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Estimated Magnitude of Sea Turtle Interactions in U.S. Sink Gillnet Gear, 2017-2021

US DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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Estimated Magnitude of Sea Turtle Interactions in U.S. Sink Gillnet Gear, 2017-2021

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Editorial Notes

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ABSTRACT

This document reports updated estimates of turtle interactions, mortality, and adult equivalents in gillnet fisheries from 2017-2021. In addition, this document provides information needed to evaluate levels of observer sea day coverage in gillnet fisheries to monitor turtle interactions in 2023 under the Standardized Bycatch Reporting Methodology (SBRM). Interaction rates for each turtle species were estimated with the same stratified ratio estimators used to estimate interactions in this gear type from 2012-2016 (by region, season, and mesh size). From 2017-2021, the total number of estimated interactions of sea turtles in sink gillnet gear was 142 loggerheads (*Caretta caretta*), of which 88 were mortalities (coefficient of variation [CV]=0.89, 95% CI over all years: 15-376); 91 Kemp's ridleys (*Lepidochelys kempii*), of which there were 56 mortalities (CV=0.62, 95% CI over all years: 0-218); 49 greens (*Chelonia mydas*), of which there were 30 mortalities (CV=1.01, 95% CI over all years: 0-177); 26 leatherbacks (*Dermocheyls coriacea*), of which there were 16 mortalities (CV=0.98, 95% CI over all years: 0-79); and 32 unidentified hard-shelled turtles, of which there were 20 mortalities (CV=0.59, 95% CI over all years: 0-75). Total estimated loggerhead interactions was equivalent to 2.5 adults. To evaluate the impact of reduced observer monitoring in 2020 and 2021 as a result of the COVID-19 pandemic, a reduced time series spanning only years 2017-2019 was used to estimate interaction rates, confidence intervals, and CVs, and was then compared to those generated from the 5-year time series. Estimated interactions derived from the 3-year time series did not differ significantly from those derived from the 5-year time series, suggesting that reduced and uneven observer monitoring in 2020 and 2021 did not bias the results using the longer time series.

1. INTRODUCTION

The purpose of this report is to update estimates of turtle interactions and mortality in sink gillnet fisheries operating from Maine to North Carolina from 2017-2021. In the previous analysis, which spanned years 2012-2016, an estimated 705 loggerhead (*Caretta caretta*), 145 Kemp's ridley (*Lepidochelys kempii*), 27 leatherback (*Dermocheyls coriacea*), and 112 unidentified hard-shelled turtle interactions occurred in the Georges Bank and Mid-Atlantic regions (Murray 2018). This report expands the study region to also include the Gulf of Maine and also includes an estimate of green turtle (*Chelonia mydas*) interactions. As in previous analyses of turtle interactions in commercial fishing gear, this document also reports adult equivalent (AE) losses of the Northwest Atlantic distinct population segment of loggerhead sea turtle. Adult equivalency translates the loss of individual turtles into the number of adults expected, based on chances of the individual surviving to adulthood and reproducing. Compared to individual losses, monitoring AE losses from fisheries interactions can be a more informative metric to assess population-level impacts. Within the study area, fishers continue to be prohibited from using gillnets with mesh sizes ≥7 in. during certain times and areas that overlap with the seasonal occurrence of loggerheads (Sea Turtle Conservation…2002)[1].

[1] https://www.fisheries.noaa.gov/resource/map/large-mesh-gillnet-restricted-area-map-gis-data

2. METHODS

2.1 Study Region

The extent of the study region was defined by the boundaries of the Gulf of Maine, Georges Bank, and Mid-Atlantic Ecological Production Units (EPUs), characterized by distinct patterns in oceanographic properties, fish distributions, and primary production (Ecosystems Assessment Report 2012). The study region extended eastward from the continental coastline to the Exclusive Economic Zone (EEZ) and southward to the southern extent of Northeast Fisheries Observer Program (NEFOP) data collection (~34^0N).

2.2 Data Sources

2.2.1 Observer Data

Data collected by NEFOP observers and at-sea monitors (ASMs) aboard commercial sink gillnet vessels from 2017-2021 were used to compute interaction rates of loggerhead, Kemp's ridley, green, leatherback, and unidentified hard-shelled turtles. A total of 5,221 trips were observed encompassing 23,604 hauls from 2017-2021 in Northeast region sink gillnet fisheries (Maine to North Carolina; Figure 1). Observer coverage ranged from 4-14% each year, with the lowest coverage occurring in 2020 during the COVID-19 pandemic (Table 1). Due to the pandemic, observer coverage was waived from March 20-August 15, 2020[2].

2.2.2 Commercial Data

Vessel Trip Reporting (VTR) data were the primary data used in estimating total interactions because most VTRs contained the information on fishing location and characteristics (i.e., mesh size) necessary to derive total interactions in this analysis. VTR landings were scaled by an adjustment factor (AF; Murray 2015) so that VTR landings equaled the landings reported in the dealer database, which is assumed to be a near census of commercial catch (Wigley et al. 2007). Commercial fishing effort for gillnet trips in North Carolina were poorly represented in the dealer database, so for vessels landing catch in North Carolina, VTR landings were scaled using oceanside landings reported by the North Carolina Division of Marine Fisheries (NCDMF) trip ticket program (Murray 2015).

To adjust VTR data to match the magnitude of landings in the dealer data, VTR and dealer landings were first totaled by each state, year, and season combination, where seasons were defined to match those in this analysis (July-October, November-June). Next, an AF for each combination was calculated as:

$$AF_i = \frac{\sum Dealer\ landings_{ijk}}{\sum VTR\ landings_{ijk}}$$

where *i* = year, *j*=state, and *k*=season in which catch was landed. VTR data in North Carolina, and NCDMF data, were further stratified depending on whether catch was landed inside or outside of North Carolina internal waters.

