding the Mudhole) MA	≤ 4,800 ft
Twine size	≥ 0.90 mm
Tie downs	Required
Net number per vessel	80 gillnets
Net size	≤ 300 ft
Net tagging	Required
Number of gillnets within a gillnet string:	
Mudhole MA and southern mid-Atlantic MA	≤ 13 gillnets
Waters off New Jersey (excluding the Mudhole) MA	≤ 16 gillnets
Time/area closures:	
Waters off New Jersey, including the Mudhole, MAs	Closed 1–20 April
Mudhole MA and southern mid–Atlantic MA	Closed 15 February – 15 March
Gear modification requirements:	
Waters off New Jersey (excluding the Mudhole) MA	1 January – 30 March and 21 – 30 April
Mudhole MA	1 January – 14 February; 16 March – 31 March; and 21 – 30 April
southern mid–Atlantic MA	1 February – 14 February and 16 March – 30 April
SMALL MESH FISHERY (> 5–< 7 in)	
Floatline length:	
Waters off New Jersey, including the Mudhole, MAs	≤ 3,000 ft
southern mid–Atlantic MA	≤ 2,118 ft
Twine size	≥ 0.81 mm
Tie downs	Prohibited
Net number per vessel	45 gillnets
Net size	≤ 300 ft
Net tagging	Required
Number of gillnets within a gillnet string:	
Waters off New Jersey, including the Mudhole, MAs	≤ 10 gillnets
southern mid–Atlantic MA	≤ 7 gillnets
Time/area closures:	
Mudhole MA	Closed 15 February – 15 March
Gear modification requirements:	
Waters off New Jersey (excluding Mudhole) MA	1 January – 30 April
Mudhole MA	1 January – 14 February and 16 March – 30 April
southern mid–Atlantic MA	1 February – 30 April

Table 2. Times and areas in the Northeast gillnet fishery that are either closed to all gillnets (Closed) or closed to all gillnets that do not use pingers (Closed – pingers allowed). Note that only the areas that are considered in this paper are included below (e.g., not all of the Multispecies Fishery Management Plan management areas (MA) and closed areas (CA) are included).

AREA	DATES	STATUS OF GILLNETS
Northeast MA	15 August – 13 September	Closed
Mid–coast MA	15 September – 31 May	Closed – pingers[1] allowed
Massachusetts Bay MA	1 December – 28/29 February	Closed – pingers allowed
	1 – 31 March	Closed
	1 April – 31 May	Closed – pingers allowed
Offshore MA	1 November – 31 May	Closed – pingers allowed
Cashes Ledge MA	1 – 28/29 February	Closed
Western Gulf of Maine CA	All year round	Closed
Cape Cod South MA	1 December – 28/29 February	Closed – pingers allowed
	1 – 31 March	Closed
	1 April – 31 May	Closed – pingers allowed

[1] A pinger is defined as an acoustic deterrent device which, when immersed in water, broadcasts a 10kHz (± 2kHz) sound at 132dB (± 4dB) re 1 micropascal at 1m, lasting 300 milliseconds (± 15 milliseconds), and repeating every 4 seconds (± 2 seconds).

Figure 1. Location of management areas (MA) under the harbor porpoise (*phocena phocena*) take reduction plan, Western Gulf of Maine Closure Area (WGOM CA) and Stellwagen Bank Area. In the insert are locations of the two regions in the Northeast gillnet fishery (Gulf of Maine and Cape Cod regions) and two regions in the Mid-Atlantic gillnet fishery (New Jersey and southern mid–Atlantic regions), which are all located within the US Exclusive Economic Zone (EEZ).

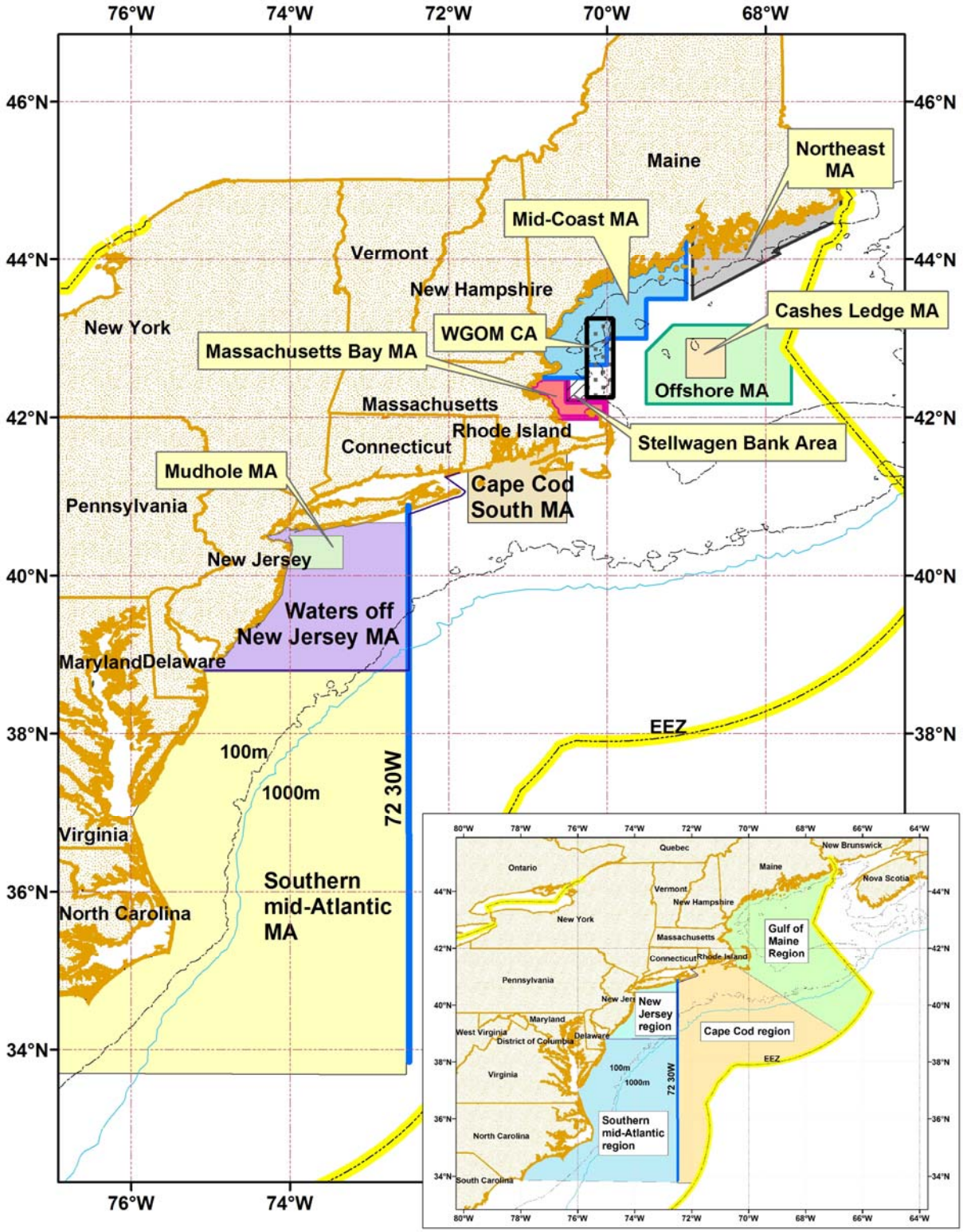
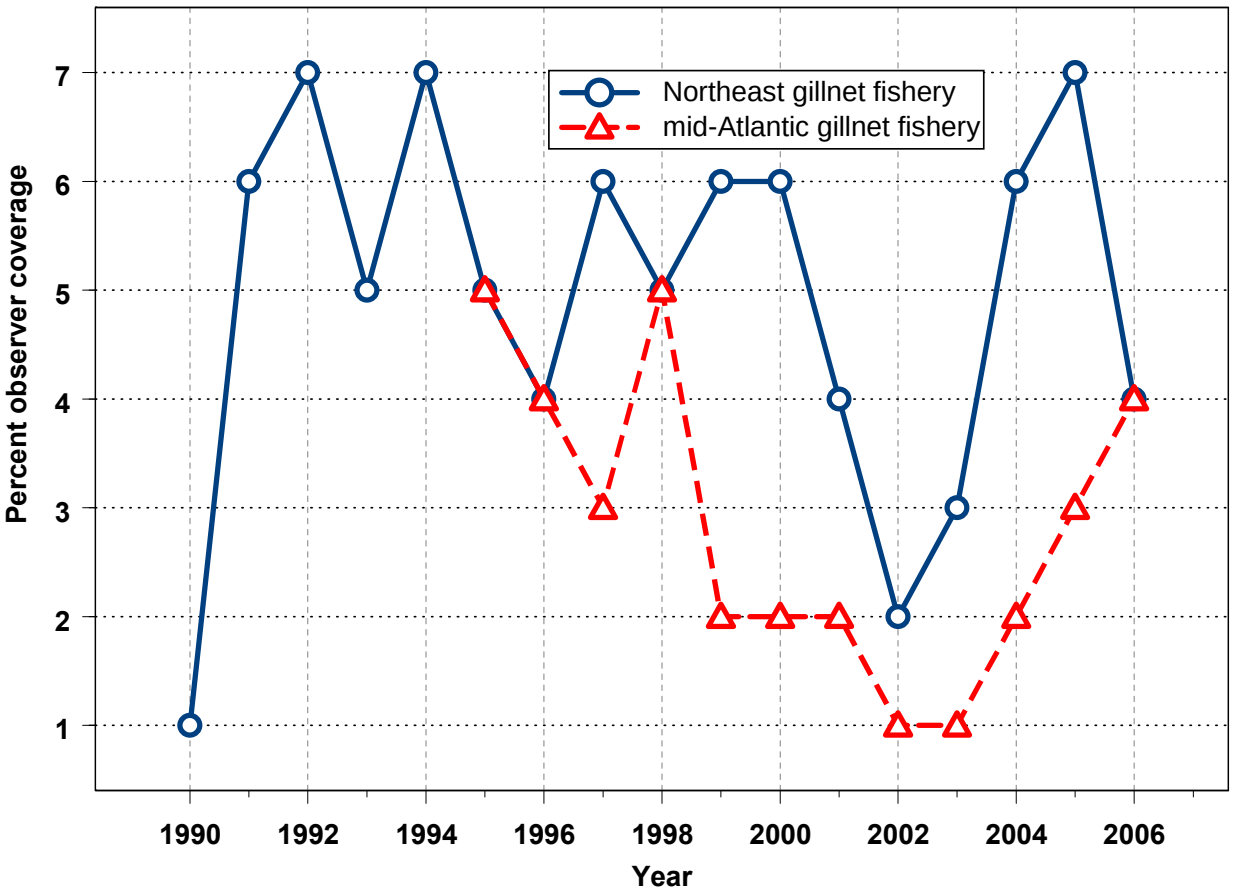


Figure 2. Percent observer coverage (in terms of mtons landed) by year in the Mid–Atlantic and Northeast gillnet fisheries.



2. SOUTHERN MID–ATLANTIC REGION

2.1 Summary

The southern mid-Atlantic region (Figure 1) is the southern portion of the Mid–Atlantic gillnet fishery and is the southern mid-Atlantic MA under the HPTRP. Since the implementation of the HPTRP on 1 January 1999, harbor porpoise bycatch in waters in the southern mid–Atlantic region has been relatively low. Takes were observed February – April from 1999–2007. Out of the 4,673 observed gillnet hauls, 8 harbor porpoise takes were observed. Takes were observed in gillnets targeting American shad (*Alosa sapidissima*), monkfish (*Leptoscopus americanus*), and striped bass (*Morone saxatilis*). Bycatch rates were highest in March.

Four observed hauls with takes used very small mesh sizes (≤5 in), which are not managed under the HPTRP. These hauls targeted American shad in March 1999 or March 2000, used twine sizes of 0.81 or 0.52 mm in strings that were 600 ft or less. The ocean–intercept American shad and river herring (*Alosa chrysochloris*) fishery was slowly phased out starting in 2000 and has been completely closed since 2005.

Four observed hauls with takes used large mesh sizes (7–18 in), targeted monkfish or striped bass, and used twine sizes of 0.66 or 0.9 mm in strings that were 1,200–4,500 ft. One take was observed in February, one in March, and two in April. All four of these large mesh hauls with takes were out of compliance with the HPTRP.

About 65% of the observed small mesh hauls (>5–<7 in) were completely in compliance. No harbor porpoise takes were observed in small mesh gillnets in this time and area. Most of the hauls that were out of compliance used twine sizes that were too small.

About 21% of the observed large mesh hauls were completely in compliance. Most of the hauls that were out of compliance used twine sizes that were too small. About half of the observed large mesh hauls did not use tie downs, as the HPTRP requires. About 30% of the observed large mesh hauls were fished during the time period closed to all large mesh gillnets, 15 February – 15 March.

2.2 Observer Coverage

In the southern mid–Atlantic region (Figure 1) from 1 January 1999 – 31 May 2007, there were observed hauls year round, with the least number of observed hauls per month in the summer, June – August (Figure 3). Harbor porpoise bycatch was observed only during February – April (Figure 4), the same time period this region is regulated by the HPTRP. Thus, further analyses focused on the southern mid–Atlantic region include only the months February – April.

In the southern mid–Atlantic region from February – April of the years 1999–2007 (Figure 5), there were 4,673 hauls observed, which were from 930 trips and 214 vessels. These totals are from 271–782 hauls observed per year, which were from 54–169 trips per year and from 26–66 vessels per year (Table 3).

2.3 General Bycatch Patterns

Of the 4,673 hauls observed February – April in 1999–2007, eight hauls each took a single harbor porpoise. The bycatch rates were highest in March (Table 4).

Four of the observed takes were in strings using very small mesh sizes (≤5 in), and the other four were in strings using large mesh sizes (7–18 in). The very small mesh sizes are not managed under the HPTRP. The bycatch rate was nearly three times higher in the observed large mesh strings than in the observed very small mesh strings: 0.0095 versus 0.0279 harbor porpoises per mtons landed (Table 4; Figure 6).

The four observed hauls using very small mesh sizes that had takes targeted American shad in 1999 or 2000, used twine sizes of 0.81 or 0.52 mm in strings that were 600 ft or less, and occurred in March.

The four observed hauls using large mesh sizes that had takes targeted monkfish or striped bass, and used twine sizes of 0.66 or 0.9 mm in strings 1200–4500 ft long. One take occurred in February, one in March, and two in April. All of these large mesh hauls with takes were out of compliance with the HPTRP (see details below).

2.4 Compliance

2.4.1 Small mesh

From February – April of 1999–2007, there were 721 observed hauls (from 184 trips and 85 vessels) that used small mesh in the southern mid–Atlantic region. No harbor porpoise takes were observed in small mesh gillnets in this time and area. Overall, about 65% of the observed hauls using small mesh were completely in compliance (Table 5).

Looking only at the gear length requirement, there were 53 (7.4%) hauls (20 trips from 14 vessels) that were using small mesh sizes (5.3 – 6.5 in) and had total gear lengths greater than 2,118 ft, the limit set in the HPTRP. The lengths ranged from 2,160 – 6,600 ft. The 53 hauls were observed in each month and during most years: February (15), March (23) and April (15), and in 1999 (24), 2000 (8), 2003 (3), 2004 (5) and 2007 (13). These out of compliance hauls were targeting a variety of species: bluefish (*Pomatomus saltatrix*; 1), smooth dogfish (*Mustelus canis*; 15), spiny dogfish (*Squalus acanthias*; 32), and summer flounder (*Paralichthys dentatus*; 5).

Looking only at the twine size requirements, there were 206 hauls (29%) from 54 trips and 33 vessels that used small mesh (5.1 – 6.5 in) and twine sizes less than 0.81 mm, the limit set in the HPTRP (0.47 – 0.74 mm). The 206 hauls were observed in each month and during most years: February (32), March (69), and April (105) and in 1999 (32), 2000 (67), 2001 (10), 2002 (3), 2003 (6), 2004 (8), 2005 (41), and 2007 (39). These out of compliance hauls were targeting a variety of species: shads (American shad and herring; *Clupeidae*), Atlantic croaker (*Micropogonias undulatus*), bluefish, kingfish (*Menticirrhus* sp), red drum (*Sciaenops ocellatus*), smooth dogfish, spiny dogfish, striped bass, southern flounder (*Paralichthys lethostigma*), summer flounder, and weakfish (*Cynoscion regalis*).

2.4.2 Large mesh

From February – April of 1999 – 2007, there were 874 observed hauls (from 229 trips and 45 vessels) that used large mesh in the southern mid–Atlantic region. Overall, only 21% of the observed hauls using large mesh were completely in compliance (Table 5). Four harbor porpoises were observed taken in large mesh gillnets, and all of these hauls were out of compliance.

Looking only at the gear length requirements, in the southern mid–Atlantic region during February – April, there were 198 hauls (23%) from 69 trips and 17 unique vessels that used large mesh and floatline lengths greater than 3,900 ft, the limit set in the HPTRP (4,200–6,000 ft). The 198 hauls were observed mostly in April and in most years: February (3), March (12), and April (183) and in 1999 (2), 2001 (77), 2002 (88), 2004 (14), 2005 (3), and 2007 (14). All of these out of compliance hauls were targeting monkfish.

Looking only at the twine size requirements, there were 90 hauls (10%) from 32 trips and 18 vessels that used large mesh (7–8 in) and twine sizes less than 0.9mm, the limit set in the HPTRP (0.47–0.81 mm). The 90 hauls were observed in each month and in most years: February (29), March (37), and April (24), and in 1999 (16), 2000 (13), 2001 (18), 2002 (4), 2003 (1), 2004 (5), 2005 (2), 2006 (3), and 2007 (28). These out of compliance hauls were targeting monkfish (43), smooth dogfish (5) and striped bass (42).

Looking only at the closure requirements for large mesh, there were 251 observed hauls (30%) using large mesh in the southern mid–Atlantic region during the closed period, 15 February – 15 March.

Looking only at the requirement to use tie downs, there were 473 (54%) observed hauls (from 108 trips and 23 unique vessels) that did not use tie downs.

2.5 Correlated Factors

Because there were only eight takes, a bycatch rate model was not developed.

Table 3. Descriptive statistics about the bycatch of harbor porpoises (Phocoena phocoena) in the southern mid–Atlantic region February – April of 1999–2007.

	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Number of observed hauls	698	782	776	456	271	371	377	313	629	4673
Number of observed trips	129	150	169	80	54	81	87	59	121	930
Number of observed vessels	56	57	43	26	33	50	50	34	66	214
Number of observed hauls with one or more takes	3	1	1	0	0	2	0	0	1	8
Total number of observed takes	3	1	1	0	0	2	0	0	1	8
Bycatch rate (observed takes/observed number of hauls)	0.004	0.001	0.001	0	0	0.005	0	0	0.002	0.002
Bycatch rate (observed takes/observed mtons landed)	0.028	0.008	0.008	0	0	0.026	0	0	0.009	0.010

Table 4. Using observer data from February – April, 1999–2007 in the southern mid–Atlantic region, the number of observed hauls and takes of harbor porpoises (Phocoena phocoena), and the resulting bycatch rates by month and by mesh size (in inches).

	Month			Mesh size			
	Feb	Mar	Apr	Very small ≤ 5 in	Small >5 – <7 in	Large 7–18 in	Unknown
Number of observed hauls	1369	1592	1712	3005	721	878	69
Number of observed takes	1	5	2	4	0	4	0
Bycatch rate (observed takes/observed hauls)	0.001	0.003	0.001	0.001	0	0.005	0
Bycatch rate (observed takes/observed mtons landed)	0.004	0.016	0.010	0.010	0	0.028	0

Table 5. Number of observed hauls and takes of harbor porpoises (Phocoena phocoena) in gillnets that were in and out of compliance from the southern mid–Atlantic region February – April, 1999–2007. Note, any one haul could have been out of compliance for one or more of the requirements.

Large mesh is 7–18 in; small mesh is >5–<7 in; and very small mesh (not regulated in HPTRP) is ≤5 in.

ALL HAULS	In compliance?	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
	No	125	138	219	182	45	50	88	10	92	949
	Yes	573	644	557	274	226	321	289	303	537	3724
	% compliant	82	82	72	60	83	87	77	97	85	80
Number of hauls	TOTAL	698	782	776	456	271	371	377	313	629	4673
	No	0	0	1	0	0	2	0	0	1	4
	Yes	3	1	0	0	0	0	0	0	0	4
Number of takes	TOTAL	3	1	1	0	0	2	0	0	1	8

SMALL MESH	In compliance?	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
	No	56	74	10	3	9	13	41	0	47	253
	Yes	152	136	44	40	12	14	1	13	56	468
	% compliant	73	65	82	93	57	52	2	100	54	65
Number of hauls	TOTAL	208	210	54	43	21	27	42	13	103	721
	No	0	0	0	0	0	0	0	0	0	0
	Yes	0	0	0	0	0	0	0	0	0	0
Number of takes	TOTAL	0	0	0	0	0	0	0	0	0	0

LARGE MESH	In compliance?	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
	No	69	64	208	179	36	35	47	10	44	692
	Yes	0	0	102	2	3	7	4	46	18	182
	% compliant	0	0	33	1	8	17	8	82	29	21
Number of hauls	TOTAL	69	64	310	181	39	42	51	56	62	874
	No	0	0	1	0	0	2	0	0	1	4
	Yes	0	0	0	0	0	0	0	0	0	0
Number of takes	TOTAL	0	0	1	0	0	2	0	0	1	4

VERY SMALL	Not regulated	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Number of hauls	Not regulated	396	507	411	232	211	300	284	244	416	3078
Number of takes	Not regulated	3	1	0	0	0	0	0	0	0	4

Figure 3. By year, number of observed hauls in the southern mid–Atlantic region 1 January 1999 – 31 May 2007.

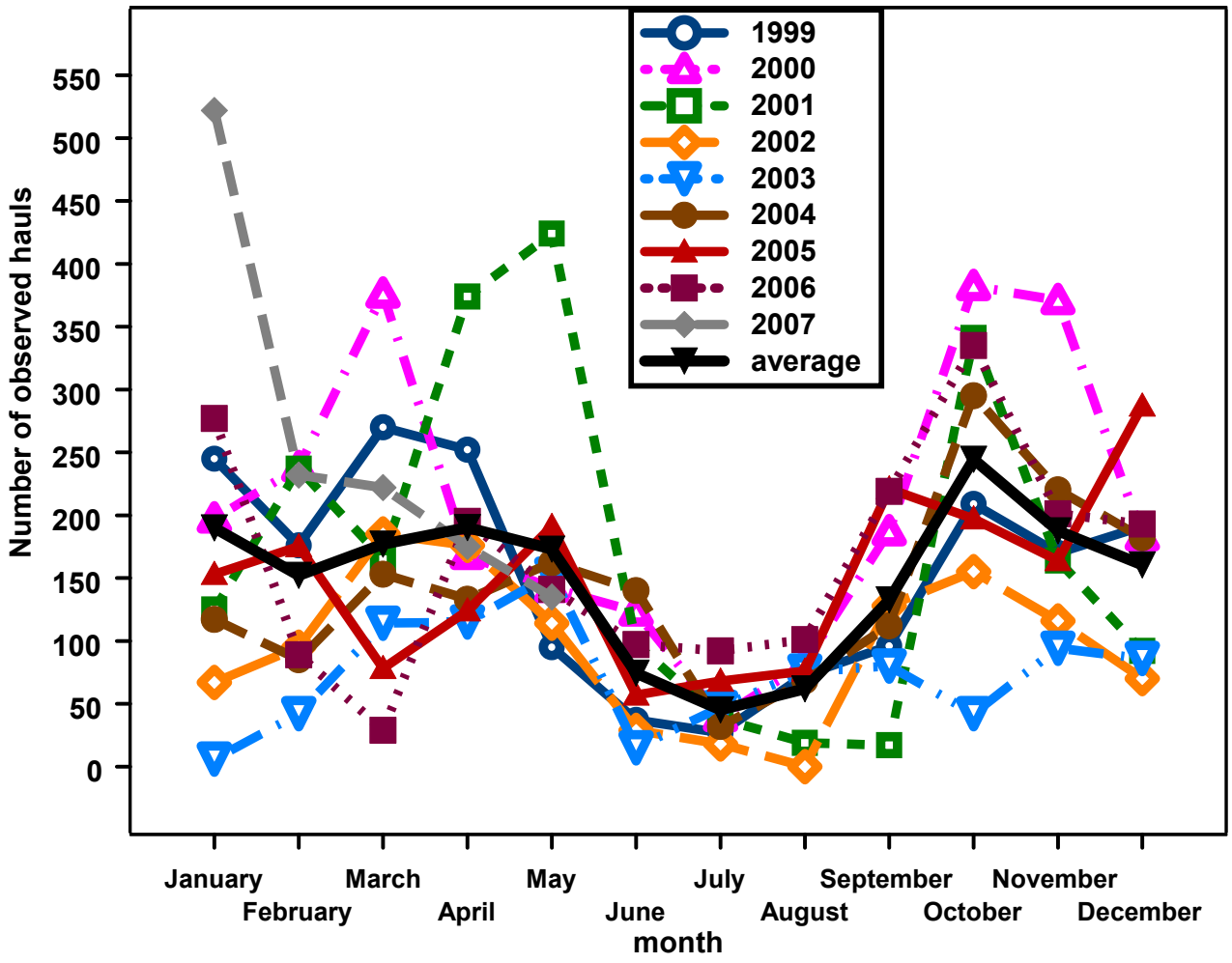


Figure 4. Location of hauls in the southern mid-Atlantic management area (shaded blue) by month (colored dots) and hauls with observed harbor porpoise (Phocoena phocoena) takes (diamonds). Data used were from February – April in 1999–2007. Depth contours are 30, 50, and 100 m.

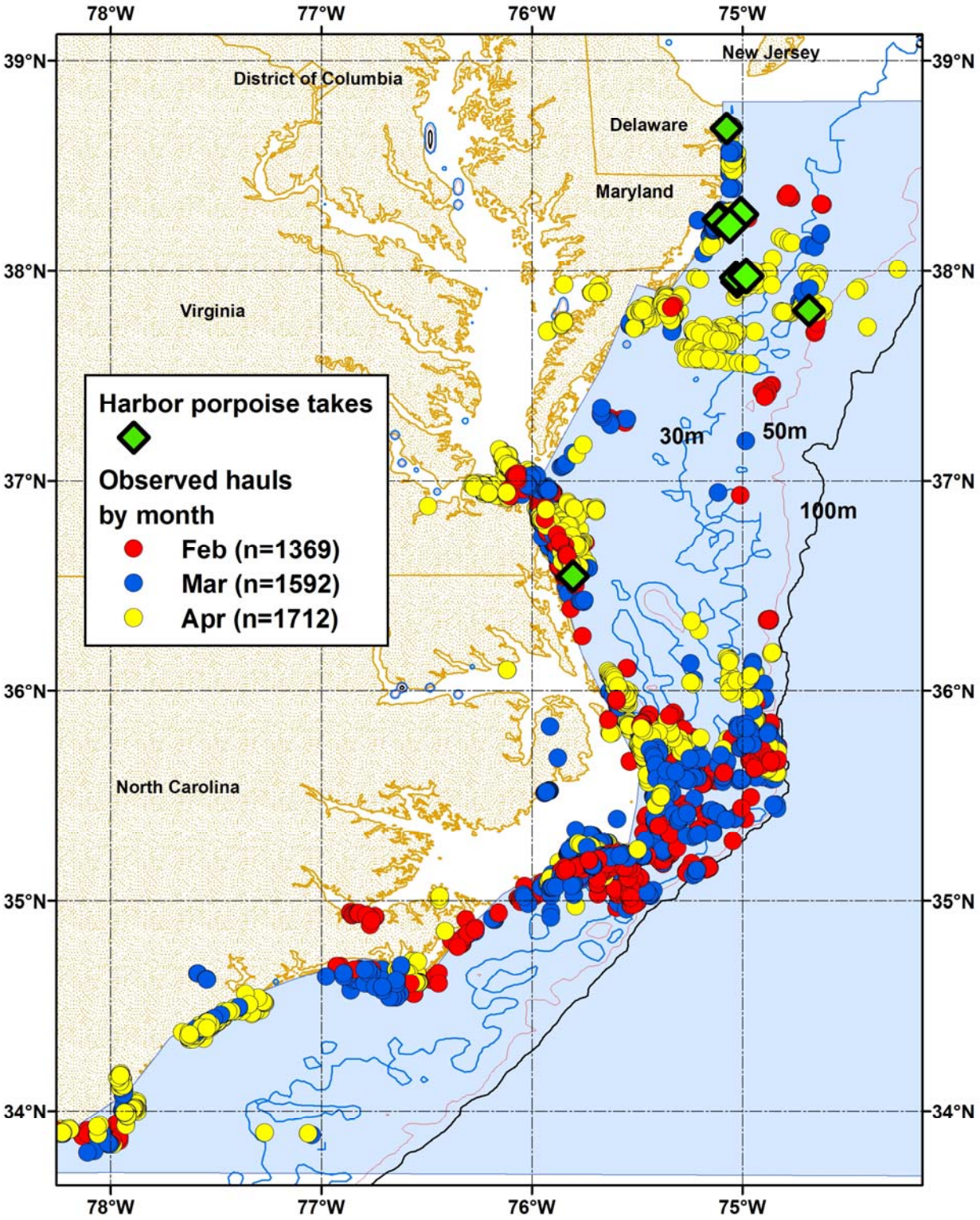


Figure 5. Location of hauls in the southern mid-Atlantic management area (shaded blue) by year (colored dot) and hauls with observed harbor porpoises (Phocoena phocoena) takes (diamonds). Data used were from February – April in 1999–2007. Depth contours are 30, 50, and 100 m.

