Incidental captures of seabirds in the U.S. Atlantic pelagic longline fishery, 1986-2005

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Summary

The NMFS Pelagic Observer Program observed 6949 longline sets from 1992 to 2005. A total of 114 seabirds were captured on 52 sets in the regular POP, with 79 seabirds dead upon retrieval (an additional 15 seabirds were caught in the NED experimental fishery). Seabirds were most numerous in the Northeast Coastal and Middle Atlantic Bight regions, followed by the South Atlantic Bight, Gulf of Mexico, and Northeast Distant regions. Unspecified seabirds were the most numerous group, followed by gulls. Greater shearwaters suffered the highest mortality, with 95% of those caught dead. Seabirds were caught every year except 1996. The highest rate of occurrence was from July to September. More seabirds may be caught on J hooks than on circle hooks, whereas fewer seabirds may occur on sets that use extra line weights than on sets without extra weights. There was no apparent correlation between untransformed catch and effort, although log-transformed catch and effort in the Middle Atlantic Bight were correlated. The average incidental take is estimated to be about 220 seabirds annually. Use of either circle hooks or line weights might have reduced annual takes to 24-37 seabirds each year. The mandated use of circle hooks to reduce sea turtle takes was in effect in 2005. The annual incidental seabird take is low relative to pelagic longline fisheries elsewhere, and, based on identified taxa, does not include species of concern. Recently implemented mitigation measures should significantly reduce the take even more.

Introduction

Incidental catch of seabirds by demersal and pelagic longline fisheries has been identified as a significant source of mortality for a number of bird species. Seabirds are attracted to baits and waste (offal) from fishing vessels and may become hooked or entangled by the gear when they attempt to remove the baits from hooks, often resulting in drowning (Brothers et al., 1999). Incidental mortality from longline fisheries has been implicated in the population declines of many seabird species, which are sensitive to non-natural mortality due to their longevity, low reproductive rates, and delayed maturity (Tuck et al., 2003). Incidental mortality from longlining apparently is most significant in polar waters, but information is limited for most mid-latitude fisheries (Brothers et al., 1999; Tuck et al., 2003). Concern regarding the sustainability of seabird populations, many of which are considered species of particular concern, led to the development of an international plan of action to reduce incidental longline catch (FAO, 1999) and a subsequent national plan of action (NPOA) in the U. S. (DOC, 2001). The NPOA called for an assessment of the longline fisheries to determine the extent of seabird bycatch, and, if a problem is deemed to exist, to identify means of reducing the bycatch.

The U. S. Atlantic pelagic longline fishery targets swordfish and various tuna and shark species in the Gulf of Mexico, Caribbean Sea and North Atlantic Ocean. Less than 200 vessels actively participate in the fishery (Federal Register, 2004a). The fishery is regulated under the Highly Migratory Species Fishery Management Plan through size limits, quotas, limited entry permits, time/area closures, mandatory logbooks, vessel monitoring systems, and fishery observers. The National Marine Fisheries Service initiated the Pelagic Observer Program (POP) in 1992 to monitor the U. S. swordfish fishery, and later, Atlantic highly migratory species (Beerkircher et al., 2002). A random sample of permitted vessels is selected each year for POP participation, with a target coverage of 5% of the fleet. The NMFS-trained on-board observer records detailed information on gear characteristics, target species, set and haul time, location, hydrographic and atmospheric conditions, directed catch, bycatch, and discards, including marine mammals, sea turtles, and seabirds. Mandatory logbook reporting by fleet vessels includes date, time, location, target species, basic gear characteristics, directed catch, bycatch, and discards, including sea turtles, but not seabirds (Cramer and Adams, 2000).

The purpose of this study is to utilize POP records to evaluate factors that may influence the chances of seabird capture and to use POP and fishery logbook records to estimate the fishery-wide incidental seabird take.

Methods

Pelagic Observer Program

The Pelagic Observer Program (POP) records information such as set and haul date, time, position, and water depth, hook depth (sum of dropline length, gangion length and leader length), hook models, types and sizes, number of hooks set and retrieved, types and conditions of baits, soak time, and target species. For each haul, specimen-level information is recorded for fish and bycatch including taxon and condition (alive/dead). Information is recorded for individual gear hauls, which may be gear sets that were intentionally or unintentionally split. This study examined gear sets - that is, split haul characteristics and catches were combined to the originating set based on trip identifier, beginning set date and time. POP records were available from 1992 (partial year) through 2005. Records from the Northeast Distant experimental fishery in 2001-2003 (see below) were not included in analyses.

Seabirds reported as bycatch were recorded at varying taxonomic levels. Recorded taxa were seabird, gull (*Larus sp.*), herring gull (*L. argentatus*), laughing gull (*L. atricilla*), black beaked gull[1] (sic), northern gannet (*Morus bassanus*), greater shearwater (*Puffinus gravis*), and storm-petrel[2]. Most analyses combined all taxa.

Each gear set was categorized by region and quarter based on begin-set position and end-haul date, respectively. Sets were assigned to one of the following regions: Caribbean (CAR), Gulf of Mexico (GOM), Florida East Coast (FEC), Middle Atlantic Bight (MAB), North-Central Atlantic (NCA), Northeast Coastal (NEC), Northeast Distant (NED), Sargasso Sea (SAR), South Atlantic Bight (SAB), Tuna-North (TUN) or Tuna-South (TUS) (Figure 1). Quarters were 1: January-March, 2: April-June, 3: July-September, and 4: October-December. The number of hooks fished was determined as the number of hooks set minus the number of hooks lost. Hook set depth and bottom set depth were determined, respectively, as the midpoints of the minimum and maximum hook depth and bottom depth. The use of additional equipment or adjuncts was also recorded, but not for all sets. These included rattlers, chemical light sticks, surface lights, and line weights. Characteristics of baits used were recorded for most sets as kind, type, and condition (Table 1). Up to three different entries could be made for each bait category, but usually only one was made. Therefore, analyses only examined the first entry.

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[1] Reported elsewhere (Brothers et al., 1999; Anon., 2004) as great black-backed gull, *L. marinus*.

[2] Reported elsewhere (Brothers et al., 1999) as Wilson's storm-petrel, *Oceanites oceanicus.*

Chi-square tests were used to evaluate if sets in which seabirds occurred were distributed among regions, seasons, and target species in proportion to overall effort. Hook types were recorded only on the trip-level, if at all, and individual captures often could not be associated with hook type. The hook type an animal was captured on could only be determined where only one type of hook was used on a trip. For trips that used only circle hooks or J hooks, a chi-square test was used to evaluate whether hook type used on sets that caught seabirds was proportional to the overall proportion of hook type used in the fishery. Chi-square tests were used to evaluate whether adjuncts or bait characteristics were disproportionately represented in sets in which seabirds occurred. Tests included only categories in which the expected number of responses was greater than one (Snedecor and Cochran, 1989: 77). T-tests were used to evaluate whether the mean soaktime, hook depth and bottom depth of sets that caught seabirds was similar to the overall mean. The t-test used depended on the test for equal variance for the given parameter. Sets were excluded if the measurement was questionable - e.g. recorded bottom depth less than hook depth.

Extrapolating takes from logbook records

Seabird takes for the entire pelagic longline fishery were extrapolated from self-reported longline effort from the Atlantic large pelagic logbook records for 1992 to 2004. Only gear sets reported as pelagic longline sets were used. Analyses of the Pelagic Observer Program (POP) longline fishery indicated no seasonal influence on seabird catches, so estimations included only yearly effort. Numbers of longline sets, hooks set, and hook/hours from the POP were all highly correlated, so sets were considered as the units of effort. Logbook sets were assigned to reporting regions based on set locations. When set locations were not reported or were considered invalid, the numbers of unknown sets were arbitrary assigned to regions in proportion to the number of valid sets. No seabirds were observed in the Florida East Coast (FEC), North-Central Atlantic (NCA), Sargasso Sea (SAR), Caribbean (CAR), Tuna-North (TUN) or Tuna-South (TUS) region POP records, so those regions were excluded from catch estimations (i.e. catches in those regions were assumed to be zero). Hook set depth and bottom depth indicated that the Northeast Coastal (NEC) and Middle Atlantic Bight (MAB) regions were similar, so they were combined for analyses. The Northeast Distant (NED), South Atlantic Bight (SAB), and Gulf of Mexico (GOM) regions were usually treated separately. However, when no POP observations were made in the NED (1996, 1998, 2002, 2003), the logbook effort there was combined with the NEC and MAB regions.

Annual seabirds takes were calculated following methodology used to estimate sea turtle and marine mammal takes (Yeung, 1999). This method assumes a delta-distribution for calculating mean catch per effort and variance (Pennington, 1983). Mean catches were combined using a stratified random sampling design, where POP effort was treated as the sample, and mean catches per set were extrapolated to the population of logbook effort. The NEC and MAB regions were combined as a single Atlantic stratum (ATL). The GOM, NED and SAB regions were treated as individual strata, except when the NED was combined with the ATL as described above. Total takes were estimated for all seabirds, and for dead seabirds, by taxon. Seabirds were classified as unidentified seabirds, gulls (all gull categories were combined), northern gannets, storm-petrels, or greater shearwaters.