For each VTR trip in stratum *ijk*, the landed catch was multiplied by the AF of stratum *ijk*.

[2] https://www.fisheries.noaa.gov/bulletin/temporary-waivers-northeast-observers-monitors-through-august-13-resuming-coverage

2.3 Interaction Rates

Interaction rates for each turtle species were estimated with similar stratified ratio estimators used to estimate turtles in gillnet gear from 2012-2016 (Murray 2018). Observer and commercial data were stratified by region, season, and mesh size based on factors associated with loggerhead interaction rates in previous gillnet analyses (latitude, sea surface temperature [SST], mesh size; Murray 2009, 2013). Regions included the Gulf of Maine, Georges Bank, and Mid-Atlantic, with the boundaries of each matching these respective EPUs. The Mid-Atlantic EPU was further divided into the northern Mid-Atlantic (>37^{0}N to the Georges Bank boundary) and southern Mid-Atlantic (<=37^{0}N to 34^{0}N). Season was used as a proxy for SST. Seasonal groups were defined as summer (July-October) or winter (November-June). Mesh groups were defined as small (<7") or large (>=7") and corresponded to sizes associated with low and high interaction rates, respectively, in previous analyses (Murray 2009, 2013). The stratification for loggerheads was maintained for the other turtle species (Kemp's ridley, green, leatherback) because it was assumed to capture the temporal and spatial presence of each species on the Northeast continental shelf while distinguishing between large and small mesh gillnet fisheries.

Within each stratum (*j*), interaction rates (*R*) were defined as:

$$R_j = \sum_{i=1}^{n} \frac{observed\ turtles_j}{observed\ tons\ landed_j}$$

where *n* = the number of observed NEFOP hauls

Bootstrap resampling was used to estimate uncertainty (coefficient of variation [CV] and confidence intervals [CIs]) around interaction rates within each stratum, using trips as the resampling unit. Bootstrap replicates were generated by resampling trips with replacement 1000 times from the original observer dataset, and then interaction rates within each stratum were computed for each replicate. The 95% CIs for the interaction rates were computed from the upper 97.5% and lower 2.5% quartiles of the bootstrap replicates. A combined CV over all stratum-specific CVs (*j*) was calculated as:

$$\text{Combined CV} = \sqrt{\frac{CV_j^2}{n}}$$

where *n* = the number of strata

To evaluate the impact of reduced observer monitoring in 2020 and 2021 as a result of the COVID-19 pandemic, percent observer coverage was evaluated by month and EPU within each year. Because sampling may not have been representative in time and space of commercial effort in 2020 and 2021, a reduced time series spanning only years 2017-2019 was used to estimate interaction rates, CIs, and the combined CV. Stratified rates were calculated from the 3-year time series and then applied to VTR data from 2017-2021. Results were then compared against the estimates and uncertainty generated from the 5-year time series.

2.4 Estimated Interactions: Total & Adult Equivalents

Total estimated interactions (TI) for each turtle species from 2017-2021 was the sum over all strata (*h*) of the product of the interaction rate and total adjusted VTR fishing effort within each stratum (*j*):

$$TI = \sum_{j=1}^{h} R_j * \ Adjusted\ VTR\ Effort_j$$

The number of mortalities was estimated by applying the most recent mortality rate determined for sink gillnet gear (62%; Upite et al. in review) to the total estimated interactions. This mortality rate was determined by members of a working group who applied injury guidelines (NMFS 2022) to 17 observed turtle interactions in sink gillnet gear between 2017 and 2021.

The finite population correction factor (fpc) was applied to CVs in strata where observer coverage was >10% (Cochran 1977). The fpc adjusts standard errors to be more precise when greater than 10% of the population is sampled. It is defined as:

$$fpc_j = \sqrt{\frac{N-n}{N-1}}$$

where N = total adjusted VTR fishing effort in stratum j, and n = observed tons in stratum j.

To estimate loggerhead interactions in terms of adult equivalents, each observed loggerhead turtle with a curved carapace measurement was assigned a Reproductive Value (RV) based on slow-growth high fecundity RVs in Wallace (2008). As there were only 5 turtles with a recorded length measurement, the total estimated loggerhead interactions was multiplied by the average RV of all turtles (0.018) to compute AE losses. AEs were only computed for loggerheads because RVs are not available for the other turtle species.

2.5 Estimated Sea Day Needs

Prior to estimating observer coverage needs for future fishing years, the probability of encountering loggerhead turtles over all strata was estimated by using results of this analysis. This approach has been used in turtle bycatch analyses in other gear types (Hogan 2019; Murray 2020) and was designed to ensure that observer coverage in the upcoming year is not driven by imprecise estimates of interaction rates owing to an extremely rare event. The probability of observing 1 or more turtle species, assuming a Poisson distribution (Smith 1999), was estimated for varying amounts of observer coverage based on the average annual number of interactions and VTR trips using sink gillnet gear from 2017-2021. In the Standardized Bycatch Reporting Methodology (SBRM) process, sea days are typically allocated for monitoring a turtle species if there is a >50% probability of observing 5 or more turtles over 800 trips in a year. Sea days for turtles are then combined with those needed to monitor fish discards and adjusted under a prioritization scheme based on available funding (NEFSC and GARFO 2020).

CVs around the interactions rates in this analysis was used to estimate the amount of observer sea days needed in 2023 to achieve 30% CV precision around the rate. The number of observed sea days needed to achieve a 30% CV around interaction rates from 2017-2021 was derived from Rossman (2007):

$$n_{proj} = (CV_{obs} * \sqrt{n_{obs}}/CV_{proj})^2$$

where n_{proj}= the amount of projected effort (converted to sea days[3]); CV_{obs} = the precision levels around estimated rates in this analysis; n_{obs}= the observed effort (trips) underlying the interaction rates; and CV_{proj} = the projected precision levels.