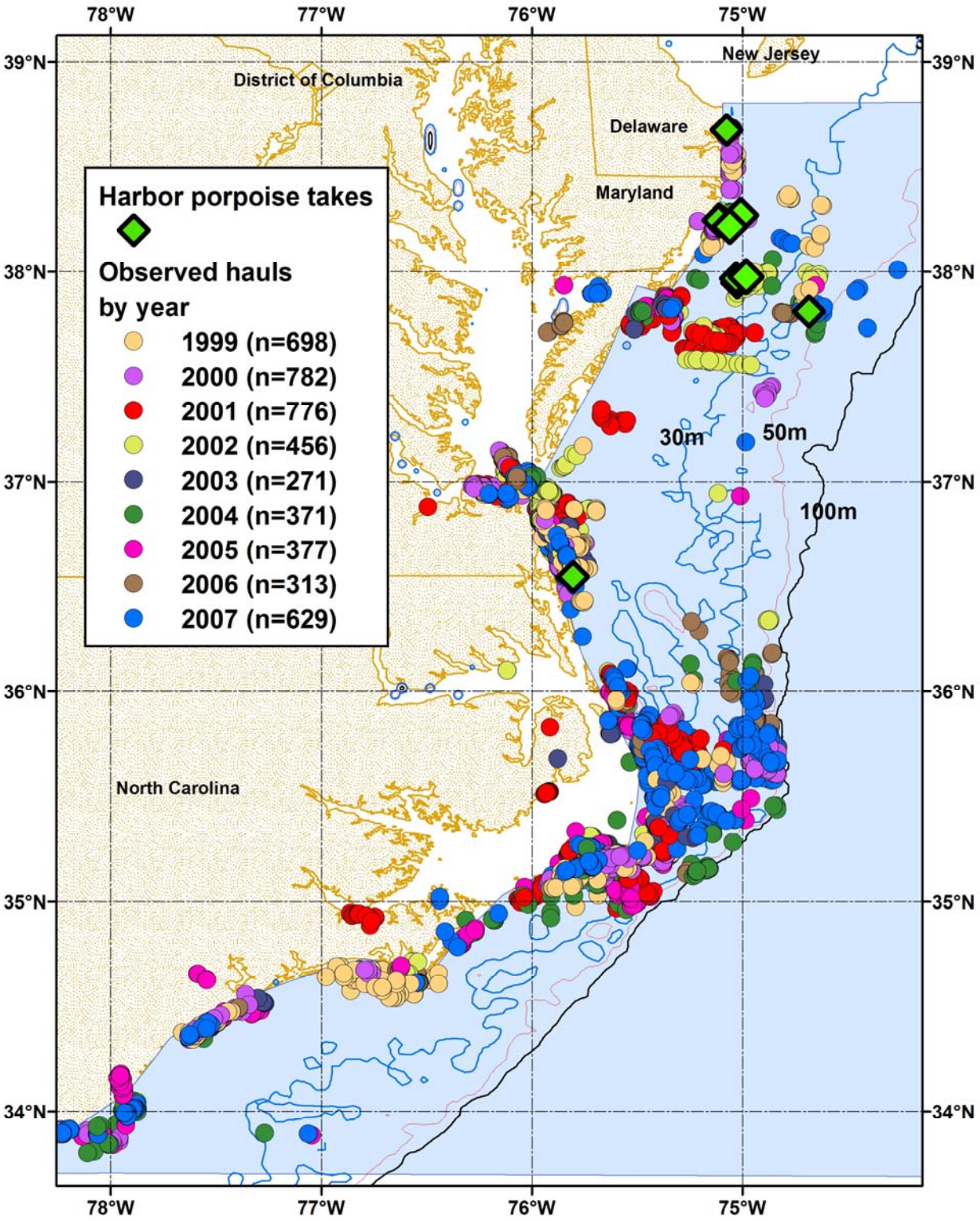
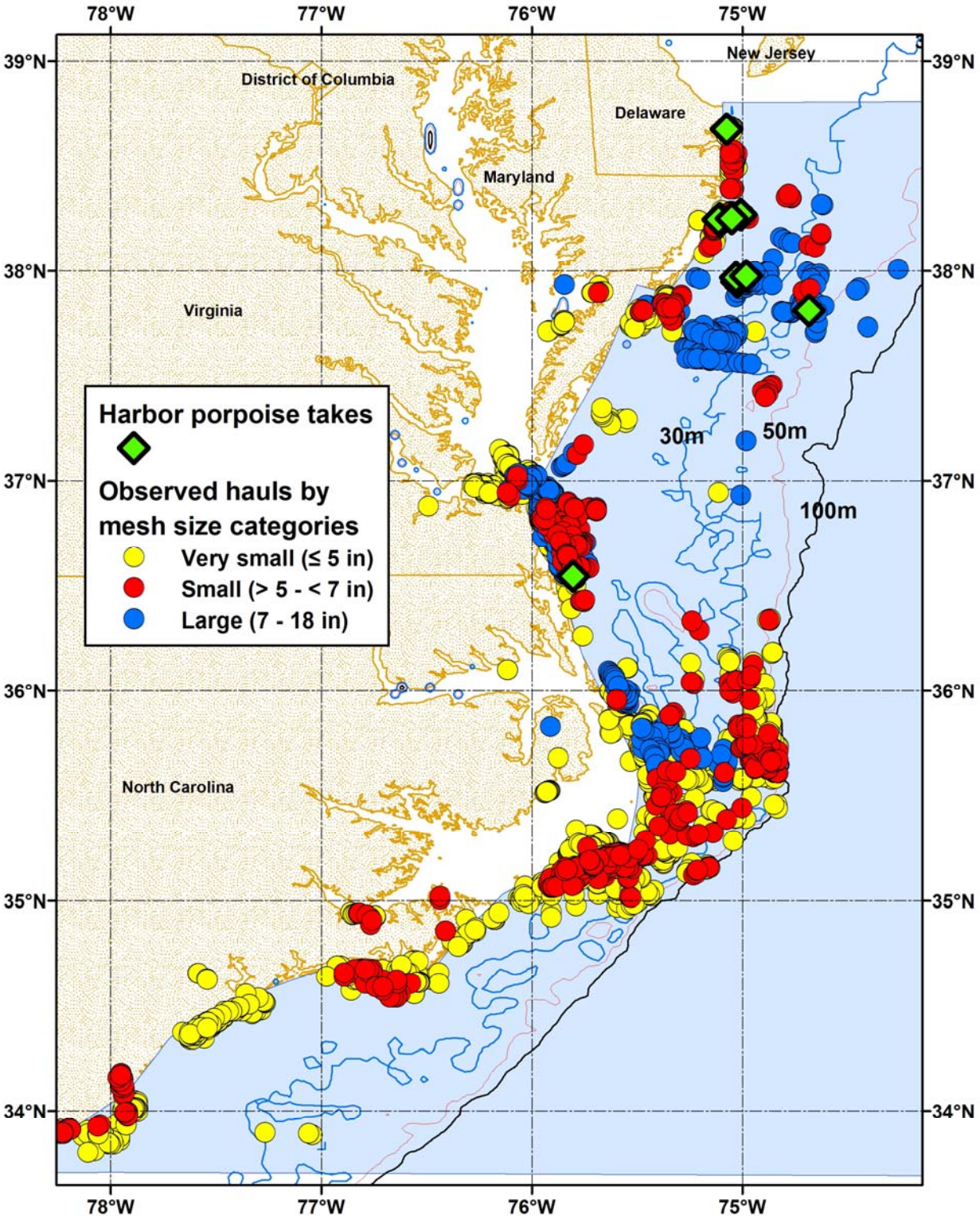


Figure 6. Location of hauls in the southern mid–Atlantic management area (shaded blue), by mesh size categories (colored dot) and hauls with observed harbor porpoise (Phocoena phocoena) takes (diamonds). Data used were from February – April in 1999–2007. Depth contours are 30, 50, and 100 m.



3. NEW JERSEY REGION

3.1 Summary

The New Jersey region (Figure 1) is the northern portion of the Mid-Atlantic gillnet fishery and is the area covered by two HPTRP management areas, the Mudhole MA and Waters off New Jersey (excluding the Mudhole) MA. Since the implementation of the HPTRP, NEFOP observed 43 harbor porpoises taken in gillnets in the New Jersey region. Most of these takes occurred in and around Hudson Canyon. All the takes were in large mesh gillnets that were targeting monkfish. Harbor porpoise bycatch in winter (January – April) in the New Jersey region increased dramatically in the last few years, particularly in 2005 and 2006.

Less than half (40%) of the large mesh gillnets observed were in compliance with the HPTRP, where the length of the strings was the most common regulation measure that was out of compliance. The level of compliance during 2007 improved markedly over the previous four years. Bycatch rates of strings greater than 4,000 ft were three times greater than the rates for strings less than 4,000 ft. Over all years, about 77% of the small mesh gillnets were in compliance with the HPTRP, and nearly all of the observed small mesh gillnets during 2006 and 2007 were in compliance.

A statistical model that best predicted the bycatch rates in this region included fixed environmental factors (bottom depth and distance to the 50 m depth contour), varying environmental factors (sea surface and bottom water temperatures and winter North Atlantic Oscillation [NAO] index value), and fishery characteristics (ship's gross tonnage, anchor weight, number of anchors on the gillnet, and duration of time the gillnet was in the water [i.e., soak duration]). One interpretation of these factors is that (1) fixed environmental factors indicated the general location of the majority of the takes (i.e., in and around Hudson Canyon), (2) varying environmental factors helped explain the annual and monthly differences in bycatch rates, and (3) fishing characteristics indicated the types of strings with higher bycatch.

All of the observed takes were in gillnets that soaked for 48 or more hours; 63% of the observed hauls and 81% of the observed landings (mtons) were from gillnets that soaked for 48 or more hours. The bycatch rate of gillnets that soaked for more than one week was five times greater than for gillnets that soaked for less than one week.

Investigating the fishing characteristic factors in these models further showed that the bycatch rate of the hauls that used four anchors was 100 times larger than that for hauls that used two anchors. The hauls that used four anchors had long soak durations (greater than 6.5 days), and when the soak duration was shorter than 6.5 days, the wind speeds were fairly high (greater than 13.5 knots). Thus, gillnets with four anchors appear to be correlated to high bycatch rates not because of a cause and effect relationship between number of anchors and harbor porpoise bycatch, but because of the small sample of observed hauls with four anchors (only 77 hauls) and the high correlation between the number of anchors and soak duration. This can be interpreted as a statistical correlation between bycatch rates and the number of anchors, where the driving reason for the correlation is most likely the location of the haul and the soak duration.

3.2 Observer Coverage

In the New Jersey region (Figure 1), from 1 January 1999 – 31 May 2007, the number of observed hauls per month for this region ranged from 0 to about 140 hauls per month, with an

average of 34 hauls per month (Figure 7). All observed harbor porpoise takes were documented January – April, the same time period this region is managed by the HPTRP. Thus, further analyses focused on hauls observed in the New Jersey region January – April in 1999–2007.

In this region and time period, there were 721 hauls observed, which were from 202 trips and 119 vessels. This represents 7–201 hauls observed per year, 2–61 trips per year, and from 1–32 vessels per year (Table 6).

3.3 General Bycatch Patterns

Most of the harbor porpoise bycatch was near Hudson Canyon, both inside and outside of the Mudhole MA (Figure 8). Takes from the different years were located in similar areas. Of the 721 hauls observed in the New Jersey region January – April, 691 hauls did not have any harbor porpoise bycatch, 22 hauls had 1 take, 4 hauls had 2 takes, 3 hauls had 3 takes, and 1 haul had 4 harbor porpoise takes. Most of the hauls that took more than one harbor porpoise were in deeper waters, 40–50 m (Figure 9).

Bycatch rates were highest in 2005 and 2006 (Table 6). All of the takes were from hauls that were targeting monkfish in large mesh gillnets, where 60% of the observed hauls (with and without takes) were targeting monkfish. There were no observed takes January – April 2007. The bycatch rate in February (0.775 harbor porpoises per mtons landed) was considerably higher than the rate in other months, 0–0.109 harbor porpoises per mtons landed (Table 7).

Bycatch rates (numbers of observed hauls with one or more harbor porpoises per observed mtons landed) for categorizations of many factors are listed in Table 8. Categories with high bycatch rates include: the year 2006, the month of February, waters 60–100 fathoms (fa) deep, hauls targeting monkfish, surface water temperatures of 2–4ºC, a fairly steeply sloped bottom, long soak durations (greater than 200 hrs), long string lengths (greater than 4,000 ft), tie downs with a length of 3–4 ft, gillnets that used four anchors weighing 80–100 lbs, years with a small winter NAO index value, leadlines fished at 30–50 fa depth, and waters with low concentrations of chlorophyll.

3.4 Compliance

3.4.1 Small mesh

From January – April in 1999–2007, 133 observed hauls (from 42 trips and 25 vessels) used small mesh gillnets in the New Jersey region, where only one observed haul was in the Mudhole MA. No harbor porpoise takes were observed in small mesh gillnets in the New Jersey region (Table 9).

Looking only at the gear length requirement, in 1999 there were 23 observed hauls (12 trips from 6 vessels) that were using small mesh sizes (5.5, 6, and 6.5 in) and had total string lengths greater than 3,000 ft (the limit set in the HPTRP). The string lengths ranged from 3,027–4,200 ft. Of these 23 hauls, 9 hauls from 6 trips had total string lengths that were 3,027–3,036 ft, which were 3,000 ft of gillnetting plus the spaces between the gillnets. These nine hauls will be considered in compliance in this manuscript, since the differences in string lengths is simply the gaps between the gillnet panels. The 23 hauls occurred in January (3), February (1), March (9), and April (10).

Looking only at the twine size requirements, the hauls out of compliance were observed during 2004 (15 hauls, 3 trips, and 2 vessels) and 2006 (1 haul). These hauls used small mesh (5.5 in) and twine sizes of 0.4–0.7 mm, which are less than 0.81 mm, the limit set in the HPTRP.

No other observed small mesh gillnets in the New Jersey region were out of compliance.

3.4.2 Large mesh

From January – April in 1999–2007, 119 observed hauls (from 36 trips and 21 vessels) used large mesh in the Mudhole MA, and 316 observed hauls (from 108 trips and 54 vessels) used large mesh in the Waters off New Jersey (excluding the Mudhole) MA. The level of compliance increased markedly in 2007 over that from the previous four years (Table 9).

Looking only at the gear length requirements, in the Mudhole MA there were 62 (52%) observed hauls (23 trips and 14 unique vessels) that used large mesh and string lengths greater than 3,900 ft (4,500–8,400 ft), which were out of compliance (Table 10). These occurred in 2002, 2003, and 2005–2007 (Table 10). In the Waters off New Jersey (excluding the Mudhole) MA, there were 163 (52%) observed hauls (70 trips and 36 unique vessels) that used string lengths greater than 4,800 ft (5,100–12,000 ft), which were out of compliance. These hauls occurred in 1999, 2001, and 2003–2007.

Looking only at the closure requirements, there were six observed hauls in 2001 and 2006 in the Mudhole MA and Waters off New Jersey (excluding the Mudhole) MA during the closed period (1–20 April); these hauls caught a total of three harbor porpoises (Table 10). Additionally, there was one observed haul in the Mudhole MA closed period (15 February – 15 March); a harbor porpoise was not taken on this haul (Table 10).

About 60% (261 of 437) of the observed large mesh hauls had at least one gear characteristic or closure requirement out of compliance. In addition, 65% (28 of 43) of the harbor porpoise takes were in large mesh hauls that were out of compliance for at least one of the gear characteristics or closures requirements of the HPTRP (Table 10).

Most of the hauls that were out of compliance were violating the string length requirement (Table 10). Bycatch rates increased as string length increased (Figure 10). For example, the bycatch rate of all large mesh hauls was 0.320 harbor porpoises per mtons landed (43 takes in 437 hauls). In comparison, the bycatch rate of hauls that used strings less than or equal to 4,000 ft was 0.121 harbor porpoises per mtons landed (3 takes in 139 hauls) and the rate for strings greater than 4,000 ft was 0.368 harbor porpoises per mtons landed (40 takes in 295 hauls). Note that under the HPTRP, the large mesh gillnets fishing within the Waters off New Jersey (excluding the Mudhole) MA may not exceed 4,800 ft.

Other hauls that were out of compliance used smaller than required twine sizes and did not use tie downs (Table 10).

3.5 Correlated Factors

When developing a 1–factor model, three factors (bottom depth, distance to the 50 m depth contour and number of anchors) were equally highly significant. Thus, because the AIC values were so similar (a difference of about one AIC unit), it was not possible to tell which factor was appropriate to use as the best 1-factor model. In conclusion, three 1-factor models were expanded upon to develop three final models (Table 11). Two of these three final models ended up having

the same factors included, just in a different order; thus, there were two unique final models. These two unique final models included fixed environmental factors (bottom depth and distance to the 50 m depth contour), varying environmental factors (surface and bottom water temperatures and winter NAO index value), and fishery characteristics (ship's gross tonnage, anchor weight, number of anchors, and duration of time gillnet was in the water [i.e., soak duration]).

For the two final unique models, Figures 11 and 12 indicate the values of each factor (x–axis) that were associated with a higher than average bycatch rate (y–axis value greater than zero, that is, above the dashed horizontal line).

A description and interpretation of the factors follows.

3.5.1 Fixed environmental factors

One interpretation of the fixed environmental factors (bottom depth and distance to the 50 m depth contour) is that these factors define the area of highest bycatch rates (inside and around Hudson Canyon). This area is also an area with the majority of gillnet fishing effort, as shown by the location of gillnet trips recorded in the vessel trip reports (VTR) during January – April, 2004 – 2005, which are two years in the center of the study time period (Figures 13 and 14).

3.5.2 Varying environmental factors

One interpretation of the inclusion of the varying environmental factors (surface and bottom water temperatures and winter NAO index value) is that these factors explain why the bycatch rates varied from year to year and month to month. That is, higher than average bycatch rates were observed when the winter NAO index value[6] was smaller (<0.25), and when the water temperatures were cooler than about 7°C surface temperature and 6°C bottom temperature (Figures 11 and 12).

These results suggest that these environmental factors may cause the spatial/temporal distribution of harbor porpoises and fish (and/or fishers) to overlap more in some years (with small NAO index values and cooler water temperatures) than in other years (with large NAO index values and warmer water temperatures). However, there are not enough fishery–independent sighting surveys in the winter in this region to fully investigate this hypothesis.

3.5.3 Gear and fishing characteristic factors

The gear and fishing characteristics that were most highly correlated with bycatch were the numbers of anchors used, total weight of the anchors, soak duration, and gross tonnage of the vessel.

All of the observed takes in this region were on hauls that soaked for 48 or more hours. Overall, 63% of all observed hauls soaked for 48 or more hours, and 81% of the observed landings came from hauls that soaked for 48 or more hours. Half of the takes were from hauls that soaked for more than one week; however, only 11% of the observed hauls soaked for more than one week, and 15% of the observed landings were from hauls that soaked for more than one week. The bycatch rate from hauls that soaked for more than one week was 0.53 harbor porpoises per mtons

[6] See the Appendix for the definition of the North Atlantic oscillation (NAO) index value and how it is related to weather conditions and marine life distribution and abundance in northwestern Atlantic waters.

landed (15 takes per 28.2 mtons landed) as compared to 0.10 harbor porpoises per mtons landed (15 takes per 155.349 mtons landed) for hauls that soaked for less than one week. If it is assumed that there is a cause and effect relationship between the bycatch rate and soak duration, and if it is assumed the soak durations of all hauls were less than one week, it might be possible to reduce the observed bycatch rate by about five times. Average landings on hauls targeting monkfish that soaked for less than one week (0.30 mtons) were about the same for monkfish hauls that soaked for more than one week (0.35 mtons).

The relationship between soak duration and the bycatch rate still held when looking only at 2006, the year with the most takes and a low winter NAO index value. The bycatch rate for hauls that soaked for less than one week was 0.31 harbor porpoises per mtons landed, and the rate for hauls that soaked more than one week was 0.99 harbor porpoises per mtons landed.

Most (93%) of the observed hauls used two anchors, an additional 6% used four anchors, and a few hauls used one, three, or six anchors. As expected, as the number of anchors increased so did the total weight of the anchors. Thus, the factors number of anchors and total weight of anchors are correlated with each other. Bycatch rates of hauls that used four anchors (usually 88 lbs) were 100 times larger than that of hauls that used two anchors (usually 44 lbs). For hauls that used four anchors, there were 11 takes in 26 hauls, which resulted in a bycatch rate of 0.423 takes per haul. For hauls that used two anchors, there were 18 takes in 401 hauls, which resulted in a bycatch rate of 0.045 takes per haul. All observed hauls that used four anchors were targeting monkfish, though only 8.3% of the observed monkfish hauls used four anchors. It should not be surmised that using four anchors caused the higher bycatch. The higher bycatch rate could be related to the reason for using four anchors, to some other factor that happened to be statistically correlated with the number of anchors, or by simple chance since there were only 26 observed hauls that used four anchors.

To investigate possible reasons for why four anchors were used instead of the usual two anchors, a classification tree analysis was used to determine which fishing practices and gear characteristics were most common for hauls with four anchors. This analysis showed that hauls that used four anchors had either long soak durations (>6.5 days) or were hauled back when the wind speeds were fairly high (>13.5 knots) (Figure 15). The average (and median) string lengths were not different for strings with two versus four anchors (two anchors: mean = 4,074 ft and median = 4,500 ft versus four anchors: mean = 4,569 ft and median = 4,500 ft). Observed monkfish hauls with four anchors were on average on steeper bottom slopes (Figure 16). Perhaps more anchors were used when the captain knew the soak duration would be long, when the weather was predicted to be poor, or when the bottom slope was steep. On the other hand, use of four anchors could have been a personal preference since only two of the 63 observed vessels targeting monkfish used four anchors. Thus, it appears that numbers of anchors and amount of anchor weights are related to the water depth and soak duration, which were also related to harbor porpoise bycatch rates. High bycatch rates were probably not directly caused by the number of anchors (or anchor weight) but were more directly related to the reasons for their use: location (water depth and bottom slope) and soak duration.

All of the takes were from vessels that were either small, less than or equal to 20 tons (10 takes from 67 hauls), or from vessels that did not have the tonnage reported (33 takes from 300 hauls). Until the tonnage of all the vessels is identified, this factor does not provide much information about which fishery characteristics were related to the bycatch rate.

Table 6. Descriptive statistics about the bycatch of harbor porpoises (Phocoena phocoena) in the New Jersey region in January – April, 1999–2007.

	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Number of observed hauls	186	16	26	7	20	66	84	201	115	721
Number of observed trips	61	3	8	2	8	18	27	54	21	202
Number of observed vessels	26	3	4	1	5	14	17	32	17	119
Number of observed hauls with one or more take	0	0	0	0	1	0	7	22	0	30
Total number of observed takes	0	0	0	0	1	0	15	27	0	43
Bycatch rate (observed takes/observed number of hauls)	0	0	0	0	0.050	0	0.179	0.134	0	0.060
Bycatch rate (observed takes/observed mtons landed)	0	0	0	0	0.110	0	0.445	0.530	0	0.233

Table 7. For each month, the number of observed hauls and takes of harbor porpoises (Phocoena phocoena) and resulting bycatch rates in the New Jersey region.

	Month			
	Jan	Feb	Mar	Apr
Number of observed hauls	328	114	46	233
Number of observed takes	12	28	0	3
Bycatch rate (observed takes/observed hauls)	0.037	0.246	0	0.013
Bycatch rate (observed takes/observed mtons landed)	0.109	0.775	0	0.105

Table 8. For the New Jersey region, observed bycatch rates (Byc Rate) of harbor porpoises (Phocoena phocoena) and numbers of observed hauls (Num Obs) for various gear characteristics, fishing practices, and environmental factors. The bycatch rate was defined as observed number of hauls with one or more takes per the observed mtons landed. The overall average bycatch rate was 0.163 harbor porpoises per mtons landed.

Categories of factors with ** in the Num Obs column had less than 6 mtons landed (thus given the overall bycatch rate for this region, there was a very small chance of observing a take). Categories of factors with * in the Num Obs column had less than 12 mtons landed (thus, there was a small chance of observing a take).

High bycatch rates (≥ 0.3 harbor porpoises per mtons landed) are highlighted.

Data were collected from January – April, 1999 –2007.

Category	*Num Obs*	*Byc Rate*
MONTH		
Jan	328	0.109
Feb	114	0.443
Mar	46*	0
Apr	233	0.070
YEAR		
1999	186	0
2000	16**	0
2001	26**	0
2002	7**	0
2003	20*	0.110
2004	66	0
2005	84	0.208
2006	201	0.432
2007	115*	0
BIOLOGICAL SAMPLING?		
yes	146	0.140
no	575	0.170
STEAM TIME (hrs)		
0–2	377	0.033
2–4	185	0.310
4–6	99	0.200
6–8	38	0.053
8–10	19*	0.213
10–14	2**	0
WIND SPEED (kts)		
0–10	413	0.171
10–20	256	0.181
20–30	27*	0
30–40	3**	0

Category	*Num Obs*	*Byc Rate*
TARGET SPECIES		
Leptoscopus americanus	430	0.225
Pomatomus saltatrix	20**	0
Clupea harengus	2**	0
Scomber scombrus	37*	0
Brevoortia tyrannus	9**	0
Cynoscion regalis	81**	0
Alosa sapidissima	47**	0
Mustelus, Squalus	41	0
Rajidae	4**	0
Leucoraja ocellata	3**	0
Morone saxatilis	24**	0
Groundfish	21**	0
Scombridae	2**	0
SURFACE TEMPERATURE (°C)		
2–4	11**	0.524
4–6	199	0.104
6–8	216	0.284
8–10	155	0.066
10–12	17**	0
BOTTOM TEMPERATURE (°C)		
3–4	12**	0
4–5	115	0.175
5–6	171	0.257
6–7	139	0.177
7–8	74	0.181
8–9	44	0
9–10	8**	0
SOAK DURATION (hrs)		
0–100	540	0.051
100-200	141	0.287
200-700	39**	0.591

Category	*Num Obs*	*Byc Rate*
LENGTH OF STRING (ft)		
0–2,000	235	0
2,000–4,000	174	0.056
4,000–6,000	213	0.393
6,000–8,000	74	0.025
8,000–14,000	11**	0.184
HANGING RATIO		
0.33	61	0.080
0.5	648	0.172
TWINE SIZE (mm)		
0.33	7**	0
0.4	5**	0
0.47	1**	0
0.52	19**	0
0.57	41*	0
0.62	12**	0
0.66	18**	0
0.7	45	0
0.74	9**	0
0.81	60	0.054
0.9	375	0.244
MESH SIZE (in)		
2–4	70	0
4–6	186	0
6–8	27*	0
8–10	3**	0
10–12	434	0.224
USED TIE DOWNS?		
no	300	0
yes	407	0.241
unknown	14**	0

Table 8 (cont). For the New Jersey region, observed bycatch rates (Byc Rate) of harbor porpoises (Phocoena phocoena) and numbers of observed hauls (Num Obs) for various gear characteristics, fishing practices, and environmental factors. The bycatch rate was defined as observed number of hauls with one or more takes per the observed mtons landed. The overall average bycatch rate was 0.163 harbor porpoises per mtons landed.

Categories of factors with ** in the Num Obs column had less than 6 mtons landed (thus given the overall bycatch rate for this region, there was a very small chance of observing a take). Categories of factors with * in the Num Obs column had less than 12 mtons landed (thus, there was a small chance of observing a take).

High bycatch rates (≥ 0.3 harbor porpoises per mtons landed) are highlighted.

Data were collected from January – April, 1999 –2007.

Category	*Num Obs*	*Byc Rate*
AMOUNT DISCARD (lbs)		
0–200	120	0.103
200–400	14*	0.185
400–1,400	8**	0
LENGTH OF TIE DOWN (ft)		
2–3	216	0.123
3–4	144	0.405
4–5	4**	0
5–6	8**	0
NUMBER OF ANCHORS		
1	1**	0
2	401	0.166
3	1**	0
4	26	1.070
6	4**	0
VESSEL GROSS TONS		
0–20	80	0.365
20–40	84	0
40–60	23**	0
60–120	20*	0

Category	*Num Obs*	*Byc Rate*
NET HEIGHT (ft)		
0–5	23	0
5–10	312	0.110
10–15	221	0.280
15–30	91*	0
NUMBER OF SPACES		
0–10	76	0
10–20	75	0.042
20–40	11*	0
30–40	1**	0
ANCHOR WEIGHT (lbs)		
0–20	2**	0
20–40	89	0.163
40–60	424	0.114
60–80	39**	0
80–100	40	0.925
100–160	41**	0
AMOUNT LANDED (mtons)		
0–0.5	602	0.227
0.5–1	82	0.125
1–1.5	15	0
1.5–3	7	0.071

Category	*Num Obs*	*Byc Rate*
USED ANCHORS?		
no	77**	0
yes	644	0.165
USED ADDED WEIGHTS?		
no	453	0
yes	66*	0.238
unknown	198	0.166
ANCHOR WEIGHT TYPE		
Unknown	80**	0
Danforth-type	278	0.064
Dead weight	363	0.275
DEPTH OF LEADLINE (fm)		
0–10	194	0
10–20	132	0.134
20–30	95	0.132
30–40	61	0.438
40–50	22*	0.715
50–60	8**	0

Table 8 (cont). For the New Jersey region, observed bycatch rates (Byc Rate) of harbor porpoises (Phocoena phocoena) and numbers of observed hauls (Num Obs) for various gear characteristics, fishing practices, and environmental factors. The bycatch rate was defined as observed number of hauls with one or more takes per the observed mtons landed. The overall average bycatch rate was 0.163 harbor porpoises per mtons landed.

Categories of factors with ** in the Num Obs column had less than 6 mtons landed (thus given the overall bycatch rate for this region, there was a very small chance of observing a take). Categories of factors with * in the Num Obs column had less than 12 mtons landed (thus, there was a small chance of observing a take).

High bycatch rates (≥ 0.3 harbor porpoises per mtons landed) are highlighted.

Data were collected from January – April, 1999 –2007.

Category	*Num Obs*	*Byc Rate*
SEDIMENT TYPE		
Clay – Silt/Sand	105	0.295
Gravel	24	0
Gravel – Sand	97	0.078
Sand	367	0.174
Sand – Clay/Silt	5	0
DISTANCE TO 50 M DEPTH CONTOUR (m)		
0–2,000	83	0.28
2,000–4,000	73	0.498
4,000–6,000	45	0.325
6,000–8,000	42	0.366
>8,000	356	0

Category	*Num Obs*	*Byc Rate*
WINTER NORTH ATLANTIC OSCILLATION INDEX		
–0.4 – –0.2	227	0.396
–0.2 – 0.0	0	0
0.0 – 0.2	20**	0.11
0.2 – 0.4	157	0.133
0.4 – 0.6	186	0
0.6 – 1.2	16**	0
NORTH ATLANTIC OSCILLATION INDEX		
–1 – –0.5	83	0.318
–0.5 – 0	88	0.215
0 – 0.5	77	0
0.5 – 1.0	99	0.033
1.0 – 1.5	198	0.33
1.5 – 2.0	61	0.043

Category	*Num Obs*	*Byc Rate*
CHLOROPHYLL α CONCENTATION (mg/m^3)		
0–10	210	0.422
10–20	35**	0
20–30	3**	0
30–60	3**	0
LOG_{10}(CHLOROPHYLL α) [log_{10} (mg/m^3)]		
–0.5 – 0	17**	0.52
0–0.5	86	0.331
0.5–1	107	0.556
1–1.5	38**	0
1.5–2	3**	0
DEPTH OF FLOATLINE (fm)		
0–20	238	0
20–40	243	0.061
40–60	145	0.091
60–100	91	0.611

Table 9. From January – April, 1999–2007, the numbers of observed hauls and takes of harbor porpoises (Phocoena phocoena) that were in gillnets in the New Jersey region which were in and out of compliance with the harbor porpoise take reduction plan (HPTRP). Note any one haul could have been out of compliance for one or more of the requirements.

Large mesh is 7–18 in; small mesh is >5–<7 in; very small mesh (not regulated in HPTRP) is ≤5 in.