For the years 1986 to 1991, no POP observations were available to extrapolate total seabird takes, so a regression estimator was used. Log-transformed sets and numbers of seabirds (all taxa combined) each year in the POP were significantly correlated in the MAB and in the combined ATL region, but not in any other region[3]. However, the MAB and NEC regions combined accounted for 84% of all seabird takes in the POP. The regression equation derived from the 1992-2004 POP records for the MAB and NEC regions combined was:

$$\log_{10}(y+1) = -1.1974 + 0.9735 \times \log_{10}(x+1)$$

where x = number of sets and y = number of seabirds taken. This equation was applied to MAB and NEC logbook effort for 1986-2001, and 95% confidence intervals were calculated for new predictions (Snedecor and Cochran, 1989: 165-167). In the 1992-2003 take estimates 68.1% of seabirds were dead, averaged over all years. This value was applied to regression estimates for 1986-1991 to estimate the total number of dead seabirds in those years. Because the number of seabirds, and number of dead seabirds, in

[3] Non-transformed sets and numbers captured were not correlated in the MAB (see Results).

1986-2001 were estimated using only MAB and NEC effort, these estimates may under-represent the take for the entire pelagic longline fishery.

Alternative annual take estimates were calculated by applying significant gear characteristics to the fleet effort in the five seabird-capture regions (see Results). The relative proportions of significant gear characteristics and their associated catch rates from observer records were applied to fleet logbook effort to estimate total takes. For example, the fractions of sets using circle hooks, J hooks, and sets using unknown or mixed hook types and seabird catch rates obtained from the POP were applied to the total number of sets reported in the GOM, MAB, NEC, NED, and SAB regions. For 1987 (first full year of records) to 1991 the overall fractions of characteristics were applied to logbook effort since no corresponding yearly POP records were available.

<u>NED Experimental fishery</u>

Extrapolation methods were evaluated using experimental longline fishery observations in the NED. From 2001 to 2003, a special project (Watson et al. 2005) conducted in cooperation with the POP observed all sets made in the NED. All information recorded from regular POP cruises were also recorded here. Access to the data collected in the special project was provided by John Watson and Sheryan Epperly. The mean seabird catch per set used here was calculated as above to extrapolate seabird take from logbook records, except that it combined all seabird groups, and applied the stratified mean to the NED experimental effort. In addition, alternative estimates were calculated using catch per set by gear type as above. The extrapolated catches could then be compared with the actual catch to evaluate the extrapolation methods.

Effort and seabirds captured in this experimental fishery are not included in the analyses of the regular Pelagic Observer Program records.

Results

<u>Pelagic Observer Program</u>

A total of 6949 pelagic longline sets was observed in the Pelagic Observer Program (excluding effort in the NED experimental fishery) between 1992 and 2005, primarily in the Gulf of Mexico (GOM) and Middle Atlantic Bight (MAB) regions (Tables 2; 3). Fifty-two sets accounted for 114 seabird captures, of which 79 were dead upon gear retrieval.

Seabird occurrences may be clustered within sets and within trips. Thirty sets caught only one seabird, but 22 sets caught more than one, and as many as nine birds. Likewise, the 52 occurrences were distributed over only 30 trips, with seabirds caught on as many as five sets during a trip. Fifteen trips accounted for one seabird each, but that one trip with five occurrences accounted for 18 seabirds. Northern gannets were caught on five sets in three trips, and greater shearwaters occurred on 10 sets over six trips. Unspecified seabirds were caught on 22 sets over 13 trips, and gulls were caught on 17 sets in 10 trips.

Unspecified seabirds represented the most numerous group observed, with 52 caught. They occurred in the GOM, MAB, NEC, NED, and SAB regions (Figure 2). Gulls were the second most common group, with 35 caught. Gulls were caught in the MAB and SAB in the first quarter, in the SAB in the second quarter, and the NEC and MAB in the fourth quarter (Figure 3). Nineteen greater shearwaters were caught. They occurred in the NEC in the second quarter and the MAB in the third and fourth quarters (Figure 4). Seven northern gannets and one storm-petrel were caught. Gannets occurred in the NEC in the fourth quarter, and the MAB and SAB in the first quarter, and the storm-petrel occurred in the MAB in the fall (Figure 5). No seabirds were reported from the Caribbean (CAR), Florida East Coast (FEC), North Central Atlantic (NCA), Sargasso Sea (SAR), Tuna North (TUN), or Tuna South (TUS) regions. However, the last three regions had the fewest observed sets (Table 3).

The MAB and SAB had the highest rates of mortality (percent of captured seabirds that were dead on gear retrieval) at 78 and 81%, respectively. The NEC had 53% mortality. The one storm-petrel caught was dead on gear retrieval. Of the other groups, greater shearwaters suffered the highest mortality at 95%, followed by unspecified seabirds at 69% and gulls at 66%. Northern gannets suffered a 14% mortality.

Seabirds were captured every year except 1996. The highest total number, catch per set, and rate of occurrence (at least one seabird per set) were in 1997 (Table 2). The lowest number of seabirds per set occurred in 1999 and 2005. Regionally, the highest catch per set and highest rates of occurrence were in the Northeast coastal (NEC) and MAB regions, followed by the South Atlantic Bight (SAB) (Table 3; Table 4). Unspecified seabirds were the most numerous group in the NEC and SAB, whereas gulls were the most numerous group in the MAB.

The highest overall catch rate occurred in the third quarter (Table 4). All northern gannets and nearly all gulls were caught in the first and fourth quarters. The one storm-petrel was caught in the fourth quarter. Most shearwaters and unspecified seabirds occurred in the second and third quarters. Regionally, the highest catch rate occurred in the second and third quarters in the NEC, and first quarter in the MAB. Within the regions in which seabirds were captured, the number of seabirds caught did not differ from the expectation that the number caught was proportional to the overall effort among quarters ($\chi^2 = 2.15$; df = 3; p = 0.541). Likewise, occurrences of seabirds did not differ from quarterly effort ($\chi^2 = 1.66$; df = 3; p = 0.645). The number of dead seabirds in each quarter was proportional to the total number captured ($\chi^2 = 2.47$; df = 3; p = 0.480).

There was no apparent overall correlation between seabird catch and longline effort. For all regions combined, neither the number of seabirds caught nor the number of occurrences were correlated with four measures of annual effort (Table 5). However, the different measures of effort - sets, number of hooks, hook/hours fished, and soaktime - were all correlated. Within the five regions in which seabirds were captured, the number of occurrences was significantly correlated with effort in the MAB, but neither the number of seabirds nor the number of occurrences was correlated with effort in the NEC or SAB.

Seabird captures were disproportionate to effort by target species. Expected captures in bigeye tuna, dolphin (*Coryphaena* spp.), and shark-targeted sets were less than five, so these three categories were combined. Seabird captures were greater in mixed-target sets, and less in swordfish-target sets, than would be expected solely by distribution of effort ($\chi^2 = 96.9$; df = 4; p <0.001; Table 6). Seabirds were more numerous in dolphin-target sets than expected, although only 20 dolphin-target sets were reported. Eleven seabirds were captured in three of the 20 dolphin-target sets: nine of the 11 birds were captured in one set, and another was captured in the same trip.

More seabirds may be caught on J hooks than on circle hooks. Within the five regions where seabirds were captured, hook type was unknown or not recorded on trips accounting for 1570 sets and 57 seabirds in 23 occurrences. A mix of circle and J hooks was used on an additional 112 sets accounting for no birds. Only circle hooks were used in 1067 sets accounting for three birds in three occurrences. Only J hooks were used in 2727 sets that accounted for 54 birds in 26 occurrences. A chi-square test comparing J and circle hooks indicated that hook type significantly affected the occurrences of seabirds in longline sets ($\chi^2 = 4.54$; df = 1; $p = 0.033$), and the number of seabirds caught on J hooks was greater, and the number caught on circle hooks was less, than expected ($\chi^2 = 14.74$; df = 1; $p < 0.001$). For the five seabird-capture regions, circle hooks caught seabirds at a rate of 0.003 birds/set (0.004 birds/1000 hooks), whereas J hooks caught at 0.020 birds/set (0.028 birds/1000 hooks), over six times higher. The unknown and mixed hook sets together caught at an even higher rate of 0.036 birds/set (0.050 birds/1000 hooks). The lowest number per 1000 hooks (all regions combined) occurred in 2005, when only circle hooks were used (Table 2).

The use of line weights may reduce the incidence of seabird capture, whereas other adjuncts (floats, light sticks, rattlers, surface lights) apparently do not affect seabird captures. For the five regions in which seabirds occurred, the proportion of seabird capture sets using extra line weights (4%: 2 of 52 sets) was much lower than the proportion for all other sets in the regions (29%: 1583 of 5418 non-seabird capture sets recorded) ($\chi^2 = 16.19$; df = 1; $p < 0.001$). Sets using line weights caught seabirds at a rate of 0.003 birds/set, in contrast to sets without line weights, which caught seabirds at a rate of 0.028 birds/set. The proportion of seabird capture sets using light sticks (67%) was similar to the proportion for all other sets in the regions (70%: 3805 of 5424) ($\chi^2 = 0.201$; df = 1; $p = 0.654$). The proportion of seabird capture sets using rattlers (4%) was similar to the proportion for all other sets in the regions (4%: 230 of 5423) ($\chi^2 = 0.020$; df = 1; $p = 0.888$). The proportion of seabird capture sets using surface lights (19%) was similar to the proportion for all other sets in the regions (25%: 1333 of 5422) ($\chi^2 = 0.804$; df = 1; $p = 0.370$). All sets that captured seabirds also used floats (51 of 51), while overall, 99.9% (5418 of 5424) of the sets used floats. The mean soak time for sets with seabirds (8.4

hrs) did not differ significantly from the mean for all other sets in the regions in which seabirds occurred (8.6 hrs) ($T = 0.762$; $df = 5474$; two-tailed $p = 0.446$).

