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Mortality Rate Estimates for Sea Turtles in Mid-Atlantic and Northeast Fishing Gear, 2012-2021

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Abstract

The NOAA Fisheries Northeast Sea Turtle Injury Workgroup reviewed all sea turtle interactions from 2017 to 2021 recorded by the Northeast Fisheries Observer Program (n=55) and Industry Funded Scallop observers (n=5) and reported to the Sea Turtle Disentanglement Network (n=121). While previous analyses were calculated for 5-year periods, we also combined the records from 2012 to 2021. Interactions were assigned to one of four categories with associated post-interaction mortality rates according to the criteria in NMFS (2022). Sea turtle records are presented by gear type (trawl, gillnet, dredge, pot gear) for the fishery observer records and by vertical fishing line, fish trap (weirs and pound nets), or aquaculture gear for the entanglement records. From 2017-2021, the estimated sea turtle mortality rate for observable interactions is 46% in trawl gear, 62% in gillnet gear, 30% in dredge gear, 55% in vertical line gear (or 62% if we include turtles not disentangled that we assumed died), and 40% in fish trap gear. For the longer time series (2012-2021), the estimated mortality rate for observable interactions is 47% in trawl gear, 74% in gillnet gear, 35% in dredge gear, 54% in vertical line gear (or 61% including the assumed dead cases), and 56% in fish trap gear. The limited information on the pot and aquaculture records precluded mortality rate estimates for that gear. Comparing the most recent 5-year period to the longer range is informative in assessing the consistency of sea turtle mortality rates.

Keywords

Sea turtles, Fisheries, Post-interaction mortality, Observer, Entanglement, Bycatch

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Background

Sea turtles may die from incidental capture (bycatch) in fisheries at the time of the interaction or after the animal is released alive. The latter is referred to as post-interaction mortality (PIM) and results from delayed effects of physiological disturbances or trauma caused by the capture. A determination of PIM is needed to characterize the full impact of fisheries on sea turtles, which is necessary under the Endangered Species Act (ESA) for required threats analyses and to inform sea turtle recovery actions.

Using Northeast and Mid-Atlantic specific criteria (Upite 2011, Upite et al. 2013, Upite et al. 2018), NOAA Fisheries expanded and developed national criteria for estimating PIM in various fisheries (NMFS 2022[1]). These criteria apply to all sea turtle species and life phases. The criteria are applied to information collected by observers onboard commercial fishing vessels through the Northeast Fisheries Observer Program (NEFOP), industry funded monitoring programs (e.g., Industry Funded Scallop (IFS) observer program), or the At-Sea Monitoring (ASM) program and reported by the Northeast U.S. Sea Turtle Disentanglement Network[2] (STDN).

This document updates mortality rate estimates for Northeast and Mid-Atlantic (i.e., the Greater Atlantic Region) trawl, gillnet, dredge, vertical fishing line, and fish trap (weirs and pound nets) gear types using the national PIM criteria (NMFS 2022), and includes previous estimates for pot and aquaculture gear. Additional details on the methodology and development of the guidelines can be found in Upite (2011), Stacy et al. (2016), NMFS (2022), and a memorandum from Bettridge to Damon-Randall (2022).

Methods

We applied national PIM criteria (NMFS 2022) to records of incidental captures in Northeast and Mid-Atlantic U.S. trawl, gillnet, dredge, vertical fishing line, and fish trap gear from 2017 through 2021. Mortality rates were determined for observable interactions, which are those animals brought on board the fishing vessel or that interact with the gear at the surface (Warden and Murray 2011). Mortality rates may be different for interactions unobservable because of the design of the gear or the behavior of the animal, such as animals that interact with the gear exclusively subsurface or away from view. Entanglements were identified as vertical fishing line by the STDN based upon accompanying fishing gear (e.g., buoys) and/or expert review. We did not evaluate any cases involving non-fishery related entanglements, derelict gear, or unknown sources of line. Fish trap interactions refer to actual entanglements. As indicated in NMFS (2022), free-swimming turtles freed from the pound are not included in this assessment.

