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Estimates of Cetacean and Pinniped Bycatch in Northeast and Mid-Atlantic Bottom Trawl Fisheries, 2012-2016

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**US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Estimates of Cetacean and Pinniped Bycatch in Northeast and Mid-Atlantic Bottom Trawl Fisheries, 2012-2016

Samuel Chavez-Rosales¹, Marjorie C Lyssikatos², Joshua Hatch²

¹*Integrated Statistics, 16 Sumner Street, Woods Hole, MA 02543*

²*NOAA Fisheries, Northeast Fisheries Science Center, 166 Water Street, Woods Hole, MA 02543*

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ABSTRACT

This report provides bycatch estimates for 8 species of small cetaceans and pinnipeds caught in the Northeast bottom trawl (NEBT) and Mid-Atlantic bottom trawl (MABT) fisheries during the period 2012 to 2016. Mean annual bycatch estimates from the NEBT fishery were 22.82 (coefficient of variation [CV] = 0.23) common dolphins (*Delphinus delphis delphis*), 4.18 (CV = 0.73) Risso's dolphins (*Grampus griseus*), 21.95 (CV = 0.22) long-finned pilot whales (*Globicephala melas*), 2.54 (CV = 0.67) harbor porpoises (*Phocoena phocoena phocoena*), 23.82 (CV = 0.19) Atlantic white-sided dolphins (*Lagenorhynchus acutus*), 10.42 (CV = 0.62) offshore common bottlenose dolphins (*Tursiops truncatus truncatus*), 19.81 (CV = 0.23) gray seals (*Halichoerus grypus atlantica*), and 3.54 (CV = 0.45) harbor seals (*Phoca vitulina vitulina*). Mean annual bycatch estimates in the MABT fishery were 265.68 (CV = 0.13) common dolphins, 29.97 (CV = 0.33) Risso's dolphins, 9.25 (CV = 0.48) offshore common bottlenose dolphins, 1.93 (CV = 0.94) Atlantic white-sided dolphins, 20.06 (CV = 0.47) gray seals, and 10.14 (CV = 0.53) harbor seals. Mean annual bycatch mortality for all eight species, attributed to bottom trawl fishing effort in NEBT and MABT fisheries, are below their respective potential biological removal levels.

INTRODUCTION

The bycatch of marine mammals during commercial fishing operations has been well documented around the globe with emphasis on mitigating bycatch primarily 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 because of reports of lower bycatch levels in comparison to the passive gear (Read et al. 2006).

However, with the global expansion of observer programs around the world, we have gained a better understanding of the diversity and extent to which marine mammals may be affected by interactions with mobile gear fisheries (Allen et al. 2014; Couperus 1997; Piroddi et al. 2011). Since the first estimates of cetacean bycatch in the US Northwest Atlantic bottom trawl fisheries reported by Rossman (2010), fisheries observer coverage has increased, and several additional species have been documented as bycatch in both the Northeast and Mid-Atlantic regions of the United States.

The northeast bottom trawl (NEBT) fishery is dynamic, with year-round effort that varies in time and space driven primarily by catch limits that are part of share-based fishery management (Murphy et al. 2015). The species harvested include ground fishes such as haddock (*Melanogrammus aeglefinus*), pollock (*Pollachius virens*), white hake (*Urophycis tenuis*) and yellowtail flounder (*Pleuronectes ferruginea*); elasmobranchs such as spiny dogfish (*Squalus acanthias*) and skates (*Rajidae* spp); and invertebrate species such as longfin (*Doryteuthis pealeii*) and northern shortfin squid (*Illex illecebrosus*).

The Mid-Atlantic bottom trawl fishery (MABT) also operates year round from the coastal continental shelf to the offshore slope waters. Unlike the NEBT, the MABT is not largely driven by sector shares. The harvest of several of the species by the MABT is restricted by total allowable landings, days at sea limits, or gear restricted areas (Hayes et al. 2017). The species landed by the MABT include spiny dogfish, skates, both shortfin (*Illex illecebrosus*) and longfin (*Doryteuthis pealeii*) 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*), Atlantic croaker (*Micropogonias undulatus*), and other warmer water coastal finfish species (Hayes et al. 2017). There is some overlap in the species composition harvested by both NEBT and MABT, but there are species accessible only to one or the other.

This report provides bycatch estimates, defined as mortality and serious injuries combined, for 6 cetacean and 2 pinniped species incidentally captured by NEBT and MABT fishing operations from 2012 to 2016, and are an update from Chavez-Rosales et al. (2017) which covers the fishing operations from 2011 to 2015. The marine mammal species included are: Atlantic white-sided dolphin, common dolphin, common bottlenose dolphin (offshore stock), Risso's dolphin, long-finned pilot whale, harbor porpoise, harbor seal, and gray seal. The aim of this report is to document bycatch estimates for the 5-year period 2012 through 2016 to support the US Atlantic and Gulf of Mexico 2018 marine mammal stock assessment reports.

MATERIALS AND METHODS

The study area applicable to this analysis was defined by Lyssikatos (2015) and is bounded by the Gulf of Maine ecoregion in the Northeast region south to Cape Hatteras, NC, in the Mid-Atlantic region and excludes internal bay, sound, and estuarine waters.

Sampled Commercial Bottom-Trawl Trip Data

Data from commercial bottom-trawl fishing activities were extracted from the Northeast Fisheries Observer Program (NEFOP) and At-Sea Monitoring (ASM) program databases and used to estimate marine-mammal bycatch rates in bottom trawl gear. The NEFOP samples multiple gear types in both the Northeast and Mid-Atlantic, documenting and monitoring interactions of marine mammals, sea turtles, and finfish bycatch attributed to commercial fishing operations. The ASM program collects a reduced dataset in comparison to NEFOP onboard groundfish commercial vessels with primary focus on gathering scientific, management, and compliance data. The ASM coverage is an integral part of catch monitoring to ensure that annual catch limits are not exceeded (Hayes et al. 2017). Bottom-trawl gear types included in the analysis were bottom otter trawl, haddock separator trawl, and Ruhle trawl.

“Bycatch estimates” described in this report are defined as any observed interaction where the animal's condition was recorded by observers and monitors as either (1) fresh dead, (2) dead unknown condition, or (3) alive unknown condition and are included in the annual stock assessment reports. The observations also include captain's reports when an observer or monitor was on board the vessel but did not observe the incident. Because trawl gear is actively towed for an average of 3 hours, it is assumed that animals with any stage of decomposition were already dead and decomposing when captured in the trawl and that the death was not attributed to interaction with the gear.

Annual bycatch estimates are subsequently apportioned by no serious injury, serious injury, and mortality categories based on determinations made following the guidelines described in NMFS (2012). Details on final animal determinations and their respective observed proportions (i.e., uninjured, not seriously injured, seriously injured, or dead) are described in separate reports (Josephson et al. 2017 & in prep.). Total observed and estimated bycatch partitioned by serious injury and mortality is provided in the annual stock assessment reports (Hayes et al. 2017).

Commercial Bottom Trawl Fleet Effort

Total commercial fishing effort and associated temporal and spatial fishing trip characteristics were obtained from mandatory vessel trip reports (VTRs) collected and administered by the Greater Atlantic Regional Fisheries Office (NMFS-GARFO 2018). Effort is defined as days fished (gear tow duration in hours/24). Vessel trip reports were assumed to represent a near census of Northeastern US bottom-trawl fishing effort from Maine to North Carolina when used in fish stock assessments (Rago et al. 2005; Warden 2011). Therefore, the VTR effort data collected during the 2012 through 2016 period were assumed to represent a good approximation of total bottom-trawl fishery effort when estimating total annual bycatch of cetaceans and pinnipeds.

Estimating Bycatch Rates and Mortality

Fisheries observer and VTR data were stratified by geographic region, year, season, and ecoregion. Years included 2012 through 2016, and seasons were defined by calendar year trimester (winter = January through April; spring and summer = May through August; fall = September through December). The ecoregions defined in Lyssikatos (2015) included the Gulf of Maine (GOM), Georges Bank (GB), and the Mid-Atlantic (MA). 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 were defined by the National Marine Fisheries Service (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 were used to categorize total human-induced mortality in the NMFS annual stock assessment reports (Hayes et al. 2017).