ALL HAULS	In compliance?	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
	No	25	0	9	7	19	43	63	115	11	292
	Yes	161	16	17	0	1	23	21	86	104	429
	%										
Number of	compliant	87	100	65	0	5	35	25	43	90	60
hauls	TOTAL	186	16	26	7	20	66	84	201	115	721
	No	0	0	0	0	1	0	9	18	0	28
Number of	Yes	0	0	0	0	0	0	6	9	0	15
takes	TOTAL	0	0	0	0	1	0	15	27	0	43

SMALL MESH	In compliance?	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
	No	15	0	0	0	0	15	0	1	0	31
	Yes	28	0	0	0	0	1	0	25	48	102
	%										
Number of	compliant	65	0	0	0	0	6	0	96	100	77
hauls	TOTAL	43	0	0	0	0	16	0	26	48	133
	No	0	0	0	0	0	0	0	0	0	0
Number of	Yes	0	0	0	0	0	0	0	0	0	0
takes	TOTAL	0	0	0	0	0	0	0	0	0	0

LARGE MESH	In compliance?	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
	No	10	0	9	7	19	28	63	114	11	261
	Yes	89	7	4	0	1	5	21	32	17	176
	%										
Number of	compliant	90	100	31	0	5	15	25	22	61	40
hauls	TOTAL	99	7	13	7	20	33	84	146	28	437
	No	0	0	0	0	1	0	9	18	0	28
Number of	Yes	0	0	0	0	0	0	6	9	0	15
takes	TOTAL	0	0	0	0	1	0	15	27	0	43

VERY SMALL	Not regulated	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Number of hauls	Not regulated	44	9	13	0	0	17	0	29	39	151
Number of takes	Not regulated	0	0	0	0	0	0	0	0	0	0

Table 10. From January – April, 1999–2007, the numbers of observed hauls and harbor porpoises (Phocoena phocoena) takes (HP) in large mesh gillnets in the New Jersey region which were in and out of compliance with the harbor porpoise take reduction plan (HPTRP), as applied to (A) the Mudhole management area (MA), and (B) the Waters off New Jersey (excluding the Mudhole) MA, and (C) all of the New Jersey region (A+B). Note, any one haul could have been out of compliance for one or more of the requirements.

(A) MUDHOLE MA

FLOATLINE LENGTH GREATER THAN 3,900 FT

	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Number of hauls	0	0	0	7	2	0	15	34	4	62
Number of trips	0	0	0	2	1	0	6	12	2	23
Number of vessels	0	0	0	1	1	0	4	9	2	17
Number of HP takes	0	0	0	0	0	0	1	3	0	4

HAULED GILLNETS DURING THE CLOSED PERIOD: 15 FEB – 15 MAR

	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Number of hauls	0	0	0	0	0	0	0	0	1	1
Number of trips	0	0	0	0	0	0	0	0	1	1
Number of vessels	0	0	0	0	0	0	0	0	1	1
Number of HP takes	0	0	0	0	0	0	0	0	0	0

(B) WATERS OFF NEW JERSEY (EXCLUDING THE MUDHOLE) MA

FLOATLINE LENGTH GREATER THAN 4,800 FT

	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Number of hauls	7	0	6	0	17	24	37	65	7	163
Number of trips	5	0	4	0	7	9	16	26	3	70
Number of vessels	5	0	3	0	4	7	12	16	3	50
Number of HP takes	0	0	0	0	1	0	8	14	0	23

Table 10 (cont.). From January – April, 1999–2007, the numbers of observed hauls and harbor porpoises (Phocoena phocoena) takes (HP) in large mesh gillnets in the New Jersey region which were in and out of compliance with the harbor porpoise take reduction plan (HPTRP), as applied to (A) the Mudhole management area (MA), and (B) the Waters off New Jersey (excluding the Mudhole) MA, and (C) all of the New Jersey region (A+B). Note, any one haul could have been out of compliance for one or more of the requirements.

(C) ENTIRE NEW JERSEY REGION: MUDHOLE MA AND WATERS OFF OF NEW JERSEY (EXCLUDING THE MUDHOLE) MA

TWINE SIZE LESS THAN 0.90 MM

	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Number of hauls	0	0	0	0	0	12	16	20	0	48
Number of trips	0	0	0	0	0	4	7	5	0	16
Number of vessels	0	0	0	0	0	4	5	4	0	13
Number of HP takes	0	0	0	0	0	0	0	1	0	1

TIED DOWNS NOT USED

	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Number of hauls	3	0	0	0	0	3	11	0	6	23
Number of trips	1	0	0	0	0	1	4	0	2	8
Number of vessels	1	0	0	0	0	1	1	0	2	5
Number of HP takes	0	0	0	0	0	0	0	0	0	0

HAULED NETS DURING THE CLOSED PERIOD 1–20 APRIL

	1999	2000	2001	2002	2003	2004	2005	2006	2007	Total
Number of hauls	0	0	3	0	0	0	0	3	0	6
Number of trips	0	0	1	0	0	0	0	2	0	3
Number of vessels	0	0	1	0	0	0	0	1	0	2
Number of HP takes	0	0	0	0	0	0	0	3	0	3

Table 11. Final models of the bycatch rates of harbor porpoises (Phocoena phocoena) in the New Jersey region when starting with three different 1-factor models (A-C). The last column is the difference in the Akaike Information Criterion (AIC) from the row above; the larger the difference, the more that factor contributed to explaining the bycatch rate patterns. The lower the AIC, the better the model fits.

(A) Starting variable: Bottom depth

Model number	Factors	AIC	Difference from above
1	None	249	0
2	Bottom depth	186	63
3	Above + Surface water temperature	159	27
4	Above + Winter North Atlantic oscillation index	136	23
5	Above + Distance to 50 m depth contour	128	8
6	Above + Vessel gross tons	121	7
7	Above + Anchor weight	119	2

(B) Starting variable: Distance to 50 m depth contour

Model number	Factors	AIC	Difference from above
1	None	249	0
2	Distance to 50 m depth contour	185	64
3	Above + Number of anchors	152	33
4	Above + Bottom water temperature	138	14
5	Above + Winter North Atlantic oscillation index	130	8
6	Above + Vessel gross tons	121	9
7	Above + Soak duration	119	2

(C) Starting variable: Number of anchors

Model number	Factors	AIC	Difference from above
1	None	249	0
2	Number of anchors	187	62
3	Above + Distance to 50 m depth contour	152	35
4	Above + Bottom water temperature	138	14
5	Above + Winter North Atlantic oscillation index	130	8
6	Above + Vessel gross tons	121	9
7	Above + Soak duration	119	2

Figure 7. By year, numbers of observed hauls in the New Jersey region, 1 January 1999 – 31 May 2007.

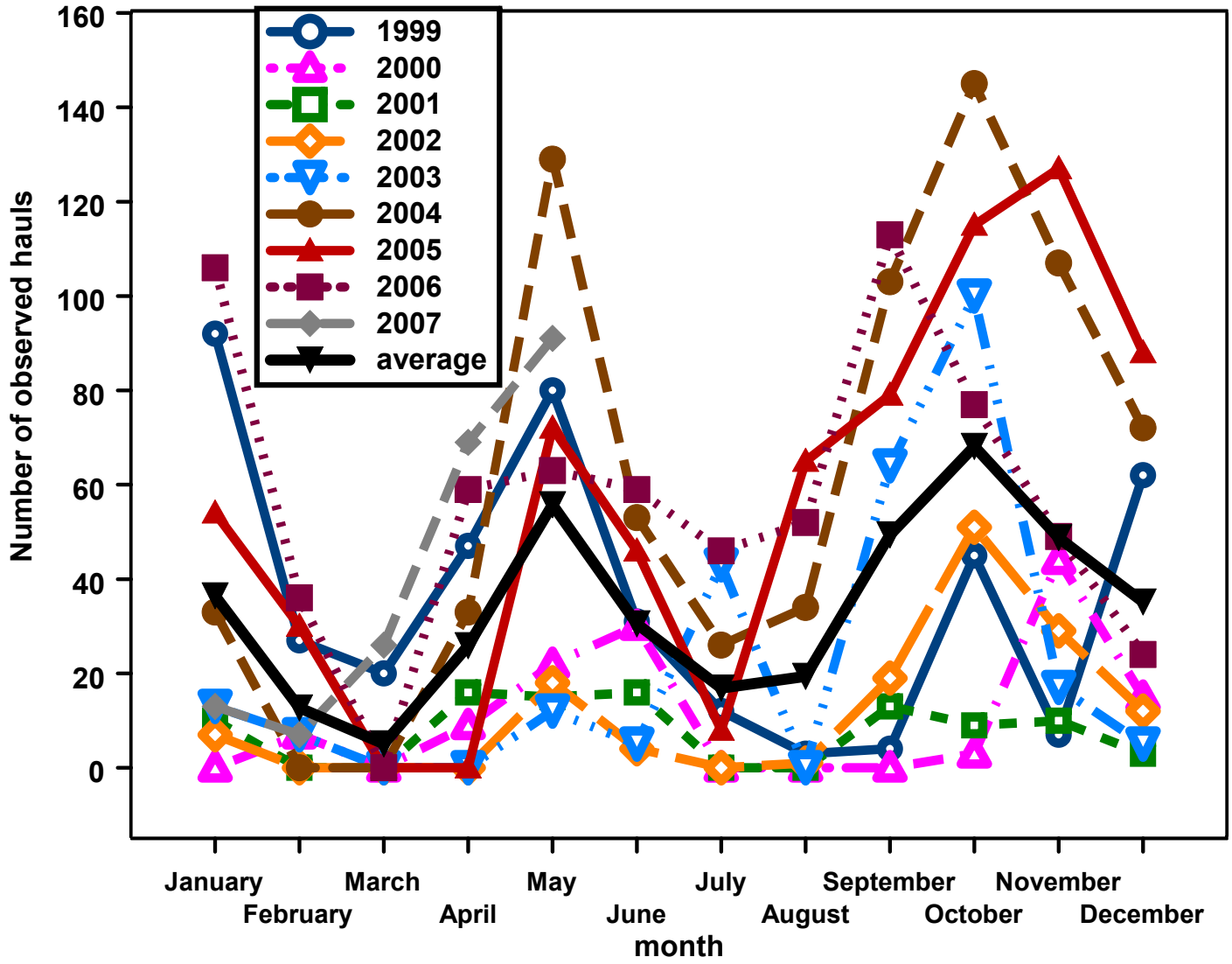


Figure 8. Locations of observed hauls by year (colored circles) and observed hauls with harbor porpoise (Phocoena phocoena) takes (white crosses) in the New Jersey region, which includes the Mudhole management area (MA), Waters off New Jersey (excluding the Mudhole) MA, and Hudson Canyon. Data are from January – April, 1999–2007. Depth contours are 10, 30, 40, 50, 100, and 200 m.

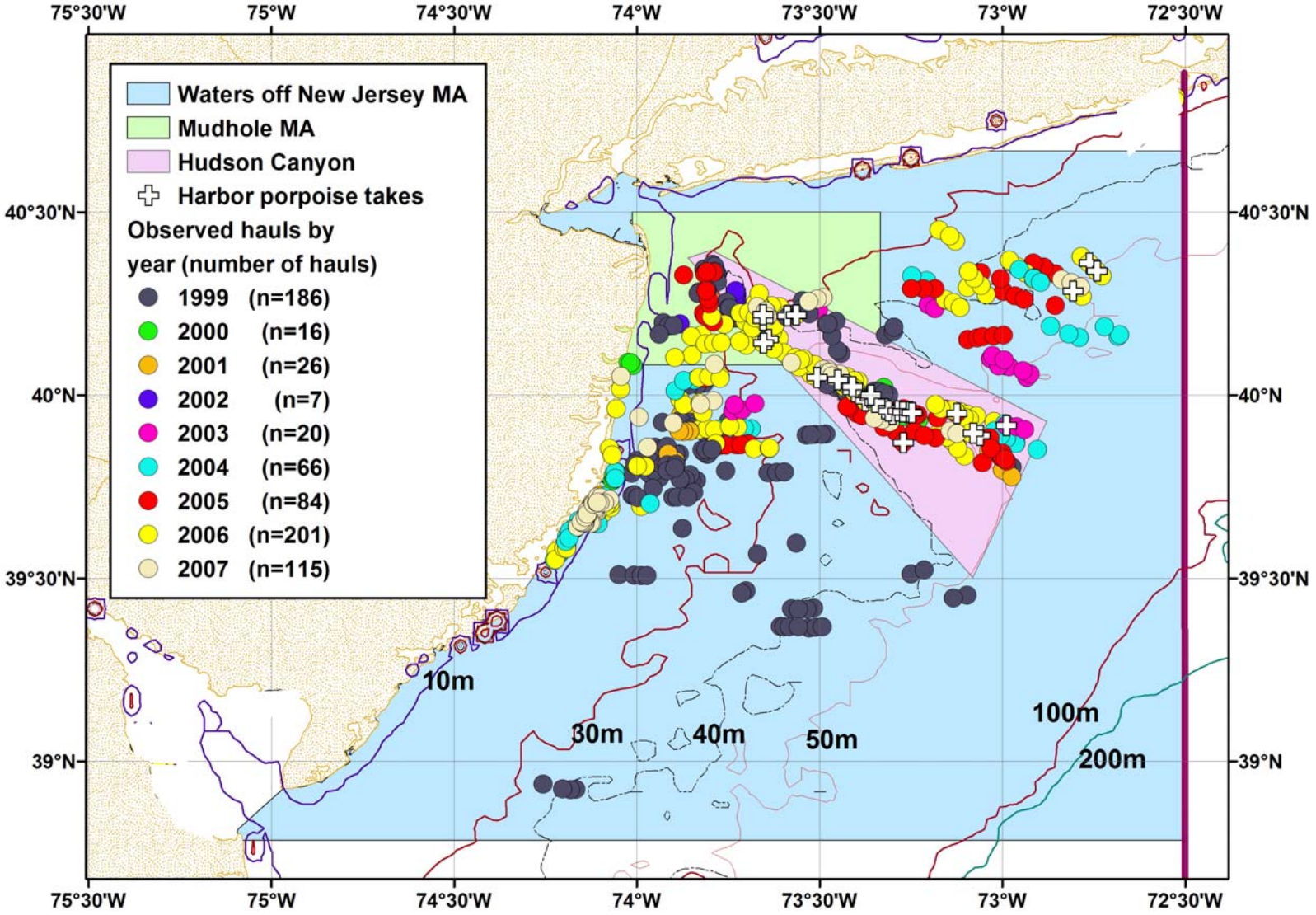


Figure 9. Locations of observed hauls without harbor porpoise (Phocoena phocoena) takes (black dashes) and observed hauls with takes, where the numbers of takes per haul is identified. Size of stack indicates number of takes: dash represents no takes; tallest stack represents four animals per haul. Data from the New Jersey region, which include the Mudhole management area (MA), Waters off New Jersey (excluding the Mudhole) MA, and Hudson Canyon and are from January – April, 1999–2007. Depth contours are 10, 20, 30, 40, 50, 100, and 200 m.

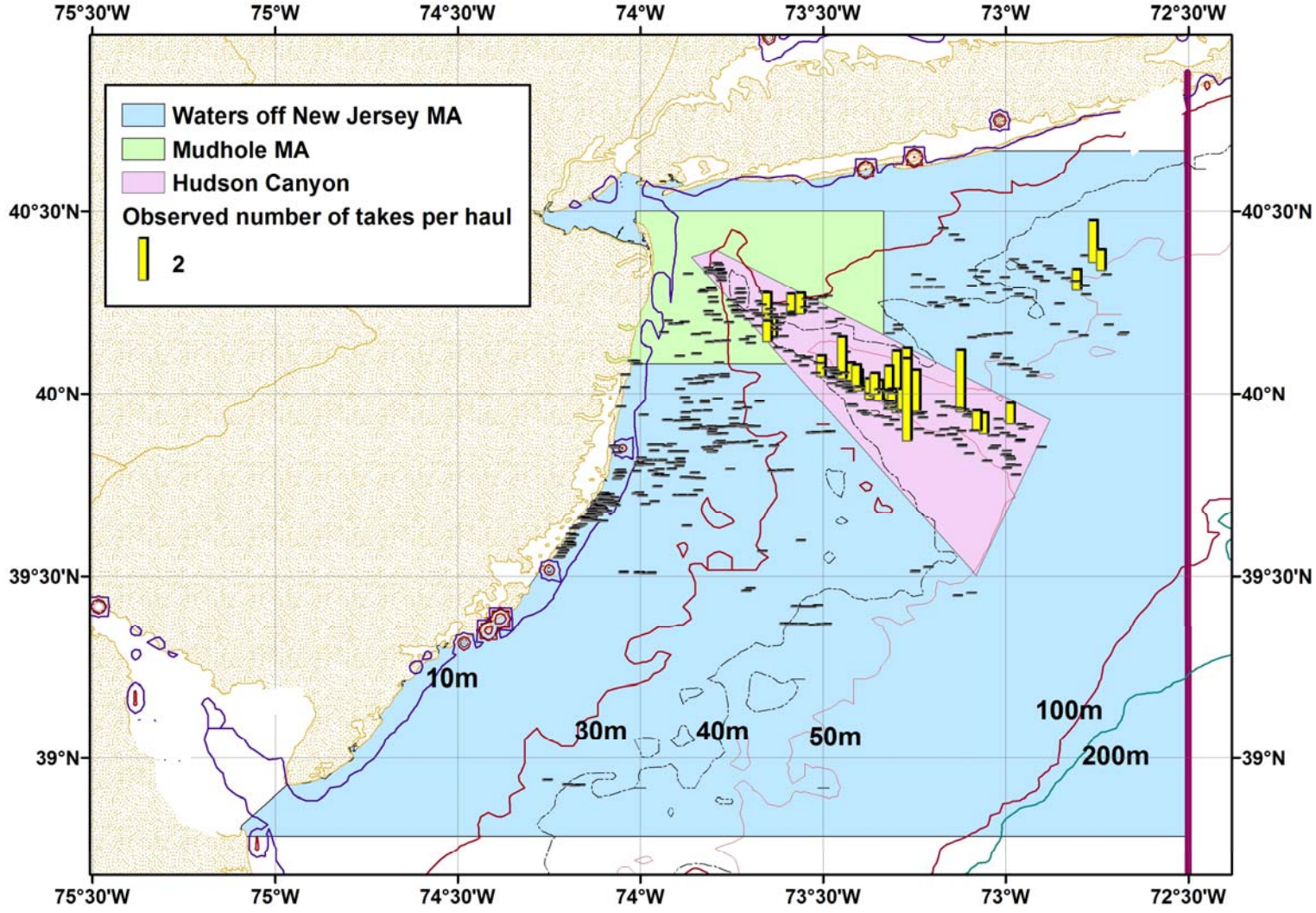


Figure 10. Relationship between the relative harbor porpoise (Phocoena phocoena) bycatch rate (y-axis) and total gear length (ft) (x-axis) using data from the New Jersey region, collected January – April, 1999–2007. This plot shows that hauls that have higher than average bycatch rates are hauls with total gear lengths greater than about 4,000 ft. Tick marks on the x–axis indicate the values of the observations, and the tick marks are jittered (spread out) to help display where there are values that are shared by many observations. The solid black line represents the overall pattern of these many observations and indicates the best estimate of the bycatch rate at any given total gear length. Dotted lines are the upper and lower one standard error (SE) confidence limits about the best estimate line. The red reference line indicates the average relative bycatch rate (y = 0), and values along the y axis indicate the difference relative to this average. Values above the red line have higher than average bycatch rates, and those below have a lower than average bycatch rate. The blue reference line indicates the total gear length with the average bycatch rate (less than 4,000).

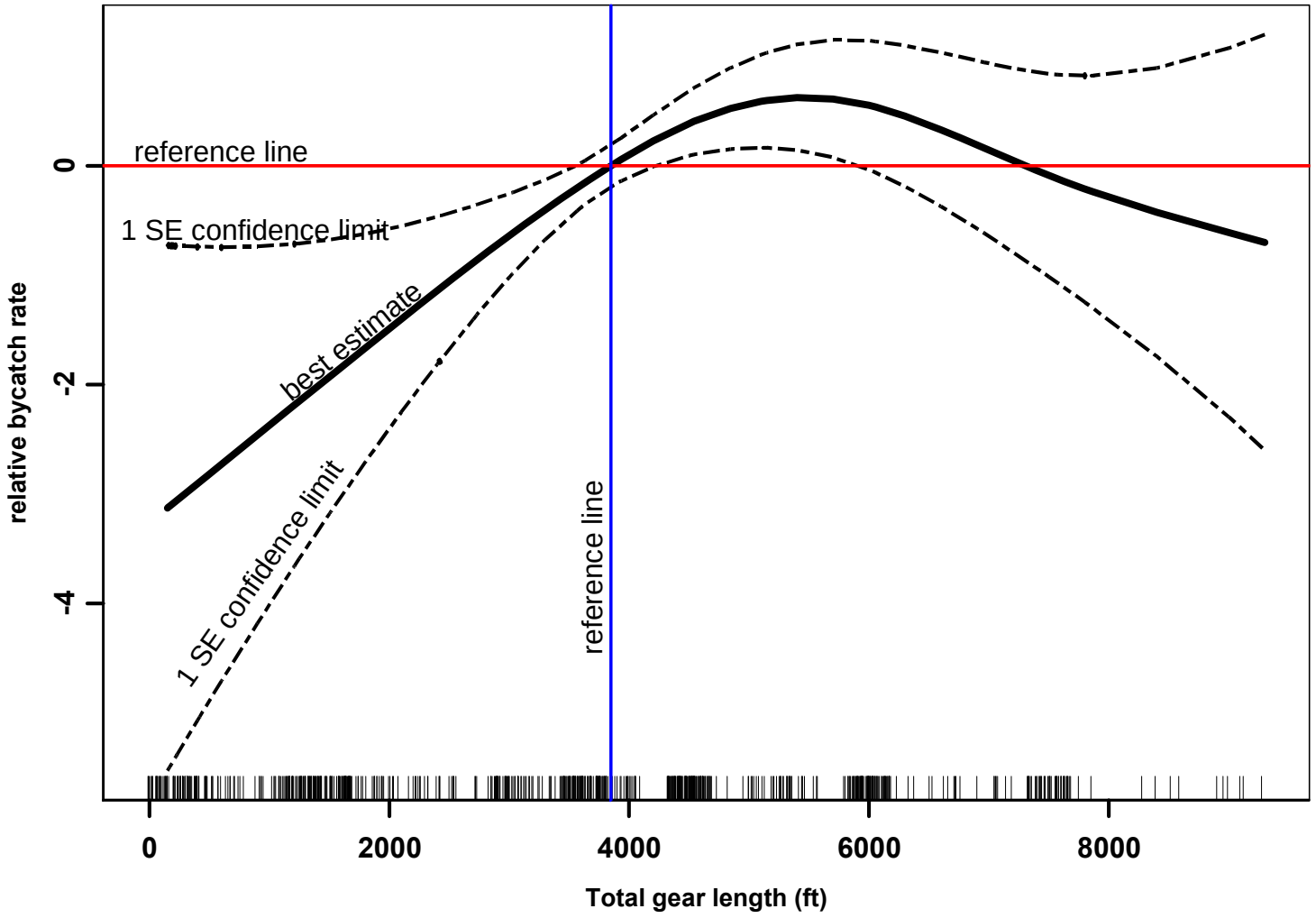


Figure 11. Results of stepwise analysis to model harbor porpoise (Phocoena phocoena) bycatch rates in the New Jersey region, where the first factor in the model was bottom depth (fa). Tick marks on the x–axis indicate the values of the observations, and the tick marks are jittered (spread out) to help display where there are values that are shared by many observations. The solid black line represents the overall pattern of these many observations and indicates the best estimate of the bycatch rate at any given value of the x-axis variable. The dashed horizontal line indicates the average relative bycatch rate (y = 0), and values along the y axis indicate the difference relative to this average. Values above this line have higher than average bycatch rates, and those below have a lower than average bycatch rate.

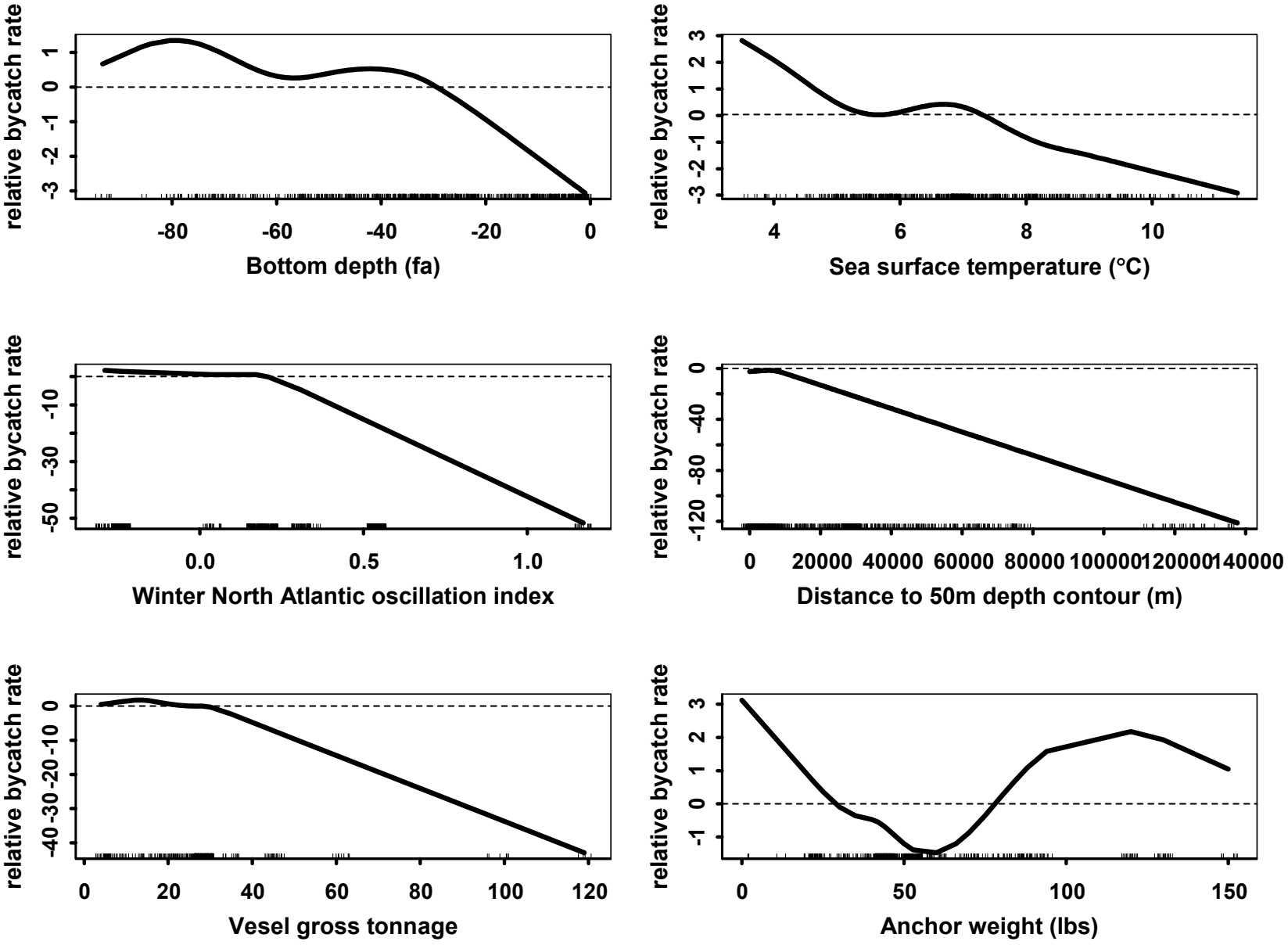


Figure 12. Results of stepwise analysis to model harbor porpoise (Phocoena phocoena) bycatch rates in the New Jersey region, where the first factor in the model was distance to the 50 m depth contour (m). Tick marks on the x–axis indicate the values of the observations, and the tick marks are jittered (spread out) to help display where there are values that are shared by many observations. The solid black line represents the overall pattern of these many observations and indicates the best estimate of the bycatch rate at any given value of the x-axis variable. The dashed horizontal line indicates the average relative bycatch rate (y = 0), and values along the y axis indicate the difference relative to this average. Values above this line have higher than average bycatch rates, and those below have a lower than average bycatch rate.

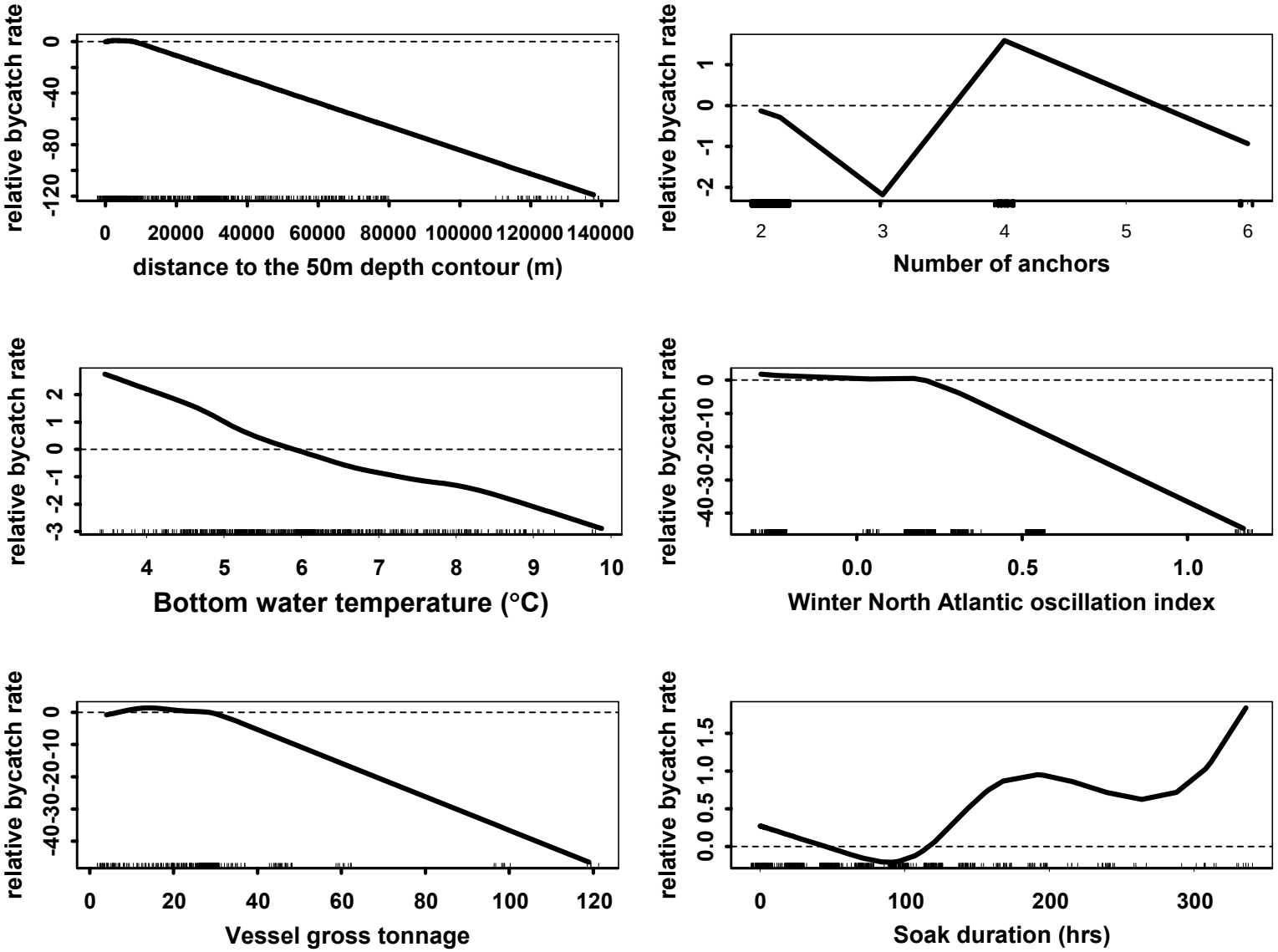


Figure 13. Locations of gillnet trips within the New Jersey region, which includes the Mudhole management area (MA), Waters off New Jersey (excluding the Mudhole) MA, and Hudson Canyon during January and February in 2004 and 2005, according to gillnet vessel trip reports (VTR). Depth contours are 10, 30, 40, 50, 100, and 200 m.