Fifty-four seabirds were caught on 26 of 3096 sets that used J hooks and no line weights (0.017 birds/set), compared to no birds on 886 sets that used J hooks and additional line weights. Three seabirds were caught on three of 5139 sets that used circle hooks and no line weights (0.0006 birds/set). No birds were caught on 258 sets that used circle hooks and additional line weights. Of the sets with unknown hook types, 53 seabirds were caught on 21 of 1294 sets that did not use line weights (0.041 birds/set), and four birds were caught on two of 365 sets that used line weights (0.011 birds/set).

Bait apparently affects the frequency of seabird captures. The proportion of bait kinds in sets with seabirds significantly differed from the proportion found in all sets in which bait kind was recorded ($\chi^2 = 9.725$; $df = 4$; $p = 0.045$). Squid caught seabirds more often than expected, while sardines caught seabirds less often. Likewise, the proportion of bait conditions in sets with seabirds significantly differed from the proportion found in all sets in which bait condition was recorded ($\chi^2 = 7.984$; $df = 3$; $p = 0.046$). Seabirds were caught on thawed baits more often than expected, whereas they occurred less often on semi-frozen baits than expected. Apparently, whole and live baits did not catch seabirds at greater or lesser frequencies than expected ($\chi^2 = 1.167$; $df = 1$; $p = 0.280$).

The time of day when a set is begun does not affect the occurrence of seabirds. Most sets were made from 1600 to 2000 hrs, and most seabirds were caught during those sets (Figure 6). A chi-square test indicated that the distribution of occurrences of seabirds through the day did not differ significantly from the overall distribution of sets through the day for the five regions in which seabirds were captured ($\chi^2 = 5.34$; $df = 5$; $p = 0.376$). Mortality may be lower in sets made later in the day, but this may be an artifact of the low numbers caught (Figure 6). Unspecified seabirds and gulls did not display obvious temporal patterns, but shearwaters were caught exclusively in morning (0400-0800 hrs) and evening (1600-2000 hrs), and the storm-petrel was caught in the evening (Figure 7).

The mean hook depth for sets with seabirds (27.5 m) differed significantly from the mean for all other sets in the regions in which seabirds occurred (44.1 m) ($T = 13.5$; $df = 59$; two-tailed $p < 0.001$). The mean bottom depth for sets with seabirds (1094 m) differed significantly from the mean for all other sets in the regions in which seabirds occurred (1648 m) ($T = 3.51$; $df = 5474$; two-tailed $p < 0.001$). However, within regions, hook depth was only significantly different in the SAB, and bottom depth did not differ between seabird and non-seabird-capture sets in any region (Table 7).

<u>Extrapolated takes from logbook records</u>

Total pelagic longline effort ranged from about 7900 to 19,500 sets per year. Logbook reporting for 1986 included only part of that year. The fewest number of reported sets occurred in 2005. The highest reported annual effort was in the GOM, followed by the FEC and MAB regions (Table 8). Unknown or invalid set locations represented nearly 5% of all sets in 1992 and 1993, but no such locations were recorded since 2001.

An estimated average of 219 seabirds was caught annually from 1987 to 2005 (excluding the partially covered 1986) using stratification by region. Excluding 2005, when only circle hooks were used, the 1987-2004 average was 230 seabirds per year. The number caught ranged from none in 1996 to 1109 in 1997 (Table 9). Possible annual takes were as high as 4445 seabirds in 1990. Since 1992, unspecified seabirds were the most numerous group taken, followed by gulls. An estimated average of 150 seabirds taken annually from 1987 to 2005 were dead, but the yearly average increased slightly to 157 seabirds if 2005 is not included. The estimated number of dead seabirds ranged from none in 1996 to 623 in 1997 (Table 10). Although the estimated number of seabirds captured in 2005 was the lowest since 1996, the total effort was also the lowest reported.

Assuming hook types were used throughout the fishery in the same proportion as in the POP program and capture rates were the same, the annual seabird take would range from 139 to 333, averaging 233 seabirds per year from 1987 to 2004 (Table 11). The estimated annual seabird take in 2005, when only circle hooks were allowed, was 21 - an order of magnitude lower than the 1987-2004 average. Alternatively, assuming line weights were used in the same proportion and capture rates were the same, between 126 and 313 seabirds would be caught annually (Table 12). If either line weights or circle hooks were exclusively used, the estimated captures would have ranged from 21 to 37 seabirds annually, averaging 30 birds. Few seabirds were caught in the GOM and NED, so overall catch rates were used. However, these rates may overestimate true rates in those regions. Also, the capture rate for mixed/unknown hook types used here (0.034 seabirds/set) is higher than the rate for either circle (0.002) or J (0.020) hooks. If the true rate for that class is no higher than the highest rate for known hook types, then the catch was probably overestimated.

From 1992 to 2005, annual estimated catches of all seabirds from the hook-type and line weight methods were significantly correlated ($r = 0.713$; $p = 0.004$) (proportions of hook types and line weight usage were estimated for 1987-1991). In contrast, catch estimates from neither the hook-type method ($r = 0.321$; $p = 0.263$) nor the line weight method ($r = 0.285$; $p = 0.323$) were correlated with estimates from the stratified region method over the same period. However, the overall mean annual number captured estimated from the three methods were similar (stratification: 219, line weight: 223, hook-type: 225).

<u>NED experimental fishery</u>

A total of 15 seabirds were caught in 12 of 1225 longline sets in the NED experimental fishery. There were 7 unspecified seabirds, one northern gannet, and seven shearwaters (five recorded as greater shearwaters, two recorded as unidentified shearwaters) (Table 13). J hooks were used from 2001 to 2003, while circle hooks were used in 2002 and 2003. Sets using only J hooks were only made in 2001, whereas sets using only circle hooks were only made in 2003. Gear sets using both hook types were made in 2002 and 2003 (Table 13). Only one set used additional line weights, so line weight usage was not considered for estimating catches.

Seabird categories from the NED experimental fishery did not correspond with the categories obtained from the POP, so stratified mean catch per set for all seabirds combined was applied to the experimental effort. The use of stratified means overestimated the total incidental seabird take (Table 13). However, the estimates appeared consistent across years - i.e., the highest estimate occurred in 2002, the year with the highest actual take. In contrast, the use of hook type produced similar results for 2001 and 2002, but overestimated the incidental take for 2003.

Discussion

The number of seabirds captured in the POP, and the extrapolated numbers for the fishery, do not include seabirds that may have unhooked themselves, fallen off the hook, or been removed by predators/scavengers or by the crew out of view of the observer (Klaer and Polacheck, 1997). Long soak times may result in fewer animals boarded than short soak times due to such losses (Ward et al., 2004). Assuming seabirds are only caught during gear set, Ward et al. (2004) predicted that up to 45% of seabirds caught are lost prior to boarding.

This study indicated that hook type may influence incidental catch rates. This influence may be an artifact of unexamined covariables, although Brothers et al. (1999) suggested that hook type may be a useful attribute to mitigate seabird captures. However, the effect does not appear to be well documented for pelagic longline fisheries. Circle hooks have been documented to capture fewer sea turtles than J hooks in the pelagic longline fishery, and hook size and offset may also have impacts on hooking rates (Watson et al., 2005). The use of circle hooks was mandated for the pelagic longline fishery in 2005 to mitigate incidental sea turtle takes (Federal Register 2004b).

Seabirds take baits from hooks floating at or near the surface during setting and, to a lesser degree, during gear haul (Brothers and Foster, 1997; Brothers et al., 1999; Lokkeborg, 2003). In this study, the use of additional line weights apparently reduced the number of seabirds captured on sets that used them. Seabirds also occurred on sets that used thawed bait more often than expected. In contrast, other studies suggested that additional line weights and thawed baits increased hook sinking rate and put the hooks out of range of surface-feeding seabirds and below the range of diving seabirds to reduce captures (Brothers and Foster, 1997; Boggs, 2001; Anderson and McArdle, 2002). The use of line weights and thawed baits are recommended mitigation measures to reduce seabird captures (FAO, 1999).

Seabird bycatch has been reported to be taken mostly around sunrise and from mid afternoon to sunset (Belda and Sanchez, 2001; Sanchez and Belda, 2003), and night setting has been recommended as a mitigation measure that prevents seabirds from seeing the baits (Brothers et al., 1999). Most seabird captures in this study occurred on sets deployed between 1600 and 2000 hours, but there did not appear to be higher incidences of capture relative to effort for all seabirds combined. However, greater shearwaters may display a pattern of dawn and dusk activity.