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 (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 estimates were calculated by using a standard ratio-estimator, defined as the product of the ratio of the sum of the observed bycatch mortality (y) to the sum of 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):

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

In the particular case of pilot whales, long-finned pilot whale distribution is known to overlap with that of the short-finned pilot whale (*Globicephala macrorhynchus*) between the southern flank of Georges Bank and New Jersey. However, long-finned pilot whales bycaught in bottom trawl gear during 2012-2016 were all north of 39°N latitude, a region assigned with low probability for the presence of short-finned pilot whale species, based on water temperature and depth (Hayes et al.

2017). As a result, all pilot whales bycaught during 2012-2016 were assigned to the long-finned pilot whale species.

The keyword search method described in Lyssikatos (2015) was performed to evaluate the use of acoustic deterrents (pingers) by bottom trawl fishermen. There was no evidence of pinger usage on bottom trawl gear from observer records since 2011. As a result, pinger effects on small cetacean and pinniped bycatch rates from bottom trawl gear are not evaluated in this report. See Lyssikatos (2015) for details on pinger effects from 2011 and earlier years.

Estimating Uncertainty

Standard errors were estimated by using a standard bootstrap procedure (Efron and Tibshirani 1993). An observed trip was defined as the sampling unit and the finite population correction factor was applied to the bycatch rate standard error for all strata with 10% or higher observer coverage (Cochran 1977). The coefficient of variation was calculated with the standard formula for independent variables, and the lognormal 95% confidence intervals were calculated for annual estimates reported by region, year, and species following the method proposed by Buckland et al. (1993) where:

$$VAR(\log_e M) = 1 + \log_e \left[\frac{VAR(M)}{M^2} \right]$$

$$C = \exp[z_\alpha \cdot \sqrt{VAR(\log_e M)}]$$

M is mortality and z_α is the z-value of the standardized normal deviate. The lower and upper intervals are then given by:

$$\frac{M}{C} \text{ and } M \times C$$

RESULTS

Eight species of marine mammals were bycaught during 2012 through 2016 by bottom trawl fisheries in the NE and MA geographic regions. Observer coverage, defined as the percentage of the VTR trips in which an observer was onboard a fishing vessel, averaged 16.62% for the NE, ranging from 12.12% for 2016 with a maximum coverage of 19.30% in 2014. For the MA region the average coverage was 7.97%, ranging from 5.14% for 2012 with a maximum coverage 9.74% in 2016 (Table 1).

Total observed bycatch of 287 animals included 167 common dolphins, 28 Atlantic white-sided dolphins, 28 gray seals, 23 long-finned pilot whales, 17 Risso's dolphins, 10 harbor seals, 12 offshore common bottlenose dolphins, and 2 harbor porpoise (Table 1; Figs. 1 to 5). Annual mean bycatch estimate for common dolphins is 288.5 (CV=0.27), Risso's dolphins is 34.15(CV=0.80), long-finned pilot whales is 21.95(CV=0.22), gray seals 39.87(CV=0.52), harbor porpoise 2.54(CV=0.67), Atlantic white-sided dolphins 25.75(CV=0.96), harbor seals 13.68 (CV=0.70) and offshore common bottlenose dolphins 19.25 (CV=0.78). Those mortality estimates fall below their respective potential biological removal levels (Table 2).

Overall for species bycaught in both regions, the mean mortality estimates were higher for the MA region in comparison to the NE region with the exception of 2 species, Atlantic white-sided dolphin and offshore common bottlenose dolphin (Table 2). By ecoregion there were 47 bycatch events reported for Georges Bank, 63 for the Gulf of Maine, and 177 in the Mid-Atlantic (Table 3).

Northeast Region Bycatch Mortality Estimate

Average annual bycatch estimates were highest for Atlantic white-sided dolphins (23.82, CV = 0.19), common dolphins (22.82, CV = 0.23), long-finned pilot whales (21.95, CV = 0.22), gray seals (19.81, CV = 0.23), and offshore common bottlenose dolphin (10.42, CV = 0.62). Risso's dolphin, harbor porpoise, and harbor seal bycatch was sporadic in the region with estimates averaging fewer than 5 animals per year (Table 2; Fig. 1 to 6).

During 2012 through 2016, there was a difference of 6.53% in the average observer coverage rates measured in days fished across the strata. GOM ranged from 12.48 to 35.36%, while GB ranged from 8.37 to 25.99%. Bycatch mortality occurred year-round in both the GOM and GB ecoregions. However, the total bycatch mortality estimate was greater in the GOM ecoregion, with the highest values in winter attributed to Atlantic white-sided dolphin (Table 3; Fig. 7).

Mid-Atlantic Region Bycatch Mortality Estimates

Average annual bycatch estimates during the 2012 through 2016 period were highest for common dolphins (265.68, CV = 0.13) followed by Risso's (29.97, CV = 0.33) and offshore bottlenose (9.25, CV = 0.48) dolphins. Both gray seal and harbor seal takes were observed in the MA, with estimates of 20.06 (CV = 0.47) and 10.14 (CV = 0.53) annual bycatch respectively. Atlantic white-sided dolphin bycatch was rare in the region, with an estimate of fewer than 2 animals per year (Table 2; Fig. 1 to 6).

During the 2012 through 2016 period, the observer coverage ranged from 2.37% to 14.32% in the MA region across the strata where bycatch was observed. Bycatch occurred year round but was dominated by common dolphin for all seasons, followed by Risso's dolphin (Table 3; Fig. 7).

DISCUSSION

During the period 2012 through 2016, 8 species of small cetaceans and pinnipeds were bycaught through interactions with bottom trawl fisheries. For species bycaught in both regions, the mean mortality estimates were higher for the MA region than for the NE region, with the exception of offshore common bottlenose and Atlantic white-sided dolphins. The bycatch composition was more diverse in the NE than in the MA bottom trawl fisheries; 6 species were bycaught in both regions; and 2 species were unique to the NE region: harbor porpoise, and long-finned pilot whale (Table 2; Fig. 6). Lyssikatos (2015) reported a similar difference between areas in relation to the species composition and bycatch estimates with the exception of minke whale bycatch in the NE region, which has not been observed since 2008.

Common and White-Sided Dolphin Catch Frequency

Common and Atlantic white-sided dolphins were the most frequently bycaught marine mammal species observed in bottom trawl gear during the 2012 through 2016 period. White-sided dolphin showed high interannual variability in total bycatch estimates. The distribution of white-sided dolphins is considered to be restricted to temperate and subpolar waters of the North Atlantic, primarily in continental shelf waters to the 100 m depth contour (Evans 1987; Hamazaki 2002; Doksaeter et al. 2008). This distribution would explain the higher incidence of bycatch recorded during winter for the species in the NE region and the presence of a single individual bycaught during winter in the MA region.

This tendency contrasts with the common dolphin bycatch that occurs across both the NE and the MA geographic regions. This species is distributed along the continental shelf between the 100 and 2000 m isobaths and is also associated with Gulf Stream features (Doksaeter et al. 2008; Waring et al. 2008; CETAP 1982; Selzer and Payne 1988; Waring et al. 1992; Hamazaki 2002). The distribution of the species would explain the high bycatch rate in the MA region, which made up 64.65% of the total mortality reported and the highest recorded for the entire study area for the 2012 through 2016 period.

Bycatch Rate Comparison to Prior Estimates

The observed bycatch and the estimated bycatch rate from this report are comparable to the values reported by Lyssikatos (2015) and Chavez-Rosales et al. (2017) for the study area. Changes in the species distribution might modify bycatch rates in a particular region. For instance Lyssikatos (2015) identified a change in the long-finned pilot whale bycatch between the years 2000 through 2005 where the species was largely restricted to the MA, and during 2008 through 2013 where it shifted completely to the NE region. The distribution of this species remains consistent for the 2014 through 2016 period.