Information reviewed included the turtle photos, video, and observer comments on the vessel and trip information logs, incidental take logs, and sea turtle biological sample logs (for fishery observer cases) or STDN responder comments on the Sea Turtle Entanglement Reporting Form (for entanglement cases). Independently, workgroup members determined whether the turtle was likely captured while alive (ante-mortem) and whether

[1] The Procedure Directive 02-110-21 was originally issued on March 23, 2017, but was renewed on March 23, 2022, without revision.

[2] The STDN responds to and opportunistically collects information on any reported entanglement from Maine through Virginia. For more information, see https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/sea-turtle-disentanglement-network.

any injuries or other apparent effects (e.g., abnormal behavior, lethargy) were attributable to the interaction. Interactions not attributed to the observed haul/tow/set were noted as such and excluded from further analysis. For ante-mortem interactions, turtles were placed into one of four categories with associated PIM rates (Table 1). Workgroup members reviewed each case to make independent injury determinations, which were then discussed to develop consensus determinations and estimated mortality rates. The mortality rates include an assessment of PIM (e.g., our determination of Categories 1, 2, 3) for turtles captured alive and turtles found dead as a result of the interaction. We combined all species in the mortality rate estimates for each gear type.

For each Category 1 case, we used the depth recorded in the observer database (typically for the haul or trip, not where the interaction occurred) to inform the PIM determination. Following previously published procedures (NMFS 2022), cases at depths less than 40 m were given a 10% mortality rate; cases at depths of 40 m or greater were given a 20% mortality rate given the relative risk of decompression sickness (Table 1).

Table 1. The estimated rate of post-interaction mortality for the respective risk categories, as defined in NMFS (2022).

	Low Risk		Intermediate risk	High risk	Incompatible with survival (deceased)
Category	1A[a]	1B[b]	2	3	
Estimated rate of post-interaction mortality	10%	20%	50%	80%	100%

[a]1A: fisheries at minimal risk of causing decompression sickness. Applies to fisheries operating at a depth less than 40 m (22 fathoms).

[b]1B: fisheries at risk of causing decompression sickness. Applies to fisheries operating at a depth of 40 m (22 fathoms) or greater.

For those interactions where there was insufficient information on which to base the assessment, an injury category was not assigned. These cases were considered “unknown” and excluded from further analysis.

For cases where a credible report verified an entanglement, but no response was mounted, the turtle was not located, or details were unclear on whether the turtle was disentangled, the workgroup assumed the turtle was not released from the gear and eventually died from the interaction. Because this mortality determination was based on assumptions without a review of the injuries, we calculated estimated mortality rates with and without these “assumed dead” cases.

There were other instances where the entanglement data were reviewed, but the case was not included in the overall mortality rate. In those situations, the available information was unclear or sparse, but some assessment of the animal’s condition was possible. We assigned a PIM category determination to make the most use of all

available observations; however, we had less confidence in the assignments and, therefore, excluded these results from the overall mortality rate. While not included in the overall mortality rates, these cases are noted and labeled as Less Confident (LC) 1, 2, or 3 in the results. The following conditions had to be met for a case to receive a less confident determination (as opposed to an unknown determination):

1. There was a photo or other reliable information (e.g., interview) to confirm the entanglement regardless of whether the configuration or injury were visible.
2. There was a description of the areas of the body involved.
3. There was a notation of presence/absence of visible injury.
4. There was some description of behavior that informed assessment.

If these criteria for "Less Confident" were not met, the case determination was unknown.

For consistency with previous mortality estimates in Northeast and Mid-Atlantic fishing gear (Upite et al. 2013, Upite et al. 2018, Upite et al. 2019) and for applicability to science and management needs, mortality estimates were calculated over rolling 5-year periods by gear type (e.g., 2017-2021). Additionally, records from 2012 to 2021 were combined into a 10-year mortality rate. Previous reviews using the national criteria evaluated cases from 2012 through 2016 (Upite et al. 2019). There were few sea turtle observed takes in 2020 and 2021 due to an emergency waiver of observer coverage from March to August 2020 in the Greater Atlantic Region followed by limited coverage due to the COVID-19 pandemic and related restrictions. The longer time series allows for comparison between time periods with an increased sample size.

