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Estimates of Cetacean and Pinniped Bycatch in Northeast and Mid-Atlantic Bottom Trawl Fisheries, 2008-2013

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ABSTRACT

This report provides bycatch mortality estimates for 10 species of small cetaceans and pinnipeds caught in Northeast (NEBT) and mid-Atlantic (MABT) bottom trawl fisheries during 2008-2013. Mean annual serious injuries and mortalities from the NEBT fishery were 1.40 (coefficient of variation [CV]=0.58) minke whales (*Balaenoptera acutorostrata*), 46.48 (CV=0.17) short-beaked common dolphins (*Delphinus delphis*), 0.43 (CV=0.79) Risso's dolphins (*Grampus griseus*), 24.74 (CV=0.15) long-finned pilot whales (*Globicephala melas)*, 3.10 (CV=0.50) harbor porpoise (*Phocoena phocoena*), 69.60 (CV=0.13) Atlantic white-sided dolphins (*Lagenorhynchus acutus*), 3.96 (CV=0.63) offshore common bottlenose dolphins (*Tursiops truncatus)*, 30.76 (CV=0.14) gray seals (*Halichoerus grypus*), 1.40 (CV=0.69) harp seals (*Phagophilus groenlandicus*), and 2.64 (CV=0.38) harbor seals (*Phoca vitulina concolor*). Mean annual serious injury and mortality in the MABT fishery were 179.81 (CV=0.14) short-beaked common dolphins, 38.28 (CV=0.28) Risso's dolphins, 15.71 (CV=0.42) offshore common bottlenose dolphins, 28.06 (CV=0.39) gray seals, and 11.40 (CV=0.40) harbor seals. Mean annual serious injury and mortality estimates for 8 species described in this report are below their respective potential biological removal (PBR) levels. The 2 exceptions are gray and harp seals that have unknown PBRs. There was evidence of acoustic deterrent devices being used on bottom trawl gear primarily in the MABT fishery, resulting in higher bycatch rates for offshore bottlenose dolphin and Risso's dolphins when pingers were used. Observer reports show no evidence of continued use of pingers on bottom trawl gear since 2012. However, uncertainty exists on the use of pingers and their effect on bottom trawl bycatch rates given non-systematic data collection by fisheries observers on pinger usage in NEBT and MABT fisheries in the Northwest Atlantic region.

INTRODUCTION

Bycatch of marine mammals incidental to commercial fishing operations has been well documented around the globe with appropriate emphasis on mitigating bycatch in passive gears such as gillnets (Northridge 1991; Reeves et al. 2013). Marine mammal bycatch in active gears such as bottom and midwater trawls has received less attention due lower bycatch levels (Read et al. 2006). However, with global expansion of observer programs around the world, it is important to understand the diversity and extent to which marine mammals may be affected by these lesser known interactions with mobile gear fisheries (Allen et al. 2014; Couperus 1997; Piroddi et al. 2011).

Rossman (2010) reported the first estimates of cetacean bycatch in US Northwest Atlantic bottom trawl fisheries. Since then, fisheries observer coverage has increased and several additional species have been documented as bycatch in bottom trawl gear in both the Northeast and mid-Atlantic regions of the Northwest Atlantic (Figure 1).

Several different species of demersal fish (both round and flatfish) in addition to some elasmobranchs (such as spiny dogfish [*Squalus acanthias*] and skates [*Rajidae*]) and invertebrate species (such as longfin inshore [*Doryteuthis (Amerigo) pealeii*] and shortfin [*Illex illecebrosus*] squid) are harvested by bottom trawl gear operating in the Northeast region. The northeast bottom trawl (NEBT) fishery is a dynamic fishery with year-round effort that varies in time and space, predicated primarily on a sector style (i.e., shares) based fishery management system driven by annual catch limits (i.e., hard quotas; Murphy et al. 2015). Several of the groundfish species common in the Northeast are less abundant in the mid-Atlantic bottom trawl (MABT) fishery. The predominant species landed by the MABT fishery also include spiny dogfish, skates, both shortfin and longfin inshore squid, monkfish (*Lophius americanus*), Atlantic mackerel (*Scomber scombrus*), butterfish (*Peprilus triacanthus*), summer flounder (*Paralichthys dentatus*), scup (*Stenotomus chrysops*), black sea bass (*Centropristes striatus*), weakfish (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), croaker (*Micropogonias undulatus*), and other warmer water coastal finfish species (Waring et al. 2014a). The MABT fishery also operates year-round from coastal continental shelf to offshore slope waters. Unlike the NEBT fishery, the MABT fishery is not largely driven by sector shares, but several of the species harvested by MABT are restricted by total allowable landings, days at sea limitations, or gear restricted areas (Waring et al. 2014a).

This report provides bycatch estimates (mortality and serious injury combined) for 7 cetacean and 3 pinniped species incidentally captured in NEBT and MABT fisheries from 2008 to 2013.

Northwest Atlantic marine mammal species included in this report are: Atlantic white-sided dolphin (*Lagenorhynchus acutus*), short-beaked common dolphin (*Delphinus delphis*), common bottlenose dolphin (offshore stock; *Tursiops truncatus*), Risso's dolphin (*Grampus griseus*), long-finned pilot whale (*Globicephala melas*), minke whale (*Balaenoptera acutorostrata*), harbor porpoise (*Phocoena phocoena*), harbor seal (*Phoca vitulina concolor*), gray seal (*Halichoerus grypus*), and harp seal (*Phagophilus groenlandicus*). Long-finned pilot whale distribution is known to overlap with short-finned pilot whale *(Globicephala macrorhynchus)* distribution between the southern flank of Georges Bank and New Jersey. However, long-finned pilot whales bycaught in bottom trawl gear during 2008-2013 were all north of 39°N latitude, a region assigned low probability for the presence of short-finned pilot whale species based on water temperature and depth (Waring et al. 2014a). As a result, all pilot

whales bycaught in bottom trawl gear during 2008-2013 were assigned to the long-finned pilot whale species.

Additionally, it was discovered in 2010, after several bycatch events of Risso's dolphins were reported by fisheries observers on bottom trawl trips operating in mid-Atlantic region, that a small number of vessels were exploring the effectiveness of acoustic deterrents (i.e., pingers) for reducing marine mammal bycatch. As a result, this report includes a description of an analytical approach developed to evaluate the extent of pinger use by bottom trawl vessels, which in turn allowed for estimation of bycatch rates taking pinger use into account.

Total estimated serious injury and mortality is necessary to measure against potential biological removal (PBR) for each respective stock. PBR is the maximum number of animals that can be removed from a stock (excluding natural mortalities) while still allowing a stock to reach or maintain its optimal sustainable population (OSP) size. This is a requirement under the Marine Mammal Protection Act (MMPA; 16 US Code 1387) where the primary goal is for each stock to reach or be maintained at OSP. Annual stratified bycatch rates and total serious injury and mortality are estimated for each marine mammal species observed during the period 2008-2013. Mean annual estimates of bycatch are then compared to each respective stock's PBR to evaluate the total impact of bottom trawl bycatch for each stock.