Fishery Monitoring Coverage

Total fisheries observer coverage was higher in the GOM and GB ecoregions than in the MA because of 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, reaching 67.58% of the total observer effort. This tendency is consistent with the findings by Lyssikatos (2015).

The ASM program is intended to transition to an industry-funded program in the future (US Department of Commerce 2016). The impact on the quality assurance/quality control standards of switching to an industry-funded at-Sea monitoring program in the NE region and subsequent reporting of marine mammal bycatch events from those trips is uncertain. The integrity of traditional NEFOP observer coverage and its data collection will not be affected.

Mean annual bycatch estimates from 2012 to 2016 attributed to bottom trawl gear for 7 of the species described in this report are below their respective potential biological removal level, with the exception of gray seal which have an unknown removal level. Maintaining consistent fisheries observer sampling of commercial bottom-trawl fishing effort will allow continued monitoring of

cetacean and pinniped bycatch, informing future evaluation of changes in bycatch patterns in the greater Northwest Atlantic large marine ecosystem.

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Table 1 Total number of observed marine mammals bycaught, excluding decomposed animals, in Northeast and Mid-Atlantic commercial bottom trawl gear, 2012-2016. Observer coverage (Obs Cov %) is the percentage of observed trips relative to total Vessel Trip Report (VTR) trips.

Species	Region	2012	2013	2014	2015	2016	Total
Atlantic white-sided dolphin (<i>Lagenorhynchus acutus</i>)	Northeast	9	8	3	3	4	27
	Mid-Atlantic	0	0	1	0	0	1
Common dolphin (<i>Delphinus delphis</i>)	Northeast	10	4	3	4	2	23
	Mid-Atlantic	34	24	38	26	22	144
Risso's dolphin (<i>Grampus griseus</i>)	Northeast	0	0	0	0	2	2
	Mid-Atlantic	1	4	3	3	4	15
Offshore Common bottlenose dolphin (<i>Tursiops truncatus</i>)	Northeast	0	0	0	3	4	7
	Mid-Atlantic	1	0	3	0	1	5
Harbor porpoise (<i>Phocoena phocoena</i>)	Northeast	0	1	1	0	0	2
Long-finned pilot whale (<i>Globicephala melas</i>)	Northeast	10	4	5	0	4	23
Harbor seal (<i>Phoca vitulina vitulina</i>)	Northeast	1	1	2	0	0	4
	Mid-Atlantic	3	1	1	1	0	6
Gray seal (<i>Halichoerus grypus atlantica</i>)	Northeast	8	5	4	4	0	21
	Mid-Atlantic	1	2	1	0	3	7
Observed Trips	Northeast	1436	953	1,092	857	590	4,928
	Mid-Atlantic	658	877	1,096	904	1,078	4,613
Observed Tows	Northeast	15,064	11,659	12,215	10,361	5,926	55,225
	Mid-Atlantic	4,871	5,521	7,236	5,486	6,834	29,948
Total VTR Trips	Northeast	8,148	6,361	5,657	4,611	4,868	29,645
	Mid-Atlantic	12,798	12,220	12,191	9,572	11,069	57,850
Obs Cov %	Northeast	17.62	14.98	19.30	18.59	12.12	16.62
	Mid-Atlantic	5.14	7.18	8.99	9.44	9.74	7.97

Table 2 Total and mean annual bycatch estimates in Northeast and Mid-Atlantic commercial bottom trawl trips for years 2012-2016 by species and region. The annual coefficients of variation (CV) are in parentheses. NA = not applicable. PBR= potential biological removal.

Species	Region	2012	2013	2014	2015	2016	5 year Total Bycatch	Annual Mean Bycatch	CV	PBR*
Common dolphin (<i>Delphinus delphis delphis</i>)	Northeast	42.26 (0.47)	16.84 (0.54)	17.47 (0.53)	21.58 (0.45)	15.93 (0.46)	114.08	22.82	0.23	557
	Mid-Atlantic	318.04 (0.24)	254.29 (0.29)	328.81 (0.29)	250.11 (0.32)	177.17 (0.33)	1328.42	265.68	0.13	
Risso's dolphin (<i>Grampus griseus</i>)	Northeast	0.00 (NA)	0.00 (NA)	4.16 (0.91)	0.00 (NA)	16.73 (0.88)	20.89	4.18	0.73	126
	Mid-Atlantic	7.57 (0.92)	42.08 (0.71)	21.15 (0.93)	40.08 (0.63)	38.96 (0.56)	149.84	29.97	0.33	
Long-finned pilot whale (<i>Globicephala melas</i>)	Northeast	32.79 (0.27)	16.16 (0.42)	31.75 (0.44)	0.00 (NA)	29.05 (0.58)	109.75	21.95	0.22	35
Gray seal (<i>Halichoerus grypus atlantica</i>)	Northeast	37.38 (0.44)	19.96 (0.37)	19.01 (0.45)	22.69 (0.46)	0.00 (NA)	99.04	19.81	0.23	unknown
	Mid-Atlantic	42.22 (0.96)	25.19 (0.67)	6.96 (0.96)	0.00 (NA)	25.94 (0.57)	100.31	20.06	0.47	
Harbor porpoise (<i>Phocoena phocoena phocoena</i>)	Northeast	0.00 (NA)	7.18 (0.98)	5.50 (0.86)	0.00 (NA)	0.00 (NA)	12.68	2.54	0.67	706
Atlantic white-sided dolphin (<i>Lagenorhynchus acutus</i>)	Northeast	27.15 (0.38)	33.24 (0.31)	16.21 (0.50)	14.86 (0.52)	27.65 (0.46)	119.11	23.82	0.19	304
	Mid-Atlantic	0.00 (NA)	0.00 (NA)	9.67 (0.94)	0.00 (NA)	0.00 (NA)	9.67	1.93	0.94	
Harbor seal (<i>Phoca vitulina vitulina</i>)	Northeast	2.83 (0.81)	4.19 (0.89)	10.70 (0.63)	0.00 (NA)	0.00 (NA)	17.72	3.54	0.45	2006
	Mid-Atlantic	22.72 (0.96)	10.90 (0.96)	9.67 (0.95)	7.41 (1.00)	0.00 (NA)	50.70	10.14	0.53	
Common bottlenose dolphin offshore stock (<i>Tursiops truncatus truncatus</i>)	Northeast	0.00 (NA)	0.00 (NA)	0.00 (NA)	18.65 (0.65)	33.47 (0.89)	52.12	10.42	0.62	561
	Mid-Atlantic	14.30 (0.93)	0.00 (NA)	24.62 (0.66)	0.00 (NA)	7.33 (0.93)	46.25	9.25	0.48	

* Hayes et al. 2017

Table 3 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 (NE = Northeast, MA = Mid-Atlantic; shaded rows), year (2012-2016), 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. Years and seasons absent from the 5-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
Common dolphin (<i>Delphinus delphis delphis</i>)	NE	2012	f	GB	770	196	25.39	4	0.0205	15.75	0.88
	NE	2012	w	GB	671	142	21.12	5	0.0353	23.68	0.59
	NE	2012	w	GOM	2860	1011	35.36	1	0.001	2.83	0.78
	NE	2013	f	GB	858	188	21.86	2	0.0107	9.15	0.64
	NE	2013	s	GB	1009	262	25.99	2	0.0076	7.69	0.92
	NE	2014	f	GB	947	145	15.31	2	0.0137	12.97	0.65
	NE	2014	f	GOM	2144	471	21.97	1	0.0021	4.50	0.89
	NE	2015	f	GB	881	141	16.00	1	0.0071	6.26	0.88
	NE	2015	s	GB	1183	229	19.36	2	0.0087	10.29	0.66
	NE	2015	w	GOM	2397	481	20.07	1	0.0021	5.03	0.89
	NE	2016	f	GOM	1626	203	12.48	2	0.0098	15.93	0.67
	MA	2012	f	MA	2054	144	6.99	9	0.0627	128.72	0.36
	MA	2012	w	MA	2553	337	13.20	25	0.0741	189.32	0.33
	MA	2013	f	MA	2029	206	10.18	10	0.0484	98.28	0.51
	MA	2013	s	MA	1943	154	7.94	2	0.0130	25.19	0.97
	MA	2013	w	MA	2040	187	9.17	12	0.0641	130.82	0.37
	MA	2014	f	MA	1990	285	14.32	19	0.0666	132.53	0.25
	MA	2014	s	MA	2274	214	9.41	13	0.0607	138.03	0.65
	MA	2014	w	MA	2249	231	10.27	6	0.0259	58.25	0.54
	MA	2015	f	MA	1808	207	11.45	16	0.0775	140.12	0.47
	MA	2015	s	MA	2320	93	4.01	2	0.0216	50.11	0.67
	MA	2015	w	MA	1901	254	13.36	8	0.0315	59.88	0.41
	MA	2016	f	MA	1789	247	13.81	15	0.0608	108.77	0.32
	MA	2016	w	MA	2265	232	10.24	7	0.0302	68.4	0.68