Results

Fishery Observer Data (NEFOP, IFS, and ASM)

We evaluated 211 observed sea turtle interactions (Table 2) from 2012-2021. Observed sea turtle species included loggerhead (Northwest Atlantic Ocean Distinct Population Segment (*Caretta caretta*)), green (North Atlantic Distinct Population Segment (*Chelonia mydas*)), leatherback (*Dermochelys coriacea*), and Kemp's ridley (*Lepidochelys kempii*) turtles, as well as unidentified sea turtle species.

Table 2. The number of observer records reviewed as well as the records excluded from overall mortality rate estimates from 2012 to 2021. T=trawl; G=gillnet; D=dredge; P=pot.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
NEFOP records	34	22	27	27	17	19	18	14	0	4
IFS records	0	2	0	4	3	2	2	1	0	0
ASM records	5	1	9	0	0	0	0	0	0	0
Total records reviewed	39 T 27 G 12 D 0	25 T 20 G 4 D 1	36 T 23 G 12 D 0 P 1	31 T 14 G 15 D 2	20 T 12 G 5 D 3	21 T 13 G 6 D 2	20 T 9 G 9 D 2	15 T 8 G 6 D 1	0	4 T 4
Insufficient information	3 T 2 G 1	2 T 2	1 G 1	1 G 1	0	2 G 1 D 1	0	3 T 1 G 2	0	0
Not attributable to observed fishery	0	4 T 3 D 1	0	0	2 D 2	1 D 1	1 G 1	0	0	0
Total records with determinations	**191**									

Trawl Gear

2017-2021

From 2017-2021, there were 34 observed turtle interactions in trawls. As one record (unidentified species) had insufficient information, we determined post-interaction mortality for 33 interactions involving trawl gear. All cases were deemed attributable to the gear interaction under discussion. The resulting estimated mortality rate for observable interactions in trawl gear from 2017-2021 is 46% (Table 3).

Table 3. Mortality rate assessment for sea turtles observed in trawl gear from 2017 to 2021.

	Category 1		Category 2 50% mortality	Category 3 80% mortality	100% mortality	**TOTAL**	**Estimated Mortality Rate**
	10% mortality	20% mortality					
Loggerhead	9	2	6	3	4	**24**	
Leatherback	1	0	0	1	0	**2**	
Kemp's ridley	2	0	2	2	0	**6**	
Green	0	0	0	1	0	**1**	
TOTAL	**12**	**2**	**8**	**7**	**4**	**33**	
Percentage of turtles in each category^	36%	6%	24%	21%	12%		
Dead turtles (total × % mortality)	1.2	0.4	4	5.6	4	15.2	**46%**

^ The combined percentages do not equal 100% because of rounding.

2012-2021

From 2012-2021, there were 130 observed turtle interactions in trawl gear. We determined post-interaction mortality for 122 of these interactions, after those cases with insufficient information (n=5; 4 unidentified, 1 loggerhead) and not attributable to the gear interaction under discussion (n=3; 2 loggerhead, 1 unidentified) were removed. The resulting estimated mortality rate for observable interactions in trawl gear from 2012-2021 is 47% (Table 4).

Table 4. Mortality rate assessment for sea turtles observed in trawl gear from 2012 to 2021.

	Category 1		Category 2 50% mortality	Category 3 80% mortality	100% mortality	**TOTAL**	**Estimated Mortality Rate**
	10% mortality	20% mortality					
Loggerhead	25	19	24	20	12	**100**	
Leatherback	1	0	1	1	1	**4**	
Kemp's ridley	6	0	2	4	0	**12**	
Green	1	0	1	2	1	**5**	
Unidentified	0	1	0	0	0	**1**	
TOTAL	**33**	**20**	**28**	**27**	**14**	**122**	
Percentage of turtles in each category^	27%	16%	23%	22%	11%		
Dead turtles (total × % mortality)	3.3	4	14	21.6	14	56.9	**47%**

^ The combined percentages do not equal 100% because of rounding.