MATERIALS AND METHODS

The study area applicable to this analysis is bound by the Gulf of Maine ecoregion in the Northeast region south to Cape Hatteras North Carolina in the mid-Atlantic region and excludes internal bay, sound, and estuarine waters (Figure 1).

Sampled Commercial Bottom Trawl Trip Data

Data collected by both fisheries observers and at-sea monitors were used to estimate bottom trawl marine mammal bycatch rates. Bottom trawl gear types included in the analysis are fish bottom otter trawl, haddock separator trawl, and Rhule trawl. The Northeast Fisheries Observer (FOP) and At-Sea Monitoring (ASM) programs document commercial fishing locations and practices, fish catch and discard composition, vessel and trip characteristics, and incidental bycatch of protected species (Waring et al. 2014a). The FOP commenced in 1989 whereas the ASM is a newer data collection program that began in May 2010 (NMFS 2010, 2013). The combined FOP and ASM database (collectively referred to as the Northeast Fisheries Observer Program [NEFOP]) is used to support a variety of marine science and management purposes including fish stock and ecosystem assessments, catch quota monitoring, marine mammal stock assessments, sea turtle and seabird bycatch analyses, and economic studies.

For the purpose of estimating total serious injury and mortality of small cetaceans and pinnipeds, 'bycatch mortality' is defined as any observed interaction where the animal's condition was recorded as either fresh dead or alive with a serious injury. Because trawl gear is actively towed for an average of only 3 hours, it is assumed that animals with any stage of decomposition were already dead and decomposing when captured in the trawl and the death was not attributed to the gear. Details on final animal determinations and total serious injury estimates (i.e., not injured, not seriously injured, or seriously injured) are described by Waring et al. (2014a, 2014b, 2015), and the process for making serious injury determinations is described by NMFS (2012).

Commercial Bottom Trawl Fleet Effort

Total commercial fishing effort and associated temporal and spatial fishing trip characteristics were obtained from mandatory vessel trip report (VTRs) collected and administered by the Greater Atlantic Regional Fisheries Office (NMFS and GARFO 2014). Effort is defined as days fished (gear tow duration in hours / 24). VTR data are assumed to represent a near census of Northeastern US bottom trawl fishing effort (Maine to North Carolina) when used in fish stock assessments to manage these fisheries (Rago et al. 2005; Warden 2011). Therefore, the VTR effort data collected during 2008-2013 were assumed to represent a good approximation of total bottom trawl fishery effort when estimating total annual bycatch of cetaceans and pinnipeds in bottom trawl fisheries.

Estimating Bycatch Rates and Mortality

Fisheries observer and VTR data were stratified by geographic region, year, season, and ecoregion. Years include 2008-2013 and seasons were defined by calendar year trimester (winter=Jan-Apr; spring and summer=May-Aug; fall=Sep-Dec). Ecoregions include Gulf of Maine (GOM), Georges Bank (GB), and Mid-Atlantic (MA) (Figure 1). These ecoregions were informed by both geographic regions and ecological production units. There are 2 geographic regions applicable to our study area: the Northeast (NE) and the Mid-Atlantic (MA). The geographic regions are defined by the NMFS annual List of Fisheries published in the Federal Register (NMFS 2014) and used to categorize various commercial fishing gears according to their risk of interacting with marine mammals. The same geographic regions are used to categorize total human-induced mortality in the NMFS annual stock assessment reports (Waring et al. 2014a). Ecological production units are areas within the Northwest Atlantic large marine ecosystem that have unique biological, chemical, and physical characteristics supporting various assemblages of marine life (Ecosystem Assessment Program 2012). The NE geographic region was further stratified by ecoregion (GOM and GB) as a comprehensive means of capturing unique habitat characteristics that influence the presence of marine mammals in these areas, thereby decreasing variance in estimated bycatch rates (Waring et al. 2014b; Rossman 2010; Murray 2013). The MA geographic and ecoregion represent the same spatial area so the 2 terms are used interchangeably throughout this report.

Stratified bycatch rates and mortality estimates were estimated using a standard ratio-estimator defined as the product of the ratio of observed bycatch mortality (y) to observed days fished (x) times total days fished (X) for each cetacean species (i) and stratum defined by geographic region (r), year (t), season (s), and ecoregion (e):

$$\hat{Y}_{irtse} = \frac{\sum y_{irtse}}{\sum x_{rtse}} X_{rtse}$$

Pinger Effects

Currently, the NEFOP data collection logs for bottom trawl gear are not designed to collect data on the presence/absence and characteristics of acoustic deterrent devices. Consequently there is limited information on the quantity, type (manufacturer and frequency), and overall usage of acoustic deterrents by bottom trawl vessels. However, there was evidence of

pingers being used on bottom trawls beginning in 2008, when some fisheries observers recorded this information on bottom trawl gear logs and/or incidental take comment fields.

A 2-tiered approach was used to evaluate and confirm the extent to which pingers were used on bottom trawl gear. First, a keyword search was performed using standard query language (SQL) on the NEFOP Oracle database tables where fisheries observer data are electronically stored. The following SQL string-like characters were searched: '%inger%' or '%ddd%' or '%DDD%' or '%coustic%' or '%irma%' or like '%eterrant%'. Second, telephone interviews were conducted with 4 fisheries observers who recorded the presence of pingers, to fact-check what was learned from the keyword search in terms of the number of vessels they had observed that used pingers on their bottom trawl gear. Results from the telephone interviews were used to confirm results from the keyword search.

Preliminary data analysis showed that only Risso's and offshore bottlenose dolphins were observed in pingered nets; therefore, the following analysis was limited only to Risso's and offshore bottlenose dolphins. Pingered bycatch rates were estimated from tows using acoustic deterrents only from vessels confirmed by the keyword search and verified by observer interviews. The pingered bycatch rates were then applied to the total effort only for the vessels confirmed to have used pingers (n=3). Pingered bycatch rates and associated mortality were estimated following the same method described above (i.e., stratified by geographic region, year, season, and ecoregion). The remaining non-pingered tows with observed takes were used to estimate non-pingered bycatch rates and were expanded by effort from all other vessels in the fleet that were assumed not to be using pingers.

Estimating Uncertainty

Standard errors were estimated using a standard bootstrap procedure (Efron and Tibshirani 1993). An observed trip was defined as the sampling unit for species not affected by the use of pingers. Species affected by pingers were bootstrapped at the haul level due to sparseness of individual trip observations (e.g., only 1 haul from 1 trip). The finite population correction factor was applied to the bycatch rate standard error for all strata with greater than or equal to 10% observer coverage (Cochran 1977). Lognormal 95% confidence intervals were calculated for annual estimates reported by region, year, and species.