Table 3 (Cont'd) 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 (NE = Northeast, MA = Mid-Atlantic; shaded rows), year (2012-2016), 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. Years and seasons absent from the 5-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
Long-finned pilot whale (<i>Globicephala melas</i>)	NE	2012	f	GB	770	196	25.39	1	0.0051	3.94	0.86
	NE	2012	f	GOM	1983	597	30.09	3	0.0050	9.97	0.47
	NE	2012	w	GB	671	142	21.12	1	0.0071	4.74	0.84
	NE	2012	w	GOM	2860	1011	35.36	5	0.0049	14.14	0.37
	NE	2013	f	GOM	1612	432	26.81	2	0.0046	7.46	0.59
	NE	2013	s	GOM	1481	340	22.98	2	0.0059	8.70	0.60
	NE	2014	w	GB	478	40	8.37	1	0.0252	12.05	1.01
	NE	2014	f	GOM	2144	471	21.97	2	0.0042	9.00	0.63
	NE	2014	w	GOM	3058	570	18.64	2	0.0035	10.70	0.64
	NE	2016	f	GOM	1626	203	12.48	2	0.0098	15.93	0.92
	NE	2016	w	GOM	2262	344	15.21	2	0.0058	13.12	0.65
Atlantic white-sided dolphin (<i>Lagenorhynchus acutus</i>)	NE	2012	s	GOM	1831	405	22.11	1	0.0025	4.52	0.91
	NE	2012	w	GOM	2860	1011	35.36	8	0.0079	22.63	0.42
	NE	2013	f	GOM	1612	432	26.81	1	0.0023	3.73	0.85
	NE	2013	s	GOM	1481	340	22.98	1	0.0029	4.35	0.84
	NE	2013	w	GOM	2552	609	23.85	6	0.0099	25.15	0.36
	NE	2014	w	GOM	3058	570	18.64	3	0.0053	16.21	0.51
	NE	2015	w	GOM	2397	481	20.07	3	0.0062	14.86	0.52
	NE	2016	f	GOM	1626	203	12.48	1	0.0049	7.97	0.93
	NE	2016	w	GOM	2262	344	15.21	3	0.0087	19.68	0.53
	MA	2014	w	MA	2249	231	10.27	1	0.0043	9.67	0.95

Table 3 (Cont'd) 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 (NE = Northeast, MA = Mid-Atlantic; shaded rows), year (2012-2016), 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. Years and seasons absent from the 5-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
Risso's Dolphin <i>(Grampus griseus)</i>	NE	2014	s	GB	1299	310	23.86	1	0.0032	4.16	0.89
	NE	2016	w	GB	461	55	11.93	2	0.0363	16.73	0.89
	MA	2012	w	MA	2553	337	13.20	1	0.0030	7.57	0.92
	MA	2013	f	MA	2029	206	10.18	3	0.0145	29.48	0.95
	MA	2013	s	MA	1843	154	7.94	1	0.0065	12.60	0.92
	MA	2014	s	MA	2274	214	9.41	2	0.0093	21.15	0.98
	MA	2015	s	MA	2320	93	4.01	1	0.0108	25.06	0.93
	MA	2015	w	MA	1901	254	13.36	2	0.0079	15.02	0.63
	MA	2016	w	MA	2265	232	10.24	4	0.0172	38.96	0.56
Offshore common bottlenose dolphin <i>(Tursiops truncatus truncatus)</i>	NE	2015	f	GB	881	141	16.00	2	0.0142	12.51	0.88
	NE	2015	w	GB	458	74	16.16	1	0.0134	6.14	0.90
	NE	2016	w	GB	461	55	11.93	4	0.0726	33.47	0.89
	MA	2012	f	MA	2054	144	6.99	1	0.0070	14.30	0.99
	MA	2014	f	MA	1990	285	14.32	2	0.0070	13.93	0.92
	MA	2014	s	MA	2274	214	9.41	1	0.0047	10.69	0.97
	MA	2016	f	MA	1789	247	13.81	1	0.0041	7.33	0.91
Harbor porpoise <i>(Phocoena phocoena phocoena)</i>	NE	2013	w	GB	625	87	13.92	1	0.0115	7.18	0.98
	NE	2014	w	GOM	3058	570	18.64	1	0.0018	5.50	0.87

Table 3 (Cont'd) 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 (NE = Northeast, MA = Mid-Atlantic; shaded rows), year (2012-2016), 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. Years and seasons absent from the 5-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
Gray seal (<i>Halichoerus grypus atlantica</i>)	NE	2012	s	GB	1076	177	16.41	4	0.0226	24.37	0.64
	NE	2012	s	GOM	1831	405	22.11	1	0.0025	4.52	0.86
	NE	2012	w	GOM	2860	1011	35.36	3	0.003	8.49	0.46
	NE	2013	f	GB	858	188	21.86	1	0.0053	4.58	0.86
	NE	2013	s	GB	1009	262	25.99	4	0.0153	15.39	0.4
	NE	2014	s	GB	1299	310	23.86	2	0.0064	8.31	0.63
	NE	2014	w	GOM	3058	570	18.64	2	0.0035	10.70	0.63
	NE	2015	f	GB	881	141	16.00	1	0.0071	6.26	0.93
	NE	2015	s	GB	1183	229	19.36	2	0.0087	10.29	0.65
	NE	2015	w	GB	458	74	16.16	1	0.0134	6.14	0.90
	MA	2012	s	MA	2305	55	2.37	1	0.0183	42.22	0.96
	MA	2013	s	MA	1943	154	7.94	2	0.0130	25.19	0.67
	MA	2014	f	MA	1990	285	14.32	1	0.0035	6.96	0.94
	MA	2016	f	MA	1789	247	13.81	2	0.0081	14.49	0.67
	MA	2016	s	MA	1941	171	8.81	1	0.0059	11.45	1.00
Harbor seal (<i>Phoca vitulina vitulina</i>)	NE	2012	w	GOM	2860	1011	35.36	1	0.0010	2.83	0.81
	NE	2013	w	GOM	2552	609	23.85	1	0.0016	4.19	0.89
	NE	2014	w	GOM	3058	570	18.64	2	0.0035	10.70	0.64
	MA	2012	w	MA	2553	337	13.20	3	0.0089	22.72	0.96
	MA	2013	w	MA	2040	187	9.17	1	0.0053	10.90	0.96
	MA	2014	w	MA	2249	231	10.27	1	0.0043	9.67	0.96
	MA	2015	w	MA	1901	254	13.36	1	0.0039	7.41	0.94