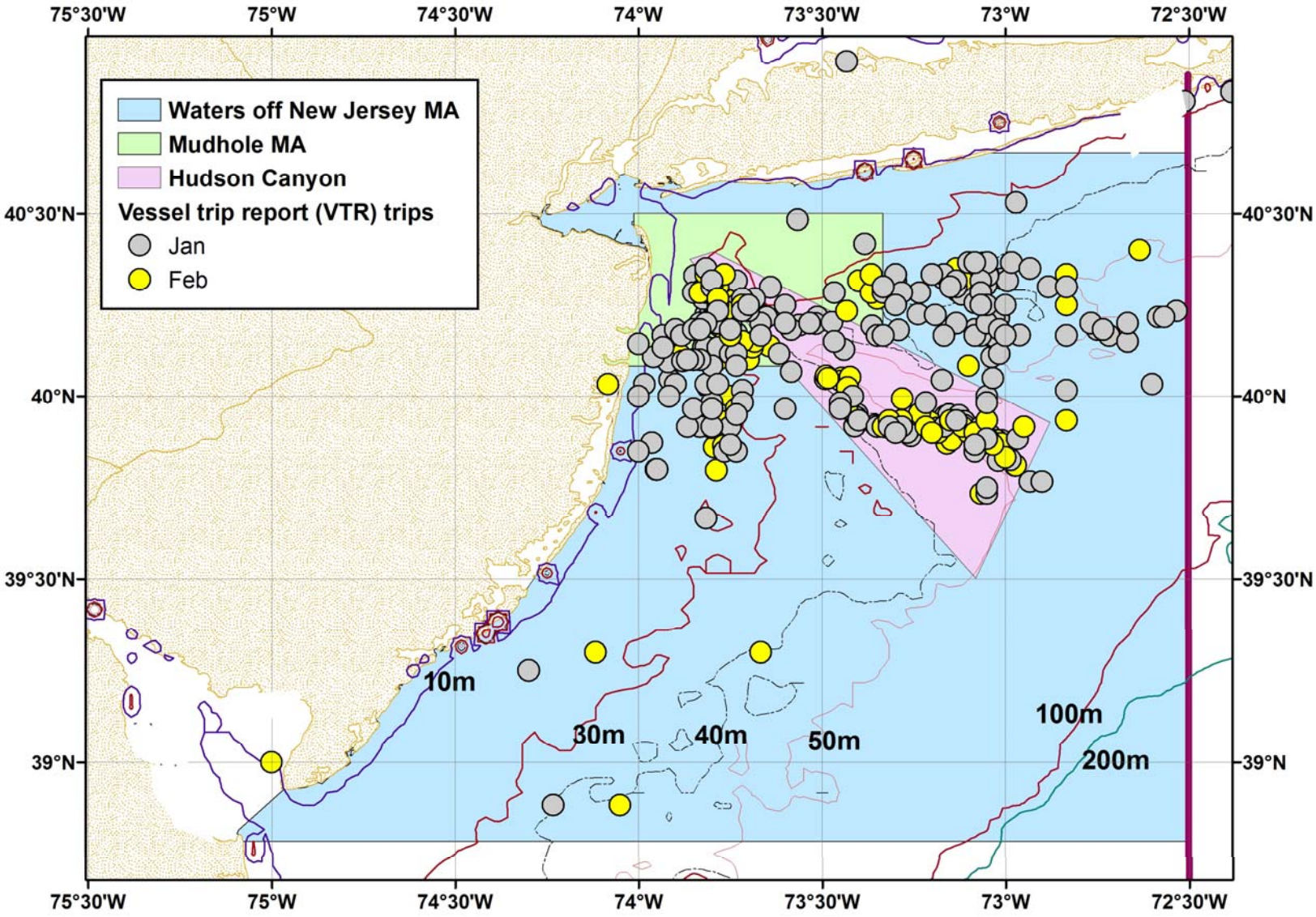


Figure 14. Locations of gillnet trips within the New Jersey region, which includes the Mudhole management area (MA), Waters off New Jersey (excluding the Mudhole) MA, and the Hudson Canyon during March and April in 2004 and 2005, according to gillnet vessel trip reports (VTR). Depth contours are 10, 30, 40, 50, 100, and 200 m.

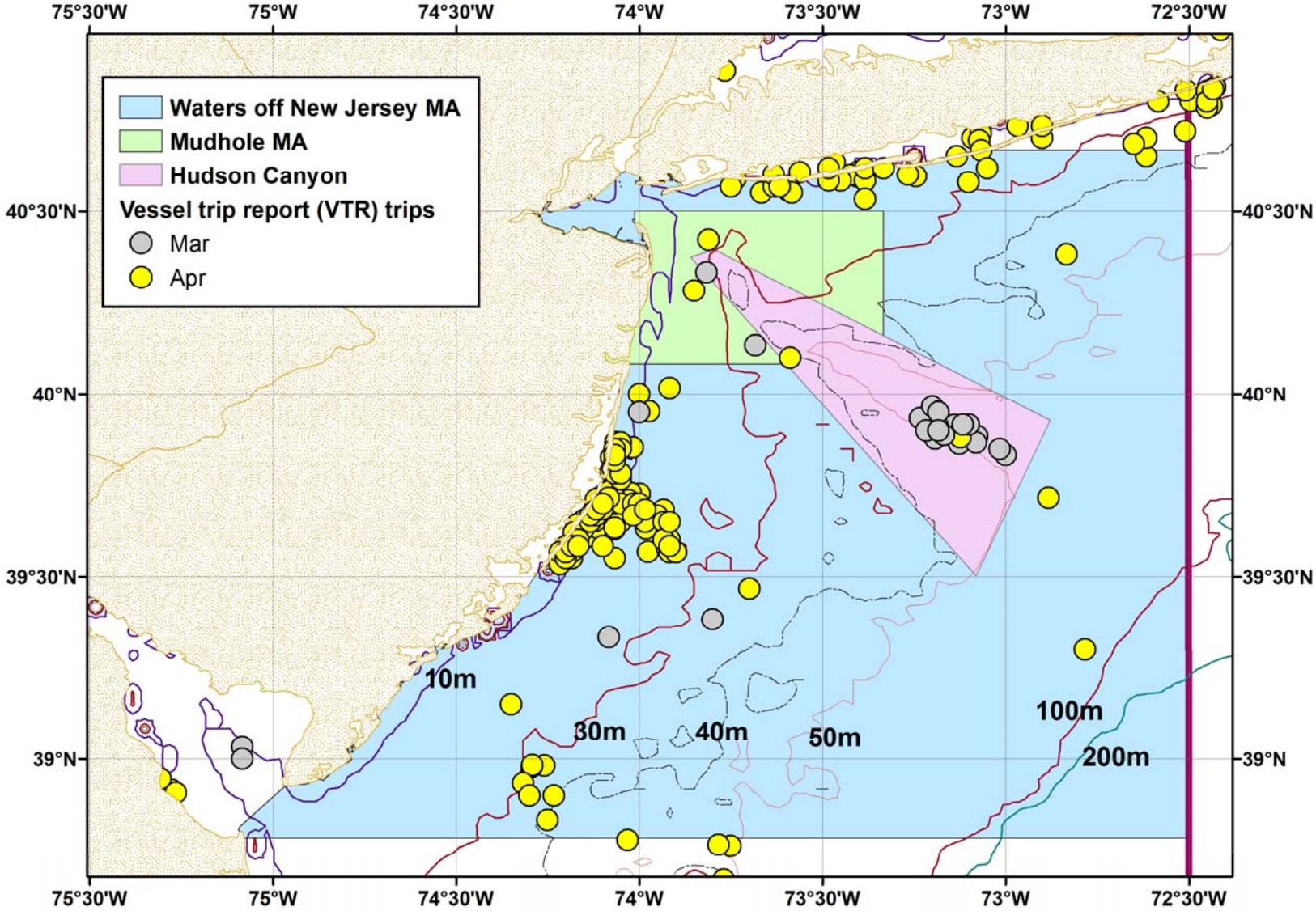


Figure 15. Using data collected from the gillnet fisheries in the New Jersey region from January – April in 1999–2007, a classification tree model was used to predict the number of anchors that were used: two versus four (ignoring the few hauls that used one, three or six anchors). To interpret a classification tree, each factor is in a different colored box. The top break means hauls that were in waters less than 59.4 fa had characteristics that are in the left branch, and hauls in deeper water (in the right branch) used two anchors. The predicted number of anchors (two or four) is the value at the end of each branch in yellow shaded boxes.

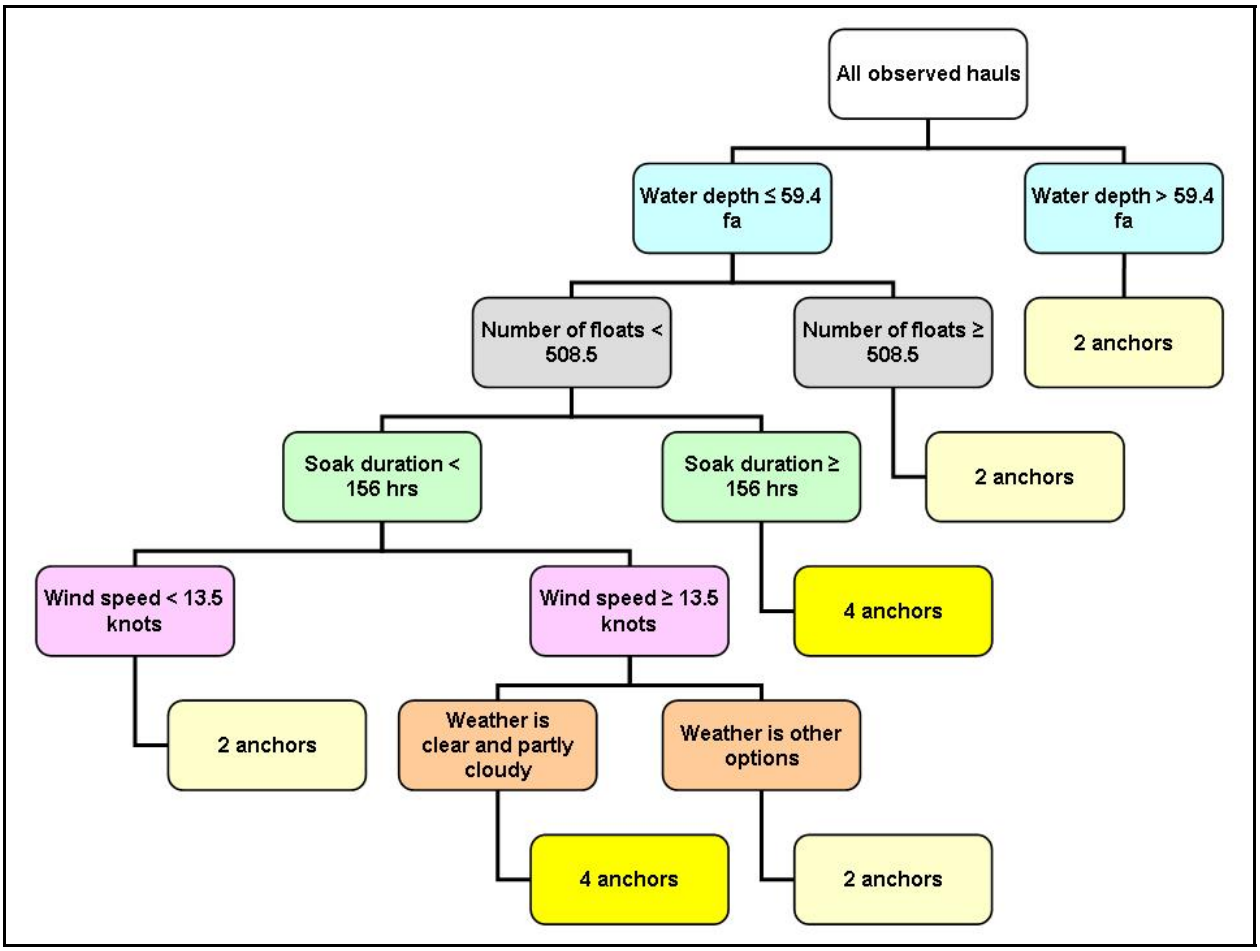
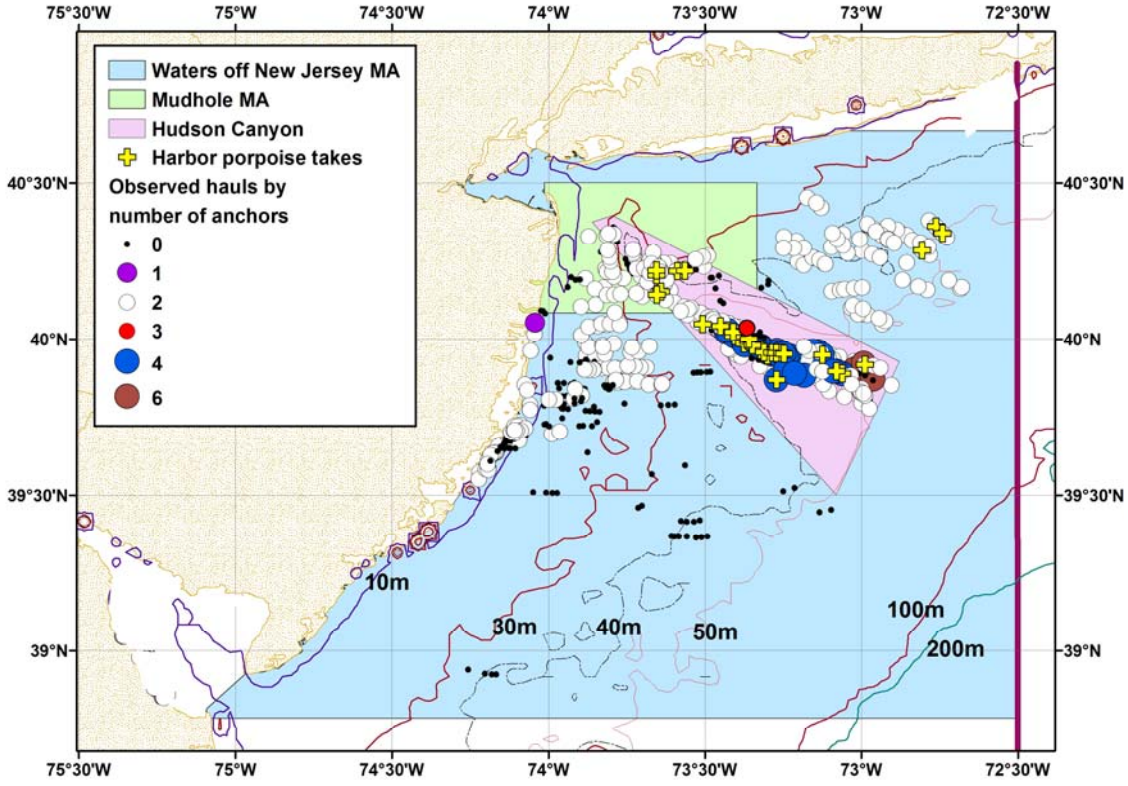
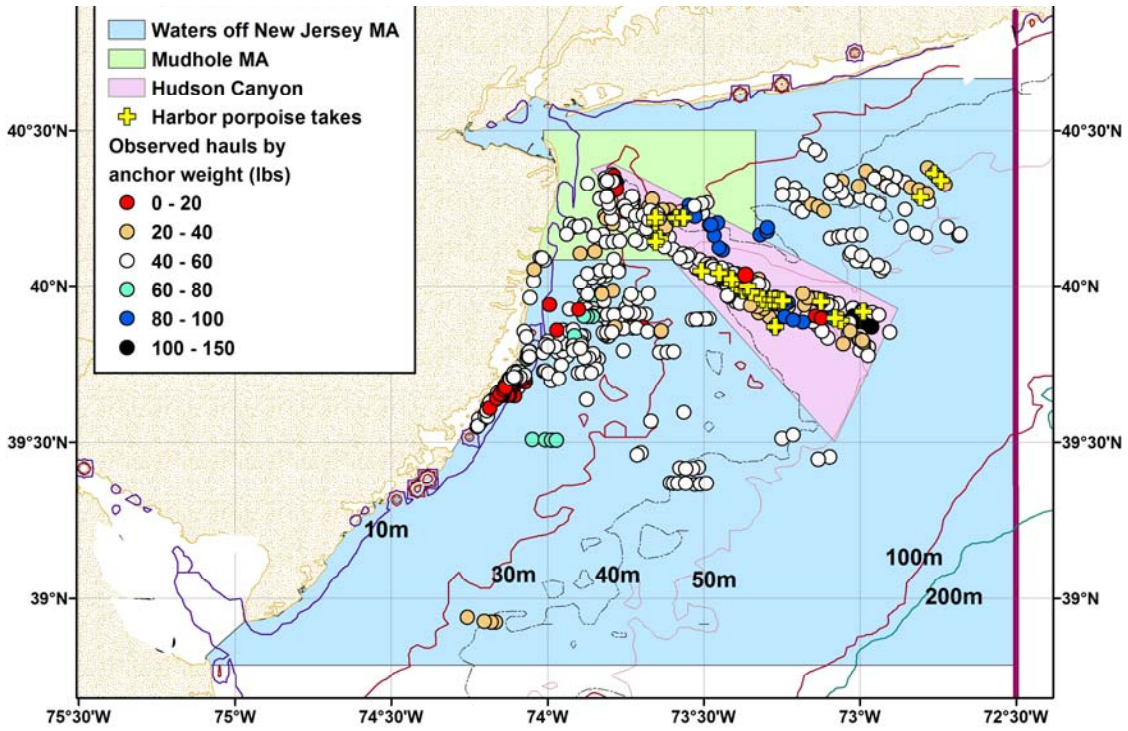


Figure 16. Locations of observed hauls with harbor porpoise (Phocoena phocoena) takes (yellow crosses) and observed hauls (colored circles) with various numbers of anchors (A) and weights of the anchors (B) in the New Jersey region, which includes the Mudhole management area (MA), Waters off New Jersey (excluding the Mudhole) MA, and Hudson Canyon. Data are from January – April, 1999 – 2007. Depth contours are 10, 30, 40, 50, 100, and 200 m.

(A)



(B)



4. CAPE COD REGION

4.1 Summary

The Cape Cod region (Figure 1) is the southern portion of the Northeast gillnet fishery, which includes the Cape Cod South HPTRP management area and is located south of Massachusetts and Rhode Island, north of the 39º 30'N latitude line and east of the 72° 30'W longitude line. Harbor porpoise bycatch rates in the Cape Cod region have been consistently high since 2000, and they were particularly high in 2005–2007.

Since the implementation of the HPTRP, the NEFOP observed 2,831 hauls in the Cape Cod region, in which 87 harbor porpoise takes were observed. Of these takes, 24 were inside the Cape Cod South MA, as defined in the HPTRP, and 63 were outside this management area. All observed harbor porpoise takes occurred from December – May and were in gillnets targeting either monkfish or winter skate (*Leucoraja ocellata*).

The bycatch rate of hauls outside the Cape Cod South MA (where pingers are not required) was about 50% higher than the bycatch rate within the Cape Cod South MA (where pingers are required): 0.102 versus 0.066 harbor porpoises per mton landed, respectively. Regardless of whether a haul was from inside or outside of the Cape Cod South MA, bycatch rates of hauls that used pingers (1,055 hauls) were about half that of hauls that did not use pingers (1,776 hauls): 0.053 versus 0.098 harbor porpoises per mtons landed, respectively.

Since January 1999, three observed hauls (from one trip) were inside the Cape Cod South MA during March, the month closed to all gillnetting. Of the 1,665 observed hauls in the Cape Cod South MA during the time period pingers were required, 45% used the required number of pingers, an additional 40% did not use any pingers, while the remaining 15% used some pingers but fewer than the required number of pingers.

A statistical model that best predicted the bycatch rates in this region included the following factors (in order of importance): steam time, day of the year, twine size, and temporary home state. This bycatch rate model identified several issues related to high bycatch. First, the bycatch rate for a twine size of 0.33 mm in strings targeting monkfish (mesh sizes ≥ 10 in) was extremely high; however, the normal practice was to use twine sizes ≥ 0.57mm. Second, the highest bycatch rates were February – April, with lower rates in the surrounding months of December, January, and May, all of which are the times that are managed under the HPTRP. Third, most of the observed takes were in a region where pingers were not required; that is, the region from the southern boundary of the Cape Cod South MA (40º 40'N latitude) to the 40ºN latitude line, and then east to the 70ºW longitude line.

4.2 Observer Coverage

In the Cape Cod region (Figure 1) from 1 January 1999 – 31 May 2007, the numbers of observed hauls per month/year ranged from 0–298 hauls per month, with an average of about 46 hauls per month, and the most observed hauls were in May (Figure 17). All observed harbor porpoises in this region were taken December – May, the same time period this area is managed by the HPTRP. Thus, further analyses focused on hauls observed in the Cape Cod region from January – May in 1999–2007 and December in 1999–2006.

In this region and time period, there were 2,831 hauls observed, which were from 659 trips and 312 vessel-years, which included 132 unique vessels. There were 123–499 hauls observed per

year, which were from 32–124 trips per year, and from 15–69 vessels per year (Table 12). The observed hauls in December and January were generally closer to shore than those observed in other months, February – May (Figure 18). The distributions of observed hauls from each year appear to span the same general fishing areas, though the observed hauls in more recent years (since 2004) appear to be located more offshore: south of the Cape Cod South MA towards the 200 m depth contour (Figure 19).

4.3 General Bycatch Patterns

Bycatch rates in this region increased over the years, where the bycatch rates from 2007 (January – May) were the highest (Table 12). Harbor porpoises were taken inside and outside of the Cape Cod South MA in many of the years since the implementation of the HPTRP (Figure 20). Of the 2,831 hauls observed in this region, 2,761 hauls did not have any harbor porpoise bycatch, 57 hauls had 1 take, 9 hauls had 2 takes, and 4 hauls had 3 harbor porpoise takes. Hauls that took more than one harbor porpoise appear to have been slightly more concentrated in or near the southern border of the Cape Cod South MA (Figure 21). Bycatch rates were highest in February – May and lowest in December (Table 13).

The bycatch rate of hauls outside the Cape Cod South MA (which were not required to use pingers) was about 50% greater than the bycatch rate of hauls within the Cape Cod South MA (which were required to use pingers): 0.102 versus 0.066 harbor porpoises per mtons landed, respectively (Table 14).

Regardless of whether a haul was inside or outside of the management area, the bycatch rate of hauls that used pingers (1,055 hauls) was about half that of hauls that did not use pingers (1,776 hauls): 0.053 versus 0.098 harbor porpoises per mtons landed, respectively (Table 14).

Bycatch rates (sum of observed takes per sum of observed mtons landed) for categorizations of many factors are listed in Table 14. Categories with high bycatch rates included: hauls without pingers, hauls outside of the Cape Cod South MA, the years of 2006 (January – May plus December) and 2007 (January – May), the months of February and April, hauls that targeted monkfish and winter skate, waters that were 50–100 fa deep, surface water temperatures of 4–6ºC and bottom water temperatures of 4–8ºC, long soak durations (>200 hrs), long strings (>4,000 ft), hang ratio of 0.5, mesh sizes of 10–12 in, gillnet heights of 10–15 ft, leadline depths of 25–50 fa (net may not be touching the bottom), hauls that used additional weights, small or large NAO index values, steam times of 5–10 hrs from the ship's temporary home port, and hauls where the observer did not conduct biological fish sampling but did concentrate watching the gillnet while it was being hauled in to make a special effort to document all incidental takes, particularly those that might fall from the net before it reaches the ship's deck.

4.4 Compliance

Since the implementation of the HPTRP, there were 2,831 hauls observed in the Cape Cod region, of which 1,665 hauls were inside the Cape Cod South MA. Only three observed hauls (from one trip) were inside the management area during March, the month closed to all gillnetting. The log from this trip stated that the nets were set on 1 March 2007 and hauled back on 4 March 2007. Locations of these hauls were close to the southern border of the Cape Cod South MA. These three strings were each 20 panels long, had 20 pingers/string (1 short of the required number), and had no harbor porpoise bycatch.

In the Cape Cod South MA, during January, February, April, May, and December (months pingers are required), about 40% (657 hauls) of the observed hauls did not use any pingers. These 657 observed hauls were from 185 trips and 53 different vessels, which were from Massachusetts, New York, and Rhode Island. These 657 hauls took 13 harbor porpoises in 12 hauls, 8 trips, and 7 vessels. The 12 hauls with takes occurred in 2003 (1 haul), 2004 (4 hauls), 2006 (4 hauls), and 2007 (3 hauls), and were in January (2 hauls), April (1 haul), May (8 hauls), and December (1 haul).

In contrast, there were 47 observed hauls (13 trips and 8 vessels) that were outside of the Cape Cod South MA and used pingers, even though pingers were not required. These hauls had no harbor porpoise takes and were observed in various years: 1 haul in 2001, 3 in 2002, 27 in 2003, 7 in 2005, and 9 in 2007.

Assuming compliance with the pinger requirements means 90% or more of the required number of pingers were on the net when it was hauled in (thus, allowing for the possibility that the commonly used 10-net string is missing one pinger, which could have fallen off accidently during the time the net was in the water), then of the 1,665 observed hauls in the Cape Cod South MA during the time period pingers were required, 47% used 90% or more of the required pingers, an additional 40% did not use any pingers, while the remaining 13% used some pingers but less than 90% of the required number. If it is assumed that compliance with the pinger requirement means 100% of the required number of pingers were on the net when it was hauled back, then of the 1,665 observed hauls in the Cape Cod South MA during the time period pingers were required, 45% used the required number of pingers, an additional 40% did not use any pingers, while the remaining 15% used some pingers but less than the required number of pingers.

The levels of compliance to the pinger usage management regulations and effectiveness of the pingers were discussed in detail in Palka et al. (2008).

4.5 Correlated Factors

The model that best predicted bycatch rates from this area included the following factors (in order of importance): steam time, day of the year, twine size, and temporary home state (Table 15). Figure 22 indicates the values of each factor (x–axis) that had higher than average bycatch rates, where a value on the y–axis value that is greater than zero (above the dashed horizontal line) has a higher than average bycatch rate. A description and discussion about the factors follows.

Steam time was the factor most highly correlated with bycatch rates. This factor appears to indicate the area with high bycatch rates. The range of steam times that had the highest bycatch rate was 4.6–9.4 hrs (Figure 22). Mapping the location of observed hauls by steam time indicates that the area with the highest bycatch rate (area with steam times of 4.6–9.4 hrs) was the area south of the Cape Cod South MA: from the southern boundary of the management area south to about the 40ºN latitude line (Figure 23).

The second most highly correlated factor was day of the year. The bycatch was highest February – April (Figure 22), as was mentioned above (Table 13).

The next factor added to the model was twine size. Twine sizes less than 0.5 mm had the highest bycatch rate, and large twine sizes (≥0.74 mm) had the second highest bycatch rate (Figure 22 and Table 14). There were nine observed hauls that used 0.33 mm twine size, of which five had

a total of 11 incidentally taken harbor porpoises. These five hauls were from a single trip that targeted monkfish using long strings (6,000 ft) that soaked for a long time (72 or 144 hrs/string). Using small twine sizes when targeting monkfish does not appear to have been typical; about 1.5% of the observed hauls that targeted monkfish used twine sizes less than 0.57 mm. Three of the five hauls with takes were inside the Cape Cod South MA and used 20 gillnet panels and 19 pingers (two pingers short of the HPTRP requirements). The other two hauls with takes were outside of the Cape Cod South MA and did not use pingers. In conclusion, the model appears to have used the twine size factor to identify two issues. First, five hauls with bycatch used strings which do not appear to have been typical fishing gear to target monkfish. Second, high bycatch rates were identified in gillnets that used large twine sizes, which were the commonly used twine sizes in this region. It is also noted that there were several other characteristics related to hauls with high bycatch, such as long string lengths and long soak durations.

The last factor added to the model was temporary home state (Table 15; Figure 22). By mapping the location of the hauls by their temporary home state (Figure 24), it appears that this factor has refined the definition of areas with high bycatch. For example, within the area of steam times of 4.6 – 9.4 hrs (Figure 23), the highest bycatch rates were from vessels from New York (Figure 22), which were west of the 71º30'W longitude line (Figure 25 in pink circle), and the bycatch rates of vessels from Massachusetts were slightly lower (though still over the average bycatch rate), and they were located east of the 71ºW longitude line (Figure 25 in black circle).

In conclusion, this bycatch rate model identified several issues related to high bycatch in the Cape Cod region. First, the bycatch rate for twine sizes of 0.33 mm in strings targeting monkfish (mesh sizes ≥ 10 in) was extremely high; however, the normal practice was to use twine sizes ≥ 0.57 mm. Second, highest bycatch rates were in February – April, with less in the surrounding months of December, January, and May, thus, encompassing the present managed times in the HPTRP. Finally, most of the observed takes were in a region where pingers were not required; that is, the area from the southern boundary of the Cape Cod South MA to the 40ºN latitude line and to the 70ºW longitude line.

Table 12. Descriptive statistics about bycatch of harbor porpoises (Phocoena phocoena) in the Cape Cod region, during January – May, 1999–2007 and during December 1999–2006.

	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007*	Total
Number of observed hauls	292	346	123	157	145	499	369	450	450	2831
Number of observed trips	56	70	32	46	32	99	78	122	124	659
Number of observed vessels	17	15	16	15	22	53	39	69	66	312
Number of observed hauls with one or more take	1	5	0	2	3	12	11	13	23	70
Total number of observed takes	1	5	0	3	3	13	12	18	32	87
Bycatch rate (observed takes/observed number of hauls)	0.003	0.015	0	0.019	0.021	0.026	0.033	0.040	0.071	0.031
Bycatch rate (observed takes/observed mtons landed)	0.028	0.092	0	0.081	0.046	0.058	0.095	0.119	0.124	0.089

* 2007 data were from 1 January – 31 May; other years included data from January – May and December.

Table 13. By month, numbers of observed hauls and takes of harbor porpoises (Phocoena phocoena) with the resulting bycatch rates. Data were from the Cape Cod region, January – May 1999–2007, and December 1999–2006.

	Month					
	Jan	Feb	Mar	Apr	May	Dec*
Number of observed hauls	257	290	158	573	1191	362
Number of observed takes	3	17	7	34	25	1
Bycatch rate (observed takes/observed hauls)	0.012	0.059	0.044	0.059	0.021	0.003
Bycatch rate (observed takes/observed mtons landed)	0.044	0.160	0.065	0.145	0.068	0.011

* 2007 data were from 1 January – 31 May; other years included data from January – May and December.