Gillnet Gear

2017-2021

From 2017-2021, we determined post-interaction mortality for 17 sea turtle interactions in gillnet gear. We reviewed 21 records, but removed three records (two unidentified, one loggerhead) due to insufficient information and one record (unidentified) as not attributable to the gear interaction under discussion. The resulting 2017-2021 mortality rate for observable interactions in gillnet gear is 62% (Table 5). There were no gillnet observations in 2020 or 2021 (Table 2).

Table 5. Mortality rate assessment for sea turtles observed in gillnet gear from 2017 to 2021.

	Category 1		Category 2 50% mortality	Category 3 80% mortality	100% mortality	**TOTAL**	**Estimated Mortality Rate**
	10% mortality	20% mortality					
Loggerhead	1	0	1	0	5	**7**	
Leatherback	1	0	0	0	1	**2**	
Kemp's ridley	3	0	1	0	1	**5**	
Green	0	0	2	0	1	**3**	
TOTAL	**5**	**0**	**4**	**0**	**8**	**17**	
Percentage of turtles in each category	29%	0%	24%	0%	47%		
Dead turtles (total × % mortality)	0.5	0	2	0	8	10.5	**62%**

2012-2021

From 2012-2021, there were 69 observed interactions in gillnets. We determined post-interaction mortality for 62 interactions after removing records with insufficient information (n=6; 4 unidentified, 2 loggerheads) and those not attributable to the gear interaction under discussion (n=1; unidentified). The resulting mortality rate for observable interactions in gillnet gear from 2012-2021 is 74% (Table 6).

Table 6. Mortality rate assessment for sea turtles observed in gillnet gear from 2012 to 2021.

	Category 1		Category 2 50% mortality	Category 3 80% mortality	100% mortality	**TOTAL**	**Estimated Mortality Rate**
	10% mortality	20% mortality					
Loggerhead	4	0	5	2	22	**33**	
Leatherback	1	0	0	0	3	**4**	
Kemp's ridley	6	0	1	0	6	**13**	
Green	0	1	2	1	1	**5**	
Unidentified	1	0	0	0	6	**7**	
TOTAL	**12**	**1**	**8**	**3**	**38**	**62**	
Percentage of turtles in each category	19%	2%	13%	5%	61%		
Dead turtles (total × % mortality)	1.2	0.2	4	2.4	38	45.8	**74%**

Dredge Gear

2017-2021

The dredge fishing gear cases reviewed by the workgroup only involved scallop dredges. There were five records reviewed from 2017 to 2021, but determinations were only made for three given that one loggerhead had insufficient information to make a determination and the other unidentified turtle species was deemed not attributable to the dredge interaction. The resulting mortality rate for observable interactions in dredge gear for 2017-2021 is 30% (Table 7). However, given the small sample size of observer records for this gear type (n=3; Table 7), results should be interpreted with caution. There were no observed dredge interactions in 2020 or 2021.

Table 7. Mortality rate assessment for sea turtles observed in dredge gear from 2017 to 2021.

	Category 1		Category 2 50% mortality	Category 3 80% mortality	100% mortality	TOTAL	Estimated Mortality Rate
	10% mortality	20% mortality					
Loggerhead	0	2	1	0	0	**3**	
TOTAL	**0**	**2**	**1**	**0**	**0**	**3**	
Percentage of turtles in each category	0%	67%	33%	0%	0%		
Dead turtles (total × % mortality)	0	0.4	0.5	0	0	0.9	**30%**

2012-2021

Even with a longer time series, the sample size for dredge gear interactions is small (n=11). Three loggerheads and one unidentified turtle species were not considered in the mortality estimate as they were determined to not be attributable to the dredge interaction, and another loggerhead was removed due to insufficient information. Using the six cases with determinations, the mortality rate estimate for dredge gear from 2012 to 2021 is 35% (Table 8).

Table 8. Mortality rate assessment for sea turtles observed in dredge gear from 2012 to 2021.