RESULTS

Between 2008 and 2013 a total of 10 species of marine mammals were observed bycaught in bottom trawl fishing gear in both the NE and MA geographic regions. Observer coverage (measured in trips) averaged 7.08% during this time period, ranging from a low of 3.94% in 2008 to a high 9.32% in 2011 (Table 1).

More species and taxonomic groups are bycaught in bottom trawl gear in the NE compared to the MA, with a total of 10 and 5 species bycaught in the NE and MA geographic regions, respectively (Table 2; Figure 2).

Northeast Region Bycatch Mortality Estimates

Average annual bycatch mortality was highest in the NE region for Atlantic white-sided (69.60, coefficient of variation [CV]=0.13) and short-beaked common (46.48, CV=0.17)

dolphins, followed by long-finned pilot whales (24.74, CV=015). Offshore bottlenose and Risso's dolphin bycatch was infrequent in New England, with bycatch mortality averaging less than 5 animals per year. Gray seals had the highest average annual bycatch mortality of the observed pinniped species (30.76, CV=0.14), followed by harbor and harp seals, which also had average annual bycatch mortality of less than 5 animals per year. Minke whale and harbor porpoise bycatch also occurred infrequently, with average annual bycatch mortality of less than 5 animals per year (Table 2; Figure 2).

During 2008-2013, observer coverage rates were similar among the NE's 2 ecoregions ranging from 13.78% to 41.57% in the GOM and 13.92% to 38.98% in the GB ecoregions. Bycatch mortality occurred year round in both the GOM and GB ecoregions. However, bycatch mortality was greater in the GOM ecoregion, dominated by Atlantic white-sided dolphins during the winter season. GB bycatch mortality was dominated by short-beaked common dolphins during the fall season followed by gray seals during the summer season. Long-finned pilot whale bycatch remained relatively constant year round on GB and was lowest during the summer season in the GOM (Table 3a; Figure 3).

Mid-Atlantic Region Bycatch Mortality Estimates

Average annual bycatch mortality was highest in the MA region for common dolphins (179.81, CV=0.14) followed by Risso's (38.28, CV=0.28) and offshore bottlenose (15.71, CV=0.42) dolphins. Both gray seals and harbor seals were observed in the MA, averaging 28.06 (CV=0.39) and 11.40 (CV=0.50) annual bycatch mortality per year, respectively (Table 2; Figure 2).

During 2008-2013, observer coverage ranged from 2.13% to 13.71% in the MA region. Bycatch mortality also occurred year round in the MA region but was dominated by short-beaked common dolphin during the winter and fall season. Gray seal bycatch mortality was highest during the summer season, followed by harbor seals mainly during the winter season. The magnitude of Risso's dolphin bycatch mortality was variable and occurred year round. Offshore bottlenose dolphin bycatch mortality was also variable and occurred primarily during the fall season (Table 3a; Figure 3).

Pinger Effects on Bycatch Rates and Mortality Estimates

The evaluation of pinger usage on bottom trawl gear showed evidence of pinger use during 2008-2012 primarily in the MA region affecting the bycatch of only offshore bottlenose and Risso's dolphins. There was no observed bycatch in pingered trawls in 2008 or 2012 and there was no evidence of pingers being used in 2013 (Table 3b). Only 3 vessels out of a total of 555 (<1%) observed vessels were identified as having used pingers during 2008-2013. A total of 12 different observers commented on the use of pingers, but only on the 3 vessels identified using the SQL query keyword search. Telephone interviews with 4 of the 12 observers also confirmed the limited use of pingers on trawl gear. These same observers sampled a diverse number of bottom trawl vessels and recorded no use of pingers other than the 3 identified in the keyword search.

Northeast Region

In the NE region during 2009, 3 offshore bottlenose dolphins were observed bycaught in hauls equipped with pingers during the summer season only on GB. The pingered bycatch rate and mortality estimate for offshore bottlenose dolphins was 1.6981 animals per days fished and 14.22 animals (CV=0.96), respectively. The non-pingered bycatch rates and mortality estimates for offshore bottlenose dolphins during the winter season on GB ranged from 0.0052 to 0.0061 animals per days fished and 4.60 (CV=0.92) to 4.97 (CV=0.92) animals, respectively. No Risso's dolphins were observed in bottom trawl hauls equipped with pingers in the NE region. The non-pingered bycatch rate and mortality estimate for Risso's dolphin on GB during the summer season were 0.0020 animals per days fished and 2.55 (CV=0.79) animals, respectively (Table 3b; Figure 3).

Mid-Atlantic Region

In the MA region, 13 Risso's dolphins and 2 offshore bottlenose dolphins were observed bycaught in hauls equipped with pingers in 2010 and 1 Risso's dolphin in 2011. The offshore bottlenose dolphin pingered bycatch rate and mortality estimate during the fall season were 0.3032 animals per days fished and 20.80 animals (CV=0.67), respectively. The non-pingered bycatch rates and mortality estimates during winter and fall seasons for offshore bottlenose dolphins ranged from 0.0034 to 0.0162 animals per days fished and 7.08 (CV=0.90) to 32.26 (CV=0.94) animals, respectively. The Risso's dolphin pingered bycatch rates and mortality estimates across all 3 seasons ranged from 0.2410 to 1.5154 animals per days fished and 20.17 (0.97) to 96.27 (CV=0.50) animals, respectively. The non-pingered bycatch rates and mortality estimates across all 3 seasons for Risso's dolphins ranged from 0.0030 to 0.0145 animals per days fished and 7.50 (CV=0.92) to 31.64 (CV=0.95) animals, respectively (Table 3b; Figure 3).

DISCUSSION

Between 2008 and 2013 a total of 10 species of marine mammals were observed bycaught in bottom trawl fishing gear (Table 1). More species were bycaught in NEBT gear compared to the MABT gear, with a total of 10 and 5 species bycaught in the NE and MA geographic regions, respectively (Table 2; Figure 2).

Short-beaked common and Atlantic white-sided dolphins are the most frequently bycaught marine mammal species observed in bottom trawl gear, followed by gray seals and long-finned pilot whales (Table 1). White-sided dolphin bycatch appears to be unique to the GOM and GB ecoregions with high interannual variability in total bycatch mortality (Figures 1 and 2). This contrasts with common dolphin bycatch that occurs across both NE and MA geographic regions. Common dolphin bycatch mortality appears to be decreasing in the NE, with the majority of bycatch remaining relatively stable in the MA geographic region (Figures 1-2). Between 2000 and 2005, long-finned pilot whale bycatch in bottom trawl gear was largely restricted to the MA geographic region (Rossman 2010). Since 2008, all of the long-finned pilot whale bycatch shifted to the NE geographic region (Figure 1). Further data analysis is needed to evaluate possible reasons for the apparent shift in spatial pattern of long-finned pilot whale bycatch in bottom trawl fisheries. Possible explanations include that the pilot whales shifted their distributions due to environmental changes, or that fishing practices changed.