3. RESULTS

3.1 Turtle Characteristics

NEFOP observers reported a total of 8 loggerheads, 5 Kemp's ridleys, 3 greens, 2 leatherbacks, and 3 unidentified hard-shelled species in gillnet gear from 2017-2021 (Table 1; Figure 2). Observers sampled 11% of commercial sink gillnet trips on average over all 5 years, but percent coverage was relatively lower after March 2020, particularly in the Mid-Atlantic (Figure 3). There were no observed turtle interactions in 2020 or 2021, and none were reported by ASM observers. Characteristics of each turtle interaction are listed in Table 2.

3.2 Interaction Rates

The highest interaction rate of loggerhead turtles occurred in the northern Mid-Atlantic strata in large mesh gear from July-October (Figure 3). Interaction rates of all other species were lower relative to loggerheads.

3.3 Total Estimated Interactions

From 2017-2021, total estimated interactions of sea turtles in sink gillnet gear was 142 loggerheads (of which 88 were mortalities; CV=0.89, 95% CI over all years: 15-376), 91 Kemp's ridleys (56 mortalities; CV=0.62, 95% CI over all years: 0-218), 49 greens (30 mortalities; CV=1.01, 95% CI over all years: 0-177), 26 leatherbacks (16 mortalities; CV=0.981, 95% CI over all years: 0-79), and 32 unidentified hard-shelled turtles (20 mortalities; CV=0.59, 95% CI over all years: 0-75; Table 4). The total number of estimated loggerhead interactions was equivalent to 2.5 adults.

Estimated interactions derived from the 3-year time series did not differ significantly from those derived from the 5-year time series (Figure 4). Estimated interactions for all species were slightly lower using the 5-year time series and had slightly lower CVs for loggerheads, Kemp's ridleys, and leatherbacks. Based on this evaluation, estimates and subsequent monitoring needs are reported here based on the 5-year time series.

3.4 Estimated Sea Day Needs

There is only an estimated 10% probability of observing >=5 loggerheads over 800 trips (Figure 5) and an even lower probability of observing Kemp's ridley, green, and leatherback turtles. Therefore, sea days to monitor turtles in gillnet gear will not enter the sea day allocation process in SBRM; instead, the targeted level of monitoring will be driven by other marine species groups. A total of 3,132 sea days per year would be needed to achieve a 30% CV precision around loggerhead interaction rates over all combined strata, which includes Gulf of Maine, Georges Bank, and Mid-Atlantic (Figure 6). Estimated sea day needs to achieve a 30% CV are still reported

[3] The conversion from trips to sea days used 1.2 mean days absent/trip, and 1 day absent = 1 sea day. Conversions were based on characteristics of observed trips from 2017-2021.

here for loggerheads to evaluate how the target CV may change based on coverage allocated for other marine species, once sea days are allocated for the 2023 fishing year. Estimated sea days to achieve a target CV are not reported for the other turtle species.

4. DISCUSSION

The average annual amount of loggerhead turtle interactions in sink gillnet gear from 2017-2021 was much lower compared to the previous 5-year period (28 interactions vs. 141), and the 95% CIs around the estimates in the 2 time periods did not overlap. This is in contrast to the average annual estimate of Kemp's ridley interactions, which were within the CIs of the previous 5-year estimate, and leatherback interactions, which were the same (see Murray 2018 for details). While the number of commercial trips was higher in almost all strata from 2012-2016, the percent of observer coverage over each pooled 5-year time series was comparable. The loggerhead interaction rate from 2012-2016 in large mesh gear in the summer in the northern Mid-Atlantic was almost 3x the rate in the same strata from 2017-2021. There does not appear to be an obvious explanation from the data as to why so few loggerhead turtles were observed in the more recent time period.

In 2020, there was no observer coverage from April- July in all regions and less than 5% coverage in the Mid-Atlantic from August-December. In 2021, coverage was relatively higher in the Gulf of Maine overall and in some months on George Bank, but it remained low in the Mid-Atlantic (where turtles are more commonly found) over all months. Eliminating 2020 and 2021 from the time series to estimate interaction rates and CVs did not significantly change the results, suggesting that the reduced and uneven spread of observer coverage in these years did not bias the estimates derived from the usual 5-year time series.

The low number of turtle interactions led to relatively high CVs in all strata and the high number of sea days needed to reach the target precision of 30% recommended by the National Working Group on Bycatch (NMFS 2004). The rarity of turtle interactions as shown by this analysis caused this group to be filtered out of the SBRM sea day allocation process (Hogan 2019). Until estimates of turtle interactions and CVs are updated again, future levels of observer monitoring in gillnet fisheries will be driven by the 30% target precision goal for other marine species groups. Therefore, monitoring for turtle interactions will still occur but at reduced levels, resulting in potentially higher (than 30%) CVs around the interaction rate.

5. ACKNOWLEDGEMENTS

Thanks to Josh Hatch and Kristin Precoda for coding aspects of this analysis, and to the many fisheries observers who collect the data to allow us to monitor protected species bycatch.

6. TABLES AND FIGURES

Table 1. Observed sea turtle interactions and sampling coverage (% of trips) in sink gillnet gear in the Gulf of Maine, Georges Bank, and Mid-Atlantic regions, 2017-2021. Cc = Loggerhead (*Caretta caretta*); Lk = Kemp's ridley (*Lepidochelys kempii*); Cm = Green (*Chelonia mydas*); Dc = Leatherback (*Dermochelys coriacea*); Unid = Unidentified species; VTR = Vessel Trip Reporting.