Table 14. For the Cape Cod region, observed bycatch rates (Byc Rate) of harbor porpoises (Phocoena phocoena) and numbers of observed hauls (Num Obs) for various gear characteristics, fishing practices, and environmental factors. The bycatch rate was defined as observed number of takes per the observed mtons landed. The overall average bycatch rate was 0.089 harbor porpoises per mtons landed.

Categories of factors with * in the Num Obs column had less than 11 mtons landed (thus given the overall bycatch rate for this region, there was a small chance of observing a take).

High bycatch rates (≥ 0.1 harbor porpoises per mtons landed) are highlighted.

Data were collected from January – May, 1999 – 2007, and December 1999 – 2006.

Categories	*Num Obs*	*Byc Rate*
MONTH		
Jan	257	0.044
Feb	290	0.160
Mar	158	0.065
Apr	573	0.145
May	1,191	0.068
Dec	362	0.010
YEAR		
1999	292	0.028
2000	346	0.092
2001	123	0
2002	157	0.081
2003	145	0.046
2004	499	0.058
2005	369	0.095
2006	450	0.119
2007	450	0.123
FISH SAMPLING?		
yes	1,014	0.050
no	1,815	0.118
WIND SPEED (kts)		
0-10	1,411	0.104
10-20	933	0.092
20-40	174	0
STEAM TIME (hrs)		
0-5	1,727	0.032
5-10	624	0.200
10-15	415	0.015
15-40	57	0.096

Categories	*Num Obs*	*Byc Rate*
TARGET SPECIES		
Leptoscopus americanus	2,107	0.097
Pomatomus saltatrix	8*	0
Gadus morhua	170	0
Pleuronectes americanus	55*	0
Paralichthys dentatus	275	0
Pleuronectiformes	5*	0
Pollachius virens	17*	0
Stenotomus chrysops	18*	0
Centropristis striata	2*	0
Cynoscion regalis	5*	0
Squalus acanthias	23*	0
Rajidae	16	0
Leucoraja ocellata	91	0.087
Morone saxatilis	1*	0
Tautoga onitis	21*	0
Groundfish	15*	0
Osteichthyes	2*	0
SURFACE TEMPERATURE (ºC)		
2-4	8*	0
4-6	477	0.126
6-8	511	0.090
8-10	641	0.087
10-12	524	0.031
12-14	194	0
14-16	25*	0
BOTTOM TEMPERATURE (ºC)		
2-4	170	0.068
4-6	547	0.182
6-8	754	0.102
8-10	389	0.035
10-12	483	0.034
12-14	20	0

Categories	*Num Obs*	*Byc Rate*
LENGTH OF STRING (ft)		
0-2000	517	0.047
2000-4000	1,224	0.060
4000-6000	805	0.122
6000-8000	206	0.071
8000-14000	60	0.081
HANGING RATIO		
<0.33	59	0
0.33	421	0.093
0.5	2,247	0.093
>0.5	6*	0
TWINE SIZE (mm)		
0.28	17	0
0.33	9*	2.474
0.40	1*	0
0.45	5*	0
0.47	15*	0
0.52	43*	0
0.57	173	0.018
0.62	330	0
0.66	154	0.044
0.70	149	0
0.74	22*	0.106
0.81	186	0.047
0.9	1,440	0.083
1.05	12	0
unknown	270	0.149
MESH SIZE (in)		
4-6	53*	0
6-8	551	0
8-10	34	0
10-12	2,118	0.097
12-14	71	0

Table 14 (cont). For the Cape Cod region, observed bycatch rates (Byc Rate) of harbor porpoises (Phocoena phocoena) and numbers of observed hauls (Num Obs) for various gear characteristics, fishing practices, and environmental factors. The bycatch rate was defined as observed number of takes per the observed mtons landed. The overall average bycatch rate was 0.089 harbor porpoises per mtons landed.

Categories of factors with * in the Num Obs column had less than 11 mtons landed (thus given the overall bycatch rate for this region, there was a small chance of observing a take).

High bycatch rates (≥ 0.1 harbor porpoises per mtons landed) are highlighted.

Data were collected from January – May, 1999 – 2007, and December 1999 – 2006.

Categories	*Num Obs*	*Byc Rate*
LENGTH OF TIE DOWN (ft)		
0-2	254	0.047
2-4	2,071	0.093
4-6	129	0.096
6-10	21*	0
NUMBER OF ANCHORS		
1	8*	0
2	2,082	0.083
4	30	0
VESSEL GROSS TONNAGE		
0-20	458	0.082
20-40	343	0.157
40-60	63	0
60-80	34	0
80-140	30	0.428
AMOUNT OF DISCARDS (lbs)		
0-500	884	0.048
500-1,000	55	0.082
1,000-5,000	27	0.054
SEDIMENT TYPE		
clay-silt/sand	545	0.089
gravel-sand	194	0
sand	1,441	0.057
sand-clay/silt	191	0.119
sand/silt/clay	10*	0.200

Categories	*Num Obs*	*Byc Rate*
NET HEIGHT (ft)		
0-5	97	0
5-10	759	0.068
10-15	1,353	0.108
15-25	37*	0
NUMBER OF SPACES		
0-5	348	0.108
5-10	657	0.106
10-15	458	0.075
15-20	161	0.104
20-25	38	0.032
25-40	23	0.209
ANCHOR WEIGHT (lbs)		
0-50	1,441	0.087
50-100	870	0.105
100-150	314	0.036
150-200	147	0.152
200-350	33	0
AMOUNT LANDED (mtons)		
0-1	2,625	0.106
1-2	138	0.058
2-3	27	0.046
3-4	5	0.114
4-7	7	0

Categories	*Num Obs*	*Byc Rate*
USED ANCHORS?		
no	14*	0
yes	2,817	0.089
USED ADDED WEIGHTS?		
no	2,077	0.086
yes	116	0.300
unknown	637	0.067
ANCHOR WEIGHT TYPE		
unknown	25*	0
Danforth-type	507	0.066
Dead Weight	2,298	0.095
DEPTH OF LEAD LINE (fa)		
0-25	985	0.028
25-50	557	0.167
50-75	392	0.073
75-100	109	0.018
100-200	83	0
CHLOROPHYLL α CONCENTRATION (mg/m^3)		
0 - 1	477	0.094
1 - 2	688	0.050
2 - 3	328	0.100
3 - 12	132	0.075
USED PINGERS?		
yes	1,055	0.053
no	1,776	0.098

Table 14 (cont). For the Cape Cod region, observed bycatch rates (Byc Rate) of harbor porpoises (Phocoena phocoena) and numbers of observed hauls (Num Obs) for various gear characteristics, fishing practices, and environmental factors. The bycatch rate was defined as observed number of takes per the observed mtons landed. The overall average bycatch rate was 0.089 harbor porpoises per mtons landed.

Categories of factors with * in the Num Obs column had less than 11 mtons landed (thus given the overall bycatch rate for this region, there was a small chance of observing a take).

High bycatch rates (≥ 0.1 harbor porpoises per mtons landed) are highlighted.

Data were collected from January – May, 1999 – 2007, and December 1999 – 2006.

Categories	*Num Obs*	*Byc Rate*
WINTER NORTH ATLANTIC OSCILLATION INDEX		
-0.4 - 0	671	0.088
0 - 0.2	110	0.072
0.2 - 0.4	972	0.073
0.4 - 0.6	248	0.033
0.6 - 1.2	380	0.085
WAVE HEIGHT (ft)		
0-2	1,127	0.120
2-4	1,022	0.086
4-6	316	0.047
6-8	95	0.072
8-10	46	0
SOAK DURATION (hrs)		
0-100	1,971	0.074
100-200	723	0.095
200-300	112	0.154
300-500	18*	0.214

Categories	*Num Obs*	*Byc Rate*
NORTH ATLANTIC OSCILLATION INDEX		
-2.0 - -1.5	19*	0.227
-1.5 - -1	431	0.091
-1 - -0.5	204	0
-0.5 - 0	518	0.081
0.0 - 0.5	361	0.054
0.5 - 1.0	200	0.022
1.0 - 1.5	385	0.123
1.5 - 2.0	263	0
1.5 - 2.0	263	0
BOTTOM SLOPE (º angle)		
0-1	2,263	0.082
1-2	77	0.023
2-4	25	0.049
4-8	16*	0
USED TIE DOWNS?		
no	320	0
yes	2,499	0.094
unknown	12*	0

Categories	*Num Obs*	*Byc Rate*
LOG10(CHLOROPHYLL α)		
-0.6 - -0.2	171	0.069
-0.2 - 0	306	0.113
0.0 - 0.2	430	0.062
0.2 - 0.4	459	0.068
0.4 - 0.6	216	0.056
0.6 - 1.2	43*	0
IN A MANAGEMENT AREA?		
yes	1,665	0.066
no	1,166	0.102
BOTTOM DEPTH (fm)		
0-50	1,794	0.080
50-100	544	0.141
100-150	336	0.044
150-200	91	0.016
200-350	54	0
USED SPACES?		
no	1,121	0.080
yes	1,699	0.099
unknown	11*	0

Table 15. Models of the bycatch rates of harbor porpoises (Phocoena phocoena) in the Cape Cod region. The last column is the difference in the Akaike Information Criterion (AIC) from the row above. The larger the difference, the more that factor contributed to explaining the bycatch rate patterns. The lower the AIC, the better the model fits.

Model number	Factors	AIC	Difference from above
1	None	631	0
2	Steam time	579	52
3	Above + day of the year	543	36
4	Above + twine size	519	24
5	Above + temporary home state	500	19

Figure 17. Numbers of observed hauls per month and year in the Cape Cod region.

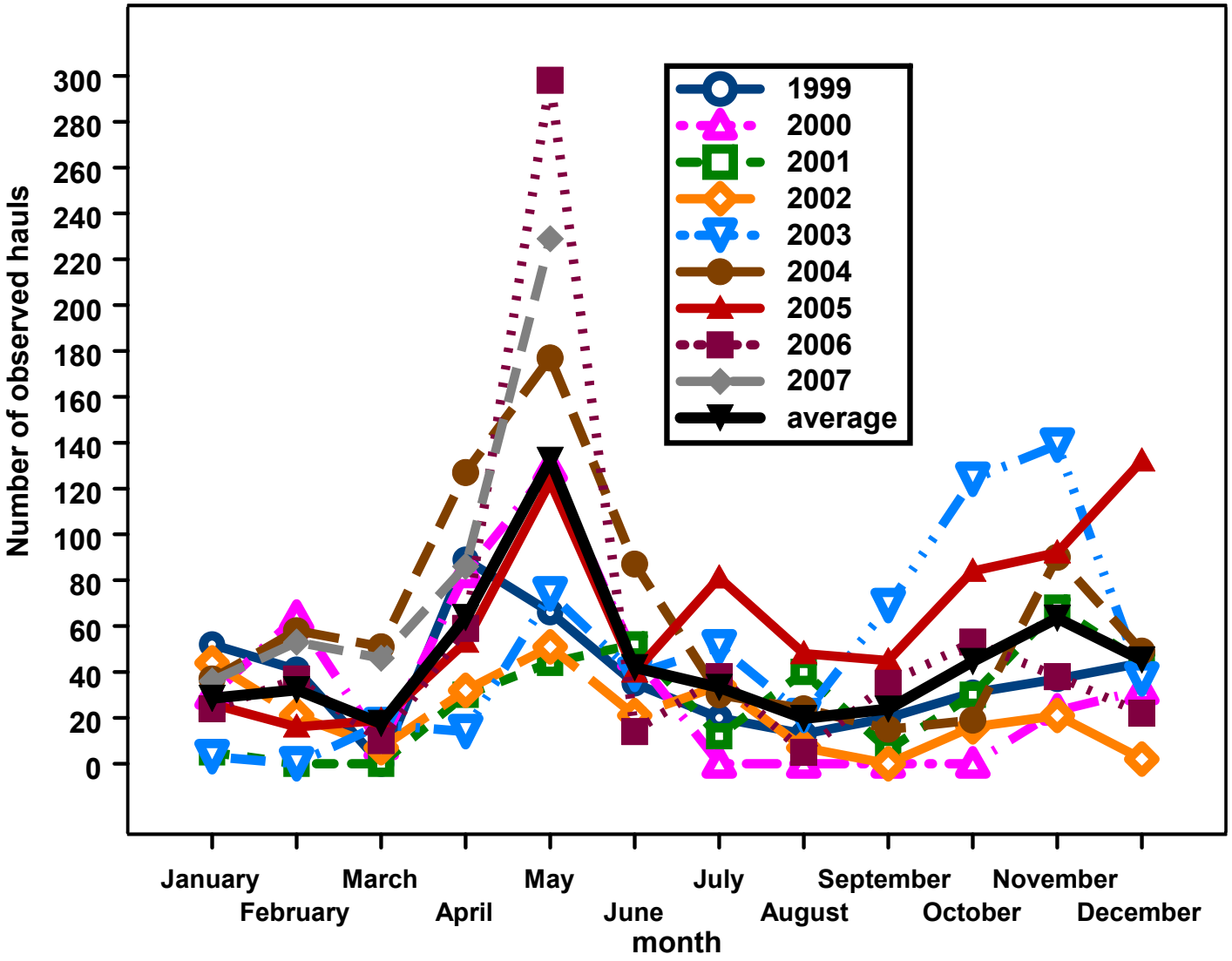


Figure 18. Locations of observed hauls by month (colored circles) and of observed hauls with harbor porpoise (Phocoena phocoena) takes (white diamonds) in the Cape Cod region, which includes the Cape Cod South management area (MA) (shaded blue). Data are from January – May in 1999–2007 and December 1999–2006. Depth contours are 50, 100, 200, and 1000 m.

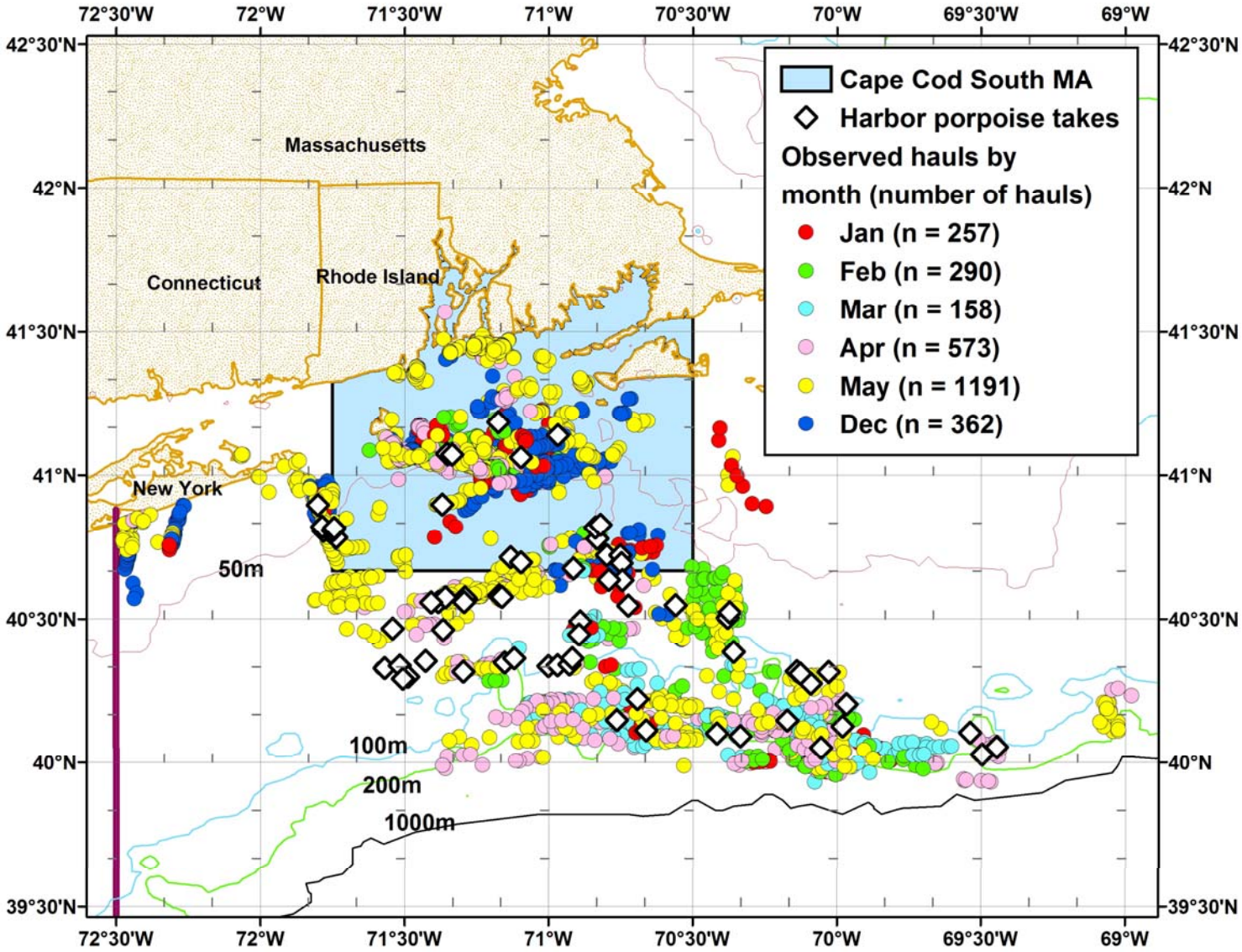


Figure 19. Locations of observed hauls by year (colored circles) and of observed hauls with harbor porpoise (Phocoena phocoena) takes (white diamonds) in the Cape Cod region, which includes the Cape Cod South management area (MA) (shaded blue). Data from January – May 1999–2007 and December 1999–2006. Depth contours are 50, 100, 200, and 1000 m.

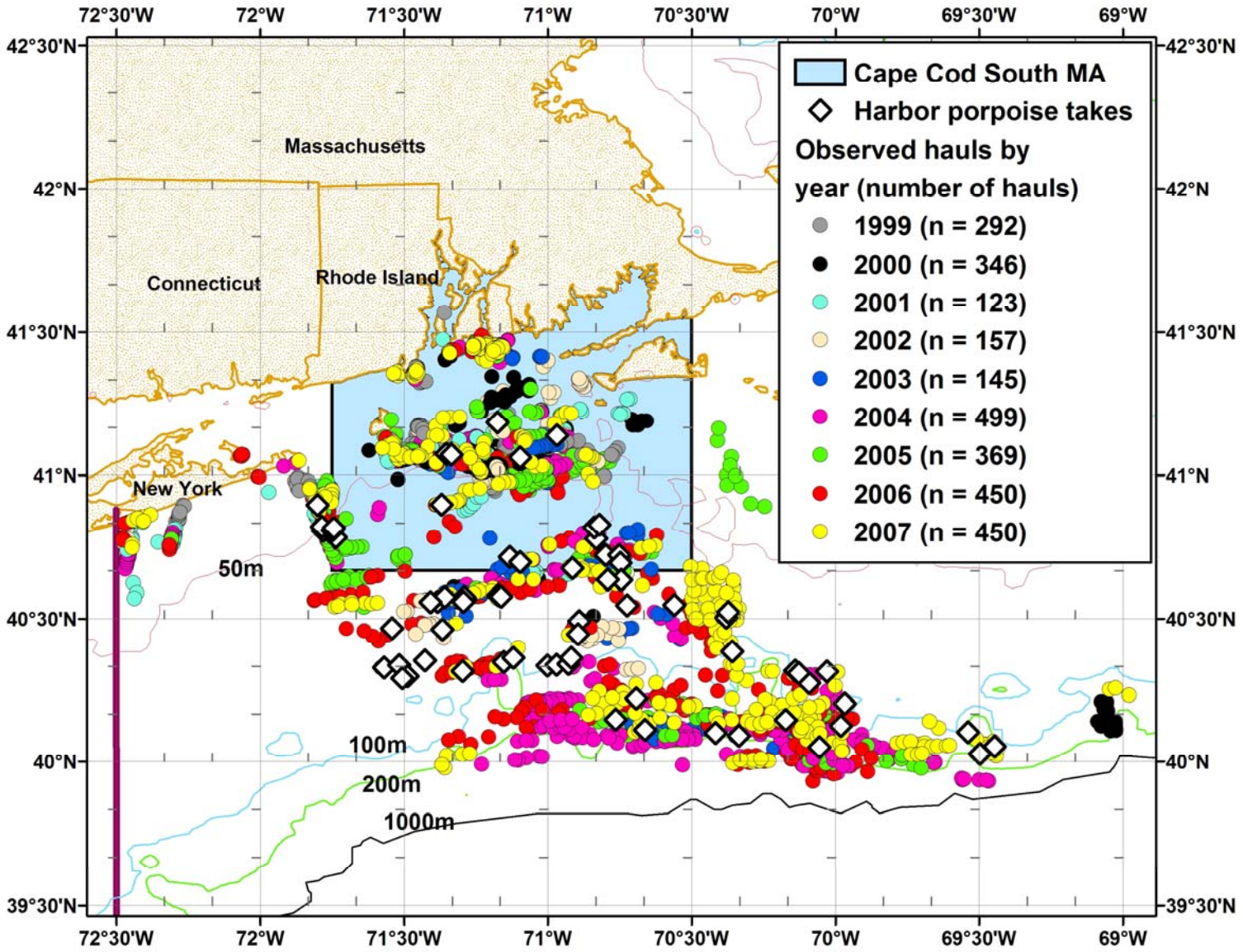


Figure 20. Locations of observed hauls without harbor porpoise (Phocoena phocoena) takes (small black dots) and observed hauls with takes indentified to year (colored circles) for hauls within the Cape Cod region, which includes the Cape Cod South management area (MA) (shaded blue). Data are from January – May 1999–2007 and December 1999–2006. Depth contours are 50, 100, 200, and 1000 m.

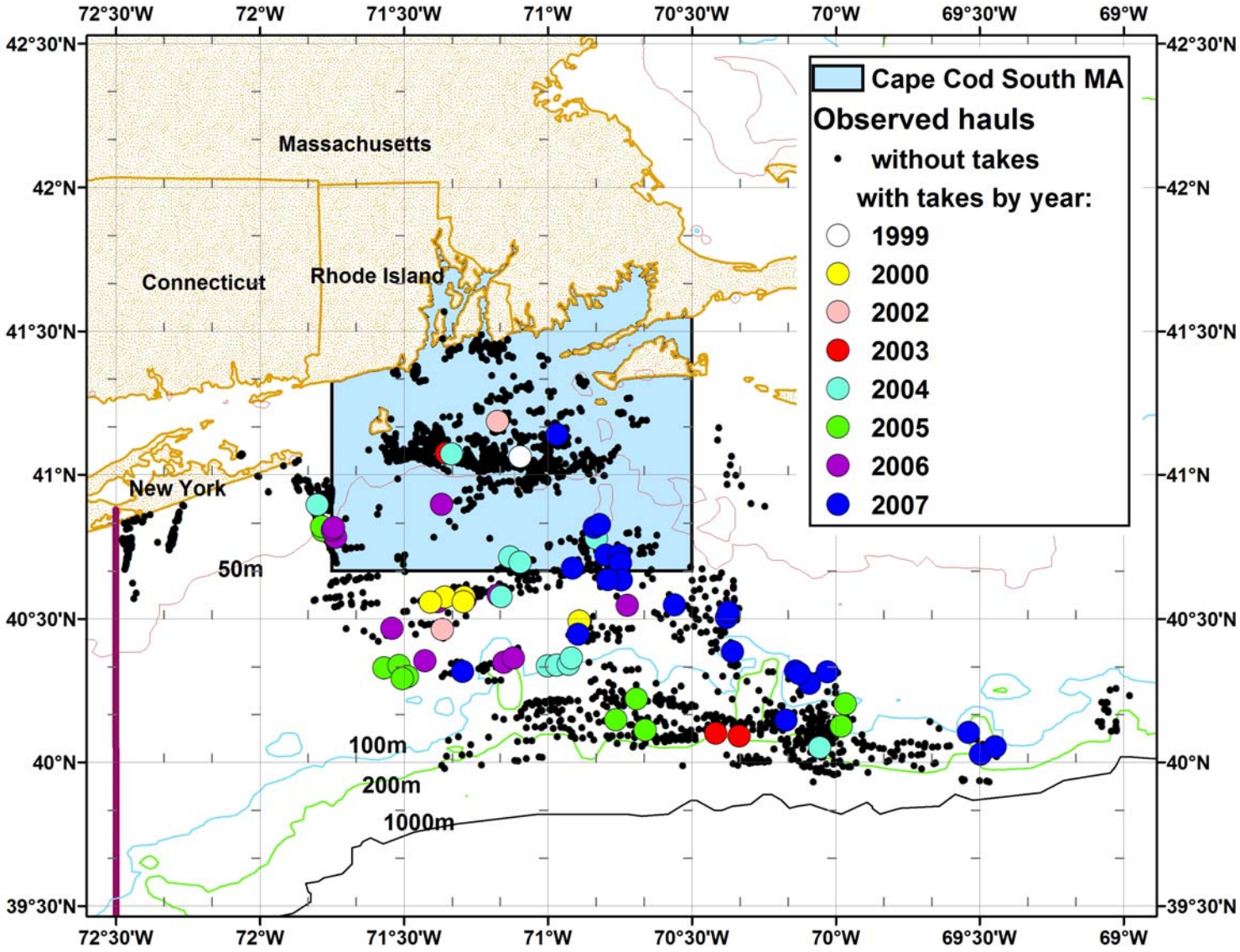


Figure 21. Locations of observed hauls without harbor porpoise (Phocoena phocoena) takes (black dashes) and observed hauls with takes, where the numbers of takes per haul is identified. Size of stack indicates number of takes: dash represents no takes; tallest stack represents three animals per haul. Data are from Cape Cod region, which includes the Cape Cod South management area (MA) (shaded blue), and are from January – May 1999–2007 and December 1999–2006. Depth contours are 50, 100, 200, and 1000 m.

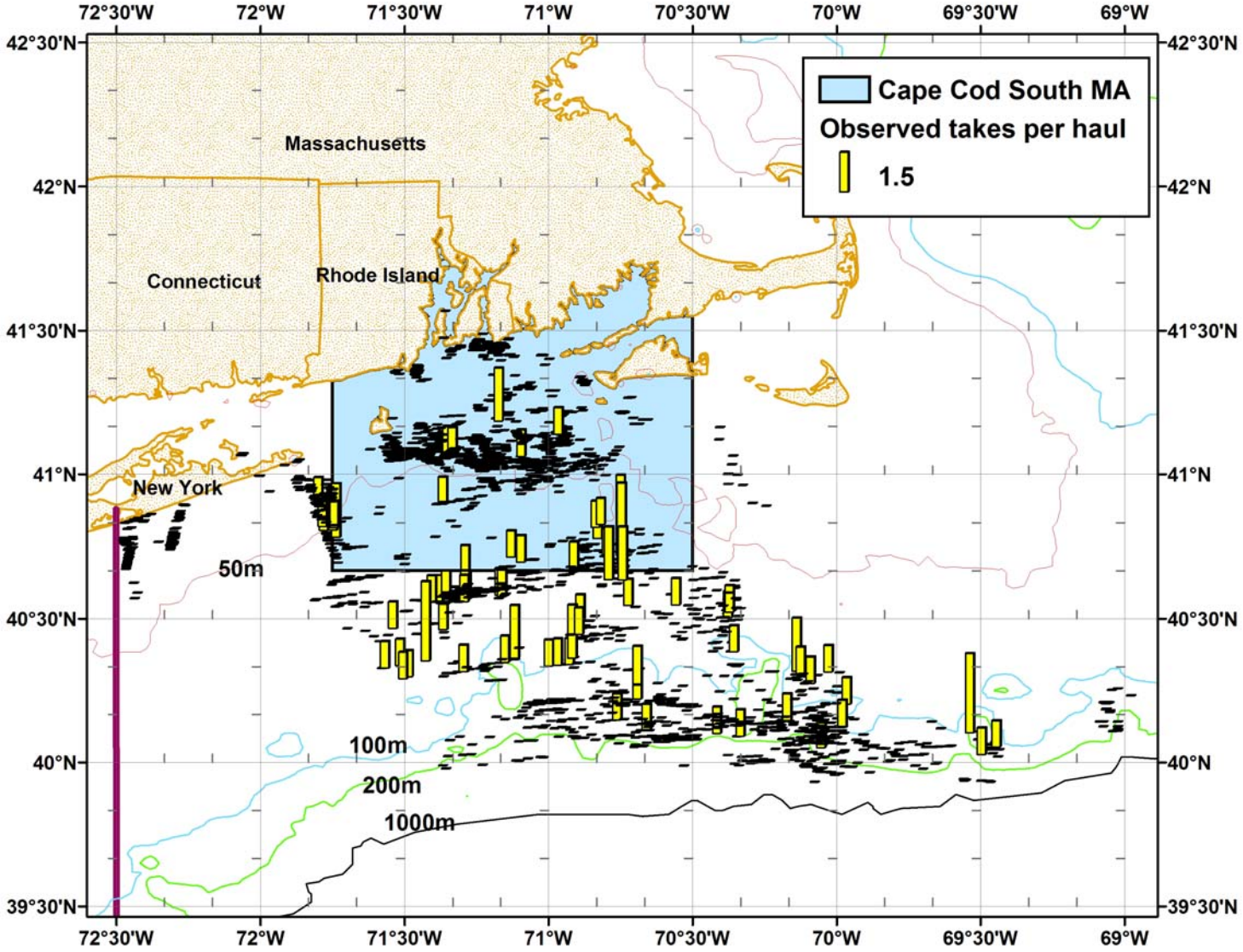


Figure 22. Results of model describing the bycatch rates of harbor porpoises (Phocoena phocoena) in the Cape Cod region. There is one plot per factor that was included in the model. Tick marks on the x–axis indicate the values of the observations, and the tick marks are jittered (spread out) to help display where there are values that are shared by many observations. The solid, bold black line represents the overall pattern of these many observations and indicates the best estimate of the bycatch rate at the value of the x-axis variable. The dashed horizontal line indicates the average relative bycatch rate (y = 0), and values along the y axis indicate the difference relative to this average. Values above this line have higher than average bycatch rates, and those below have a lower than average bycatch rate.