Total fisheries observer coverage was higher in the GOM and GB ecoregions than in the MA due to the allocation of at-sea monitors in addition to traditional fisheries observers in the

NE region. At-sea monitors are allocated to commercial fishing vessels targeting multispecies groundfish to meet quota monitoring requirements that are generally not required for the vast majority of bottom trawl effort occurring in the MA region. As a result, observer coverage rates are disproportionately higher in the NE region (Table 3a).

There was evidence of acoustic deterrent devices being used on bottom trawl gear primarily in the MABT fishery, resulting in higher bycatch rates for offshore bottlenose dolphin and Risso's dolphins when pingers were used. Bycatch rates for these stocks were consistently higher from the vessels with evidence of pinger use compared to the remainder of the fleet, which had no evidence of pinger usage (Table 3b). It is possible that the use of pingers may have deterred other small cetaceans away from the bottom trawl gear (e.g., common dolphins or pilot whales). However, data collected from the vessels observed using pingers showed no evidence of bycatch with other marine mammal species when fishing without pingers in the same areas where pingers were used. These results could be due to small samples, but the literature also lends little and inconsistent support for successful deterrence of delphinids from trawl gears equipped with acoustic deterrents (Allen et al. 2014; Dawson et al. 2013; Berrow et al. 2008).

There are also potential biases associated with estimation of the pingered bycatch rates, ranging from small sample sizes to inconsistent or nonsystematic reporting of pinger use on bottom trawl gear by fisheries observers. It was assumed that fisheries observers would have recorded the use of pingers on trawl gear in the comments section of the observer log if pingers were present. The approach used to estimate pingered bycatch rates assumes that bycatch rates from observed tows with pingers are different from observed bycatch rates from tows that did not use pingers. It also assumes that all the pinger devices were functional, operated in a similar manner, and were used only by the 3 observed vessels. In the absence of other information, the higher bycatch rates from a small number of vessels that tried acoustic deterrents on their gear are troublesome and could explain the absence of any further evidence of pinger usage on bottom trawl vessels since 2012. Pinger usage appears to have ended in 2012. Since then, the observer data indicate these vessels are no longer using pingers. Further examination of fisheries observer comments indicates possible exploration of gear modification in replacement of acoustic deterrents to reduce bycatch of marine mammals.

Mean annual serious injury and mortality estimates for 8 species described in this report are below their potential PBRs. The 2 exceptions are gray seals and harp seals, which have unknown PBRs (Table 2; Waring et al. 2014a). Maintaining consistent fisheries observer sampling of commercial bottom trawl fishing effort will allow continued monitoring of small cetacean and pinniped bycatch, informing future evaluation of changes in bycatch patterns in the greater Northwest Atlantic large marine ecoystem.

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Table 1. Number of observed seriously injured and fresh dead marine mammals bycaught in Northeast and Mid-Atlantic commercial bottom trawl gear, 2008-2013. Observer coverage (ObsCov %) is the percentage of observed trips relative to total VTR trips. Days fished (DF) is the amount of time (hours) the net was in the water divided by 24 hours.

Species	2008	2009	2010	2011	2012	2013	Total	Mean
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	3	31	10	47	9	8	108	18.00
Common dolphin (*Delphinus delphis*)	2	17	33	51	44	28	175	29.17
Risso's dolphin (*Grampus griseus*)	1	0	16	2	1	4	24	4.00
Common bottlenose dolphin (*Tursiops truncatus*)	0	5	6	2	1	0	14	2.33
Harbor porpoise (*Phocoena phocoena*)	1	0	0	2	0	1	4	1.00
Long-finned pilot whale (*Globicephala melas*)	5	3	10	12	10	4	44	7.33
Minke whale (*Balaenoptera acutorostrata*)	2	0	0	0	0	0	2	0.33
Harbor seal (*Phoca vitulina concolor*)	0	1	1	3	4	2	11	1.83
Gray seal (*Halichoerus grypus*)	4	8	9	22	9	7	59	9.83
Harp seal (*Phagophilus groenlandicus*)	0	1	0	1	0	0	2	0.33
Observed Trips	1,036	1,420	1,737	2,240	2,063	1,830	10,326	1,721
Observed Tows	17,084	16,900	19,405	25,541	19,935	17,180	116,045	19,341
Observed DF	2,358	2,234	2,740	3,664	3,062	2,466	16,524	2,754
Total VTR Trips	26,311	26,273	24,292	24,025	23,441	21,484	145,826	24,304
Total VTR DF	16,173	15,874	14,013	15,213	16,671	14,862	92,806	15,468
Obs Cov %	3.94	5.40	7.15	9.32	8.80	8.52	7.08	7.08

Table 2. Total and mean annual bycatch mortality in Northeast and Mid-Atlantic commercial bottom trawl trips for years 2008-2013, by species and region.

Species	Region	Total Mortality	Mean Mortality	CV
Minke whale (*Balaenoptera acutorostrata*)	Northeast	7.79	1.30	0.58
Common dolphin (*Delphinus delphis*)	Northeast	278.94	46.48	0.17
	Mid-Atlantic	1078.88	179.81	0.14
Risso's dolphin (*Grampus griseus*)	Northeast	2.55	0.43	0.79
	Mid-Atlantic	229.66	38.28	0.28
Long-finned pilot whale (*Globicephala melas*)	Northeast	148.45	24.74	0.15
Gray seal (*Halichoerus grypus*)	Northeast	184.57	30.76	0.14
	Mid-Atlantic	168.36	28.06	0.39
Harbor porpoise (*Phocoena phocoena*)	Northeast	18.62	3.10	0.50
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	Northeast	417.61	69.60	0.13
Harp seal (*Phagophilus groenlandicus*)	Northeast	8.39	1.40	0.69
Harbor seal (*Phoca vitulina concolor*)	Northeast	15.83	2.64	0.38
	Mid-Atlantic	68.42	11.40	0.50
Common bottlenose dolphin (*Tursiops truncatus*)	Northeast	23.79	3.96	0.63
	Mid-Atlantic	94.27	15.71	0.42

Table 3a. Stratified observed bycatch (OBS Byc), bycatch rates (Byc Rate), total (VTR DF) and observed days fished (OBS DF), percent coverage (Cov %), total bycatch mortality (M), and coefficient of variation (CV) by species, region (N-Northeast, S-mid-Atlantic; shaded rows), year (2008-2013), season (W=January-April, S=May-August, F=September-December), and ecoregion (ECO; GOM=Gulf of Maine, GB=Georges Bank, MA=Mid-Atlantic) in Northeast and Mid-Atlantic commercial bottom trawl trips, 2008-2013. Years and seasons absent from the 6-year time series means no bycatch events were observed; thus, the estimated total bycatch for that year is defined as zero.