Seabird capture rates within the NEC, MAB, and SAB were 0.081, 0.048, and 0.020 birds/set, respectively. These rates equate to 0.105, 0.072, and 0.035 birds/1000 hooks. Averaged over all years and regions, the overall catch rate was 0.024 birds/1000 hooks. In comparison, reported rates in Alaska range from 0.03 to 0.14 birds/1000 hooks depending on region (Stehn et al., 2001). Australian longline fisheries reported an overall rate of about 0.16 birds/1000 hooks, with northern areas generally <0.01 (Klaer and Polacheck, 1997). Capture rates are between 0.002 and 0.69 birds/1000 hooks in the western Mediterranean Sea (Belda and Sanchez, 2001; Valeiras and Caminas, 2003). In South Africa, Japanese longliners captured 2.6 seabirds/1000 hooks, while South African vessels caught 0.8 birds (Ryan et al., 2002). Other reported catch rates are also similar or higher (Brothers et al., 1999). Except for the waters around Hawaii, seabird catches appear to be highest at extreme latitudes in the north Pacific and Southern Oceans (Brothers et al., 1999). Catches appear to be low in tropical waters, but information is sparse. Albatross species are the most severely impacted, and all albatross species that are affected are considered threatened or endangered (Brothers et al., 1999). In contrast, species documented in the POP data base are not considered in danger; however the majority of the seabird bycatch was identified only as “seabird”, so rarer species, if present in the bycatch, went unnoted.

Total seabird capture estimates derived here are higher than estimates derived for the U. S. national plan of action for the Atlantic highly migratory species longline fisheries (Anon., 2004). Methodology was not presented there, but the differences may be due to the form of distribution assumed. For highly skewed data with many zero values, ordinary sample statistics assuming a normal distribution may underestimate the true mean and variance. In such instances the delta-distribution may be more appropriate (Pennington, 1983).

Results of estimates from the NED experimental fishery suggest that methods used here overestimate total takes, but this may be due to the manner of application. Only one seabird was caught in the NED from 1992 to 2005 in the regular POP records (which exclude the special study and the years 2001 through 2003), suggesting that catch rates there are lower than the MAB and NEC, and to a lesser extent, the SAB (Table 4). The stratified mean catch per set was derived from catches made in both high and low-catch strata, so its application to catches from only a low-catch stratum would overestimate the catch there. Likewise, hook-type catch rates were derived from sets in high and low-catch regions, so application to sets from only a low-catch region would likely overestimate total catch. In general, the stratification method tracked actual catch better than the gear character method. Incorporation.of both regional and gear differences may improve estimates.

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Table 1. Bait categories recorded in the NMFS Pelagic Observer Program. Asterisks indicate categories that were excluded from chi-square tests because the expected frequency of the category was less than one.

Category	Value
Bait kind	
1	mackerel
2	herring
3	squid
4	artificial*
5	sardine
6	scad
99	other*
Bait type	
1	whole
2	cut*
3	live
9	other*
Bait condition	
1	frozen
2	semi-frozen
3	thawed
4	fresh
5	salted*
9	other*

Table 2. Observed pelagic longline effort by year, number of seabirds caught and number of occurrences of seabirds. Effort is given by number of observed gear sets and total number of hooks retrieved (number of hooks set minus number of hooks lost).

			Number of seabirds		Number of occurrences		Catch rate	
Year	Sets	Hooks	All	Dead	All	Dead	per set	per 1000 hooks
1992	329	194,706	6	4	1	1	0.018	0.031
1993	817	524,551	9	3	5	2	0.011	0.017
1994	650	411,996	15	15	6	6	0.023	0.036
1995	686	472,105	10	7	6	5	0.015	0.021
1996	356	220,223	0	0	0	0	0	0
1997	451	311,520	33	18	11	8	0.073	0.106
1998	287	175,408	8	8	2	2	0.028	0.046
1999	424	285,083	1	1	1	1	0.002	0.004
2000	465	312,574	2	1	2	1	0.004	0.006
2001	398	284,198	8	8	4	4	0.02	0.028
2002	344	260,167	8	2	5	2	0.023	0.031
2003	551	427,575	2	1	2	1	0.004	0.005
2004	642	494,880	11	10	6	5	0.017	0.022
2005	549	424,469	1	1	1	1	0.002	0.002
Total	6949	4,799,455	114	79	52	39	0.016	0.024

Note: Two seabirds and the associated experimental sets for 2005 were incorrectly omitted from the database. Experimental sets for 2004 also were incorrectly omitted from the database, but included no birds. In addition, a new species, the Cory's Shearwater, was missed in the 2005 record. Therefore the actual number of seabirds taken in 2005 was 4, not 1, and there were more sets observed than indicated in this table.

Table 3. Observed pelagic longline effort by region, number of seabirds caught and number of occurrences of seabirds. Effort is given by number of observed gear sets and total number of hooks retrieved (number of hooks set minus number of hooks lost). Regions are: CAR-Caribbean; FEC-Florida East Coast; GOM-Gulf of Mexico; MAB-Middle Atlantic Bight; NCA-North Central Atlantic; NEC-Northeast Coastal; NED-Northeast Distant; SAB-South Atlantic Bight; SAR-Sargasso Sea; TUN-Tuna North; TUS-Tuna South.

			Number of seabirds		Number of occurrences		Catch rate	
Region	Sets	Hooks	All	Dead	All	Dead	per set	per 1000 hooks
CAR	262	149,261	0	0	0	0	0	0
FEC	730	301,028	0	0	0	0	0	0
GOM	2540	1,957,978	2	1	2	1	0.001	0.001
MAB	1144	768,989	55	43	24	19	0.048	0.072
NCA	330	245,574	0	0	0	0	0	0
NEC	493	382,316	40	21	18	13	0.081	0.105
NED	502	421,087	1	1	1	1	0.002	0.002
SAB	797	453,886	16	13	7	5	0.02	0.035
SAR	83	70,937	0	0	0	0	0	0
TUN	33	22,456	0	0	0	0	0	0
TUS	35	25,943	0	0	0	0	0	0
Total	6949	4,799,455	114	79	52	39	0.016	0.024

Table 4. Observed pelagic longline effort by region and quarter, number of seabirds caught per set and number of occurrences per set, from the Pelagic Observer Program, 1992-2004 combined.

Region		Quarter				
		1	2	3	4	All
CAR	sets	164	42	12	44	262
	seabirds/set	0	0	0	0	0
	occurrences/set	0	0	0	0	0
FEC	sets	235	204	152	139	730
	seabirds/set	0	0	0	0	0
	occurrences/set	0	0	0	0	0
GOM	sets	598	667	620	655	2540
	seabirds/set	0.002	0	0.002	0	0.001
	occurrences/set	0.002	0	0.002	0	0.001
MAB	sets	190	140	405	409	1144
	seabirds/set	0.095	0	0.030	0.061	0.048
	occurrences/set	0.032	0	0.020	0.024	0.021
NCA	sets	250	80	0	0	330
	seabirds/set	0	0			0
	occurrences/set	0	0			0
NEC	sets	0	65	280	148	493
	seabirds/set		0.123	0.096	0.034	0.081
	occurrences/set		0.062	0.039	0.020	0.037
NED	sets	0	24	258	220	502
	seabirds/set		0	0	0.005	0.002
	occurrences/set		0	0	0.005	0.002
SAB	sets	136	400	172	89	797
	seabirds/set	0.022	0.033	0	0	0.020
	occurrences/set	0.015	0.013	0	0	0.009
SAR	sets	65	1	0	17	83
	seabirds/set	0	0		0	0
	occurrences/set	0	0		0	0
TUN	sets	16	0	17	0	33
	seabirds/set	0		0		0
	occurrences/set	0		0		0
TUS	sets	19	16	0	0	35
	seabirds/set	0	0			0
	occurrences/set	0	0			0
ALL	sets	1673	1639	1916	1721	6949
	seabirds/set	0.013	0.013	0.021	0.018	0.016
	occurrences/set	0.005	0.005	0.010	0.008	0.007

Table 5. Correlation coefficients (among years, 1992-2005) for Pelagic Observer Program units of effort, number of seabirds caught, and occurrences of seabirds, for all regions, and separately for the Middle Atlantic Bight (MAB), Northeast Central (NEC), and South Atlantic Bight (SAB). Bold indicates coefficients that were significant at α = 0.05.

All Regions

	sets	hook/hrs	hooks	soaktime	number	occurrences
sets	1					
hook/hrs	**0.984**	1				
hooks	**0.962**	**0.987**	1			
soaktime	**0.990**	**0.965**	**0.922**	1		
number	0.147	0.134	0.109	0.176	1	
occurrences	0.379	0.391	0.372	0.393	**0.926**	1

MAB

	sets	hook/hrs	hooks	soaktime	number	occurrences
sets	1					
hook/hrs	**0.979**	1				
hooks	**0.982**	**0.998**	1			
soaktime	**0.998**	**0.980**	**0.979**	1		
number	0.511	0.503	0.507	0.505	1	
occurrences	**0.627**	**0.633**	**0.645**	**0.613**	**0.906**	1

NEC

	sets	hook/hrs	hooks	soaktime	number	occurrences
sets	1					
hook/hrs	**0.979**	1				
hooks	**0.980**	**0.994**	1			
soaktime	**0.995**	**0.980**	**0.971**	1		
number	0.287	0.438	0.423	0.302	1	
occurrences	0.236	0.380	0.356	0.257	**0.971**	1

SAB

	sets	hook/hrs	hooks	soaktime	number	occurrences
sets	1					
hook/hrs	**0.853**	1				
hooks	**0.844**	**0.983**	1			
soaktime	**0.985**	**0.846**	**0.806**	1		
number	-0.129	0.032	0.002	-0.115	1	
occurrences	-0.072	0.113	0.115	-0.095	**0.929**	1

Table 6. Number and percent of longline sets made and seabirds captured by target species in the Pelagic Observer Program, 1992-2005. Also shown are percent of sets that used extra line weights and number of seabirds caught per set. Target species are: BET-bigeye tuna; DOL-dolphin (*Coryphaena* spp.); SHX-unspecified sharks; MIX-two or more target species; SWO-swordfish; TUN-unspecified tuna; YFT-yellowfin tuna.