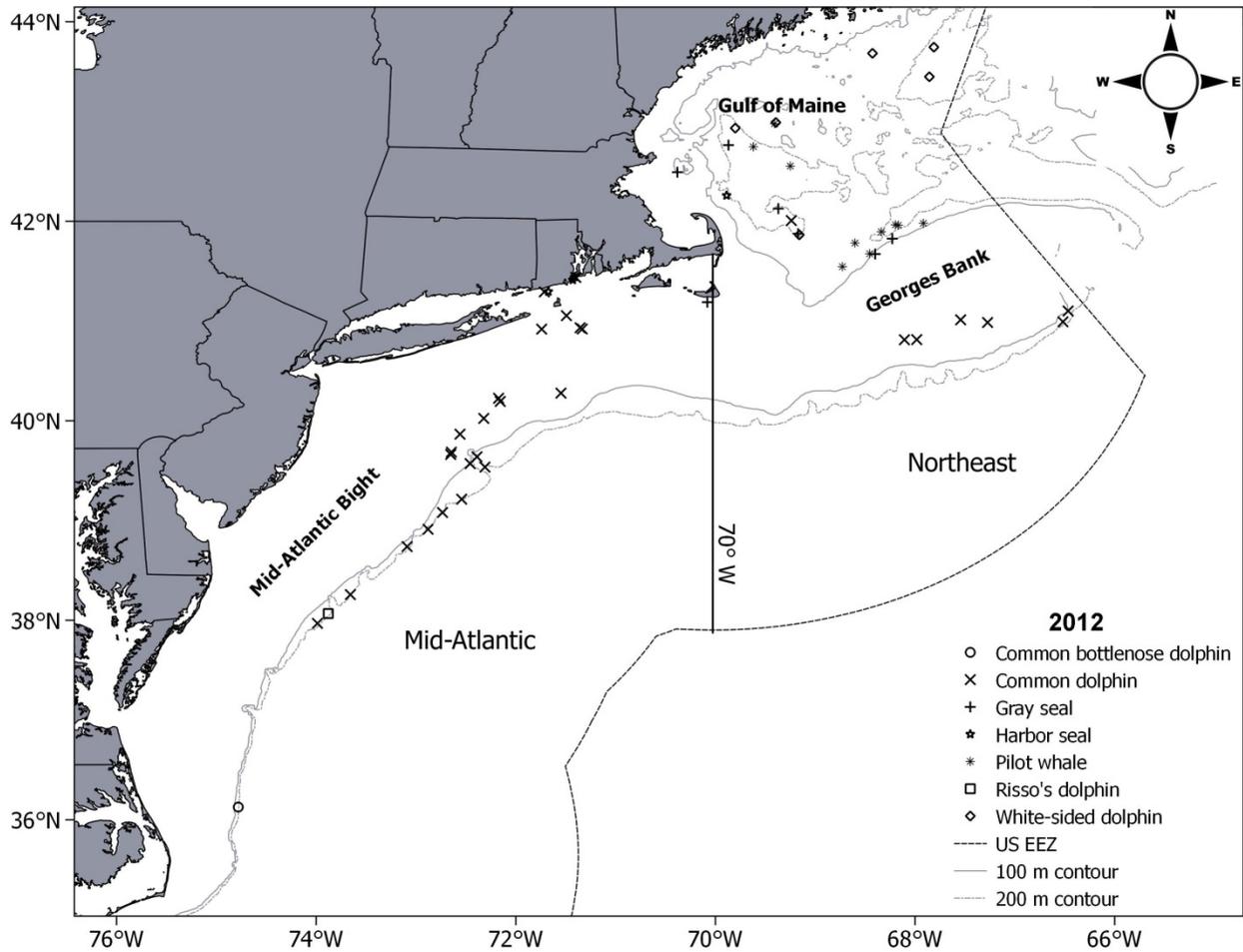


Figure 1 Incidental take locations from the observed commercial trips in the Northeast and Mid-Atlantic study areas during 2012 for Atlantic white-sided dolphin (*Lagenorhynchus acutus*), common dolphin (*Delphinus delphis delphis*), long-finned pilot whale (*Globicephala melas*), offshore common bottlenose dolphin (*Tursiops truncatus truncatus*), Risso's dolphin (*Grampus griseus*), gray seal (*Halichoerus grypus atlantica*), and harbor seal (*Phoca vitulina vitulina*). The strata were delimited by the 70°W longitude.

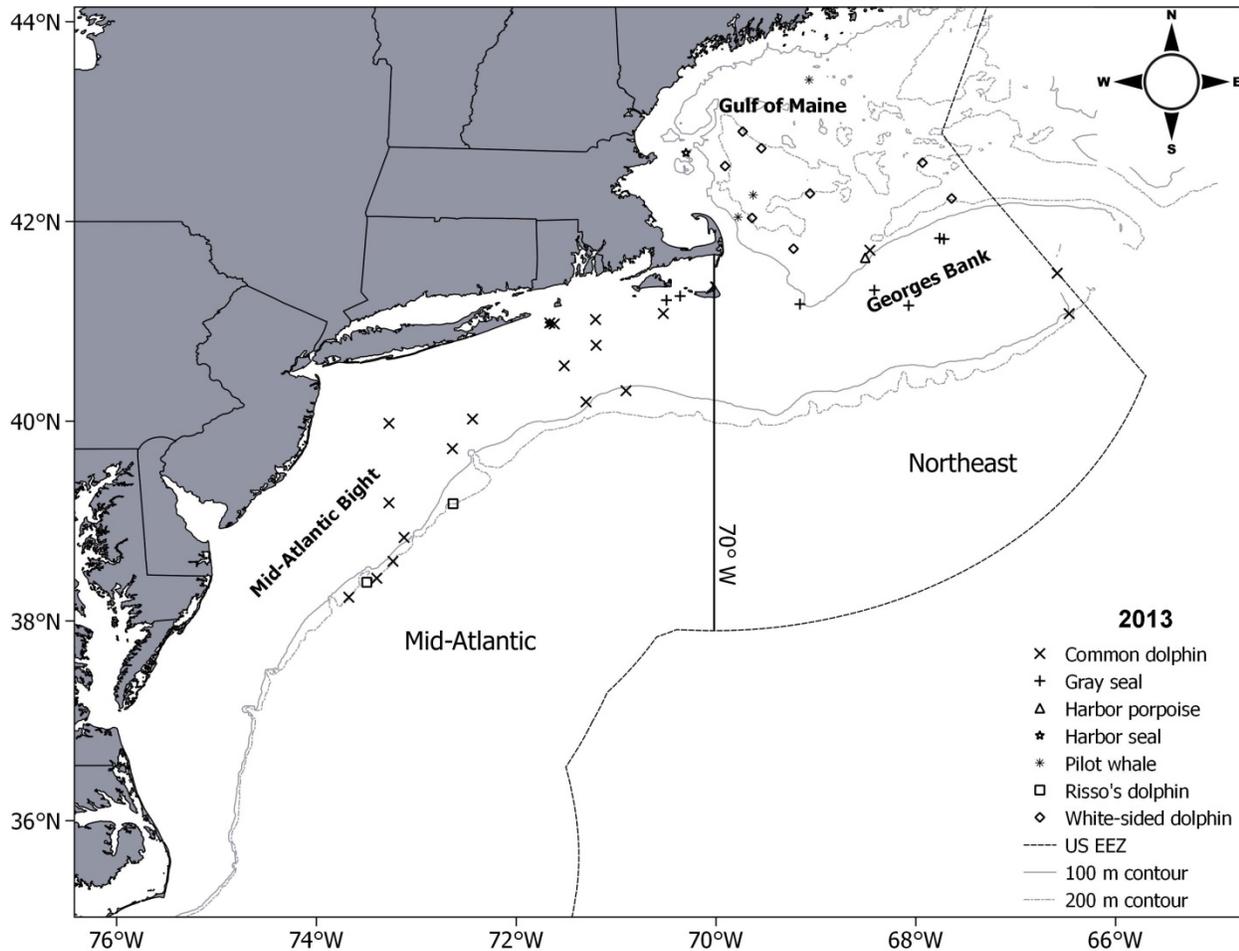


Figure 2 Incidental take locations from the observed commercial trips in the Northeast and Mid-Atlantic study areas during 2013 for Atlantic white-sided dolphin (*Lagenorhynchus acutus*), common dolphin (*Delphinus delphis delphis*), long-finned pilot whale (*Globicephala melas*), Risso's dolphin (*Grampus griseus*), harbor porpoise (*Phocoena phocoena phocoena*), gray seal (*Halichoerus grypus atlantica*), and harbor seal (*Phoca vitulina vitulina*). The strata were delimited by the 70°W longitude.