Species	Region	Year	Season	ECO	VTR DF	OBS DF	Cov %	OBS Byc	Byc Rate	M	CV
Minke whale (*Balaenoptera acutorostrata*)	N	2008	f	GOM	1660	400	24.09	1	0.0025	4.15	0.83
	N	2008	s	GB	1585	436	27.50	1	0.0023	3.64	0.81
Common dolphin (*Delphinus delphis*)	N	2008	w	GOM	2618	471	18.00	1	0.0021	5.56	0.92
	N	2009	f	GOM	1764	243	13.78	1	0.0041	7.26	0.97
	N	2009	s	GB	1343	437	32.53	2	0.0046	6.15	0.89
	N	2009	w	GOM	2698	492	18.25	2	0.0041	10.96	0.92
	N	2010	f	GB	912	206	22.61	16	0.0776	70.78	0.40
	N	2010	s	GB	1293	504	38.98	12	0.0238	30.79	0.41
	N	2010	w	GB	882	192	21.75	1	0.0052	4.60	0.92
	N	2010	w	GOM	2502	491	19.61	2	0.0041	10.20	0.63
	N	2011	f	GB	918	291	31.75	6	0.0206	18.90	0.43
	N	2011	f	GOM	1899	789	41.57	2	0.0025	4.81	0.74
	N	2011	s	GB	1202	440	36.60	8	0.0182	21.86	0.55
	N	2011	w	GB	694	174	25.05	7	0.0403	27.95	0.64
	N	2012	f	GB	770	196	25.39	4	0.0205	15.75	0.88
	N	2012	w	GB	671	142	21.12	5	0.0353	23.68	0.59
	N	2012	w	GOM	2866	1011	35.28	1	0.0010	2.83	0.78
	N	2013	f	GB	858	188	21.86	2	0.0107	9.15	0.64
	N	2013	s	GB	1009	262	25.99	2	0.0076	7.69	0.92
	S	2008	f	MA	2168	94	4.32	1	0.0107	23.12	0.96
	S	2009	f	MA	2027	185	9.11	9	0.0487	98.75	0.39
	S	2009	w	MA	2324	100	4.29	3	0.0301	70.01	0.96
	S	2010	f	MA	2062	192	9.31	2	0.0104	21.48	0.93
	S	2011	f	MA	2140	293	13.71	16	0.0545	116.69	0.32

Table 3a. (cont'd)

Species	Region	Year	Season	ECO	VTR DF	OBS DF	Cov %	OBS Byc	Byc Rate	M	CV
Common dolphin (*Delphinus delphis*) cont'd	S	2011	s	MA	2427	162	6.69	3	0.0185	44.85	0.73
	S	2011	w	MA	2280	284	12.45	13	0.0458	104.45	0.33
	S	2012	f	MA	2195	144	6.54	9	0.0627	137.56	0.36
	S	2012	w	MA	2607	337	12.93	25	0.0741	193.31	0.33
	S	2013	f	MA	2178	206	9.48	10	0.0484	105.47	0.51
	S	2013	s	MA	2270	154	6.79	2	0.0130	29.43	0.97
	S	2013	w	MA	2085	187	8.97	12	0.0641	133.75	0.37
Long-finned pilot whale (*Globicephala melas*)	N	2008	f	GOM	1660	400	24.09	1	0.0025	4.15	0.85
	N	2008	s	GB	1585	436	27.50	1	0.0023	3.64	0.88
	N	2008	w	GB	989	247	24.98	2	0.0081	8.01	0.87
	N	2008	w	GOM	2618	471	18.00	1	0.0021	5.56	0.93
	N	2009	f	GOM	1764	243	13.78	1	0.0041	7.26	0.91
	N	2009	s	GB	1343	437	32.53	2	0.0046	6.15	0.81
	N	2010	f	GB	912	206	22.61	1	0.0049	4.42	0.85
	N	2010	f	GOM	1422	510	35.84	2	0.0039	5.58	0.54
	N	2010	s	GB	1293	504	38.98	6	0.0119	15.39	0.55
	N	2010	w	GOM	2502	491	19.61	1	0.0020	5.10	0.89
	N	2011	f	GB	918	291	31.75	1	0.0034	3.15	0.84
	N	2011	f	GOM	1899	789	41.57	6	0.0076	14.43	0.37
	N	2011	s	GB	1202	440	36.60	2	0.0045	5.46	0.81
	N	2011	s	GOM	1403	477	33.97	1	0.0021	2.94	0.78
	N	2011	w	GB	694	174	25.05	2	0.0115	7.98	0.59
	N	2012	f	GB	770	196	25.39	1	0.0051	3.94	0.86
	N	2012	f	GOM	1993	597	29.94	3	0.0050	10.02	0.47

Table 3a. (cont'd)

Species	Region	Year	Season	ECO	VTR DF	OBS DF	Cov %	OBS Byc	Byc Rate	M	CV
Long-finned pilot whale (*Globicephala melas*) cont'd	N	2012	w	GB	671	142	21.12	1	0.0071	4.74	0.84
	N	2012	w	GOM	2866	1011	35.28	5	0.0049	14.17	0.37
	N	2013	f	GOM	1620	432	26.67	2	0.0046	7.50	0.59
	N	2013	s	GOM	1506	340	22.60	2	0.0059	8.85	0.60
Gray seal (*Halichoerus grypus*)	N	2008	s	GB	1585	436	27.50	3	0.0069	10.91	0.47
	N	2008	w	GOM	2618	471	18.00	1	0.0021	5.56	0.92
	N	2009	f	GB	1011	240	23.76	1	0.0042	4.21	0.87
	N	2009	s	GB	1343	437	32.53	2	0.0046	6.15	0.58
	N	2009	s	GOM	1724	258	14.99	1	0.0039	6.67	0.93
	N	2009	w	GOM	2698	492	18.25	1	0.0020	5.48	0.90
	N	2010	f	GB	912	206	22.61	1	0.0049	4.42	0.86
	N	2010	s	GB	1293	504	38.98	5	0.0099	12.83	0.33
	N	2010	s	GOM	978	367	37.50	1	0.0027	2.67	0.79
	N	2010	w	GB	882	192	21.75	1	0.0052	4.60	0.91
	N	2010	w	GOM	2502	491	19.61	1	0.0020	5.10	0.91
	N	2011	f	GB	918	291	31.75	1	0.0034	3.15	0.84
	N	2011	f	GOM	1899	789	41.57	2	0.0025	4.81	0.54
	N	2011	s	GB	1202	440	36.60	8	0.0182	21.86	0.31
	N	2011	s	GOM	1403	477	33.97	2	0.0042	5.89	0.57
	N	2011	w	GB	694	174	25.05	5	0.0288	19.96	0.45
	N	2011	w	GOM	2192	753	34.33	1	0.0013	2.91	0.81
	N	2012	s	GB	1076	177	16.41	4	0.0226	24.37	0.64
	N	2012	s	GOM	1845	405	21.95	1	0.0025	4.56	0.86
	N	2012	w	GOM	2866	1011	35.28	3	0.0030	8.50	0.46

Table 3a. (cont'd)