		BET	DOL	SHX	MIX	SWO	TUN	YFT	Total
Sets	n	102	20	32	1835	2984	1016	960	6949
	%	1.5	0.3	0.5	26.4	42.9	14.6	13.8	100
Line weights	%	13.7	0	9.4	38.5	12.4	17.7	43.5	24.3
Seabirds	n	0	11	0	65	15	15	8	114
	%	0	9.6	0	57.0	13.2	13.2	7.0	100
birds per set		0	0.550	0	0.035	0.005	0.015	0.008	0.016

Table 7. Hook depth and bottom depth (in meters) for sets with and sets without seabirds in the Pelagic Observer Program. Only regions in which seabirds were captured are included. These are: ALL-all of the five following regions; GOM-Gulf of Mexico; MAB-Middle Atlantic Bight; NEC-Northeast Coastal; NED-Northeast Distant; SAB-South Atlantic Bight. Number of sets (n), mean, and standard deviation (s) are given. F-tests tested for equal variances between sets with and sets without seabirds (F_{var}). If the F-test was significant ($p<0.05$), a two-sample t-test assuming unequal variances was conducted; otherwise a test assuming equal variances was conducted.

			n	mean	s	F_{var}	p	t-test	p
hook depth									
	ALL	no birds	5424	44.1	24.4	8.17	**<0.001**	13.50	**<0.001**
		seabirds	52	27.5	8.5				
	GOM	no birds	2538	60	23.3	324.2	**0.044**	2.41	0.138
		seabirds	2	58	1.3				
	MAB	no birds	1120	29	11.4	3.28	**<0.001**	0.88	0.385
		seabirds	24	27	6.3				
	NEC	no birds	475	27	7.3	1.46	0.180	1.34	0.181
		seabirds	18	25	6.0				
	NED	no birds	501	23	7.3	-	-	-	-
		seabirds	1	17	-				
	SAB	no birds	790	39	21.1	20.79	**<0.001**	5.67	**<0.001**
		seabirds	7	28	4.6				
bottom depth									
	ALL	no birds	5424	1648	1132	1.07	0.396	3.51	**<0.001**
		seabirds	52	1094	1095				
	GOM	no birds	2538	1962	868	3.12	0.078	0.19	0.846
		seabirds	2	1842	1533				
	MAB	no birds	1120	968	721	1.52	0.113	0.38	0.705
		seabirds	24	912	586				
	NEC	no birds	475	1539	1125	1.83	**0.023**	0.60	0.554
		seabirds	18	1321	1521				
	NED	no birds	501	3097	1344	-	-	-	-
		seabirds	1	594	-				
	SAB	no birds	790	753	788	2.26	**0.036**	0.541	0.608
		seabirds	7	995	1183				

Table 8. Reported pelagic longline effort by year and region, from logbook records. Effort is given by number of gear sets. Regions are: CAR-Caribbean; FEC-Florida East Coast; GOM-Gulf of Mexico; MAB-Middle Atlantic Bight; NCA-North Central Atlantic; NEC-Northeast Coastal; NED-Northeast Distant; SAB-South Atlantic Bight; SAR-Sargasso Sea; TUN-Tuna North; TUS-Tuna South, UNK-unknown.

	CAR	FEC	GOM	MAB	NCA	NEC	NED	SAB	SAR	TUN	TUS	UNK	Total
1986	141	418	781	305	0	244	55	93	2	0	0	16	2055
1987	1923	3448	5744	1597	12	1059	963	469	29	48	0	29	15,321
1988	2324	3740	5392	1545	14	1115	1636	946	16	111	25	0	16,864
1989	1750	4702	5526	2362	132	1436	1932	1151	78	117	77	146	19,409
1990	1587	3731	4922	2412	167	2083	1215	1500	69	241	65	117	18,109
1991	1081	3085	4099	2449	120	1851	1127	1236	114	65	7	89	15,323
1992	939	2690	4467	2555	219	1449	1205	1097	181	158	1	730	15,691
1993	1151	2212	3850	2833	330	1303	1088	1658	319	101	0	758	15,603
1994	1422	2235	3565	3269	398	1078	1034	1914	321	102	0	286	15,624
1995	1366	2043	3803	3387	1111	1315	978	1680	27	319	5	220	16,254
1996	1236	1874	5146	1655	683	1401	705	2852	143	500	189	139	16,523
1997	910	2335	4907	1888	264	1529	764	1715	30	266	478	157	15,243
1998	538	1887	4139	1885	328	1080	622	1403	4	126	221	92	12,325
1999	278	2047	4854	1829	158	736	409	1402	24	52	234	115	12,138
2000	433	2043	4820	1650	242	750	603	1308	16	21	85	54	12,025
2001	335	1016	4771	1664	283	1016	333	1257	12	73	97	0	10,857
2002	283	937	4774	1400	212	686	514	779	121	80	61	0	9847
2003	218	876	5109	964	167	557	538	895	132	43	25	0	9524
2004	356	548	5452	1210	24	551	456	1001	147	11	37	0	9793
2005	197	571	3944	1259	64	433	463	738	111	114	0	0	7894
total	18,468	42,438	90,065	38,118	4,928	21,672	16,640	25,094	1,896	2,548	1,607	2,948	266,422

Table 9. Extrapolated numbers of seabirds captured in the U.S. Atlantic pelagic longline fishery. Estimates (EST) are given for all gull species combined, northern gannets, unspecified seabirds, greater shearwaters, storm-petrels, and all seabirds combined, with upper and lower 95% confidence limits of the estimates (UCL, LCL). The average annual incidental take is based on 1992-2005.

	gulls			gannets			seabirds			shearwaters			storm-petrels			all		
year	EST	UCL	LCL	EST	UCL	LCL	EST	UCL	LCL	EST	UCL	LCL	EST	UCL	LCL	EST	UCL	LCL
1986																19	54	6
1987																136	1501	12
1988																136	1500	12
1989																194	3127	11
1990																229	4445	11
1991																219	4039	11
1992	160	806	32							80	403	16				240	1209	48
1993	84	243	29	83	265	26										167	509	55
1994	206	606	70							74	283	20				280	889	90
1995	24	119	5	48	239	10	140	368	53				24	119	5	235	846	72
1996																0	0	0
1997							1109	2305	534							1109	2305	534
1998							380	1663	87							380	1663	87
1999							28	142	6							28	142	6
2000	22	107	4	22	111	4										44	218	9
2001										283	784	102				283	784	102
2002	248	663	93				36	179	7							284	842	100
2003							39	134	12							39	134	12
2004	61	231	16				6	28	1	75	230	25				142	489	42
2005	18	88	4													18	88	4
Average	59			11			124			37			2			209		

Table 10. Extrapolated numbers of dead seabirds captured in the U.S. Atlantic pelagic longline fishery. Estimates (EST) are given for all gull species combined, northern gannets, unspecified seabirds, greater shearwaters, storm-petrels, and all seabirds combined, with upper and lower 95% confidence limits of the estimates (UCL, LCL). The average annual incidental take is based on 1992-2005.

	gulls			gannets			seabirds			shearwaters			storm-petrels			all		
year	EST	UCL	LCL	EST	UCL	LCL	EST	UCL	LCL	EST	UCL	LCL	EST	UCL	LCL	EST	UCL	LCL
1986																13	37	4
1987																93	1023	8
1988																93	1022	8
1989																132	2130	8
1990																156	3028	7
1991																149	2752	7
1992	80	403	16							80	403	16				160	806	32
1993	50	178	14	0	0	0										50	178	14
1994	206	606	70							74	283	20				280	889	90
1995	0	0	0	0	0	0	140	368	53				24	119	5	164	488	58
1996																0	0	0
1997							623	1547	251							623	1547	251
1998							380	1663	87							380	1663	87
1999							28	142	6							28	142	6
2000	0	0	0	22	111	4										22	111	4
2001										283	784	102				283	784	102
2002	36	179	7				36	179	7							71	358	14
2003							20	100	4							20	100	4
2004	61	231	16				6	28	1	61	231	16				128	490	33
2005	18	88	4													18	88	4
Average	32			2			88			36			2			143		

Table 11. Estimated numbers of seabirds captured in the pelagic longline fishery assuming proportions of hook types and catch rates observed in the POP are applicable to the whole fishery. Mixed and unknown hook types are combined as mixed. The distribution of hook types and catch rates from the POP were applied to logbook effort to estimate numbers of seabirds caught. Hook type proportions for 1987 to 1991 (in bold) were the average proportions for 1992-2004 because POP values were not available then. Logbook effort includes sets from the GOM, MAB, NEC, NED, and SAB only.