Year	Cc	Lk	Cm	Dc	Unid	Observed trips	VTR trips	% Coverage (trips)
2017	1	2	1	1	1	1,636	11,448	14
2018	4	3	1	0	1	1,159	10,230	11
2019	3	0	1	1	1	1,491	10,029	15
2020	0	0	0	0	0	331	8,470	4
2021	0	0	0	0	0	604	6,379	9
Total	**8**	**5**	**3**	**2**	**3**	**5,221**	**46,556**	**11**

Table 2. Characteristics of observed sea turtle interactions in sink gillnet gear, 2017-2021. Cc = Loggerhead (*Caretta caretta*); Lk = Kemp's ridley (*Lepidochelys kempii*); Cm = Green (*Chelonia mydas*); Dc = Leatherback (*Dermochelys coriacea*); Unid = Unidentified species. MAN = Mid-Atlantic North; MAS = Mid-Atlantic South; GOM = Gulf of Maine; NR = Not Reported.

Year	Species	Region	Month	Depth (m)	Mesh size (in)	Soak duration (hrs)	Trip Target species	Notch to tip length (cm)	Carapace width (cm)
2017	Cm	MAN	10	38.4	12.0	72.0	Monkfish	33.0	28.0
2017	Lk	MAN	9	11.0	6.0	8.0	Smooth dogfish (*Mustelus canis*)	NR	NR
2017	Lk	MAN	9	11.0	6.0	NR	Smooth dogfish	30.0	29.0
2017	Dc	MAS	5	5.5	3.5	1.8	Spanish mackerel	NR	NR
2017	Cc	MAN	9	20.1	7.0	27.0	Summer flounder (*Paralichthys dentatus*)	NR	NR
2017	Unk	MAN	11	NR	12.0	216.0	Monkfish	NR	NR
2018	Cm	MAN	5	5.5	11.5	25.0	Black drum (*Pogonias cromis*)	NR	NR
2018	Lk	MAS	2	3.7	6.0	2.2	Spiny dogfish (*Squalus acanthias*)	41.5	41.0
2018	Lk	MAS	2	7.3	6.0	3.5	Thresher shark	36.0	35.5
2018	Lk	MAS	11	12.8	5.5	1.2	King mackerel (*Scomberomorus cavalla*)	54.0	54.0
2018	Cc	MAN	7	54.9	12.0	156.0	Monkfish	62.1	NR
2018	Cc	GOM	9	49.4	12.0	96.0	Monkfish	48.5	47.0

2018	Cc	MAN	10	34.7	12.5	118.5	Winter skate (*Leucoraja ocellata*)	58.5	56.0
2018	Cc	MAN	10	40.2	12.5	120.8	Winter skate	46.0	43.0
2018	Unk	MAN	11	36.6	12.0	94.5	Monkfish	NR	NR
2019	Cm	MAN	10	7.3	6.5	4.3	Striped bass (*Morone saxatilis*)	31.0	26.5
2019	Dc	MAN	11	51.2	12.0	96.0	Monkfish	NR	NR
2019	Cc	MAN	5	21.9	12.0	48.0	Monkfish	54.0	53.0
2019	Cc	MAN	7	45.7	12.0	48.0	Monkfish	NR	NR
2019	Cc	MAS	9	1.8	3.0	25.5	Spot (*Leiostomus xanthurus*)	NR	NR
2019	Unk	MAN	5	NR	12.0	48.0	Monkfish	NR	NR

Table 3. Observed sea turtle interactions by analytical strata and observer coverage (% of trips) in sink gillnet gear, 2017-2021. Only those strata with observed interactions are reported. Some observed trips operated in multiple strata. Cc = Loggerhead (*Caretta caretta*); Lk = Kemp's ridley (*Lepidochelys kempii*); Cm = Green (*Chelonia mydas*); Dc = Leatherback (*Dermochelys coriacea*); Unid = Unidentified species; VTR = Vessel Trip Reporting.

Region	Season	Mesh Group	Obs Cc	Obs Lk	Obs Cm	Obs Dc	Obs Unid	Obs trips	VTR trips	% Cov
Gulf of Maine	July-Oct	>=7"	1	0	0	0	0	529	2834	19
Mid-Atlantic North	Jul-Oct	>=7"	5	0	1	0	0	108	1125	10
Mid-Atlantic North	July-Oct	<7"	0	2	1	0	0	482	4158	12
Mid-Atlantic North	Nov-Jun	>=7"	1	0	1	1	3	1102	10841	10
Mid-Atlantic South	July-Oct	<7"	1	0	0	0	0	251	835	30
Mid-Atlantic South	Nov-Jun	<7"	0	3	0	1	0	1115	5678	20
Total			8	5	3	2	3	3,587	25,471	14

Table 4. Total estimated sea turtle interactions (coefficient of variations [CVs], 95% confidence intervals [Cis]) in sink gillnet gear, 2017-2021. Cc = Loggerhead (*Caretta caretta*); Lk = Kemp's ridley (*Lepidochelys kempii*); Cm = Green (*Chelonia mydas*); Dc = Leatherback (*Dermochelys coriacea*); Unid = Unidentified species.

Region	Season	Mesh Group	Est. Cc	Est. Lk	Est. Cm	Est. Dc	Est. Unid.
Gulf of Maine	July-Oct	>=7"	7 (0.95, 0-21)	0	0	0	0
Mid-Atlantic North	Jul-Oct	>=7"	80 (0.53, 15-176)	0	16 (0.96, 0-50)	0	0
Mid-Atlantic North	July-Oct	<7"	0	46 (0.65, 0-11)	23 (1.03, 0-86)	0	0
Mid-Atlantic North	Nov-Jun	>=7"	11 (1.0, 0-33)	0	11 (1.03, 0-41)	11 (1.0, 0-32)	32 (0.59, 0-75)
Mid-Atlantic South	July-Oct	<7"	44 (1.0, 0-146)	0	0	0	0
Mid-Atlantic South	Nov-Jun	<7"	0	46 (0.59, 0-106)	0	15 (0.96, 0-47)	0
Total			142 (0.89)	91 (0.62)	49 (1.01)	26 (0.98)	32 (0.59)
5 year annual average (95% CI)			28 (3-75)	18 (0-44)	10 (0-35)	5 (0-16)	6 (0-15)