Species	Region	Year	Season	ECO	VTR DF	OBS DF	Cov %	OBS Byc	Byc Rate	M	CV
Gray seal (*Halichoerus grypus*) cont'd	N	2013	f	GB	858	188	21.86	1	0.0053	4.58	0.86
	N	2013	s	GB	1009	262	25.99	4	0.0153	15.39	0.40
	S	2009	s	MA	2042	113	5.55	3	0.0265	54.06	0.70
	S	2011	s	MA	2427	162	6.69	2	0.0123	29.90	0.64
	S	2011	w	MA	2280	284	12.45	1	0.0035	8.03	0.95
	S	2012	s	MA	2562	55	2.13	1	0.0183	46.93	0.96
	S	2013	s	MA	2270	154	6.79	2	0.0130	29.43	0.67
Harbor porpoise (*Phocoena phocoena*)	N	2008	w	GOM	2618	471	18.00	1	0.0021	5.56	0.92
	N	2011	f	GB	918	291	31.75	1	0.0034	3.15	0.83
	N	2011	s	GB	1202	440	36.60	1	0.0023	2.73	0.79
	N	2013	w	GB	625	87	13.92	1	0.0115	7.18	0.98
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	N	2008	f	GOM	1660	400	24.09	1	0.0025	4.15	0.83
	N	2008	w	GB	989	247	24.98	1	0.0040	4.00	0.86
	N	2008	w	GOM	2618	471	18.00	1	0.0021	5.56	0.88
	N	2009	s	GOM	1724	258	14.99	3	0.0116	20.01	0.54
	N	2009	w	GB	823	164	19.98	9	0.0547	45.05	0.74
	N	2009	w	GOM	2698	492	18.25	19	0.0386	104.12	0.24
	N	2010	f	GOM	1422	510	35.84	2	0.0039	5.58	0.56
	N	2010	s	GB	1293	504	38.98	2	0.0040	5.13	0.54
	N	2010	s	GOM	978	367	37.50	2	0.0055	5.33	0.54
	N	2010	w	GOM	2502	491	19.61	4	0.0082	20.40	0.46
	N	2011	s	GB	1202	440	36.60	2	0.0045	5.46	0.56
	N	2011	s	GOM	1403	477	33.97	2	0.0042	5.89	0.60

Table 3a. (cont'd)

Species	Region	Year	Season	ECO	VTR DF	OBS DF	Cov %	OBS Byc	Byc Rate	M	CV
Atlantic white-sided dolphin (*Lagenorhynchus acutus*) cont'd	N	2011	w	GB	694	174	25.05	1	0.0058	3.99	0.90
	N	2011	w	GOM	2192	753	34.33	42	0.0558	122.33	0.22
	N	2012	s	GOM	1845	405	21.95	1	0.0025	4.56	0.91
	N	2012	w	GOM	2866	1011	35.28	8	0.0079	22.68	0.42
	N	2013	f	GOM	1620	432	26.67	1	0.0023	3.75	0.85
	N	2013	s	GOM	1506	340	22.60	1	0.0029	4.42	0.84
	N	2013	w	GOM	2555	609	23.83	6	0.0099	25.18	0.36
Harp seal (*Phagophilus groenlandicus*)	N	2009	w	GOM	2698	492	18.25	1	0.0020	5.48	0.96
	N	2011	w	GOM	2192	753	34.33	1	0.0013	2.91	0.81
Harbor seal (*Phoca vitulina concolor*)	N	2011	s	GOM	1403	477	33.97	2	0.0042	5.89	0.57
	N	2011	w	GOM	2192	753	34.33	1	0.0013	2.91	0.81
	N	2012	w	GOM	2866	1011	35.28	1	0.0010	2.83	0.81
	N	2013	w	GOM	2555	609	23.83	1	0.0016	4.20	0.89
	S	2009	w	MA	2324	100	4.29	1	0.0100	23.34	0.91
	S	2010	f	MA	2062	192	9.31	1	0.0052	10.74	1.00
	S	2012	w	MA	2607	337	12.93	3	0.0089	23.20	0.96
	S	2013	w	MA	2085	187	8.97	1	0.0053	11.15	0.96

Table 3b. Stratified Risso's and offshore bottlenose dolphin observed bycatch (OBS Byc) and bycatch mortality rates (Byc Rate) that take pinger usage into account (shaded rows) in Northeast and Mid-Atlantic commercial bottom trawl trips, 2008-2013. Total (VTR DF) and observed days fished (OBS DF), percent coverage (Cov %), total bycatch mortality (M), and coefficient of variation (CV) by species, region (N-Northeast, S-mid-Atlantic), year, season (W=January-April, S=May-August, F=September-December), use of pingers (Y=yes; N=no), and ecoregion (ECO; GOM=Gulf of Maine, GB=Georges Bank, MA=Mid-Atlantic). Years and seasons absent from the 6-year time series means no bycatch events were observed; thus, the estimated total bycatch for that year is defined as zero.

Species	Region	Year	Season	ECO	Pingers	VTR DF	OBS DF	Cov %	OBS Byc	Byc Rate	M	CV
Risso's dolphin (*Grampus griseus*)	N	2010	s	GB	N	1286	504	39.18	1	0.0020	2.55	0.79
	S	2008	w	MA	N	2326	95	4.09	1	0.0105	24.45	1.02
	S	2010	f	MA	Y	69	7	9.61	5	0.7581	52.01	0.50
	S	2010	s	MA	Y	64	5	8.31	8	1.5154	96.27	0.50
	S	2010	w	MA	N	1844	166	9.02	2	0.0120	22.17	0.65
	S	2011	f	MA	N	2078	293	14.12	1	0.0034	7.08	0.90
	S	2011	w	MA	Y	84	4	4.96	1	0.2410	20.17	0.97
	S	2012	w	MA	N	2530	337	13.32	1	0.0030	7.50	0.92
	S	2013	f	MA	N	2178	206	9.48	3	0.0145	31.64	0.95
	S	2013	s	MA	N	2270	154	6.79	1	0.0065	14.72	0.92
Common offshore bottlenose dolphin (*Tursiops truncatus*)	N	2009	s	GB	Y	8	2	21.10	3	1.6981	14.22	0.96
	N	2009	w	GB	N	818	164	20.11	1	0.0061	4.97	0.92
	N	2010	w	GB	N	882	192	21.75	1	0.0052	4.60	0.92
	S	2009	f	MA	N	1984	185	9.30	1	0.0054	10.75	0.96
	S	2010	f	MA	N	1994	185	9.30	3	0.0162	32.26	0.94
	S	2010	f	MA	Y	69	7	9.61	2	0.3032	20.80	0.67
	S	2011	f	MA	N	2078	293	14.12	1	0.0034	7.08	0.90
	S	2011	w	MA	N	2196	280	12.73	1	0.0036	7.85	0.90
	S	2012	f	MA	N	2134	138	6.45	1	0.0073	15.51	0.99