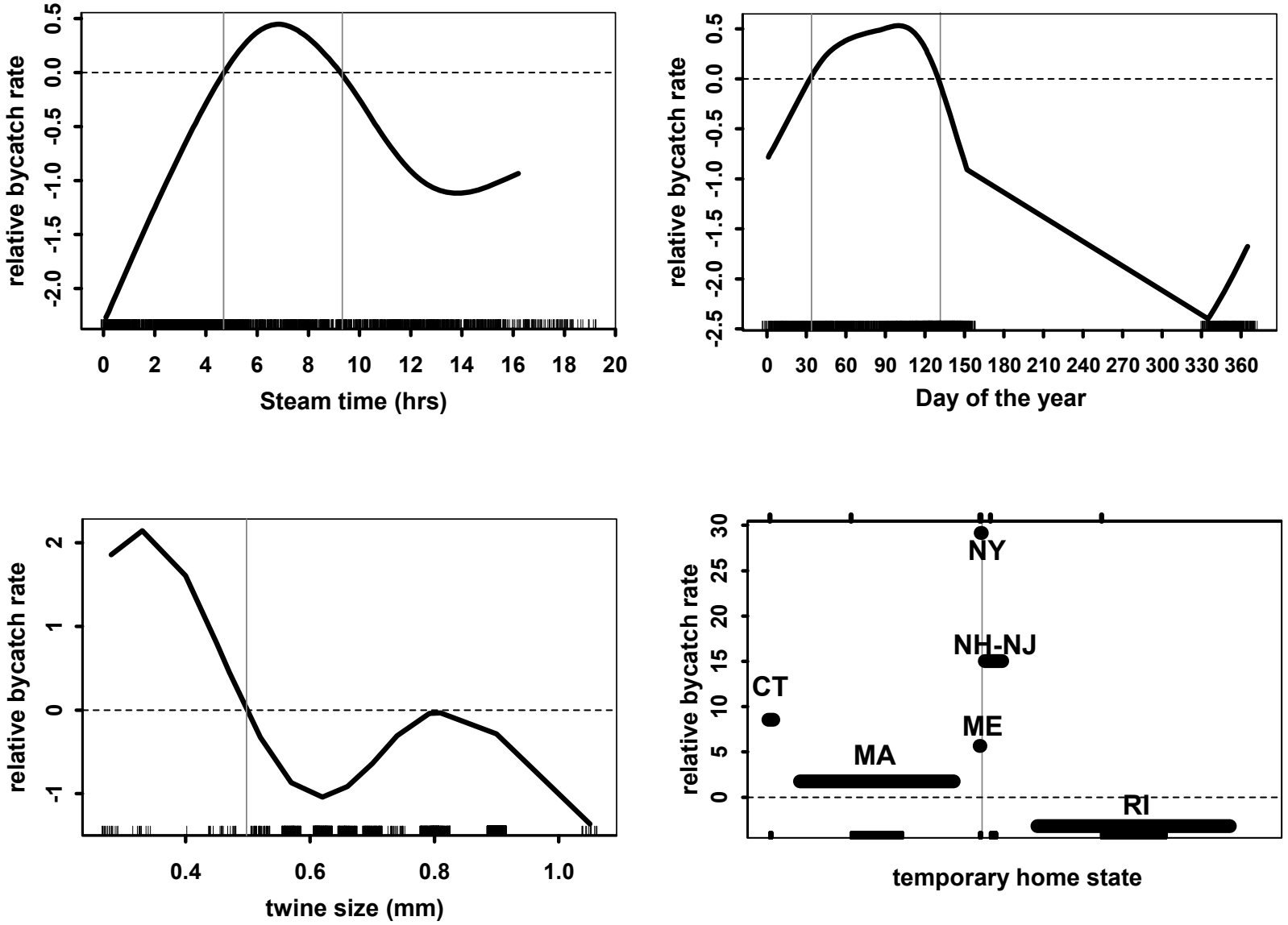


Figure 23. Locations of observed hauls by their fishing vessels' steam time in hrs from their port (colored symbols) and of observed hauls with harbor porpoise (Phocoena phocoena) takes (white diamonds) in the Cape Cod region, which includes the Cape Cod South management area (MA) (shaded blue). Steam times of 4.6–9.4 hrs (green boxes) were identified in the bycatch rate model as those with the highest bycatch rates. Data are from January – May 1999–2007 and December 1999–2006. Depth contours are 50, 100, 200, and 1000 m.

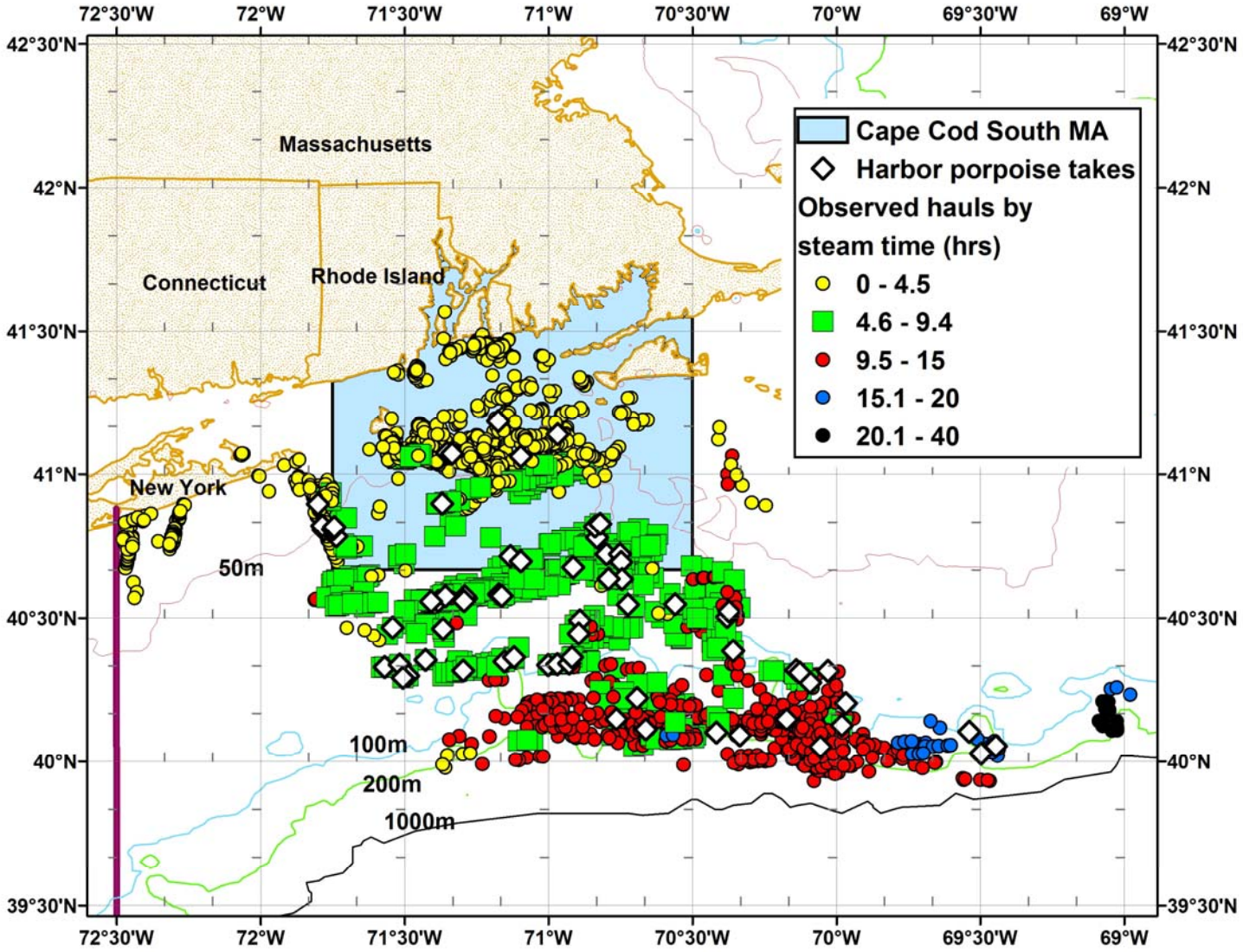


Figure 24. Locations of observed hauls by the vessels' temporary home state for the trip (colored circles) and of observed hauls with harbor porpoise (Phocoena phocoena) takes (white diamonds) in the Cape Cod region, which includes the Cape Cod South management area (MA) (shaded blue). Data are from January – May 1999–2007 and December 1999 – 2006. Depth contours are 50, 100, 200, and 1000 m.

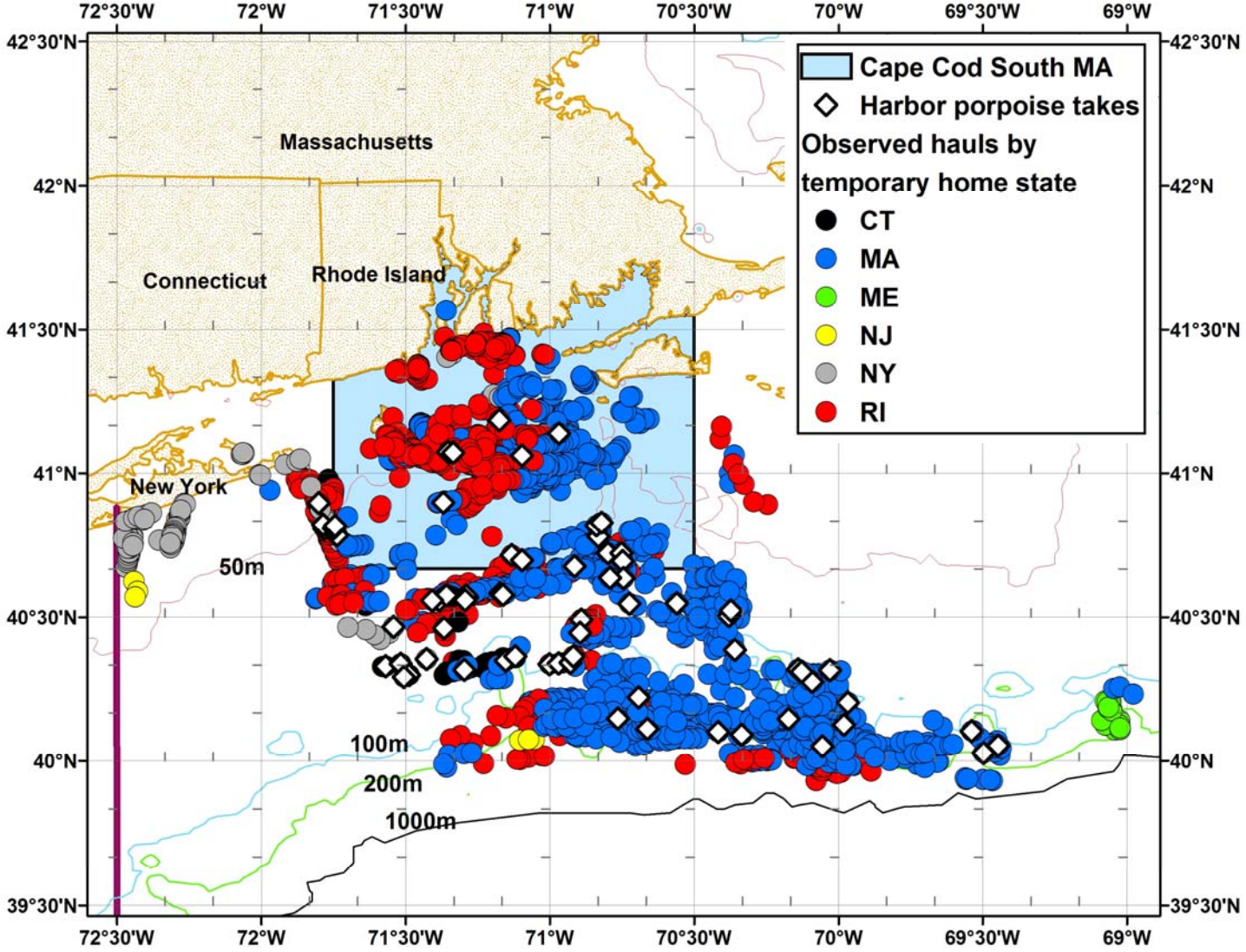
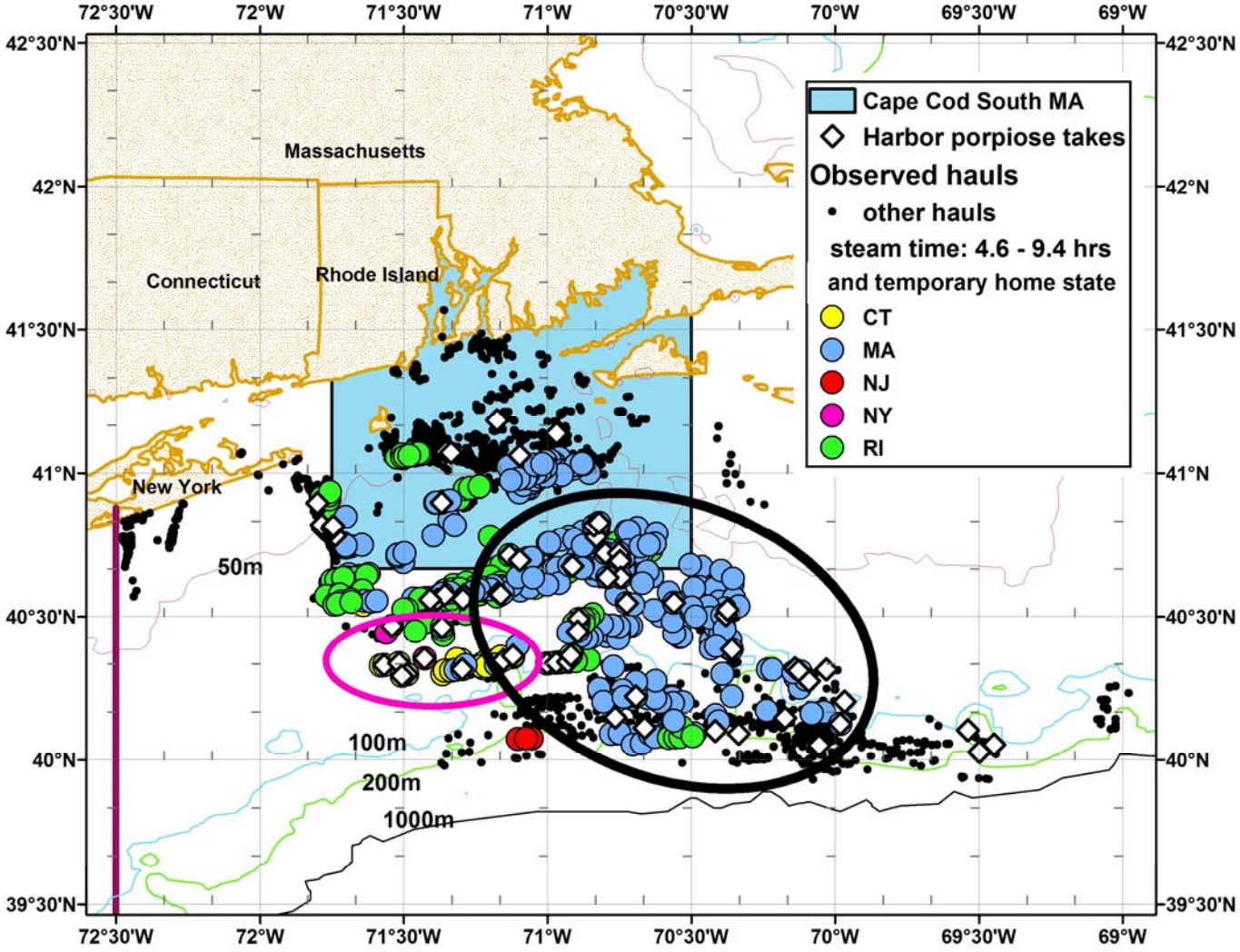


Figure 25. Locations of observed hauls by their fishing vessels' steam time, in hrs, from their port and temporary home state (colored circles) and of observed hauls with harbor porpoise (Phocoena phocoena) takes (white diamonds) in the Cape Cod region, which includes the Cape Cod South management area (MA) (shaded blue). Steam times of 4.6–9.4 hrs (area with highest bycatch rate) are divided by the vessels' temporary home state (defining finer resolution of areas with highest bycatch rates). The area in small pink circle had the highest bycatch rate, and the area in the larger black circle had the next highest bycatch rate. Data are from January – May, 1999–2007, and December 1999–2006. Depth contours are 50, 100, 200, and 1000 m.



5. GULF OF MAINE REGION

5.1 Summary

The Gulf of Maine region (Figure 1) is the northern portion of the Northeast gillnet fishery and includes five HPTRP management areas (Northeast, Mid–Coast, Massachusetts Bay, Offshore, and Cashes Ledge MAs) and two other relevant areas (Western Gulf of Maine Closure Area [WGOM CA] and the Stellwagen Bank Area). Since the implementation of the HPTRP, the NEFOP observed 20,758 gillnet hauls in the Gulf of Maine region. In this region, 104 harbor porpoises were observed taken, most of which were within the Mid–Coast and Massachusetts Bay MAs, and within the nearby areas that were outside the management areas. Highest average bycatch rates were in February and November and occurred in 2005.

Few hauls were observed in the times and areas that were totally closed to gillnets, as defined by the HPTRP. Compliance to the required number of pingers dropped substantially in 2003 and started increasing again in 2006.

A statistical model that best predicted the bycatch rates in this region included the following factors (in order of importance): area, sea surface temperature, NAO index value, average mesh size (in), and total amount of leadline weights (lbs). One way to interpret this model is that the factors that provided the most explanation of the bycatch rates patterns were time/area factors (area, SST, and NAO), where SST and NAO helped explain the annual and monthly variations. Then within these times and areas, the factors that indicated which hauls had the highest bycatch were gear characteristics (average mesh size and leadline total weight).

5.2 Observer Coverage

In the Gulf of Maine region (Figure 1) from 1 January 1999 – 31 May 2007, there were 20,758 hauls observed (Table 16), which were from 4,766 trips and 246 unique vessels. This represents 1,421 – 4,102 observed hauls per year, from 311 – 1,010 trips per year, and from 66 – 146 vessels per year (Table 16A). The number of hauls observed within each management area varied by month (Figure 26).

Because there was at least one observed take in each month in some part of the Gulf of Maine region during at least one year (Table 17), further analyses focused on the Gulf of Maine region for all months from 1 January 1999 – 31 May 2007. There were no hauls observed in the Northeast MA (Figure 27) at any time of the year after 1 January 1999, so this management area will not be discussed further.

5.3 General Bycatch Patterns

In the Gulf of Maine region 1 January 1999 – 31 May 2007, most of the harbor porpoise bycatch was close to shore within the Mid–coast and Massachusetts Bay MAs and within the nearby areas that were outside these two management areas (Figure 27). Hauls with takes were observed in the Gulf of Maine region every year, with the most observed takes in 2005 (Table 16). Takes within a year were usually spread out in more than one area (Figure 28). Hauls with takes were observed in the Gulf of Maine region during every month, though not every month in each year, where the majority of the takes were in October – December (Table 17). Takes within a month were usually spread out in more than one area (Figure 29). Most of the observed hauls (93%) that had a harbor porpoise take caught 1 harbor porpoise (89 hauls), 6 hauls caught 2

harbor porpoises (6%) and 1 haul caught 3 harbor porpoises (1%). Hauls that caught multiple animals were spread out in several areas (Figure 30).

Bycatch rates differed by area (Tables 16B–16H). The two areas with the highest bycatch rates were the WGOM CA (Table 16F) and the Mid–coast MA (Table 16D). Over all years and months, the bycatch rate was 0.056 harbor porpoises per mtons landed from the WGOM CA and 0.052 harbor porpoises per mtons landed from the Mid–coast MA. The area with the next highest bycatch rate was the Stellwagen Bank Area (Table 16G), with a bycatch rate of 0.040 harbor porpoises per mton landed. The Offshore MA did not have any observed bycatch.

Harbor porpoise bycatch was observed in each month of the year, where the highest average bycatch rates were in February and November (Table 17). On a smaller time/area scale, the highest bycatch rates were in the Massachusetts Bay and Mid–coast MAs during March, in the WGOM CA and Stellwagen Bank Area during February, and during November and December in the Massachusetts Bay and Mid–coast MAs, WGOM CA, and Stellwagen Bank Area (Table 17).

Bycatch rates (number of observed harbor porpoises per observed mtons landed) of categorizations of many factors are listed in Table 18. Some of the values of factors with high bycatch rates include: hauls targeting monkfish, the year 2005, water depths of 50–100 fa, surface water temperatures of 0–10ºC, bottom water temperatures of 2–4ºC, long soak durations (>96 hrs), long gillnet strings (>5,000 ft), mesh sizes of 8–10 in, twine sizes of 0.70 and 0.74 mm, large spaces between the panels within a string (>10 ft), gillnet heights of 10–15 ft, leadline depths at 30–40 fa (net may not be touching the bottom), 400–800 lbs of leadline weights, vessels that were 30–40 gross tons, and times with negative NAO index values.

5.4 Compliance

Few hauls were observed in the times and areas that were totally closed to gillnets as required by the HPTRP (Table 17). Within the WGOM CA (closed year round since May 1998) there was observed fishing during nearly every month, where most observed hauls were close to a border, in particular the western border (Figure 27), and harbor porpoise bycatch was observed December – March (Table 17).

Pinger compliance dropped substantially in 2003 in each HPTRP management area and started increasing again in 2006 (Figure 31). Compliance in this figure was expressed as observed hauls with greater than 90% of the required number of pingers, which reflects the commonly used 10–net string missing one pinger (which could have fallen off accidently). When expressing compliance as 100% of the required number of pingers in the Gulf of Maine region, compliance was highest in 1999 (about 75%), dropped to a low in 2003 and 2004 (about 10%), and rose again January – May 2007 (about 60%; Figure 32).

Bycatch rates of strings that had varying levels of compliance were discussed in detail in Palka et al. (2008). For example, during 1 January 1999 – 31 May 2007, in the Mid–Coast MA during times pingers were required, the harbor porpoise bycatch rate of hauls without any pingers was 0.017 harbor porpoises/haul. In the same time and area, the bycatch rate of hauls with all of the required number of pingers was 0.008 harbor porpoises/haul; that is less than half the rate than that of hauls without pingers. The bycatch rates of hauls with 90% or more and 80% or more of the required number of pingers were 0.011 and 0.014 harbor porpoises/haul, respectively. The same pattern was observed if the bycatch rate was defined as harbor porpoises/mtons landed, when looking only at the fall (September – December) or only the winter (January – May) and when data from all Gulf of Maine HPTRP management areas were pooled.

5.5 Correlated Factors

The model that best predicted the bycatch rate patterns in the Gulf of Maine region included the following factors (in order of importance): area, SST, NAO index value, average mesh size (in), and total amount of leadline weights (lbs; Table 19). Figure 33 indicates the values of each factor (x–axis) that had higher than average bycatch rates, where y=0 represents an average bycatch rate and y-values greater than zero (above the dashed horizontal line) represents higher than average bycatch rates.

One way to interpret this model is that the factors that provide the most explanation of the bycatch rates patterns are time/area factors (area, SST, and NAO index value), where SST and the NAO index value helped explain variability between the years and between the months. Then within these times and areas, the factors that indicated which hauls had the highest bycatch were gear characteristics (average mesh size and leadline total weight). A description of each factor follows.

The factor that contributed the most to predicting the bycatch rate patterns within the Gulf of Maine region was area. Bycatch rates ranged from no observed bycatch in the Offshore MA to rates over 0.05 harbor porpoises per mton landed in the Mid–Coast MA and WGOM CA.

The factor that contributed the second most was the SST. In general, higher bycatch rates were in cooler waters (SST ≤12.5°C [54.5°F]) (Figure 33). The 2–factor model can be interpreted as indicating that within each area, bycatch rates were higher when the SST was ≤12.5°C (Table 20A).

The next factor, NAO, further refined the bycatch rate patterns. In general, the bycatch rate was higher during years when the NAO index value was negative or slightly positive (≤0.15). That is, the 3–factor model can be interpreted as indicating that within a particular area and in cooler waters (≤12.5°C), the highest bycatch rates were in years when the NAO index value was small, ≤0.15 (Table 20B).

The next two factors in the model were gear characteristics. First, average mesh size was chosen. In general, bycatch rates were higher for strings using mesh sizes ≥7 in (Figure 33). The 4–factor model can then be interpreted as indicating that hauls with the highest bycatch rates were (within most areas) in waters that were cooler (≤12.5°C), in years with a small NAO index value (≤0.15), and strings with large mesh sizes (≥7 in) (Table 20C).

Lastly, the total pounds of leadline weights were chosen for the model. In general, the more the leadline weights, the higher the bycatch rate, except for hauls targeting red hake (*Urophycis chuss*) or white hake (*Urophycis tenuis*) which use a lot of leadlines weights (≥1,600 lbs) and still have no observed harbor porpoise bycatch (Figure 33). Thus, the three groups of leadline weights were able to identify the hake hauls which have no observed bycatch and have very heavy leadline weights. The 5–factor model can then be interpreted as defining hauls with the highest bycatch rates as hauls that (within each area) were in waters that were cooler (≤12.5°C), in years with a small NAO index value (≤0.15), used large mesh sizes (≥7 in), and used leadline weights of 400–1600 lbs (Table 20D).

Table 16. Descriptive statistics of bycatch of harbor porpoises (Phocoena phocoena) in the Gulf of Maine region from 1 January 1999 – 31 May 2007, for all areas and each area separately.

*** Data in the 2007 column are only from 1 January – 31 May, while data from the other years are for the full year.**

A. All of the Gulf of Maine region

	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007*	Total
Number of observed hauls	2453	2742	1967	1642	2094	4102	3711	1421	626	20758
Number of observed trips	451	628	417	399	563	1010	865	311	122	4766
Number of observed vessels	81	87	66	72	99	146	121	111	55	246
Number of observed hauls with one or more take	11	9	1	8	9	13	36	8	1	96
Total number of observed takes	13	10	2	8	9	14	39	8	1	104
Bycatch rate (observed takes/observed number of hauls)	0.005	0.004	0.001	0.005	0.004	0.003	0.011	0.006	0.002	0.005
Bycatch rate (observed takes/observed mtons landed)	0.015	0.018	0.005	0.025	0.022	0.017	0.043	0.023	0.009	0.022

B. Cashes Ledge management area

	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007*	Total
Number of observed hauls	50	0	9	5	4	73	57	8	15	221
Number of observed trips	8	0	2	1	2	8	10	2	2	35
Number of observed vessels	5	0	2	1	1	6	7	2	2	17
Number of observed hauls with one or more take	0	0	0	0	2	0	0	0	0	2
Total number of observed takes	0	0	0	0	2	0	0	0	0	2
Bycatch rate (observed takes/observed number of hauls)	0	0	0	0	0.500	0	0	0	0	0.009
Bycatch rate (observed takes/observed mtons landed)	0	0	0	0	1.159	0	0	0	0	0.023

Table 16 (cont). Descriptive statistics of bycatch of harbor porpoises (Phocoena phocoena) in the Gulf of Maine region from 1 January 1999 – 31 May 2007, for all areas and each area separately. * Data in the 2007 column are only from 1 January – 31 May, while data from the other years are for the full year.

C. Massachusetts Bay management area

	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007*	Total
Number of observed hauls	331	332	249	304	667	889	536	168	78	3554
Number of observed trips	80	95	60	91	208	282	160	61	34	1071
Number of observed vessels	16	19	17	19	36	44	36	29	22	94
Number of observed hauls with one or more take	0	0	0	2	1	0	5	0	0	8
Total number of observed takes	0	0	0	2	1	0	5	0	0	8
Bycatch rate (observed takes/observed number of hauls)	0	0	0	0.007	0.001	0	0.009	0	0	0.002
Bycatch rate (observed takes/observed mtons landed)	0	0	0	0.048	0.010	0	0.084	0	0	0.016

D. Mid–coast management area

	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007*	Total
Number of observed hauls	476	573	445	502	428	1271	1308	323	19	5345
Number of observed trips	133	198	161	169	165	376	350	93	7	1652
Number of observed vessels	26	34	24	37	41	76	73	49	7	137
Number of observed hauls with one or more take	8	6	1	5	4	5	16	3	1	49
Total number of observed takes	9	7	2	5	4	6	19	3	1	56
Bycatch rate (observed takes/observed number of hauls)	0.019	0.012	0.004	0.010	0.009	0.005	0.015	0.009	0.053	0.010
Bycatch rate (observed takes/observed mtons landed)	0.062	0.075	0.033	0.069	0.045	0.024	0.063	0.043	1.229	0.052

Table 16 (cont). Descriptive statistics of bycatch of harbor porpoises (Phocoena phocoena) in the Gulf of Maine region from 1 January 1999 – 31 May 2007, for all areas and each area separately. * Data in the 2007 column are only from 1 January – 31 May, while data from the other years are for the full year.

E. Offshore management area

	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007*	Total
Number of observed hauls	280	162	103	31	59	96	127	142	139	1139
Number of observed trips	24	15	11	7	5	14	19	12	11	118
Number of observed vessels	16	8	7	5	4	11	12	9	8	42
Number of observed hauls with one or more take	0	0	0	0	0	0	0	0	0	0
Total number of observed takes	0	0	0	0	0	0	0	0	0	0
Bycatch rate (observed takes/observed number of hauls)	0	0	0	0	0	0	0	0	0	0
Bycatch rate (observed takes/observed mtons landed)	0	0	0	0	0	0	0	0	0	0

F. Western Gulf of Maine closed area (from multispecies fishery management plan)

	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007*	Total
Number of observed hauls	62	130	58	53	47	114	154	96	14	728
Number of observed trips	36	55	36	31	19	58	79	39	9	362
Number of observed vessels	13	16	14	13	11	24	27	19	7	60
Number of observed hauls with one or more take	0	2	0	1	0	1	3	3	0	10
Total number of observed takes	0	2	0	1	0	1	3	3	0	10
Bycatch rate (observed takes/observed number of hauls)	0	0.125	0	0.077	0	0.042	0.111	0.158	0	0.014
Bycatch rate (observed takes/observed mtons landed)	0	0.076	0	0.105	0	0.025	0.073	0.138	0	0.056

Table 16 (cont). Descriptive statistics of bycatch of harbor porpoises (Phocoena phocoena) in the Gulf of Maine region from 1 January 1999 – 31 May 2007, for all areas and each area separately. * Data in the 2007 column are only from 1 January – 31 May, while data from the other years are for the full year.

G. Stellwagen Bank area

	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007*	Total
Number of observed hauls	201	265	191	117	193	618	609	285	245	2724
Number of observed trips	63	101	61	44	72	197	182	84	66	870
Number of observed vessels	19	27	20	14	23	36	32	30	27	83
Number of observed hauls with one or more take	0	0	0	0	1	6	9	2	0	18
Total number of observed takes	0	0	0	0	1	6	9	2	0	18
Bycatch rate (observed takes/observed number of hauls)	0	0	0	0	0.043	0.167	0.281	0.067	0	0.007
Bycatch rate (observed takes/observed mtons landed)	0	0	0	0	0.032	0.065	0.104	0.06	0	0.040

H. Outside all the above areas

	Year									
	1999	2000	2001	2002	2003	2004	2005	2006	2007*	Total
Number of observed hauls	1053	1280	912	630	696	1041	920	399	116	7047
Number of observed trips	178	237	169	127	136	190	193	77	17	1324
Number of observed vessels	36	42	37	36	39	46	37	37	12	120
Number of observed hauls with one or more take	3	1	0	0	1	1	3	0	0	9
Total number of observed takes	4	1	0	0	1	1	3	0	0	10
Bycatch rate (observed takes/observed number of hauls)	0.111	0.024	0	0	0.026	0.022	0.081	0	0	0.001
Bycatch rate (observed takes/observed mtons landed)	0.011	0.004	0	0	0.007	0.003	0.009	0	0	0.005

Table 17. Within the Gulf of Maine (GOM) region, by month and area: (A) number of observed harbor porpoise (Phocoena phocoena) takes and observed hauls (in parentheses) and (B) resulting bycatch rates (harbor porpoises per mtons landed). Data from 1 January 1999 – 31 May 2007. Dark shaded cells indicate the times and areas when pingers are required. Light shaded cells with bold numbers indicate the times and areas that are closed to all gillnets under the harbor porpoise take reduction plan.