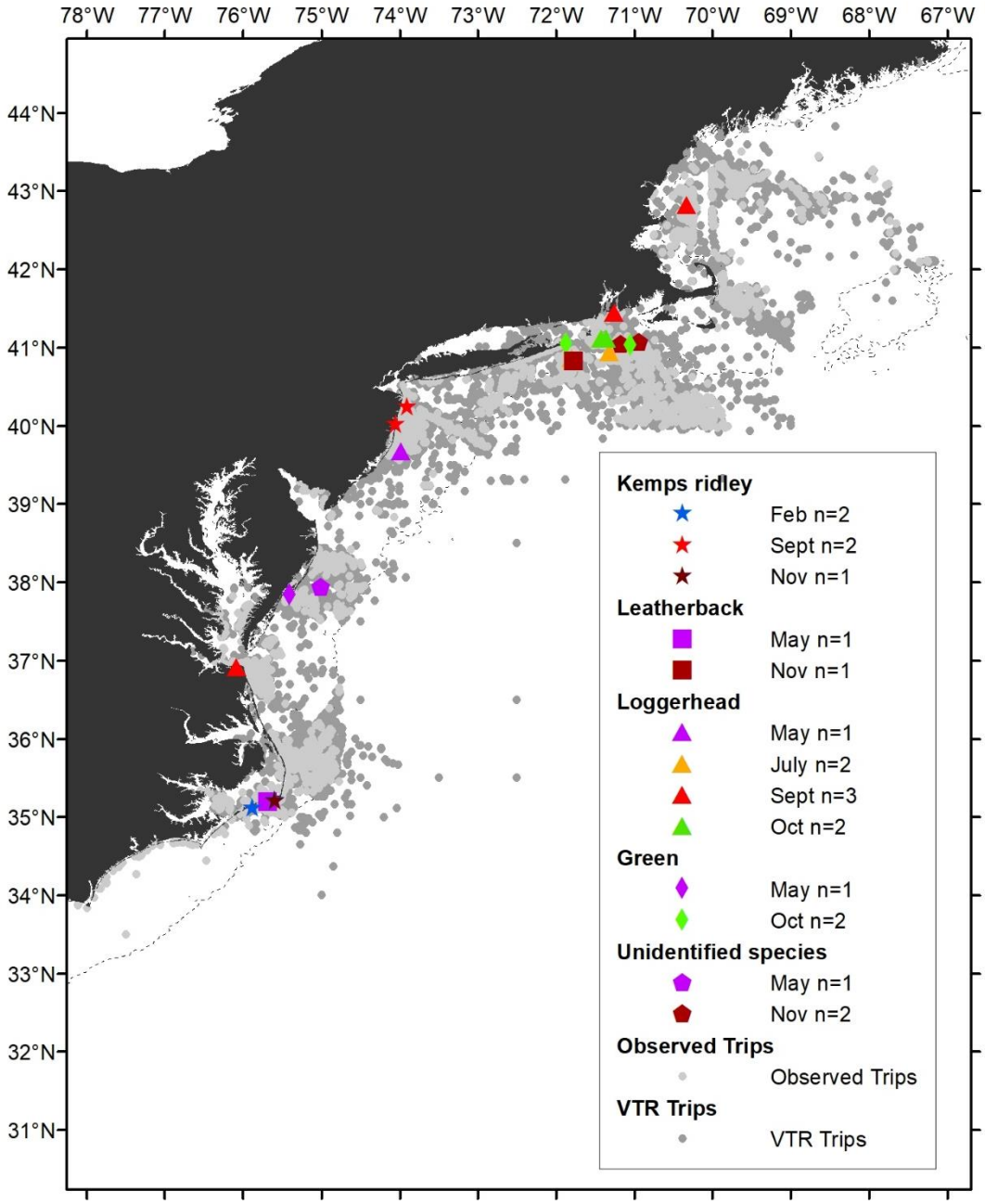


Figure 1. Observed turtle interactions, observed trips, and commercial fishing trips using sink gillnet gear, 2017-2021. VTR = Vessel Trip Reporting.