		Proportion of hook type used			
year	sets	circle	J	mixed	seabirds
POP observed sets	5007	598	2727	1682	
POP seabirds		2	54	57	113
seabirds/set		0.003	0.02	0.034	
1987	9832	**0.103**	**0.593**	**0.304**	221
1988	10,634	**0.103**	**0.593**	**0.304**	239
1989	12,407	**0.103**	**0.593**	**0.304**	279
1990	12,132	**0.103**	**0.593**	**0.304**	273
1991	10,762	**0.103**	**0.593**	**0.304**	242
1992	10,773	0.108	0.165	0.727	305
1993	10,732	0.067	0.324	0.609	294
1994	10,860	0.114	0.129	0.757	311
1995	11,163	0.039	0.214	0.748	333
1996	11,759	0.029	0.934	0.037	235
1997	10,803	0.029	0.767	0.205	242
1998	9129	0	0.407	0.593	258
1999	9230	0.255	0.684	0.061	152
2000	9131	0.062	0.894	0.044	179
2001	9041	0.025	0.918	0.057	184
2002	8153	0	0.996	0.004	164
2003	8063	0.059	0.885	0.056	159
2004	9793	0.433	0.458	0.109	139
2005	6837	1.000	0	0	21
Average					223

Table 12. Estimated numbers of seabirds captured in the pelagic longline fishery assuming use of line weights and catch rates observed in the POP are applicable to the whole fishery. The distribution of line weight usage and catch rates from the POP were applied to logbook effort to estimate numbers of seabirds caught. Usage proportions for 1987 to 1991 (in bold) were the average proportions for 1992-2004 because POP values were not available then. Logbook effort includes sets from the GOM, MAB, NEC, NED, and SAB only. Line weight usage was recorded for 6943 of 6949 sets in the five regions from 1992 to 2005.

		Line weights used		
year	sets	yes	no	seabirds
POP observed sets	5001	1407	3594	
POP seabirds		4	109	113
seabirds/set		0.003	0.030	
1987	9832	**0.287**	**0.713**	219
1988	10,634	**0.287**	**0.713**	237
1989	12,407	**0.287**	**0.713**	276
1990	12,132	**0.287**	**0.713**	270
1991	10,762	**0.287**	**0.713**	239
1992	10,773	0.119	0.881	289
1993	10,732	0.205	0.795	263
1994	10,860	0.211	0.789	264
1995	11,163	0.308	0.692	242
1996	11,759	0.124	0.876	313
1997	10,803	0.135	0.865	285
1998	9129	0.292	0.708	202
1999	9230	0.316	0.684	198
2000	9131	0.326	0.674	194
2001	9041	0.496	0.504	150
2002	8153	0.537	0.463	126
2003	8063	0.373	0.627	161
2004	9793	0.274	0.726	221
2005	6837	0.380	0.620	135
Average				225

Table 13. Effort, actual seabird take, and estimated seabird take in the NED experimental longline fishery. The number of sets is given by hook type. Catch categories were unspecified seabirds, northern gannets, and shearwaters (greater shearwaters and unidentified). Estimated take (EST) and upper and lower 95% confidence limits (UCL, LCL) were obtained from stratified mean seabird take per set for all seabird categories combined. Estimated takes derived from hook type assume hook catch rates given in Table 10. Access to the effort and actual seabird take data from the NED experiment were provided courtesy of the John Watson and Sheryan Epperly (see Watson et al. 2005).

			Year			
			2001	2002	2003	total
sets	hook type	circle			39	39
		J	186			186
		mixed		503	497	1000
		all	186	503	536	1225
actual seabirds						
	unspec. seabirds	all	1	5	1	7
		dead	1	2	1	4
	gannets	all	0	1	0	1
		dead	0	0	0	0
	shearwaters	all	0	7	0	7
		dead	0	6	0	6
		all seabirds	1	13	1	15
stratified mean/set			0.0313	0.0346	0.0049	
estimated seabirds		EST	6	17	3	26
		UCL	16	42	9	67
		LCL	2	7	1	10
estimated seabirds		circle	0	0	0	0
		J	1	0	0	1
		mixed	0	17	17	34
		total	1	17	17	35

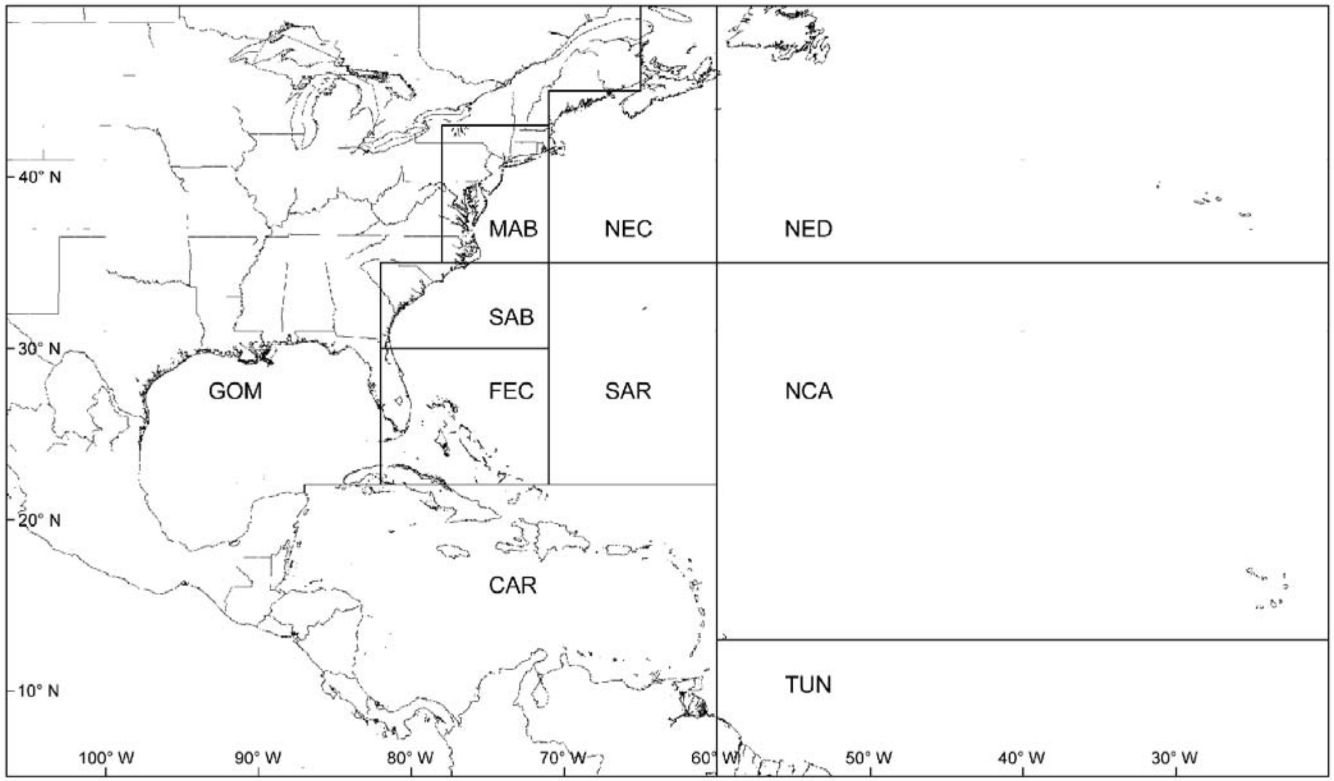

Figure 1. Map indicating National Marine Fisheries Service fishing regions used in analyses of pelagic longline data. The regions illustrated are: Caribbean (CAR), Gulf of Mexico (GOM), Florida East Coast (FEC), Middle Atlantic Bight (MAB), North-Central Atlantic (NCA), Northeast Coastal (NEC), Northeast Distant (NED), Sargasso Sea (SAR), South Atlantic Bight (SAB), and Tuna-North (TUN). The Tuna-South (TUS) region not depicted is south of the TUN.