A. Number of observed harbor porpoise takes (Number of observed hauls)

Month	Cashes Ledge	Massachusetts Bay	Mid-coast	Offshore	Western GOM	Stellwagen Bank	Outside these areas	All areas
1999 – 2007								
Jan	0 (0)	0 (273)	1 (139)	0 (55)	**1 (67)**	3 (377)	0 (433)	5 (1,344)
Feb	**0 (21)**	0 (193)	0 (177)	0 (79)	**2 (98)**	7 (396)	0 (281)	9 (1,245)
Mar	0 (13)	**1 (61)**	3 (199)	0 (95)	**1 (153)**	2 (499)	1 (370)	8 (1,390)
Apr	0 (13)	0 (0)	0 (30)	0 (145)	**0 (0)**	0 (0)	5 (649)	5 (837)
May	0 (0)	0 (326)	0 (5)	0 (77)	**0 (22)**	0 (200)	1 (614)	1 (1,244)
1999 – 2006								
Jun	2 (24)	0 (721)	1 (195)	0 (124)	**0 (29)**	0 (286)	0 (639)	3 (2,018)
Jul	0 (0)	0 (397)	2 (944)	0 (127)	**0 (60)**	0 (210)	0 (630)	2 (2,368)
Aug	0 (30)	0 (488)	1 (888)	0 (82)	**0 (67)**	0 (214)	0 (746)	1 (2,515)
Sep	0 (36)	2 (496)	4 (728)	0 (46)	**0 (67)**	0 (252)	0 (806)	6 (2,431)
Oct	0 (53)	0 (38)	11 (790)	0 (150)	**0 (60)**	0 (5)	0 (722)	11 (1,818)
Nov	0 (18)	2 (95)	26 (925)	0 (83)	**5 (74)**	0 (5)	1 (681)	34 (1,881)
Dec	0 (13)	3 (466)	7 (325)	0 (76)	**1 (31)**	6 (280)	2 (476)	19 (1,667)
Total	2 (221)	8 (3,554)	56 (5,345)	0 (1,139)	10 (728)	18 (2,724)	10 (7,047)	104 (20,758)

B. Bycatch rate (harbor porpoises per mtons landed)

Month	Cashes Ledge	Massachusetts Bay	Mid-coast	Offshore	Western GOM	Stellwagen Bank	Outside these areas	All areas
1999 – 2007								
Jan	0	0	0.045	0	**0.082**	0.047	0	0.022
Feb	**0**	0	0	0	**0.192**	0.192	0	0.056
Mar	0	**0.267**	0.156	0	**0.047**	0.037	0.017	0.038
Apr	0	0	0	0	**0**	0	0.069	0.040
May	0	0	0	0	**0**	0	0.010	0.005
1999 – 2006								
Jun	0.332	0	0.032	0	**0**	0	0	0.007
Jul	0	0	0.010	0	**0**	0	0	0.003
Aug	0	0	0.006	0	**0**	0	0	0.002
Sep	0	0.023	0.028	0	**0**	0	0	0.010
Oct	0	0	0.066	0	**0**	0	0	0.023
Nov	0	0.052	0.121	0	**0.145**	0	0.005	0.066
Dec	0	0.043	0.071	0	**0.095**	0.079	0.018	0.044
Total	0.023	0.016	0.052	0	0.056	0.040	0.005	0.022

Table 18. For the Gulf of Maine region, observed bycatch rates (Byc Rate) of harbor porpoises (Phocoena phocoena) and numbers of observed hauls (Num Obs) for various gear characteristics, fishing practices, and environmental factors. The bycatch rate was defined as observed number of takes per observed mtons landed. The overall average bycatch rate was 0.022 harbor porpoises per mtons landed.

Categories of factors with * in the Num Obs column had less than 200 observed hauls (thus given the overall bycatch rate for this region, there was a small chance of observing a take).

High bycatch rates (≥ 0.04 harbor porpoises per mtons landed) are highlighted.

Data were collected from 1 January 1999 – 31 May 2007.

Categories	Num Obs	Byc Rate
MONTH		
Jan	1,344	0.022
Feb	1,245	0.056
Mar	1,390	0.038
Apr	837	0.040
May	1,244	0.005
Jun	2,018	0.007
Jul	2,368	0.003
Aug	2,515	0.002
Sep	2,431	0.010
Oct	1,818	0.023
Nov	1,881	0.066
Dec	1,667	0.044
YEAR		
1999	2,453	0.015
2000	2,742	0.018
2001	1,967	0.005
2002	1,642	0.025
2003	2,094	0.022
2004	4,102	0.017
2005	3,711	0.043
2006	1,421	0.023
2007	626	0.009

Categories	Num Obs	Byc Rate
TARGET SPECIES		
Gadus morhua	8,957	0.029
Pleuronectiformes	1,159	0.027
Homarus americanus	54*	0
haddock	215	0
Leptoscopus americanus	3,489	0.042
Pollachius virens	1,470	0.019
Squalus acanthias	681	0.002
groundfish	1,965	0.016
Urophycis tenuis	158*	0
Pleuronectes americanus	1,231	0
Rajidae	348	0
Pleuronectes ferrugineus	1,016	0.015
SURFACE TEMPERATURE (ºC)		
0-5	2,927	0.046
5-10	4,848	0.048
10-15	4,265	0.024
15-20	7,551	0.004
20-25	519	0
SPACE WIDTH BETWEEN NETS (ft)		
3	12,771	0.015
4	433	0.057
5+	809	0.005

Categories	Num Obs	Byc Rate
LENGTH OF STRING (ft)		
0-1,000	263	0
1,001-2,000	2,186	0.019
2,001-3,000	5,538	0.026
3,001-4,000	7,978	0.018
4,001-5,000	2,451	0.020
5,001-6,000	671	0.082
6,001-30,000	1,659	0.010
TWINE SIZE (mm)		
0.28	1*	0
0.33	16*	0
0.40	42*	0
0.45	95*	0.034
0.47	1,629	0.010
0.52	1,635	0.014
0.57	4,300	0.017
0.62	8,239	0.022
0.66	1,539	0.024
0.70	316	0.088
0.74	124*	0.041
0.81	368	0.011
0.9	1,711	0.025
1.05	15*	0
unknown	721	0.036

Table 18 (cont). For the Gulf of Maine region, observed bycatch rates (Byc Rate) of harbor porpoises (Phocoena phocoena) and numbers of observed hauls (Num Obs) for various gear characteristics, fishing practices, and environmental factors. The bycatch rate was defined as observed number of takes per observed mtons landed. The overall average bycatch rate was 0.022 harbor porpoises per mtons landed.

Categories of factors with * in the Num Obs column had less than 200 observed hauls (thus given the overall bycatch rate for this region, there was a small chance of observing a take).

High bycatch rates (≥ 0.04 harbor porpoises per mtons landed) are highlighted.

Data were collected from 1 January 1999 – 31 May 2007.

Categories	Num Obs	Byc Rate
WIND SPEED (kts)		
0-10	10,537	0.026
10-20	6,796	0.025
20-30	1,580	0.008
30-40	119*	0.031
STEAM TIME (hrs)		
0-5	18,186	0.025
5-10	1,197	0.013
10-15	790	0.016
15-100	549	0
BOTTOM DEPTH (fm)		
0-50	8,831	0.009
50-100	7,964	0.048
100-150	1,727	0.007
150-200	1,160	0.016
200-300	398	0
TIE DOWN LENGTH (ft)		
0-1	35*	0
1-2	390	0.054
2-3	3,258	0.016
3-4	1,515	0.038
4-5	112*	0
>5	135*	0.184
FISH SAMPLING?		
yes	11,618	0.019
no	9,134	0.026
unknown	6*	0.000

Categories	Num Obs	Byc Rate
BOTTOM TEMPERATURE (ºC)		
0-2	270	0
2-4	2,949	0.049
4-6	7,037	0.005
6-8	6,613	0.029
8-10	3,030	0.033
10-14	29*	0
BOTTOM SLOPE (º angle)		
0-0.2	9,866	0.015
0.2-0.4	9,606	0.033
0.4-0.6	609	0.017
0.6-1.2	51*	0.077
SOAK DURATION (hrs)		
0-12	1,097	0.006
13-24	9,732	0.016
24-36	347	0.008
36-48	3,483	0.027
48-96	3,837	0.028
96-800	2,247	0.045
NET HEIGHT (ft)		
0-5	335	0
5-10	6,858	0.029
10-15	8,090	0.200
15-25	239	0.010

Categories	Num Obs	Byc Rate
MESH SIZE (in)		
2-4	9*	0
4-6	1,493	0.011
6-8	14,613	0.020
8-10	1,455	0.044
10-18	3,153	0.028
USED TIE DOWNS?		
no	15,151	0.019
yes	5,373	0.031
unknown	234	0
USED SPACES?		
no	6,583	0.031
yes	14,148	0.017
unknown	27*	0
USED DROP LINES?		
no	15,549	0.024
yes	6*	0
unknown	5,196	0.016
USED ANCHORS?		
no	2,104	0.026
yes	18,645	0.021
USED ADDED WEIGHTS?		
no	15,480	0.025
yes	70*	0
Unknown	5,192	0.016

Table 18 (cont). For the Gulf of Maine region, observed bycatch rates (Byc Rate) of harbor porpoises (Phocoena phocoena) and numbers of observed hauls (Num Obs) for various gear characteristics, fishing practices, and environmental factors. The bycatch rate was defined as observed number of takes per observed mtons landed. The overall average bycatch rate was 0.022 harbor porpoises per mtons landed.

Categories of factors with * in the Num Obs column had less than 200 observed hauls (thus given the overall bycatch rate for this region, there was a small chance of observing a take).

High bycatch rates (≥ 0.04 harbor porpoises per mtons landed) are highlighted.

Data were collected from 1 January 1999 – 31 May 2007.

Categories	Num Obs	Byc Rate
VESSEL GROSS TONNAGE		
0-10	643	0.029
10-20	1,356	0.021
20-30	838	0.009
30-40	388	0.048
40-50	151*	0.022
50-70	123*	0.000
>70	213	0.041
AMOUNT OF DISCARDS (lbs)		
0-250	8,586	0.017
250-500	1,308	0.024
500-1,000	730	0.008
1,000-1,500	218	0.073
>1,500	374	0.019
SEDIMENT TYPE		
unknown	486	0.000
clay	14*	0.000
clay-silt/sand	1,555	0.021
gravel	985	0.006
gravel-sand	3,506	0.032
sand	7,518	0.014
sand-clay/silt	1,049	0.040
sand-silt/clay	1,940	0.039
sand/silt/clay	3,063	0.017

Categories	Num Obs	Byc Rate
WINTER NORTH ATLANTIC OSCILLATION INDEX		
-0.4 - 0	3,741	0.028
0 - 0.2	1,965	0.028
0.2 - 0.4	9,317	0.023
0.4 - 0.6	2,273	0.014
0.6 - 1.2	2,836	0.020
VESSEL LENGTH (ft)		
20-30	37*	0
30-40	1,202	0.031
40-45	1,986	0.033
45-50	446	0.017
50-60	319	0.012
60-80	289	0.028
NORTH ATLANTIC OSCILLATION INDEX		
-3 - -2	330	0.050
-2 - -1	1,690	0.028
-1 - 0	7,740	0.038
0-1	7,478	0.011
1-2	2,894	0.007
NUMBER OF ANCHORS		
1	129*	0.106
2	13,753	0.024
3	51*	0
4	81*	0.064

Categories	Num Obs	Byc Rate
ANCHOR WEIGHT TYPE		
unknown	2,215	0.026
Danforth-style	3,572	0.013
Dead Weight	14971	0.023
LEAD LINE DEPTH (ft)		
0-20	2,180	0.003
20-30	5,033	0.025
30-40	3,795	0.049
40-50	2,120	0.031
>50	2,300	0.019
CHLOROPHYLL α CONCENTRATION (mg/m^3)		
0-1	3,831	0.019
1-1.5	4,732	0.013
1.5-2	2,699	0.021
2-4	3,232	0.022
>4	1,139	0.013
LOG10(CHLOROPHYLL)		
<0	3,831	0.019
0-0.1	2,571	0.011
0.1-0.2	2,658	0.017
0.2-0.4	3,678	0.023
0.4-0.6	1,753	0.020
>0.6	1,142	0.013

Table 18 (cont). For the Gulf of Maine region, observed bycatch rates (Byc Rate) of harbor porpoises (Phocoena phocoena) and numbers of observed hauls (Num Obs) for various gear characteristics, fishing practices, and environmental factors. The bycatch rate was defined as observed number of takes per observed mtons landed. The overall average bycatch rate was 0.022 harbor porpoises per mtons landed.

Categories of factors with * in the Num Obs column had less than 200 observed hauls (thus given the overall bycatch rate for this region, there was a small chance of observing a take).

High bycatch rates (≥ 0.04 harbor porpoises per mtons landed) are highlighted.

Data were collected from 1 January 1999 – 31 May 2007.

Categories	Num Obs	Byc Rate
WAVE HEIGHT (ft)		
0-2	8,763	0.027
2-4	7,011	0.022
4-6	2,457	0.019
6-8	643	0.020
8-10	219	0.014
ANCHOR WEIGHT (lbs)		
0-40	1,491	0.067
40-60	7,703	0.016
60-80	2,438	0.033
80-100	2,616	0.013
100-150	2,482	0.026
>150	1,854	0

Categories	Num Obs	Byc Rate
LEAD LINE WEIGHT (lbs)		
0-200	2,502	0.015
200-300	3,789	0.008
300-400	6,793	0.014
400-500	2,293	0.033
500-600	861	0.046
600-800	1,779	0.046
800-1000	947	0.015
1000-7000	1,421	0.019
HANGING RATIO		
<0.5	2,180	0.024
0.5	18,491	0.022
>0.5	38*	0

Categories	Num Obs	Byc Rate
AREAS		
Cashes Ledge	221	0.023
Mass Bay	3,554	0.016
Mid-Coast	5,345	0.052
Offshore	1,139	0
Western Gulf of Maine	728	0.056
Stellwagen Banks	2,724	0.040
other	7,047	0.005
NUMBER OF SPACES		
0-2	242	0.055
2-4	1,464	0.022
4-6	662	0
6-8	1,854	0.003
8-10	6,717	0.018
10-15	1,948	0.015
15-20	741	0.031
20-50	445	0.015

Table 19. Models of the bycatch rates of harbor porpoises (Phocoena phocoena) in the Gulf of Maine region. The last column is the difference in the Akaike Information Criterion (AIC) from the row above. The larger the difference, the more that factor contributed to explaining the bycatch rate patterns. The lower the AIC, the better the model fits.

Model number	Factors	AIC	Difference from above
1	None	1233	0
2	Area	1144	89
3	Above + Sea surface temperature	1066	78
4	Above + North Atlantic oscillation index	1016	50
5	Above + Average mesh size	982	34
6	Above + Leadline weight	963	19

Table 20. Bycatch rates of harbor porpoises (Phocoena phocoena) in the Gulf of Maine region by the factors in the bycatch rate model.

A. Harbor porpoise bycatch rates by area (HPTRP management areas [MA] or fishery management plan closed areas [CA]) and sea surface temperature (SST) categories. 12.5°C = 54.5°F

	SST	
Area	**2°–12.5°C**	**>12.5°C**
Cashes Ledge MA	0.058	0
Massachusetts Bay MA	0.020	0.006
Mid–coast MA	0.096	0.019
Offshore MA	0	0
WGOM CA	0.096	0
Stellwagen Bank Area	0.067	0
Other areas	0.014	0

B. Harbor porpoise bycatch rates by area (HPTRP management areas [MA] or fishery management plan closed areas [CA]), sea surface temperature (SST), and North Atlantic oscillation index (NAO) categories.

	SST: 2° – 12.5°C		**SST: > 12.5°C**	
	NAO		**NAO**	
Area	**≤0.15**	**>0.15**	**≤0.15**	**>0.15**
Cashes Ledge MA	0.104	0	0	0
Massachusetts Bay MA	0.052	0.007	0.012	0
Mid–coast MA	0.153	0.052	0.021	0.016
Offshore MA	0	0	0	0
WGOM CA	0.163	0.049	0	0
Stellwagen Bank Area	0.149	0.006	0	0
Other areas	0.030	0.002	0	0

C. Harbor porpoise bycatch rates by area (HPTRP management areas [MA] or fishery management plan closed areas [CA]) and mesh size for hauls that were in 2°–12.5°C waters, and years where the North Atlantic oscillation index (NAO) was ≤0.15.

	mesh size (in)	
Area	**<7**	**≥7**
Cashes Ledge MA	0	0.255
Massachusetts Bay MA	0	0.116
Mid–coast MA	0.071	0.215
Offshore MA	0	0
WGOM CA	0.177	0.147
Stellwagen Bank Area	0	0.183
Other areas	0.033	0.027

D. Harbor porpoise bycatch rates by area (HPTRP management areas [MA] or fishery management plan closed areas [CA]) and leadline total weight for hauls that were in 2°–12.5°C waters, years when the North Atlantic oscillation index (NAO) was ≤0.15 and mesh sizes were ≥7 in.

	Leadline total weight (lbs)		
Area	**<400**	**400–1600**	**>1600**
Cashes Ledge MA	0	0.409	0
Massachusetts Bay MA	0.158	0	0
Mid–coast MA	0.047	0.361	0
Offshore MA	0	0	0
WGOM CA	0	0.249	0
Stellwagen Bank Area	0.147	0.203	0
Other Areas	0.013	0.042	0

Figure 26. Within the Gulf of Maine region by month, numbers of observed hauls within each area (HPTRP management areas [MA], fishery management plan closed areas [CA] and outside these areas). Data are from 1 January 1999 – 31 May 2007.

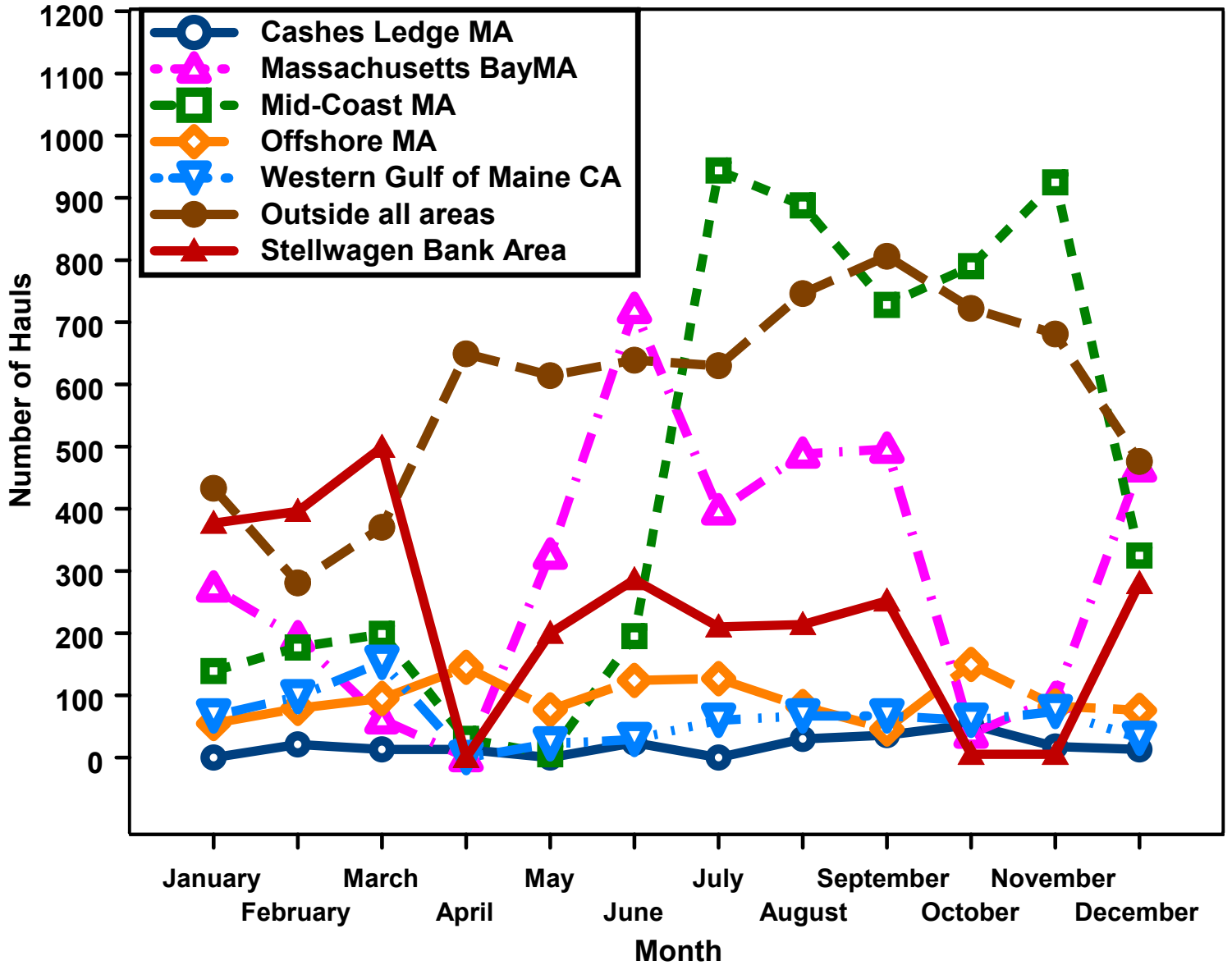


Figure 27. Locations of observed hauls without takes of harbor porpoises (Phocoena phocoena) (small dots) and observed hauls with takes (red circles). Data from 1 January 1999 – 31 May 2007 within the Gulf of Maine (GOM) region, which includes five harbor porpoise take reduction management areas (MA), the Western Gulf of Maine closed area (CA), and the Stellwagen Bank Area. Depth contours are 50, 100, and 200 m.

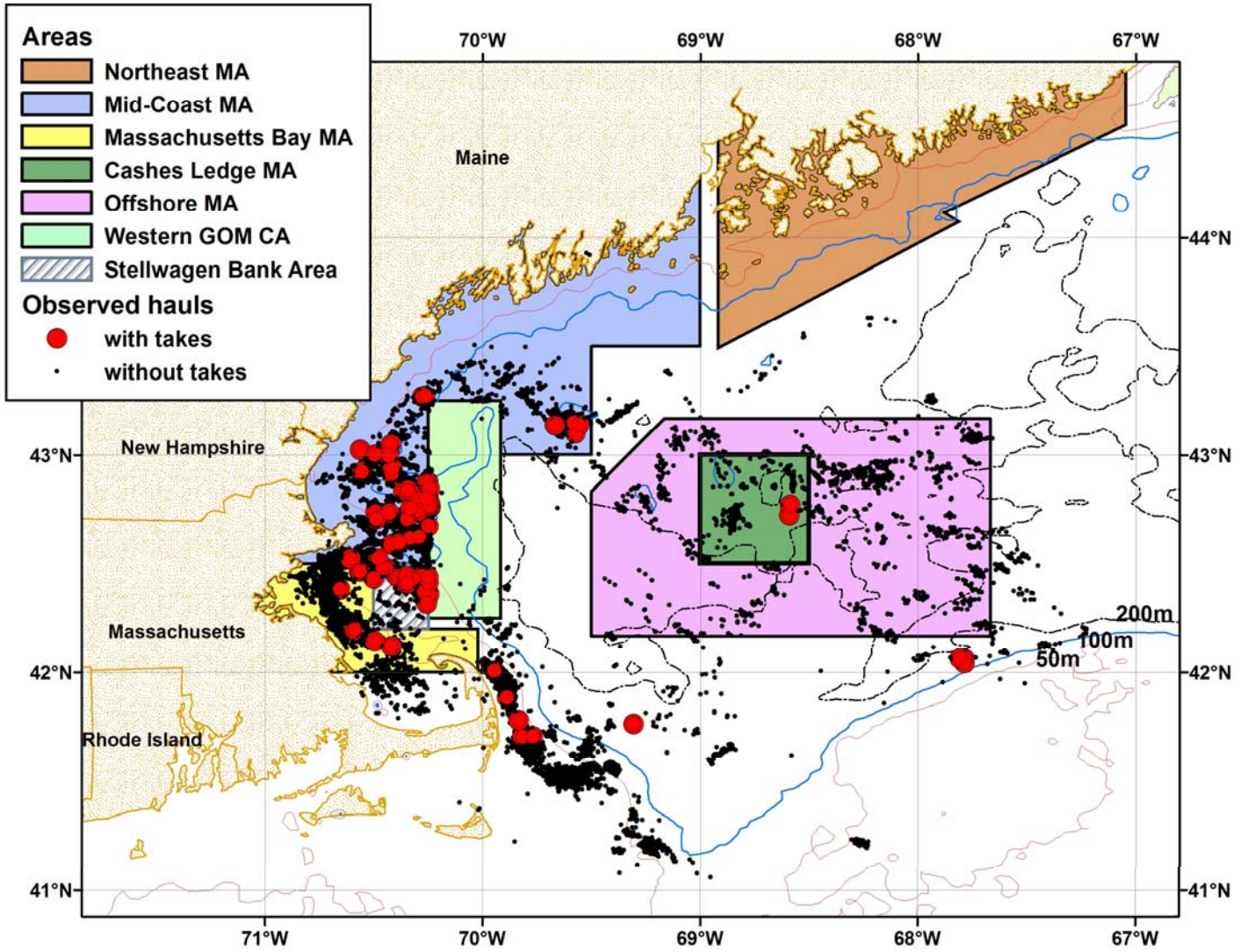


Figure 28. Locations of observed hauls without takes of harbor porpoises (Phocoena phocoena) (small dots) and observed hauls with takes identified by year (colored circles). Data are from 1 January 1999 – 31 May 2007 within the Gulf of Maine (GOM) region, which includes five harbor porpoise take reduction management areas (MA), the Western Gulf of Maine closed area (CA), and the Stellwagen Bank Area. Depth contours are 50, 100, and 200 m.

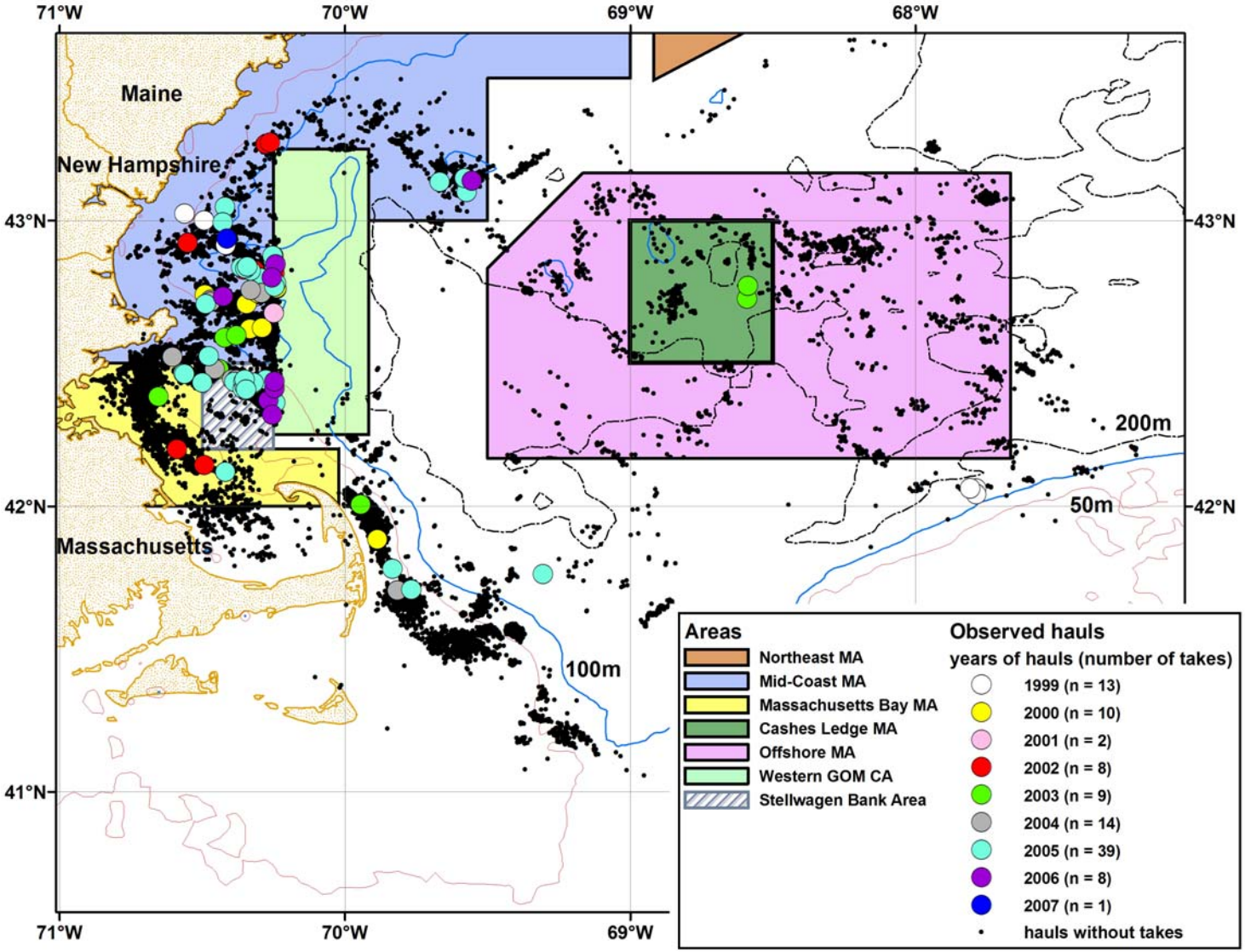


Figure 29. Locations of observed hauls without takes of harbor porpoises (Phocoena phocoena) (small dots) and observed hauls with takes identified by month (colored circles). Data are from 1 January 1999 – 31 May 2007 within the Gulf of Maine (GOM) region, which includes five harbor porpoise take reduction management areas (MA), the Western Gulf of Maine closed area (CA), and the Stellwagen Bank Area. Depth contours are 50, 100, and 200 m.