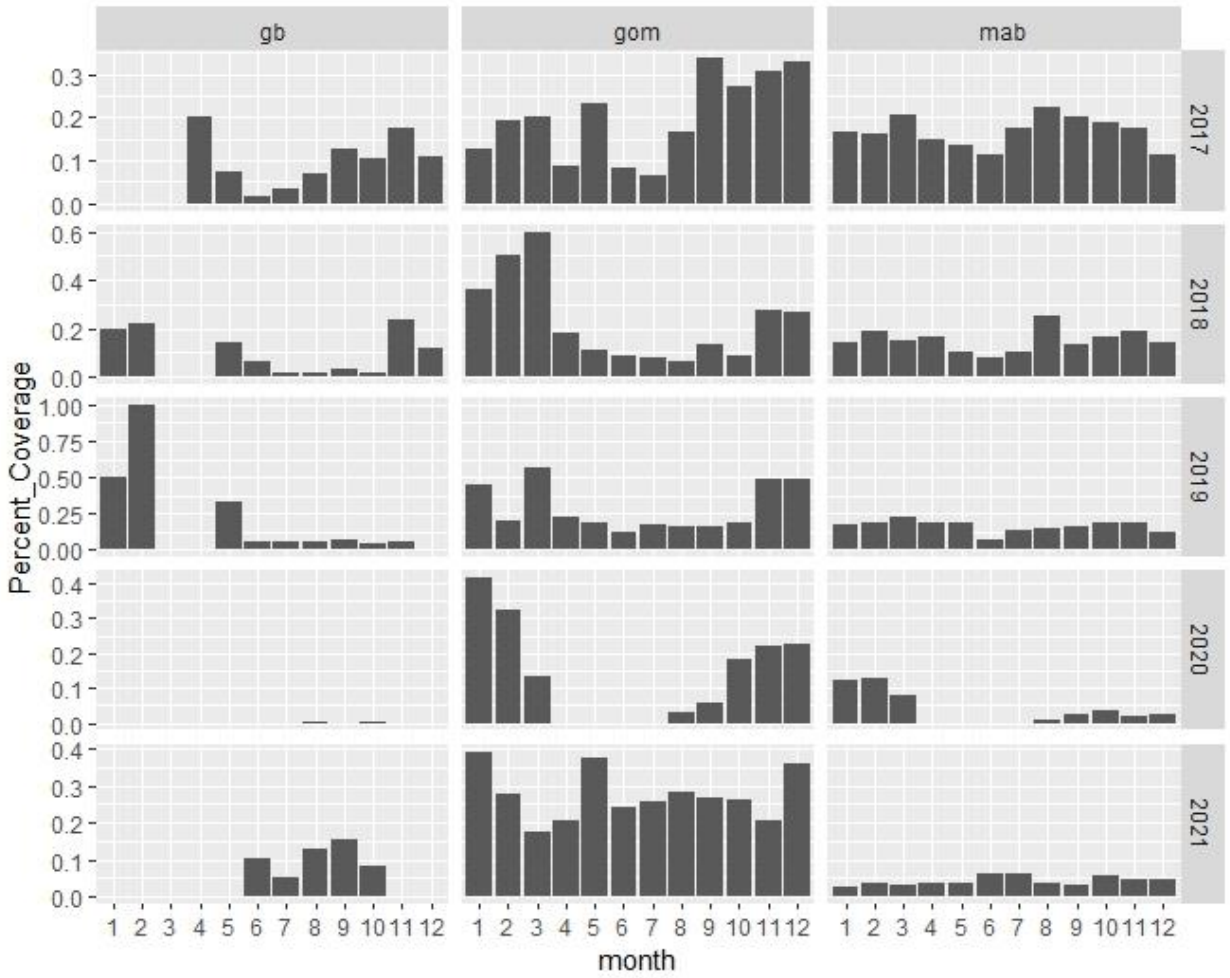
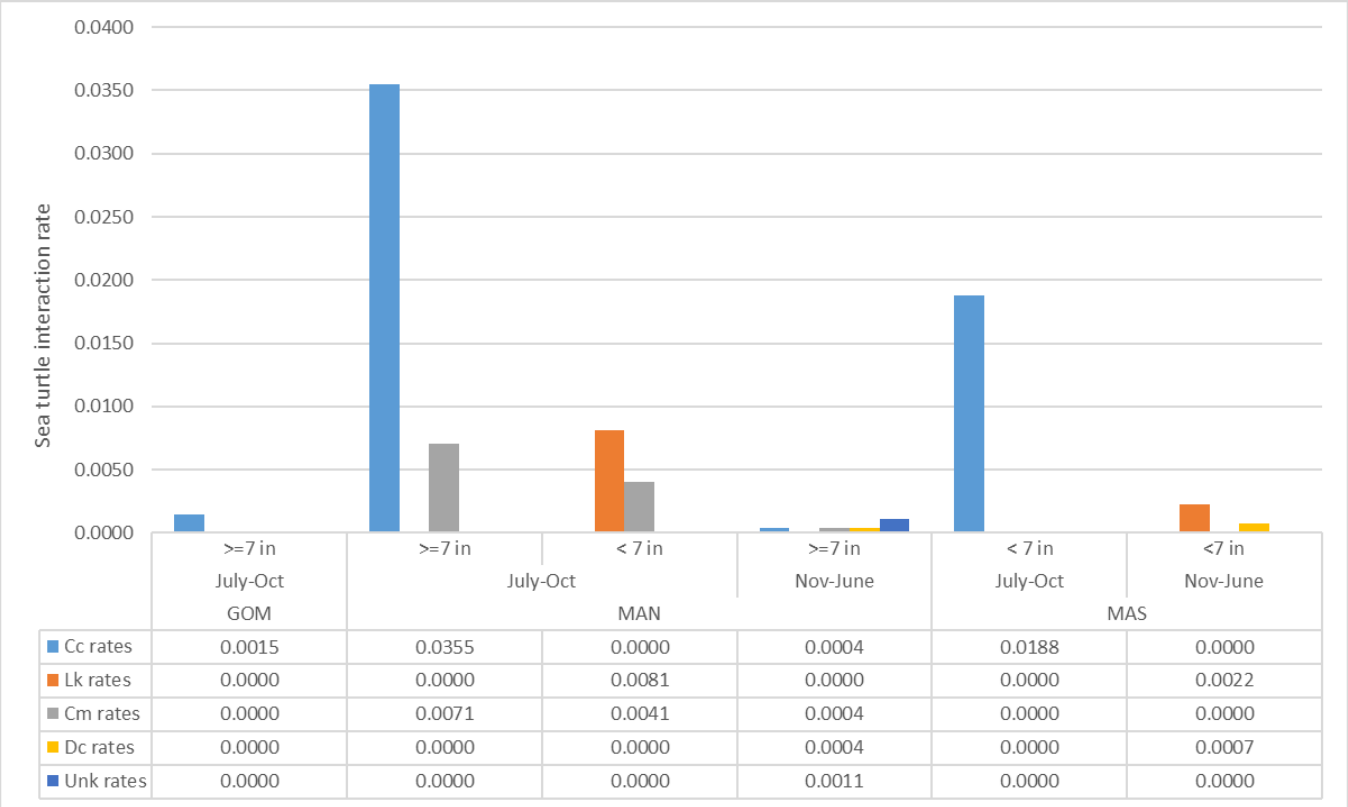


Figure 2. Observer coverage (% of trips*100) by month and year in Georges Bank (GB), Gulf of Maine (GOM), and Mid-Atlantic Bight (MAB).