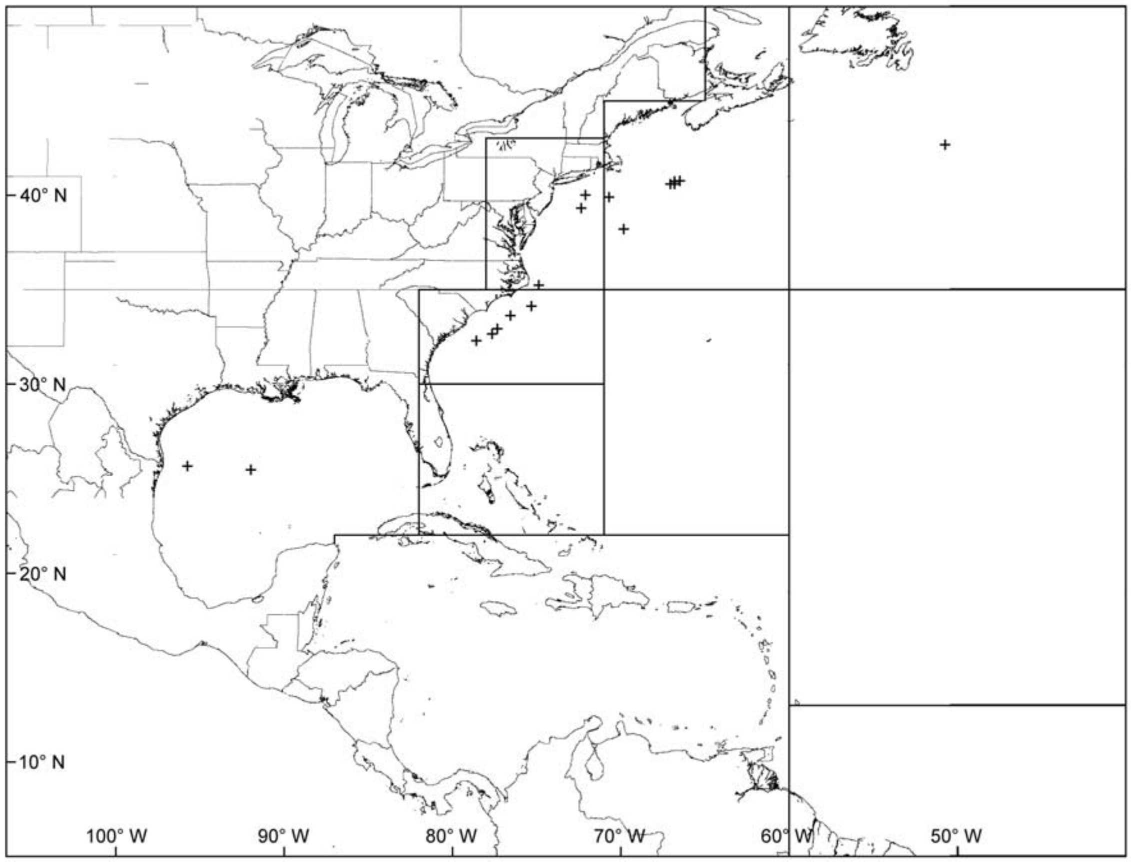

Figure 2. Map indicating locations of pelagic longline sets that captured unspecified seabirds in the Pelagic Observer Program, 1992-2005.

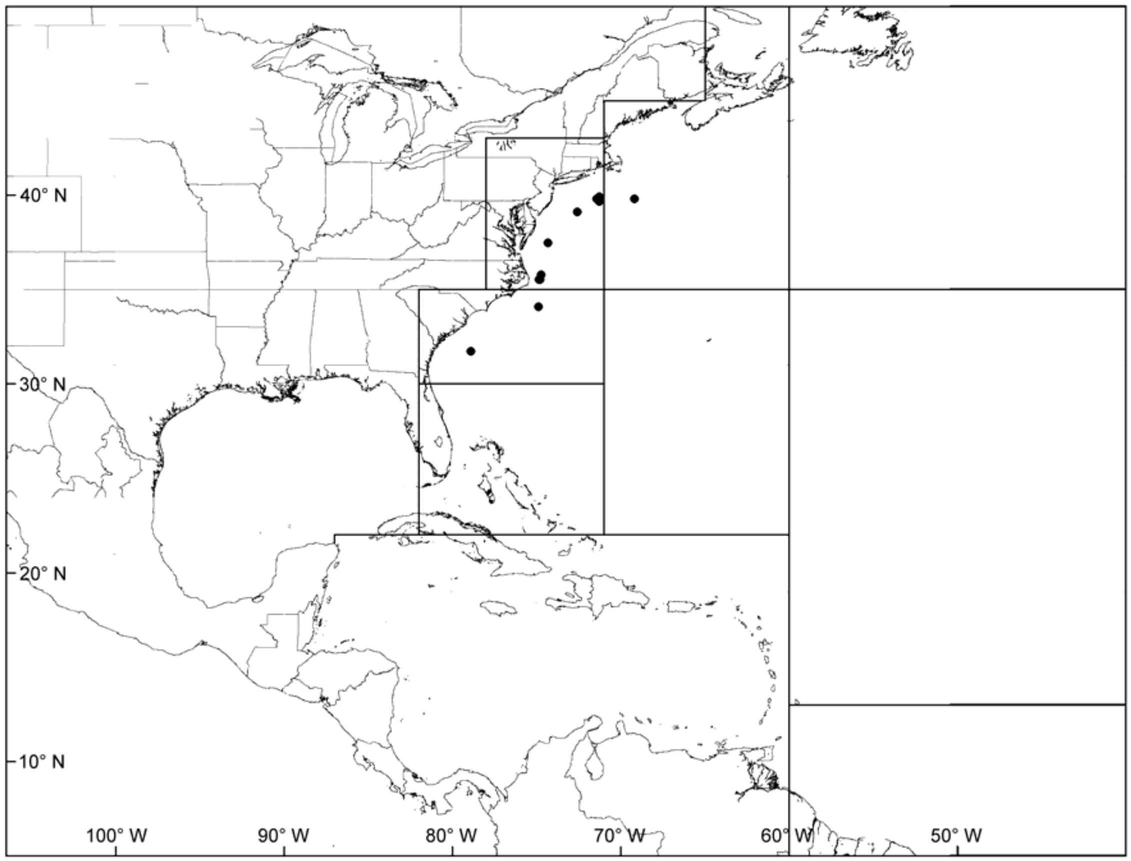

Figure 3. Map indicating locations of pelagic longline sets that captured gulls (all species combined) in the Pelagic Observer Program, 1992-2005.

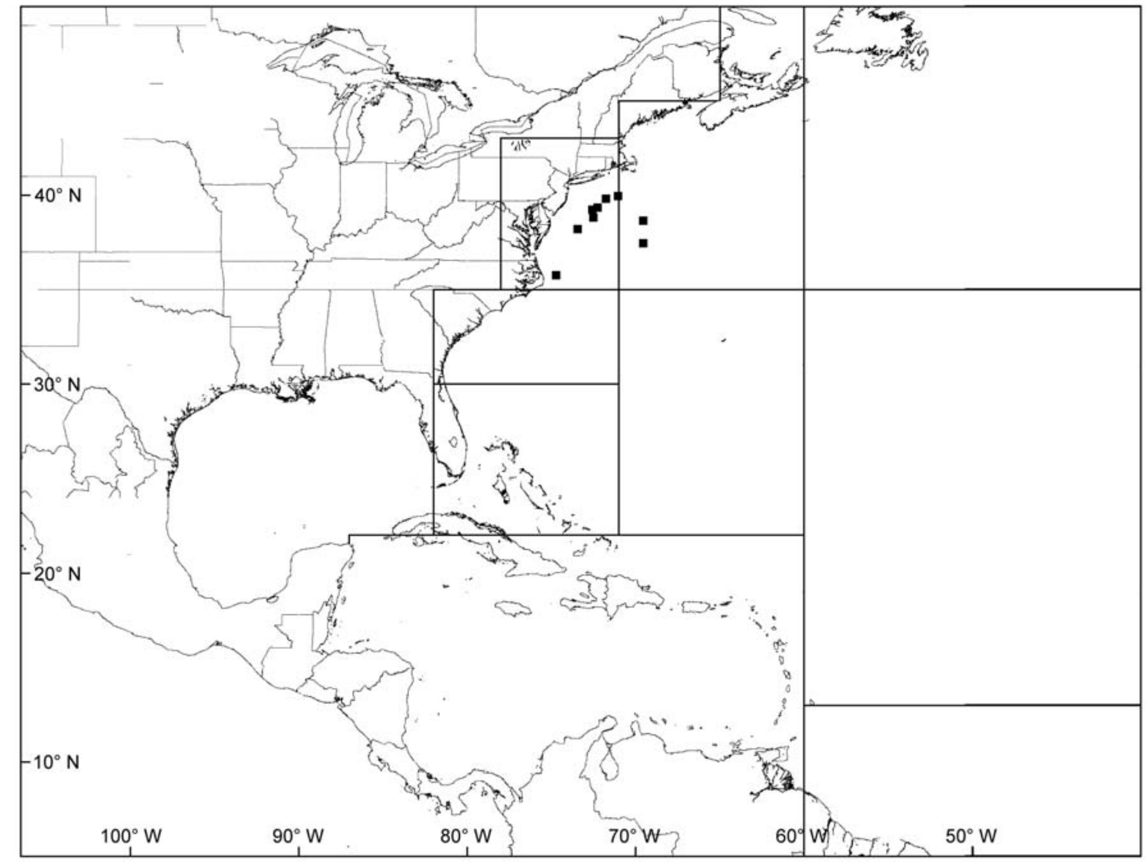

Figure 4. Map indicating locations of pelagic longline sets that captured greater shearwaters in the Pelagic Observer Program, 1992-2005.