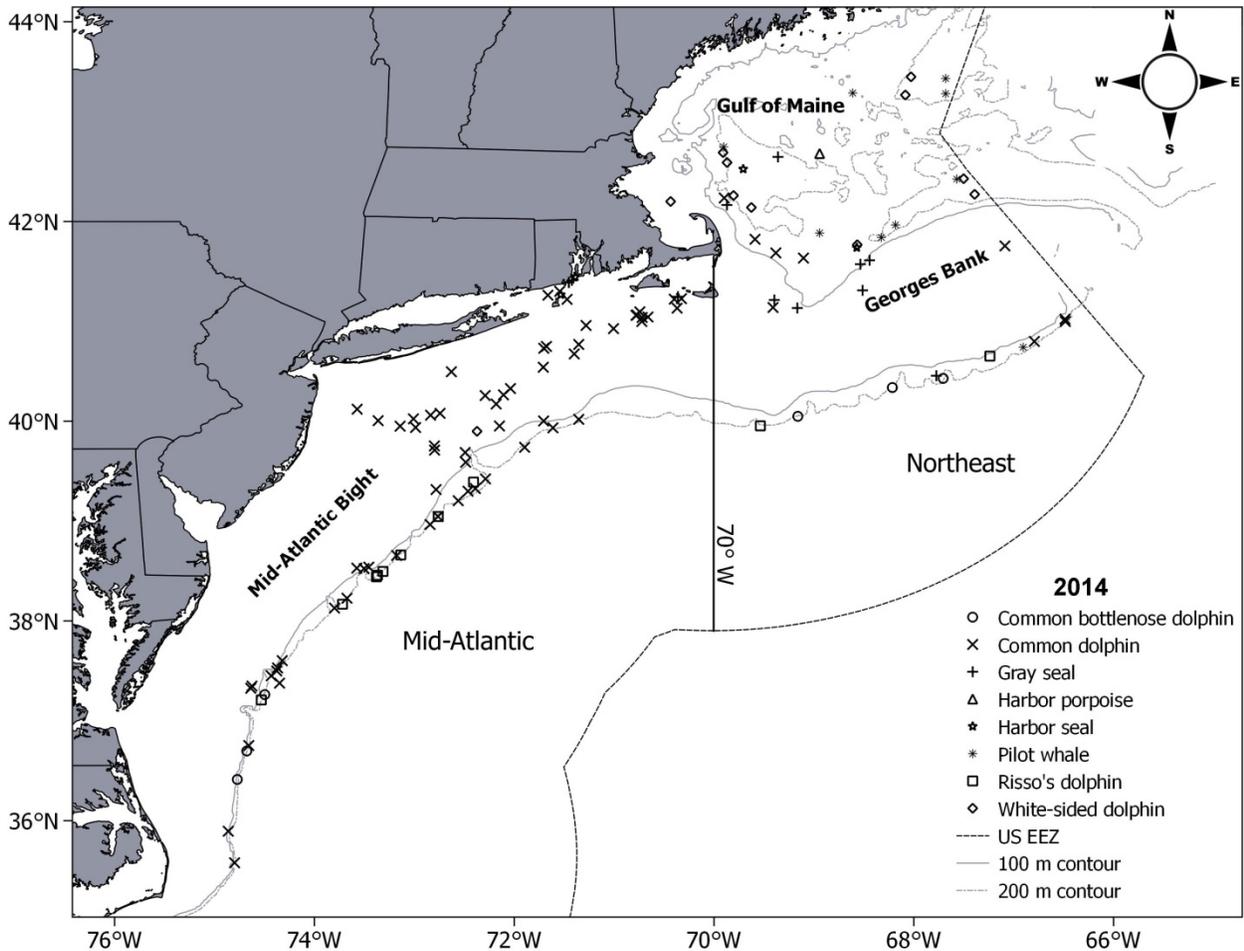


Figure 3 Incidental take locations from the observed commercial trips in the Northeast and Mid-Atlantic study areas during 2014 for Atlantic white-sided dolphin (*Lagenorhynchus acutus*), common dolphin (*Delphinus delphis delphis*), long-finned pilot whale (*Globicephala melas*), offshore common bottlenose dolphin (*Tursiops truncatus truncatus*), Risso's dolphin (*Grampus griseus*), harbor porpoise (*Phocoena phocoena phocoena*), gray seal (*Halichoerus grypus atlantica*), and harbor seal (*Phoca vitulina vitulina*). The strata were delimited by the 70°W longitude.

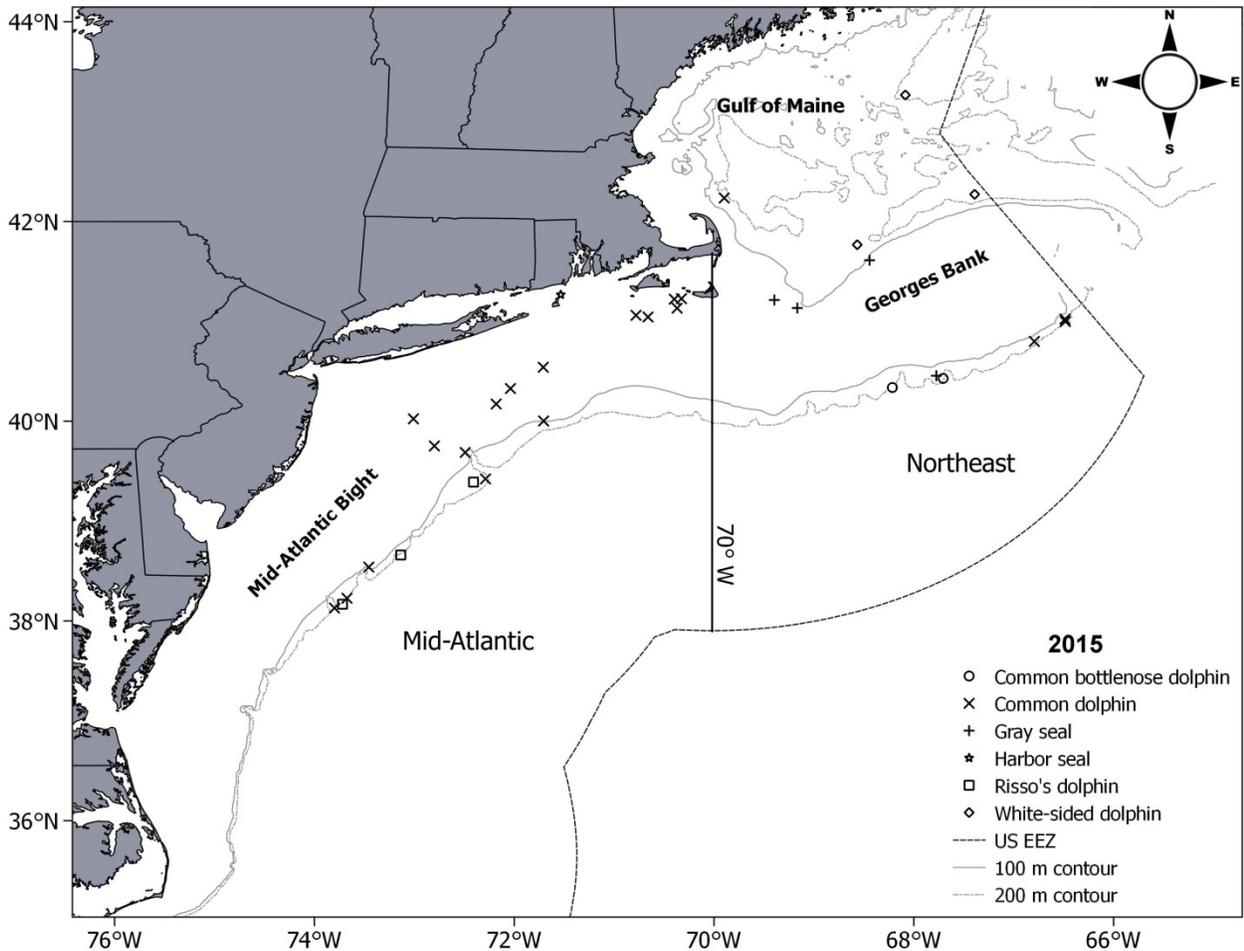


Figure 4 Incidentals take locations from the observed commercial trips in the Northeast and Mid-Atlantic study areas during 2015 for Atlantic white-sided dolphin (*Lagenorhynchus acutus*), common dolphin (*Delphinus delphis delphis*), offshore common bottlenose dolphin (*Tursiops truncatus truncatus*), Risso's dolphin (*Grampus griseus*), gray seal (*Halichoerus grypus atlantica*), and harbor seal (*Phoca vitulina vitulina*). The strata were delimited by the 70°W longitude.