	>=7 in July-Oct GOM	>=7 in July-Oct MAN	< 7 in July-Oct MAN	>=7 in Nov-June MAN	< 7 in July-Oct MAS	<7 in Nov-June MAS
Cc rates	0.0015	0.0355	0.0000	0.0004	0.0188	0.0000
Lk rates	0.0000	0.0000	0.0081	0.0000	0.0000	0.0022
Cm rates	0.0000	0.0071	0.0041	0.0004	0.0000	0.0000
Dc rates	0.0000	0.0000	0.0000	0.0004	0.0000	0.0007
Unk rates	0.0000	0.0000	0.0000	0.0011	0.0000	0.0000

Figure 1. Sea turtle interaction rates by stratum in sink gillnet gear, 2017-2021. Only those strata with turtle interactions are shown below. GOM = Gulf of Maine; MAN = Mid-Atlantic North; MAS = Mid-Atlantic South. Cc = Loggerhead (*Caretta caretta*); Lk = Kemp's ridley (*Lepidochelys kempii*); Cm = Green (*Chelonia mydas*); Dc = Leatherback (*Dermochelys coriacea*); Unid = Unidentified species.

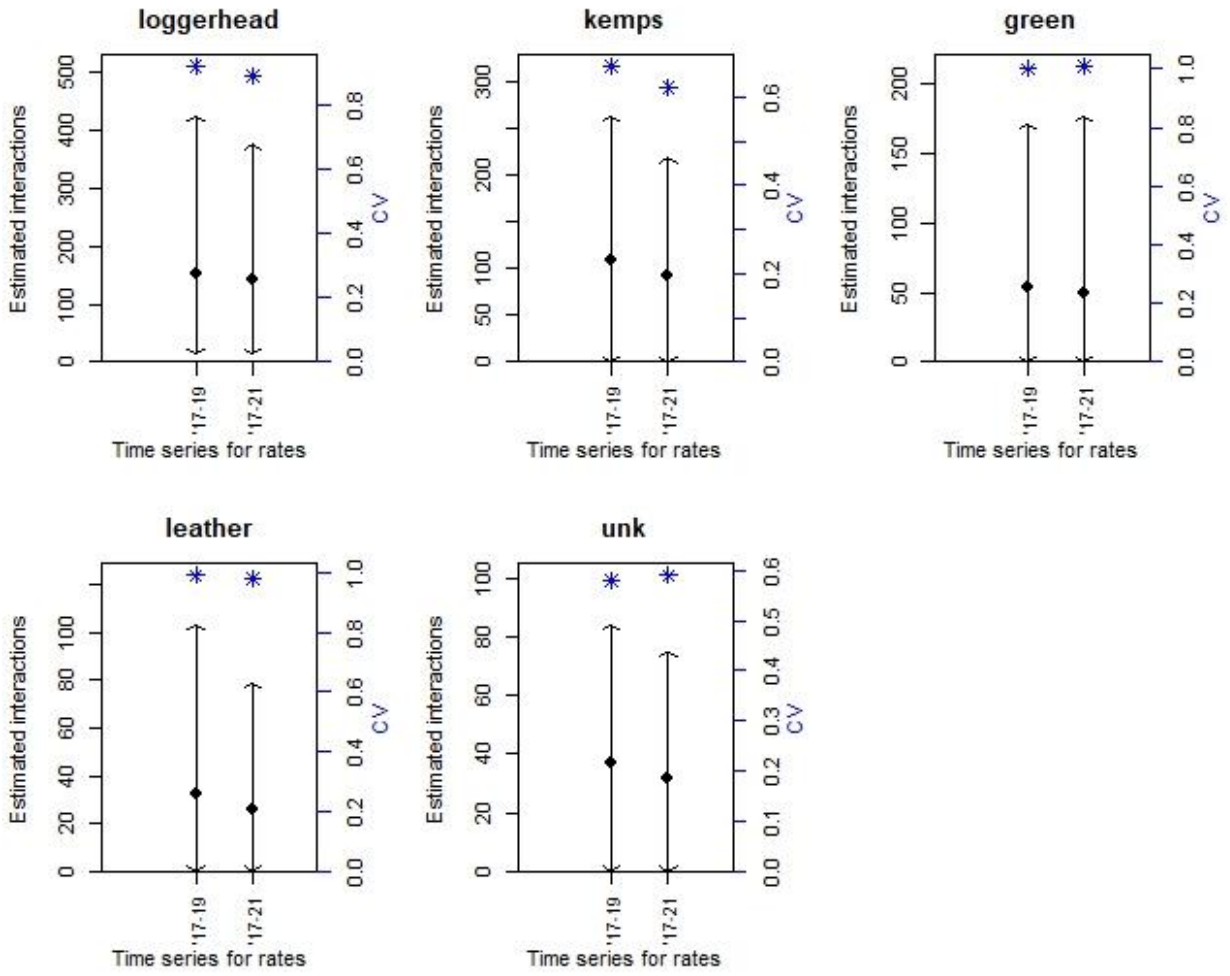


Figure 4. Estimated interactions, 95% confidence intervals, and coefficient of variation (CV; star symbols) derived from rates based on observer data collected from 2017-2019 and 2017-2021 for each turtle species. Unk = unidentified species.