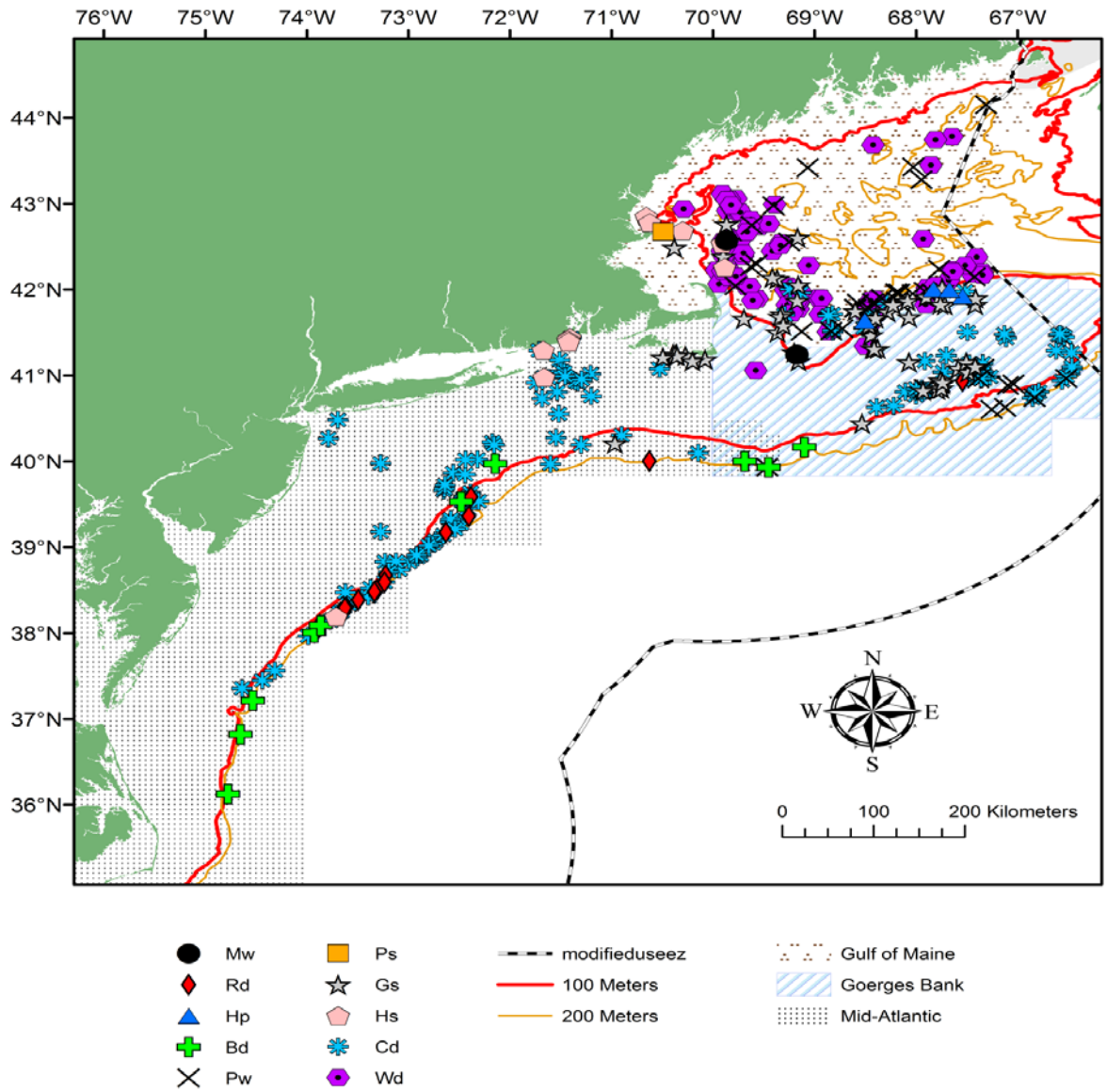

Figure 1. Chart of study area and incidental take locations in Northeast and Mid-Atlantic observed commercial bottom trawl trips, 2008-2013. Mw=minke whale (*Balaenoptera acutorostrata*), Rd=Risso's dolphin (*Grampus griseus*), Hp=harbor porpoise (*Phocoena phocoena*), Bd=offshore bottlenose dolphin (*Tursiops truncatus*), Pw=long-finned pilot whale (*Globicephala melas*), Ps=harp seal (*Phagophilus groenlandicus*), Gs=gray seal (*Halichoerus grypus*), Hs=harbor seal (*Phoca vitulina concolor*), Cd=short-beaked common dolphin (*Delphinus delphis*), Wd=Atlantic white-sided dolphin (*Lagenorhynchus acutus*).