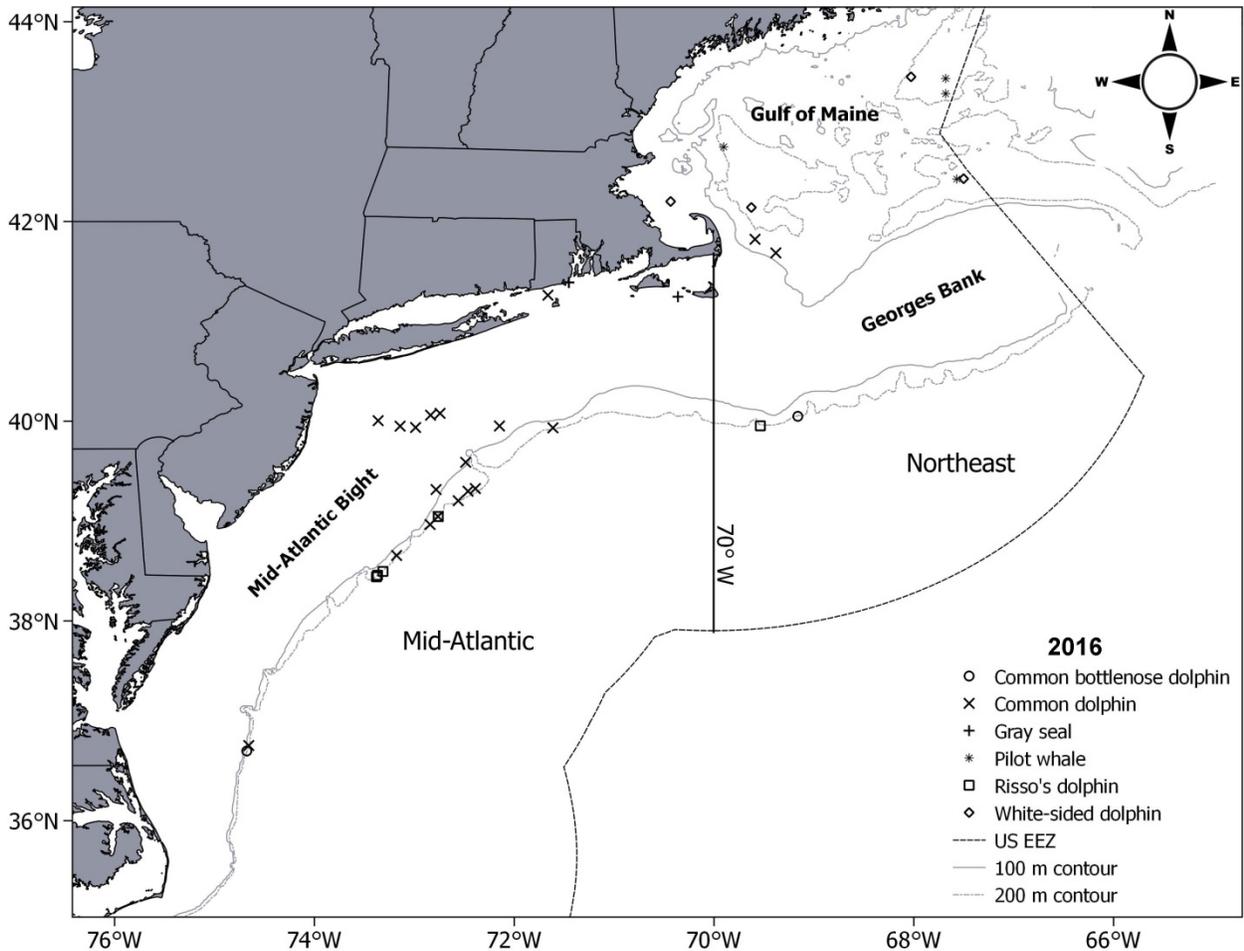


Figure 5 Incidental take locations from the observed commercial trips in the Northeast and Mid-Atlantic study areas during 2016 for Atlantic white-sided dolphin (*Lagenorhynchus acutus*), common dolphin (*Delphinus delphis delphis*), long-finned pilot whale (*Globicephala melas*), offshore common bottlenose dolphin (*Tursiops truncatus truncatus*), Risso's dolphin (*Grampus griseus*), and gray seal (*Halichoerus grypus atlantica*). The strata were delimited by the 70°W longitude.