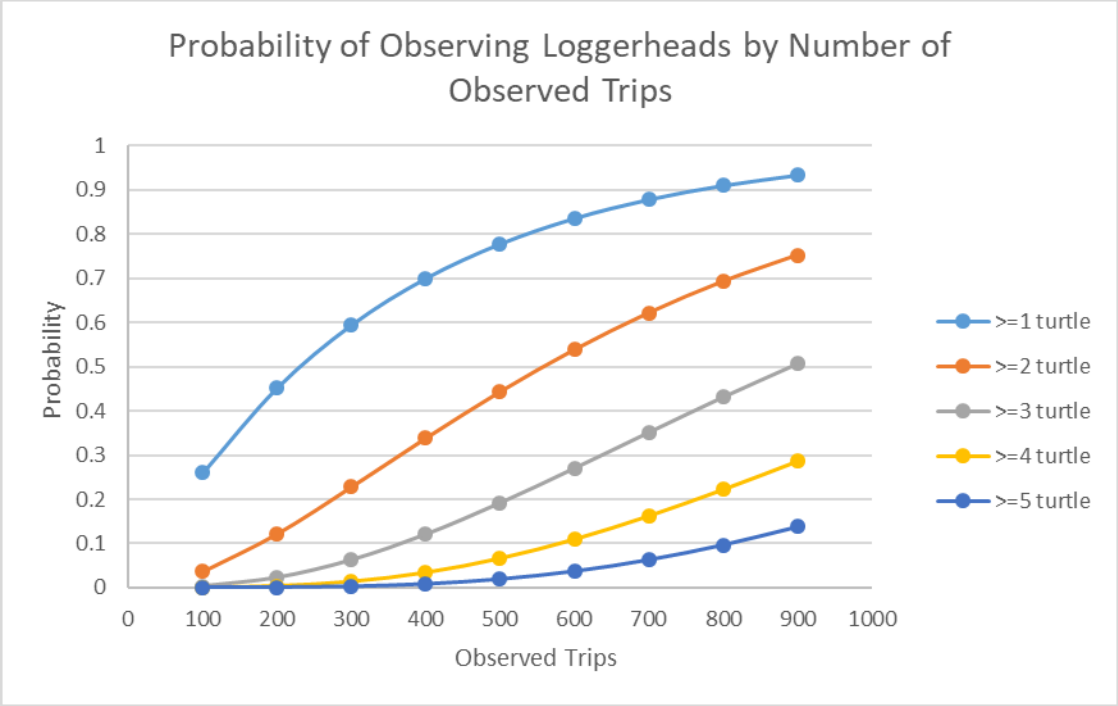


Figure 5. Cumulative probability of detecting numbers of loggerheads (*Caretta caretta*) given various amounts of observer coverage, based on annual levels of commercial gillnet trips and total interactions from 2017-2021.

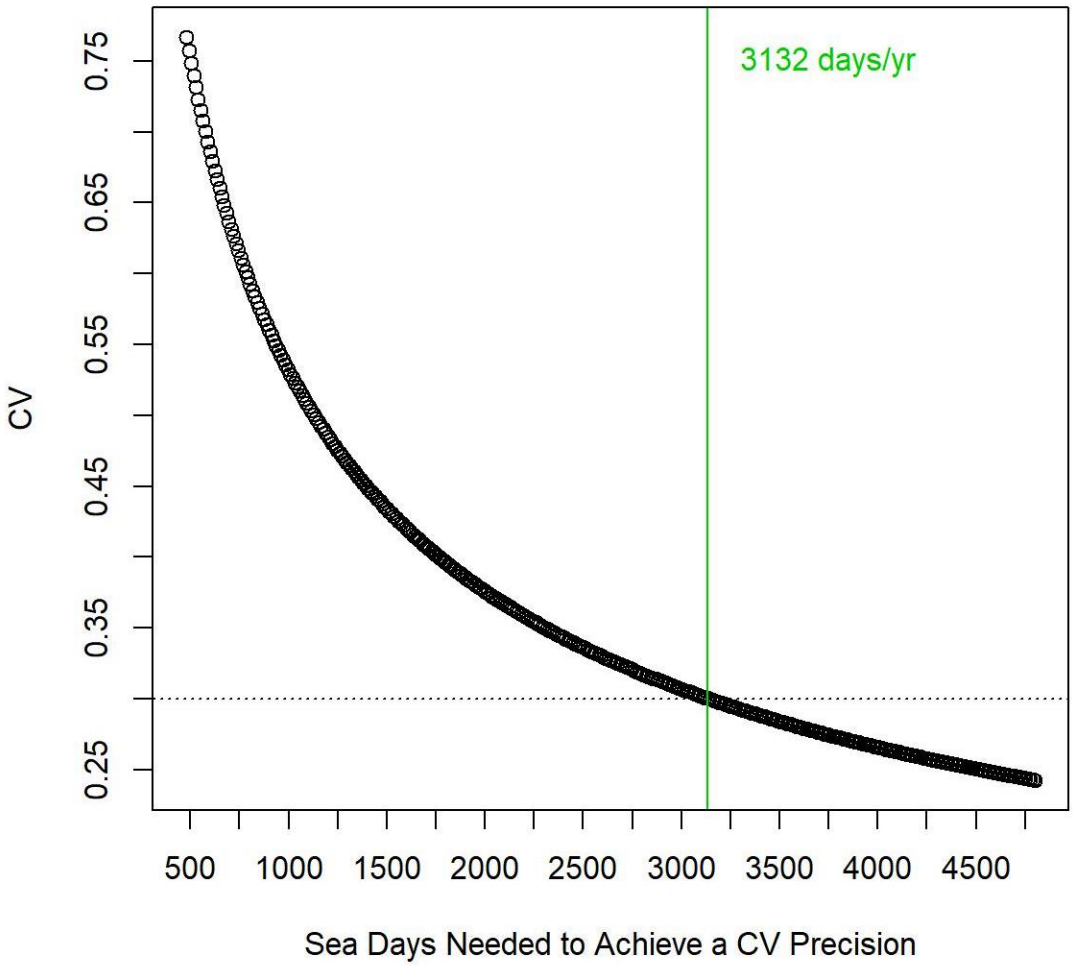


Figure 6. Estimated sea days needed to achieve a coefficient of variation (CV) precision level around loggerhead (*Caretta caretta*) interaction rates in sink gillnet gear. To achieve a 30% CV precision, 3,132 sea days/year would be needed throughout Gulf of Maine, Georges Bank, and Mid-Atlantic combined strata, based on loggerhead interaction rates in gillnet gear from 2017-2021.

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