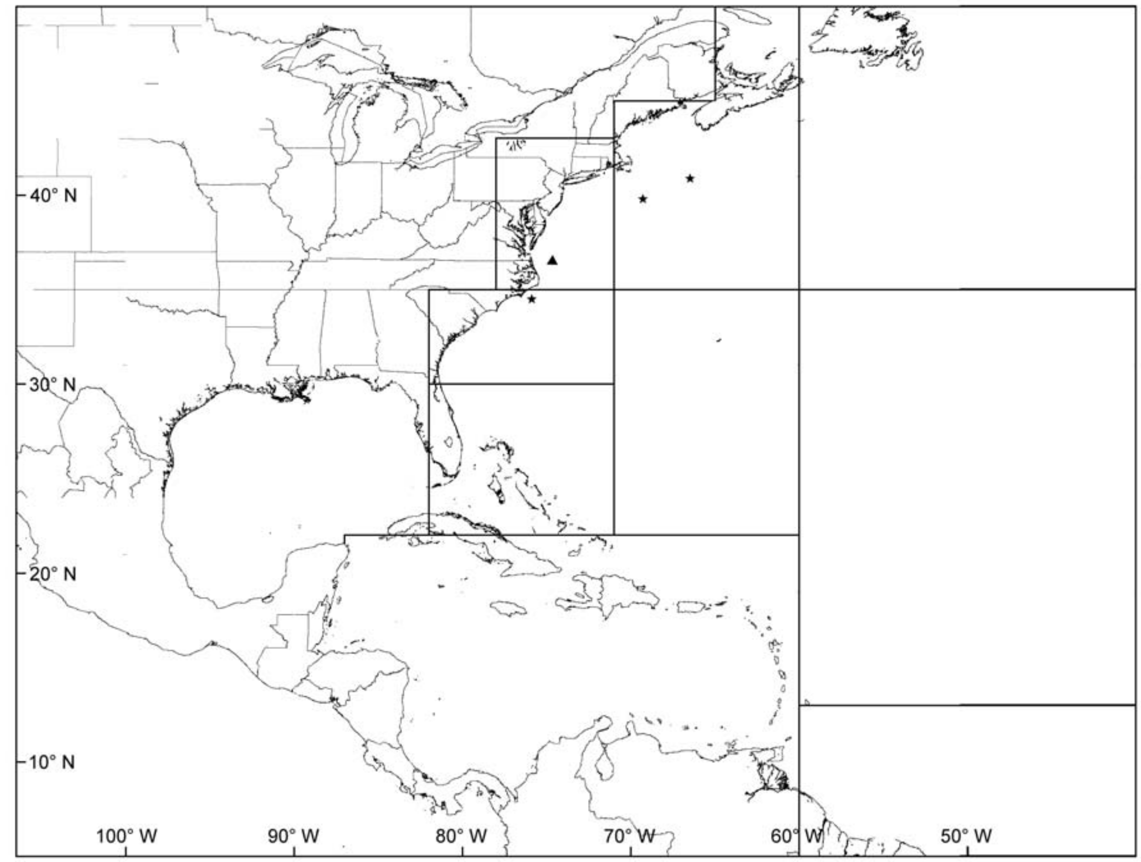

Figure 5. Map indicating locations of pelagic longline sets that captured northern gannets (stars) and storm-petrels (triangle) in the Pelagic Observer Program, 1992-2005.

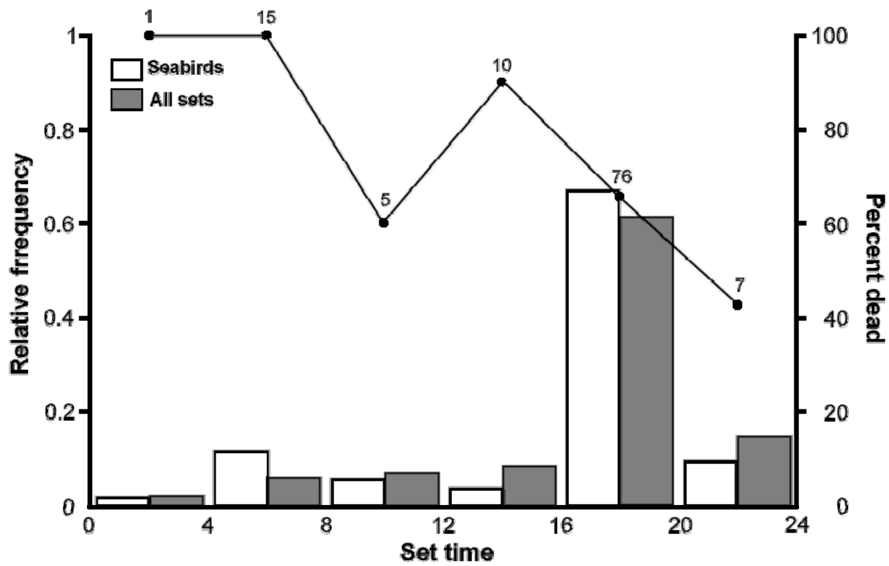

Figure 6. Relative frequency distribution of time of day a gear set was begun (set time) for all sets and for sets with seabirds. Set times are grouped in four-hour intervals. Line indicates percent of seabirds that were dead upon gear retrieval. Numbers above percent dots indicate number of seabirds captured during that set time interval.

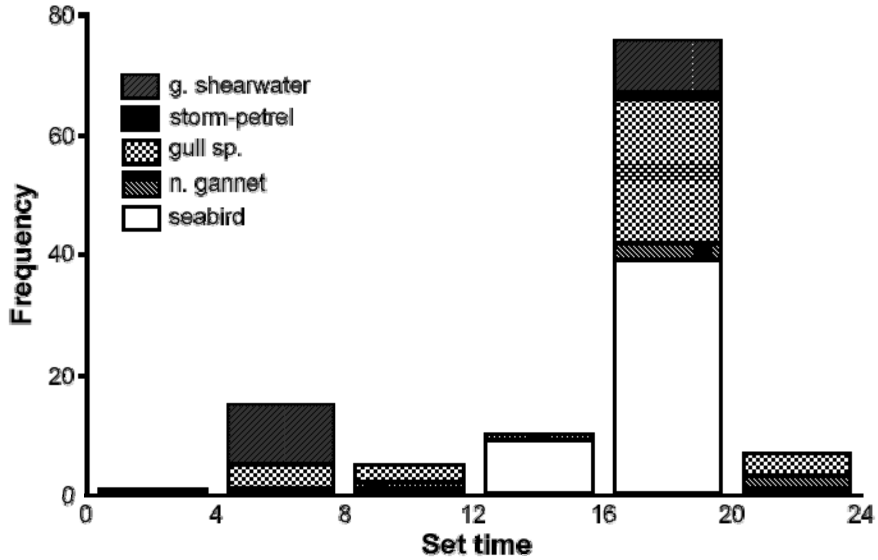

Figure 7. Frequency distribution of time of day a gear set was begun (set time) for sets with seabirds. Set times are grouped in four-hour intervals. Groups are unspecified seabirds, northern gannets, all gull species, great shearwaters, and storm-petrel.

Appendix 1. Observed pelagic longline effort (in thousands of hooks) by region and quarter, number of seabirds caught per 1000 hooks and number of occurrences per 1000 hooks, from the Pelagic Observer Program, 1992-2005 combined.

Region		Quarter				
		1	2	3	4	All
CAR	1000 hooks	95.8	23.5	5.8	24	149.3
	seabirds/1000 hooks	0	0	0	0	0
	occur/1000 hooks	0	0	0	0	0
FEC	1000 hooks	132.2	77.6	48.4	42.8	301
	seabirds/1000 hooks	0	0	0	0	0
	occur/1000 hooks	0	0	0	0	0
GOM	1000 hooks	464.3	513.9	480.3	499.5	1958
	seabirds/1000 hooks	0.002	0	0.002	0	0.001
	occur/1000 hooks	0.002	0	0.002	0	0.001
MAB	1000 hooks	112.9	91.6	272.1	292.4	769
	seabirds/1000 hooks	0.159	0	0.044	0.085	0.072
	occur/1000 hooks	0.053	0	0.029	0.034	0.031
NCA	1000 hooks	178.4	67.2	0	0	245.6
	seabirds/1000 hooks	0	0			0
	occur/1000 hooks	0	0			0
NEC	1000 hooks	0	50.1	219.5	112.7	382.3
	seabirds/1000 hooks		0.160	0.123	0.044	0.105
	occur/1000 hooks		0.080	0.050	0.027	0.047
NED	1000 hooks	0	18.4	201.8	200.9	421.1
	seabirds/1000 hooks		0	0	0.005	0.002
	occur/1000 hooks		0	0	0.005	0.002
SAB	1000 hooks	90.4	258.5	67	38	453.9
	seabirds/1000 hooks	0.033	0.050	0	0	0.035
	occur/1000 hooks	0.022	0.019	0	0	0.015
SAR	1000 hooks	50.4	0.8	0	19.7	70.9
	seabirds/1000 hooks	0	0		0	0
	occur/1000 hooks	0	0		0	0
TUN	1000 hooks	10.5	0	11.9	0	22.5
	seabirds/1000 hooks	0		0		0
	occur/1000 hooks	0		0		0
TUS	1000 hooks	14.7	11.2	0	0	25.9
	seabirds/1000 hooks	0	0			0
	occur/1000 hooks	0	0			0
ALL	1000 hooks	1149.7	1112.7	1306.9	1230.2	4799.5
	seabirds/1000 hooks	0.019	0.019	0.031	0.025	0.024
	occur/1000 hooks	0.008	0.008	0.015	0.011	0.011