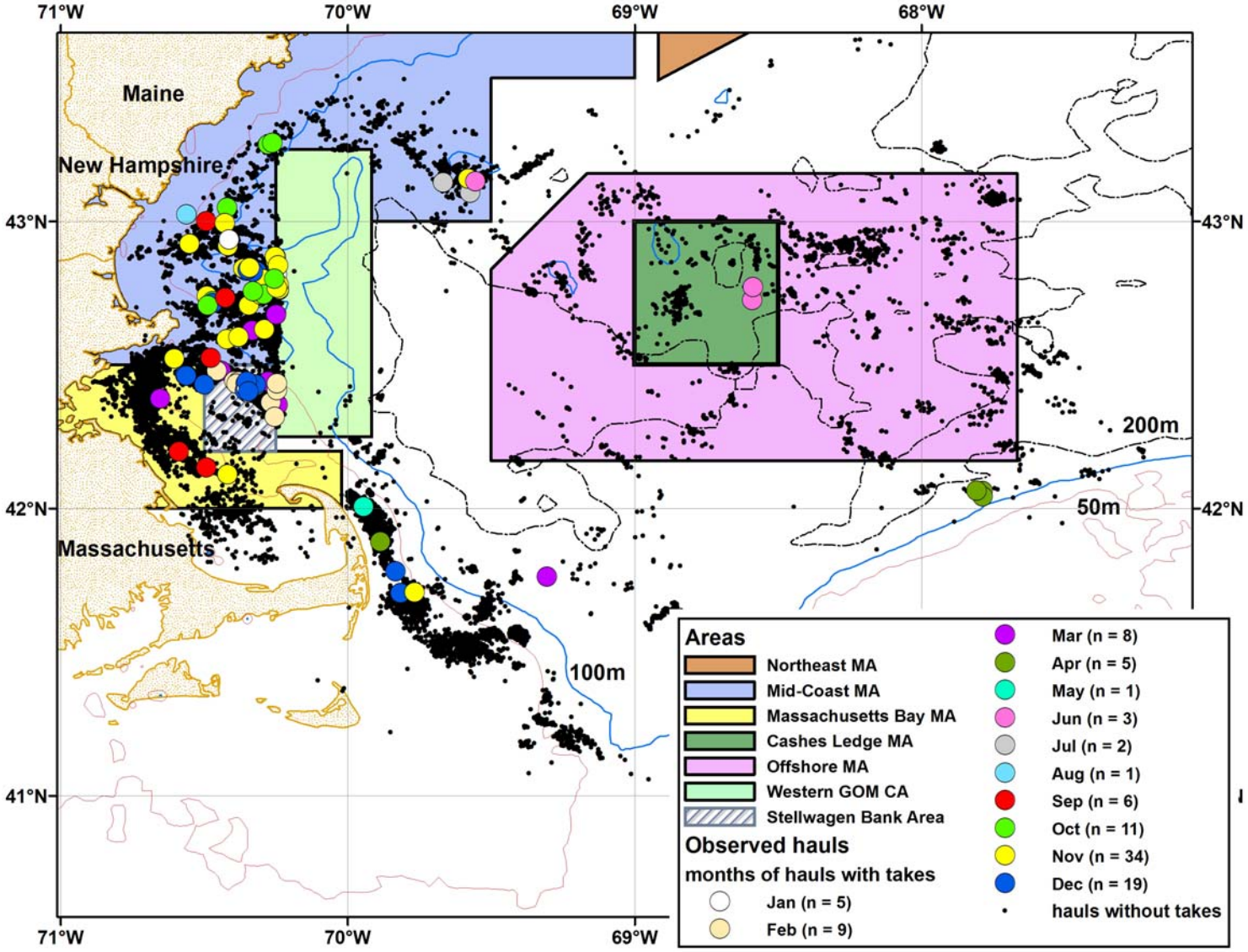


Figure 30. Locations of observed hauls without harbor porpoise (Phocoena phocoena) takes (black dots), and observed hauls with takes, where the numbers of takes per haul are identified. Size of stack indicates number of takes: dot represents no takes; tallest stack represents three animals per haul. Data are from 1 January 1999 – 31 May 2007 within the Gulf of Maine (GOM) region, which includes five harbor porpoise take reduction management areas (MA), the Western Gulf of Maine closed area (CA), and the Stellwagen Bank Area. Depth contours are 50, 100, and 200 m.

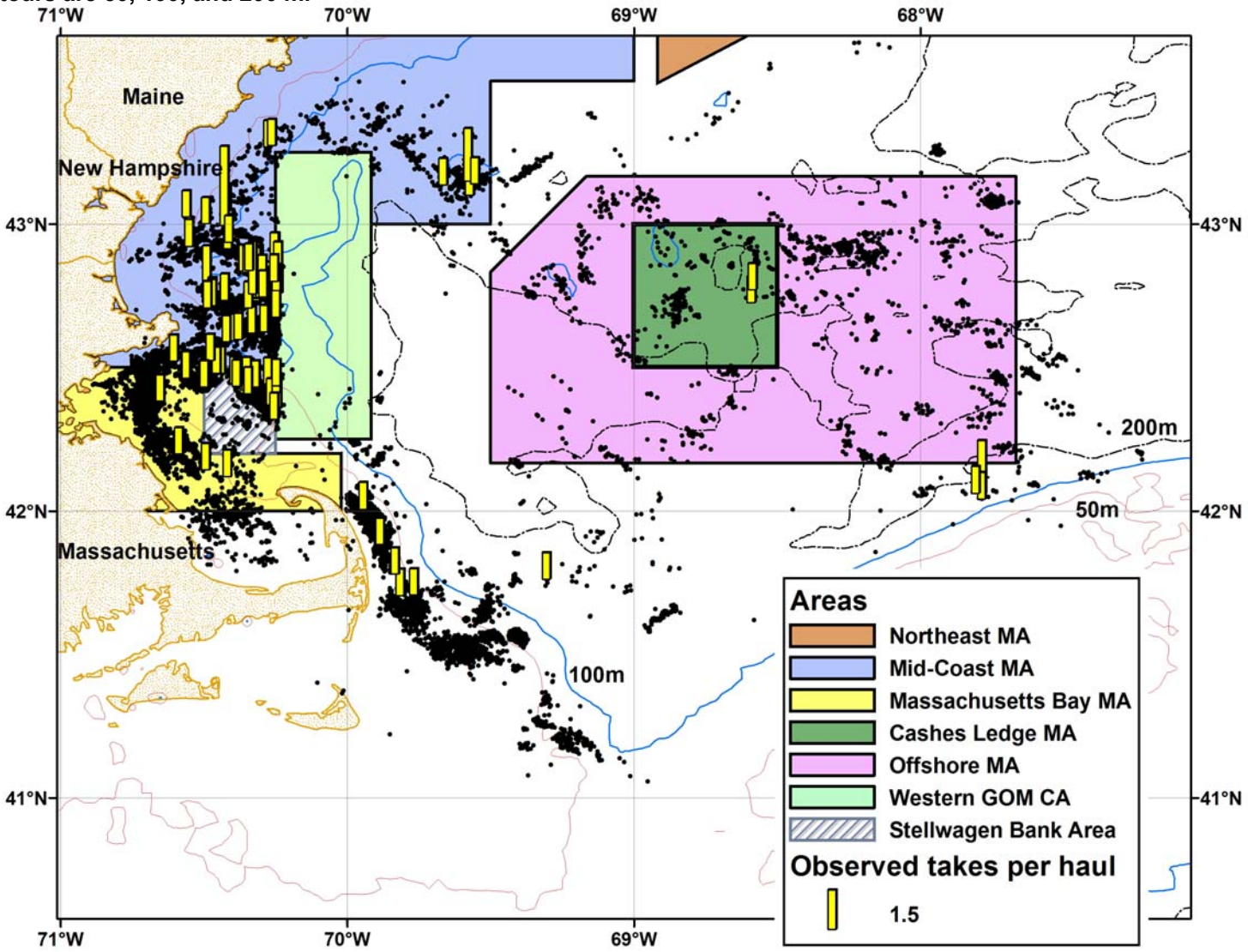


Figure 31. In the Gulf of Maine region, by harbor porpoise take reduction management areas (MA), the proportion of observed hauls that used greater than 90% of the required number of pingers during times when pingers were required. Data are from 1 January 1999 – 31 May 2007.

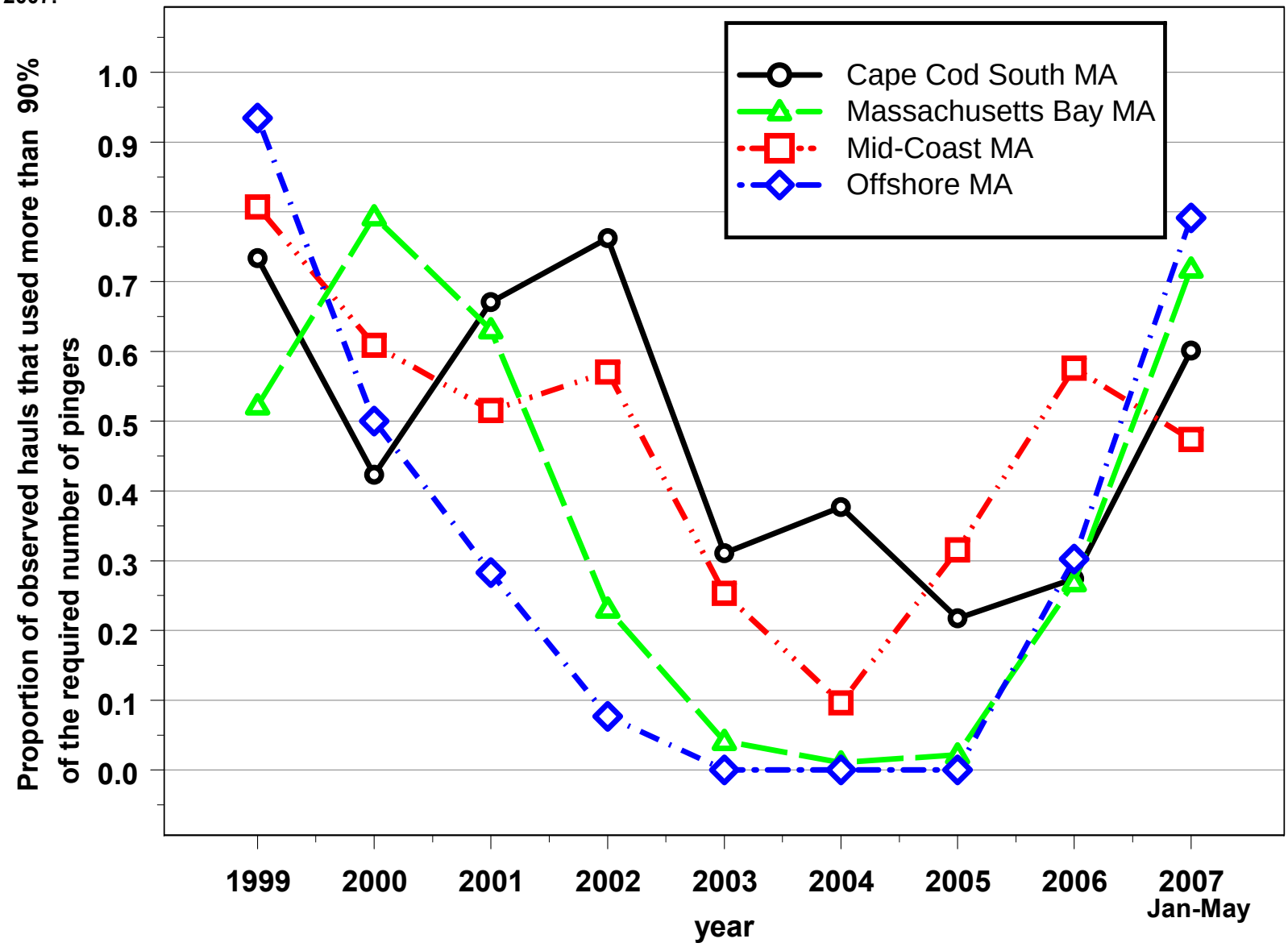


Figure 32. By year, within the Gulf of Maine region, the percentage of the required number of pingers used on gillnets.

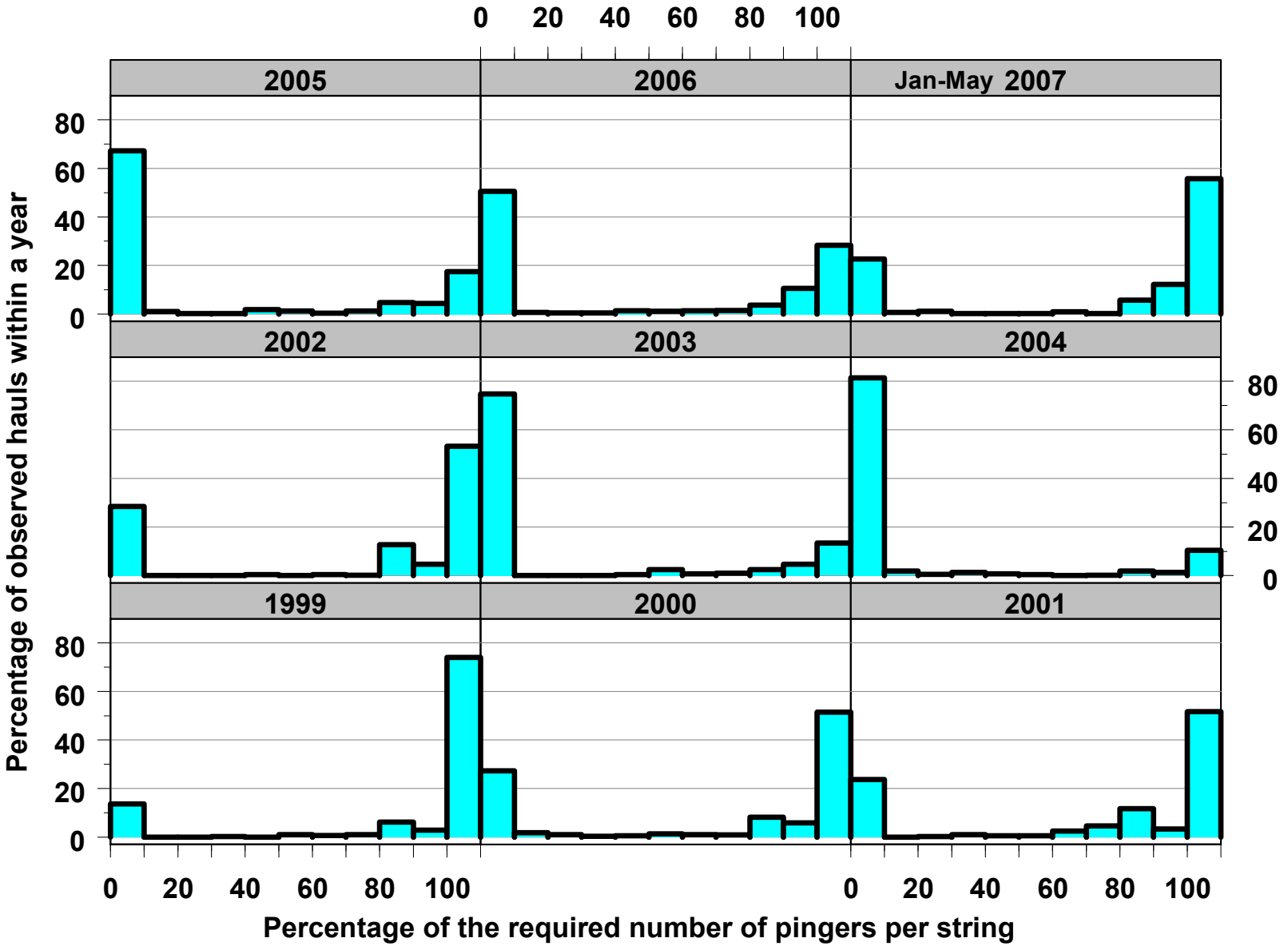
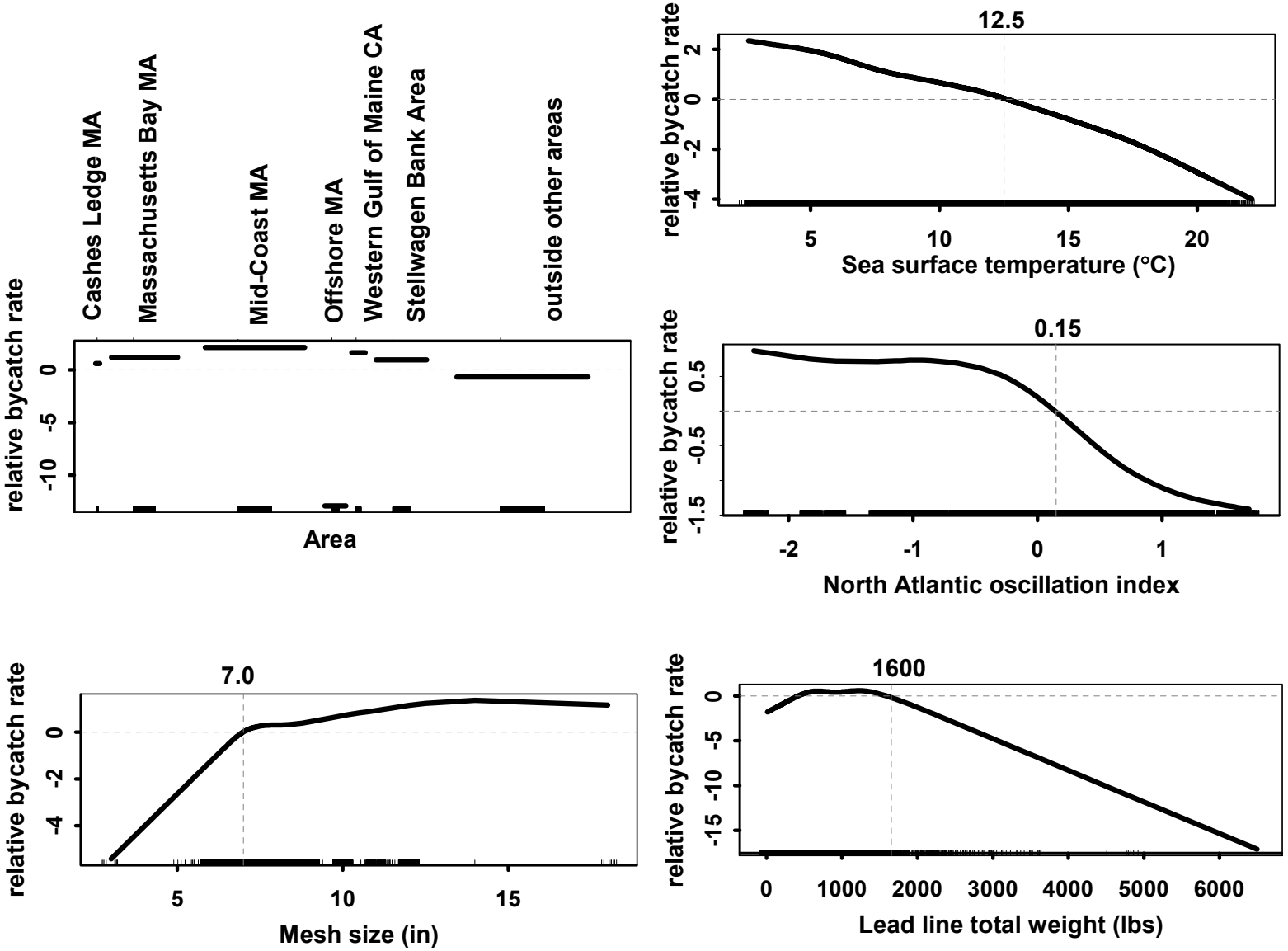


Figure 33. Results of model describing the bycatch rates of harbor porpoises (Phocoena phocoena) in the Gulf of Maine region. There is one plot per factor that was included in the model. Tick marks on the x–axis indicate the values of the observations, and the tick marks are jittered (spread out) to help display where there are values that are shared by many observations. The solid black line represents the overall pattern of these many observations and indicates the best estimate of the bycatch rate at any given value of the x-axis variable. The dashed horizontal line indicates the average relative bycatch rate (y = 0), and values along the y axis indicate the difference relative to this average. Values above this line have higher than average bycatch rates, and those below have a lower than average bycatch rate.



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APPENDIX

Factors used to develop bycatch rate models. For more information on fishing gear related characteristics see NEFSC (2008). * Factors with missing values filled in using process described in Warden and Orphanides (2008).

Factor Name	Description
LOCATION AND TIMING	
Day of year	Day of year: 1 = January 1st for each year
Year	Year beginning of haul occurred (1999 – 2007)
Month	Month beginning of haul occurred (January – December)
Longitude*	Longitude location of beginning of haul
Latitude*	Latitude location of beginning of haul
Bottom depth*	Bottom depth of location of beginning of haul (fa); see Warden and Orphanides (2008) for more description of this variable
Distance to 50 m*	Distance between location of beginning of haul and the 50 m depth contour, resolution 100 m (m) see Warden and Orphanides (2008) for more description of this variable
Distance to 100 m*	Distance between location of beginning of haul and the 100 m depth contour, resolution 100 m (m); see Warden and Orphanides (2008) for more description of this variable
Distance to 200 m*	Distance between location of beginning of haul and the 200 m depth contour, resolution 100 m (m); see Warden and Orphanides (2008) for more description of this variable
Distance to 500 m*	Distance between location of beginning of haul and the 500 m depth contour, resolution 100 m (m); see Warden and Orphanides (2008) for more description of this variable
Distance to the coast*	Distance from beginning of haul to the nearest coastline, resolution 1000 m (m)); see Warden and Orphanides (2008) for more description of this variable
North Atlantic Oscillation[7]	North Atlantic Oscillation (NAO) monthly mean index for the month and year that the beginning of haul occurred; calculated by the Climate Prediction Center[8]

[7] The North Atlantic oscillation (NAO) is a climatic phenomenon in the North Atlantic Ocean. It is the difference in the atmospheric pressure at sea level between the Icelandic low and Azores high pressure centers. This difference controls the strength and direction of westerly winds and storm tracks across the North Atlantic. Especially during the months of November – April, the NAO is responsible for much of the variability of weather in the North Atlantic region. It affects wind speed and wind direction changes, changes in temperature and moisture distribution and the intensity, number, and tracks of storms. A positive NAO index value indicates there is a stronger than usual subtropical high pressure center, thus, resulting in more and stronger winter storms that cross the Atlantic on a more northerly track. Consequently, the eastern US experiences mild and wet winter conditions, and thus warmer, less saline surface waters. This can prevent nutrient-rich upwelling which can reduce productivity and has been shown to have effects on terrestrial and marine life (Stenseth et al. 2002).

[8] Data retrieved from the Climate Prediction Center (http://www.cpc.ncep.noaa.gov/data/teledoc/nao.shtml), accessed 21 March 2007. For a description of the methods used to calculate the North Atlantic oscillation (NAO) see http://www.cpc.ncep.noaa.gov/data/teledoc/teleindcalc.shtml).

Factor Name	Description
NAO – 1[7]	NAO index from 1 year before the time of the beginning of haul
NAO – 2[7]	NAO index from 2 years before the time of the beginning of haul
Winter NAO[7]	Average of the NAO monthly index means from December – March of the year the beginning of the haul occurred in
Winter NAO – 1[7]	Winter NAO monthly index from 1 year before the time of the beginning of haul
Winter NAO – 2[7]	Winter NAO monthly index from 2 years before the time of the beginning of haul
Sea surface temperature*	Sea surface temperature (SST) at location and time of beginning of haul (°C); see Warden and Orphanides (2008) for more description of this variable
Bottom water temperature*	Climatological bottom water temperature at location and time of beginning of haul (°C); see Warden and Orphanides (2008) for more description of this variable
Bottom slope*	Bottom slope (° angle) of location of beginning of haul; see Warden and Orphanides (2008) for more description of this variable
Chlorophyll α concentration	Chlorophyll α concentration as derived from satellite data (mg/m^3) at location and time of beginning of haul; see Warden and Orphanides (2008) for more description of this variable
$\log_{10}$(Chlorophyll α concentration)	$\log_{10}$(chlorophyll α concentration as derived from satellite data) [$\log_{10}$ (mg/m^3)] ; see Warden and Orphanides (2008) for more description of this variable
Sediment	Type of bottom sediment at location of beginning of haul as derived from CONMAP sediment maps (USGS 2000)

FISHING PRACTICES

Soak duration*	Amount of time gillnet string for this haul is in the water fishing (hrs)
Target species	Principal species, or species group, sought after in this haul; often obtained from captain
Temporary home port	Name of the port, including the state, where the vessel left to begin the trip
Vessel gross tonnage	Total gross registered tonnage of the vessel (ton); often obtained from captain
Vessel length	Total length of fishing vessel (ft); often obtained from captain
Haul duration*	Length of time needed to retrieve the string from the ocean (hrs)
Days absent	Number of days absent from a port for the present trip
State landed	State that catch from this trip was landed in
Weather	Weather conditions at the beginning of the haul (unknown; clear; partly cloudy; continuous layers of clouds; drizzle; rain; showers; thunderstorms; rain and fog; fog or thick haze; snow or rain and snow mixed; blowing snow; other)
Wave height	Wave height at the beginning of the haul (ft)

Factor Name	Description
Steam time	Time elapsed between when vessel leaves the dock to go fishing, and arrives at the location where the gillnet string is first deployed or hauled back (hr)

GEAR CHARACTERISTICS **(Figure A.1)**

Twine size	Thickness of the twine in the net's webbing (mm)
Mesh count*	Average number of meshes in the vertical direction of the net
Gear length*	Total length of gillnet string and spaces between nets (ft)
Net height	Average height of a net in the string (ft)
Average mesh size*	Average mesh size calculated using the number of nets and their corresponding mesh sizes (in)
Hang ratio*	Average fractional ratio of the length of the floatline for one net to the length that the net would be if it was taken off the floatline and stretched out
Number of nets set	Total number of nets that were used for this set
Number of nets hauled	Total number of nets in this set that were hauled back
Used tie downs?*	Whether tie downs (line used between the floatline and the leadline as a way to create a pocket or bag of netting) were used (yes all nets; yes not all nets; no; unknown)
Length tie downs	Average length of tie downs used in string (ft)
Used anchors?*	Whether any anchors were used (yes; no; unknown)
Number of anchors	Number of anchors used on the string
Type of anchor	Type of anchor used (Danforth-style; dead weight [i.e., railroad tracks, mushroom weights, etc.]; combination; other; unknown)
Anchor weight	Total weight of anchors used to hold string in place (lbs)
Used additional weights?	Whether any additional weights were used on the leadline of the string (yes; no; unknown)
Additional weights	Total amount of the additional weights used on the leadline of the string (lbs)
Used droplines?	Whether droplines (line connecting the floats on the water's surface to the floatline to suspend the string in the water column) were used (yes; no; unknown)
Leadline depth	Depth from the surface at which the leadline fishes for this haul (fa)
Weight of leadline	Weight of the leadline used in an average net of the string (lbs)
Used spaces?*	Whether there were any continuous spaces greater than or equal to 2.5 feet between the nets in the string (yes; no; unknown)
Space width	Average width of spaces used between the nets in the string (ft)
Number of spaces	Total number of spaces used between the nets in the string
Color of gillnet	Color of net webbing used in the string (clear; white; pink; black; green; blue; multicolor; red, orange; purple; combination; other; unknown)
Float distance	Average distance along the floatline between floats (ft)
Total number of floats	Total number of floats attached to the floatline

Factor Name	Description
OBSERVER PRACTICE	
Biological fish sampling?	Type of observer protocol (Yes means there is complete fish sampling which is where the observer records biological data on both the kept and discarded catch and if an incidental take is brought on board then the take is worked up using the protected species take protocols; No means there is limited fish sampling which is where the observer records only the amount of kept catch and observer conducts protected species haul watch, which means the observer watches the net as it is being hauled from the water to document any incidental takes that fall out of the net before the take is brought on board)

Figure A.1. Configuration of typical gillnet string (gear). Taken from NEFSC (2008).

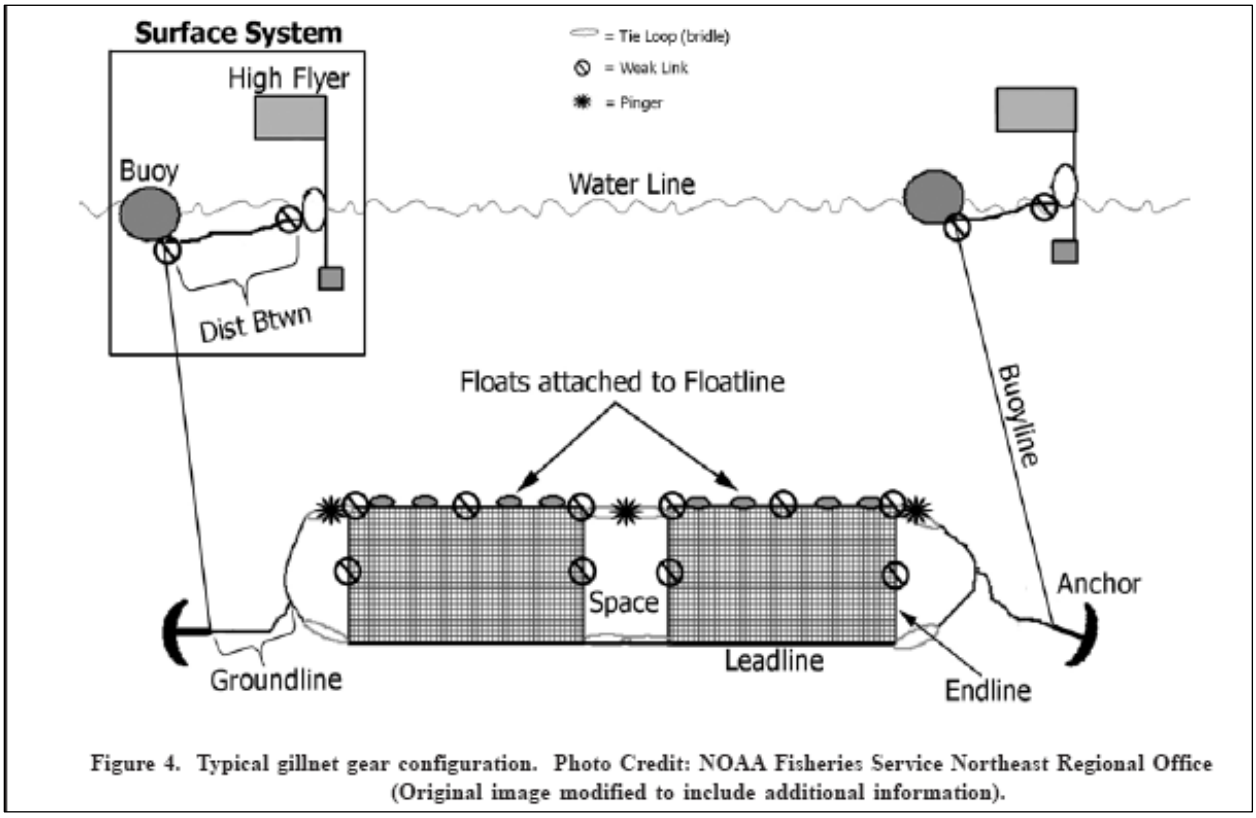

Figure 4. Typical gillnet gear configuration. Photo Credit: NOAA Fisheries Service Northeast Regional Office (Original image modified to include additional information).

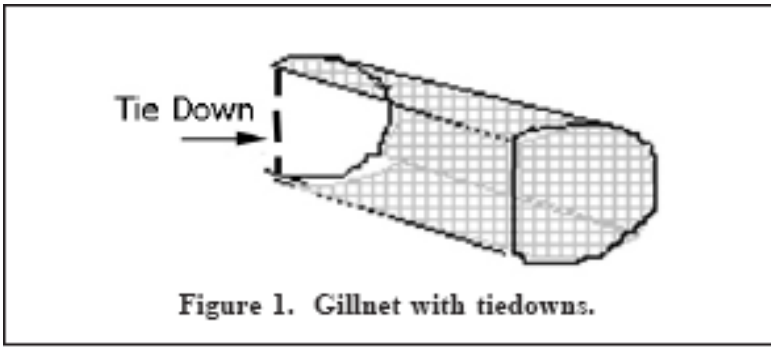

Figure 1. Gillnet with tiedowns.