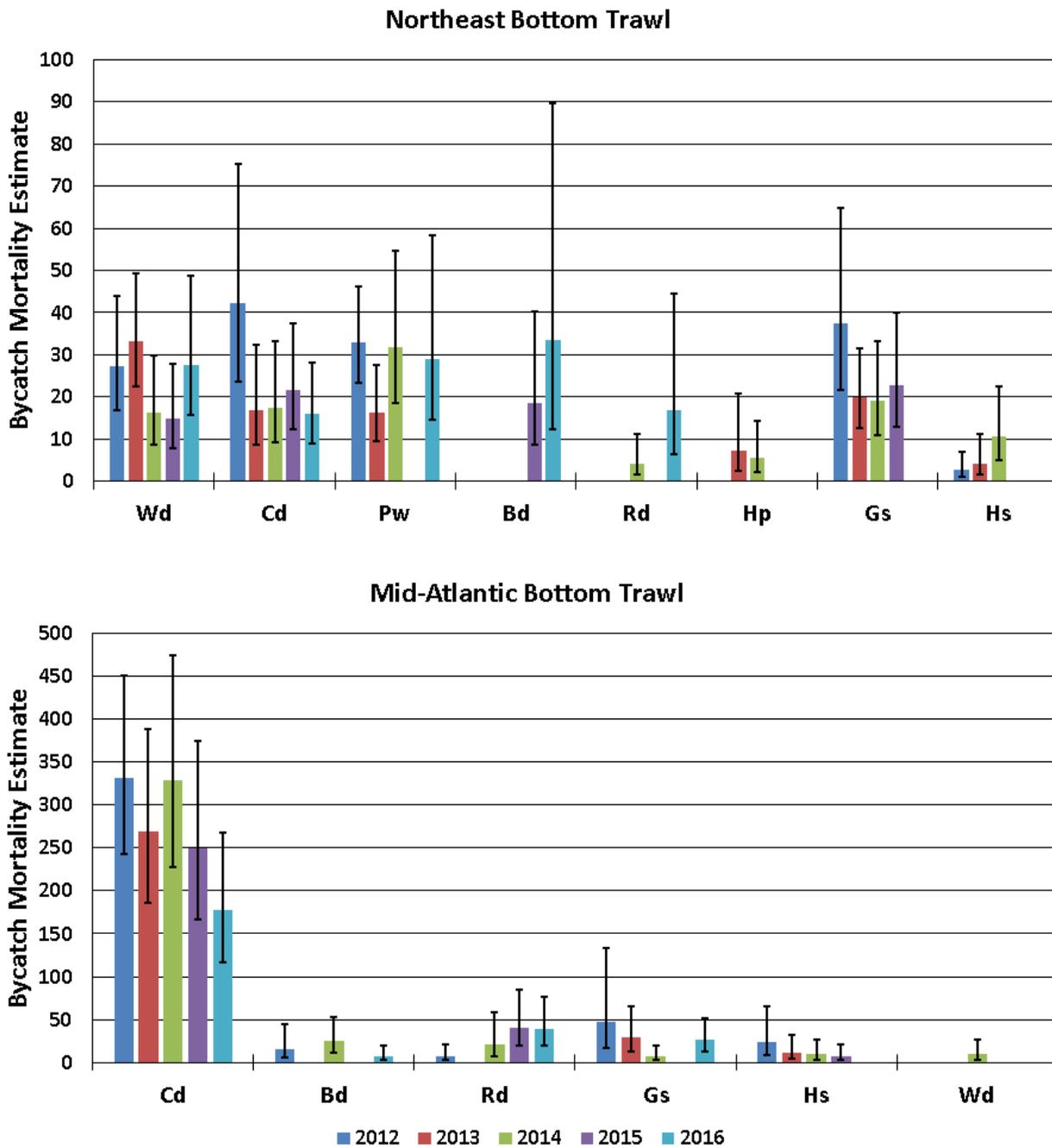


Figure 6 Annual bycatch mortality estimates (lognormal 95% Confidence interval) for bottom trawl gear by region, species and year in Northeast and Mid-Atlantic commercial bottom trawl trips, 2012-2016. Wd = Atlantic white-sided dolphin (*Lagenorhynchus acutus*), Cd = common dolphin (*Delphinus delphis delphis*), Pw = long-finned pilot whale (*Globicephala melas*), Bd = offshore common bottlenose dolphin (*Tursiops truncatus truncatus*), Rd = Risso's dolphin (*Grampus griseus*), Hp = harbor porpoise (*Phocoena phocoena phocoena*), Gs = gray seal (*Halichoerus grypus atlantica*), Hs = harbor seal (*Phoca vitulina vitulina*).

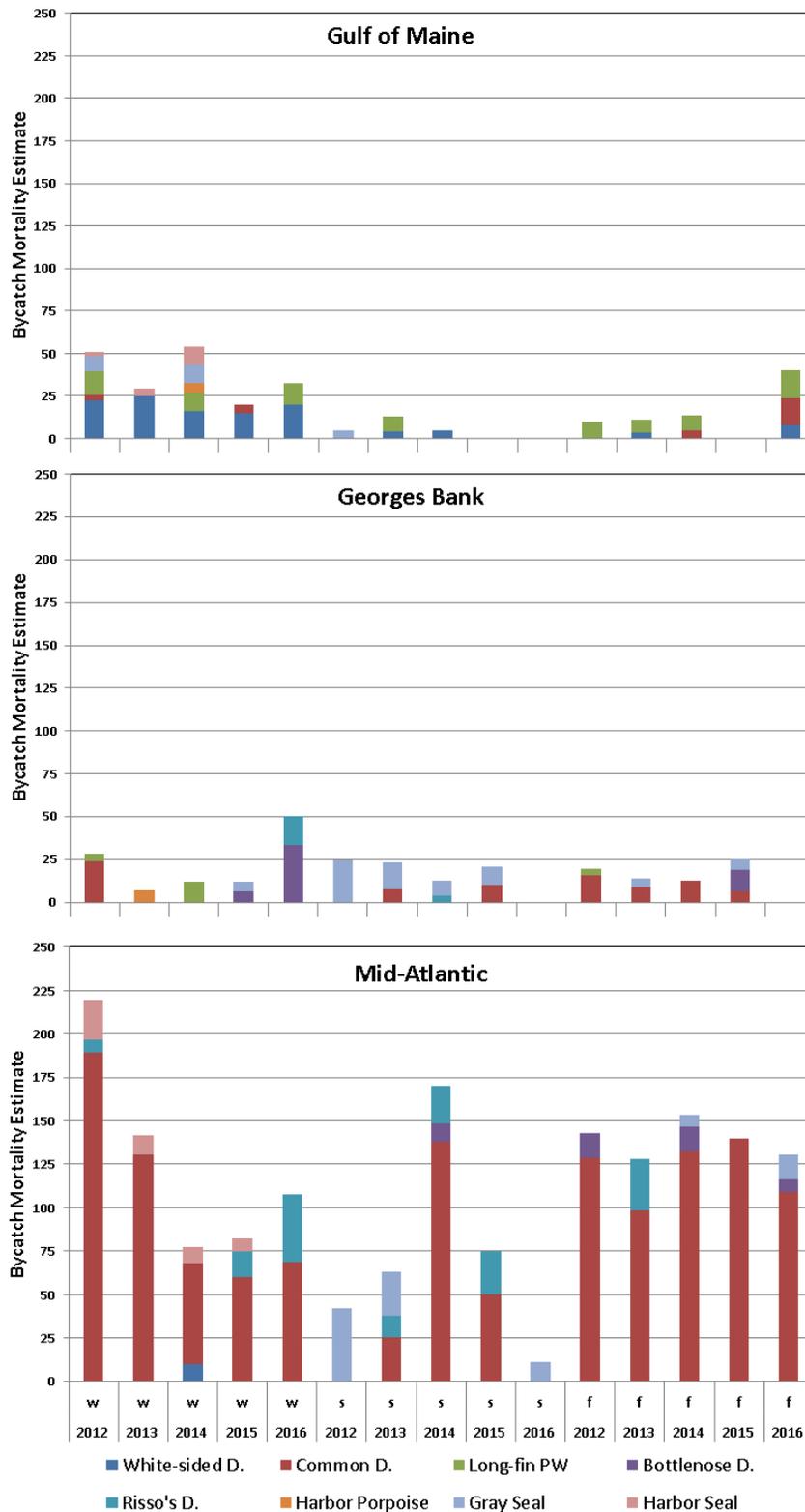


Figure 7 Bycatch mortality estimates for 2012-2016 in Northeast and Mid-Atlantic commercial bottom trawl trips stratified by ecoregion, year, season, and species (Atlantic white-sided dolphin [*Lagenorhynchus acutus*], common dolphin [*Delphinus delphis delphis*], long-finned pilot whale [*Globicephala melas*], offshore common bottlenose dolphin [*Tursiops truncatus truncatus*], Risso's dolphin [*Grampus griseus*], harbor porpoise [*Phocoena phocoena phocoena*], gray seal [*Halichoerus grypus atlantica*], and harbor seal [*Phoca vitulina vitulina*]).

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For spelling of scientific and common names of fishes, mollusks, and decapod crustaceans from the United States and Canada, use *Special Publications* No. 29 (fishes), 26 (mollusks), and 17 (decapod crustaceans) of the American Fisheries Society (Bethesda MD). For spelling of scientific and common names of marine mammals, use *Special Publication* No. 4 of the Society for Marine Mammalogy (Lawrence KS). For spelling in general, use the most recent edition of *Webster's Third New International Dictionary of the English Language Unabridged* (Springfield MA: G. & C. Merriam).

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Publications and Reports of the Northeast Fisheries Science Center

The mission of NOAA's National Marine Fisheries Service (NMFS) is "stewardship of living marine resources for the benefit of the nation through their science-based conservation and management and promotion of the health of their environment." As the research arm of the NMFS's Northeast Region, the Northeast Fisheries Science Center (NEFSC) supports the NMFS mission by "conducting ecosystem-based research and assessments of living marine resources, with a focus on the Northeast Shelf, to promote the recovery and long-term sustainability of these resources and to generate social and economic opportunities and benefits from their use." Results of NEFSC research are largely reported in primary scientific media (*e.g.*, anonymously-peer-reviewed scientific journals). However, to assist itself in providing data, information, and advice to its constituents, the NEFSC occasionally releases its results in its own media. Currently, there are three such media:

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