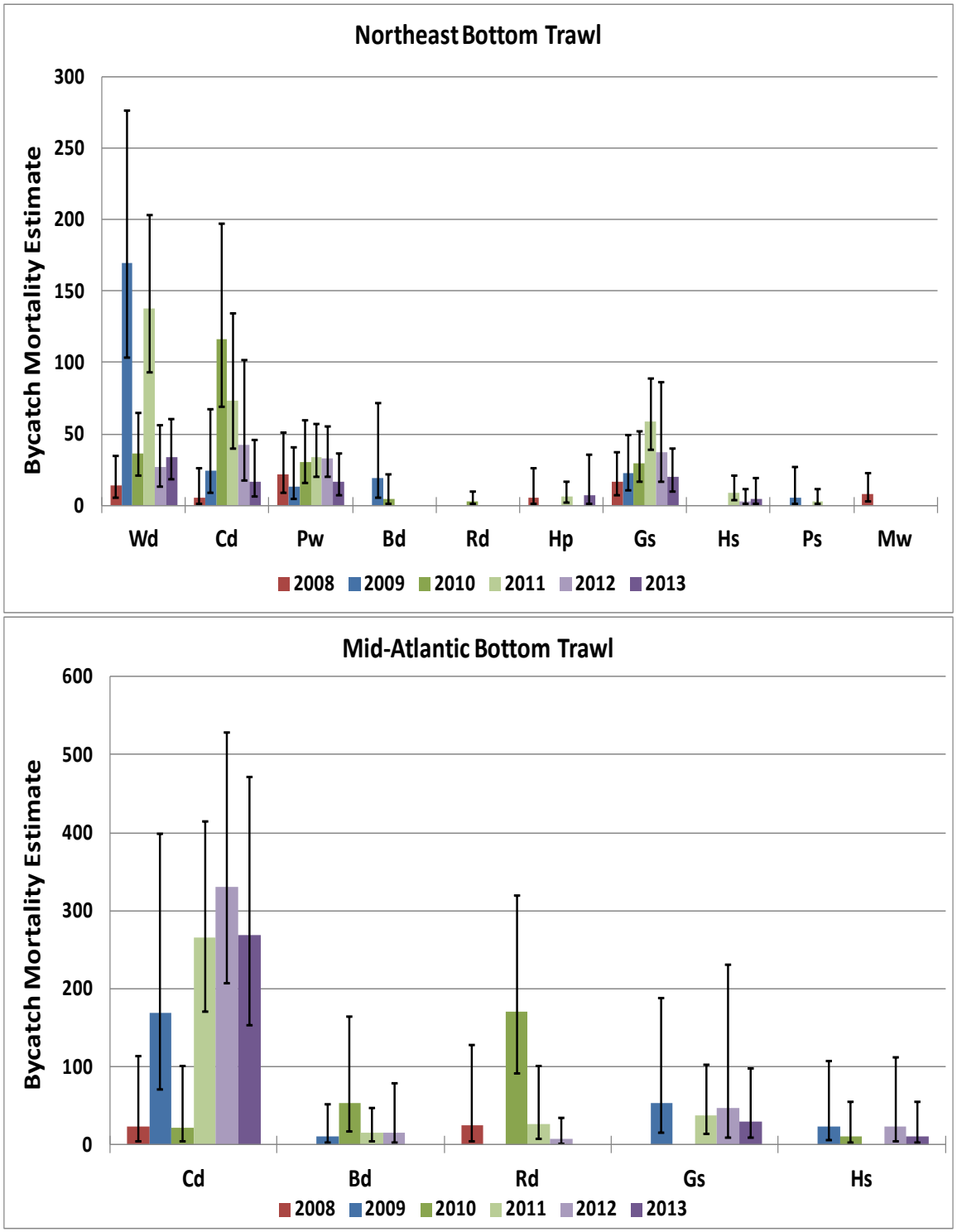

Figure 2. Annual bycatch mortality estimates (lognormal 95% CI) for bottom trawl gear by region, species and year in Northeast and Mid-Atlantic commercial bottom trawl trips, 2008-2013. Wd=Atlantic white-sided dolphin (*Lagenorhynchus acutus*), Cd=short-beaked common dolphin (*Delphinus delphis*), Pw=long-finned pilot whale (*Globicephala melas*), Bd=offshore bottlenose dolphin (*Tursiops truncatus*), Rd=Risso's dolphin (*Grampus griseus*), Hp=harbor porpoise (*Phocoena phocoena*), Gs=gray seal (*Halichoerus grypus*), Hs=harbor seal (*Phoca vitulina concolor*), Ps=harp seal (*Phagophilus groenlandicus*), Mw=minke whale (*Balaenoptera acutorostrata*).

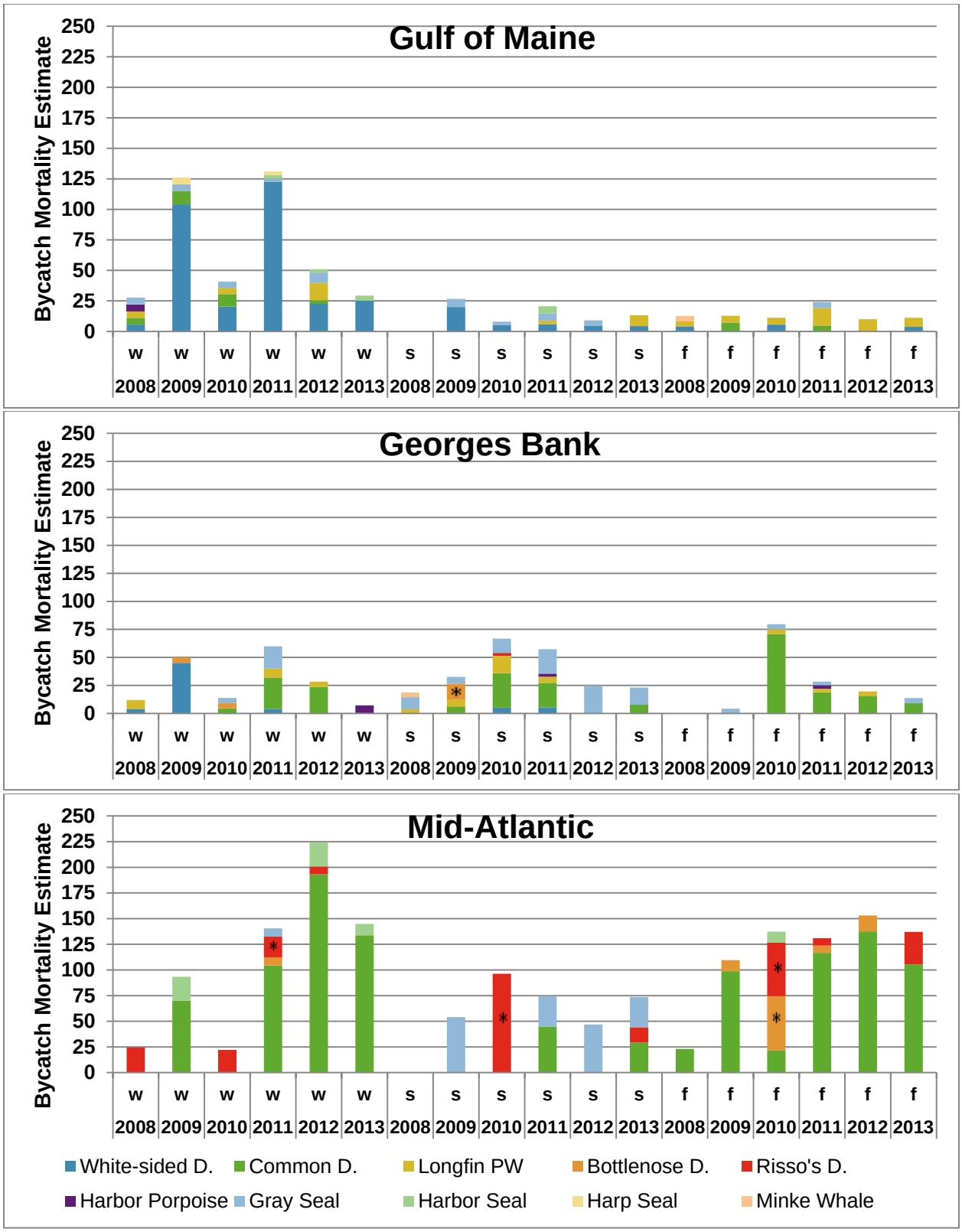

Figure 3. Bycatch mortality estimates in Northeast and Mid-Atlantic commercial bottom trawl trips stratified by ecoregion, year, season, and species (Atlantic white-sided dolphin [*Lagenorhynchus acutus*], common dolphin [*Delphinus delphis*], longfinned pilot whale [*Globicephala melas*], bottlenose dolphin [*Tursiops truncates*], Risso's dolphin [*Grampus griseus*], harbor porpoise [*Phocoena phocoena*], gray seal [*Halichoerus grypus*], harbor seal [*Phoca vitulina concolor*], harp seal [*Phagophilus groenlandicus*], and minke whale [*Balaenoptera acutorostrata*]). An asterisk (*) indicates a bycatch mortality estimate that took pinger usage into account.

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Style

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