	Category 1		Category 2 50% mortality	Category 3 80% mortality	100% mortality	TOTAL	Estimated Mortality Rate
	10% mortality	20% mortality					
Loggerhead	0	3	1	0	0	**4**	
Kemp's ridley	0	1	0	1	0	**2**	
TOTAL	**0**	**4**	**1**	**1**	**0**	**6**	
Percentage of turtles in each category^	0%	67%	17%	17%	0%		
Dead turtles (total × % mortality)	0	0.8	0.5	0.8	0	2.1	**35%**

^ The combined percentages do not equal 100% because of rounding.

Pot Gear

There was one pot record in 2014 (a dead leatherback turtle). This is the only NEFOP/IFS/ASM reported interaction in this gear type, and thus the resulting estimated mortality rate for observable interactions in pot gear for the 2012-2021 time period is 100%. However, given the extremely small sample size of observer records for this gear type, this mortality rate is highly uncertain. The STDN data for vertical fishing lines described below are more indicative of sea turtle mortality in pot gear.

Sea Turtle Disentanglement Network Data

We reviewed 281 vertical fishing line, 26 fish trap, and 1 aquaculture record (see Table 9 for details). Observed sea turtle species were primarily leatherback sea turtles, followed by loggerhead, Kemp's ridley, and unidentified sea turtle species. All of the observed entanglements occurred at depths less than 40 m, so the mortality rate for each of those Category 1 cases was 10%. The mortality rates are presented separately below for each gear type.

Table 9. The number of STDN entanglement records reviewed from 2012 to 2021. For the "Total records with determinations" cell, the number in parentheses includes those assumed dead cases. LC = Less Confident, followed by the determination category.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total records reviewed	43	61	33	20	30	36	18	21	28	18
Vertical fishing line records	41	57	31	18	24	29	18	17	28	18
Insufficient information	1	10	3	2	3	7	1	0	4	2
Assumed dead	2	8	2	3	3	0	2	2	4	6
Less confident	0	1 (LC3)	5 (all LC2)	1 (LC3)	2 (both LC2)	1 (LC2)	0	1 (LC1)	6 (5 LC1; 1 LC2)	0
Total records with determinations	199 (231)									
Fish trap gear records	2	4	1	2	6	7	0	4	0	0
Insufficient information	0	0	0	0	2	2	0	1	0	0
Less confident	0	1 (LC2)	0	0	1 (LC2)	0	0	0	0	0
Total records with determinations	19									
Aquaculture records	0	0	1	0	0	0	0	0	0	0
Insufficient information	0	0	1	0	0	0	0	0	0	0

Vertical Fishing Line

We analyzed all vertical fishing line entanglement records (excluding monofilament/longline gear), many of which were not identified to fishery. While most vertical line entanglements involve pot/trap gear, this cannot always be conclusively determined, so mortality rates are presented here for "vertical fishing line." The estimated mortality rate includes cases where the STDN responded and documented the interaction and we reviewed the case using the PIM criteria. As described in the methods, we delineated cases in the estimated mortality rate that we assumed were dead based on credible entanglement reports but no response or assessment.

2017-2021

We reviewed 110 entanglement cases. However, several were excluded from the overall mortality rate calculation due to insufficient information (n=14) or deemed less confident by the workgroup (n=8; Less Confident Category 1=6, Less Confident Category 2=2). Further, there were 14 cases where the turtle was assumed dead. The estimated mortality rate for the most recent 5-year period is 55% without the assumed dead cases and 62% including assumed dead cases (Table 10).

Table 10. Mortality rate assessment for sea turtles found entangled in vertical fishing line gear from 2017 to 2021. The number in parentheses includes the "assumed dead" cases.

	Category 1 10% mortality	Category 2 50% mortality	Category 3 80% mortality	100% mortality	**TOTAL**	**Estimated Mortality Rate**
Loggerhead	1	1	1	3 (4)	**6 (7)**	
Leatherback	20	24	9	15 (27)	**68 (80)**	
Unidentified	0	0	0	0 (1)	**0 (1)**	
TOTAL	**21**	**25**	**10**	**18 (32)**	**74 (88)**	
Percentage of turtles in each category^	28% (24%)	34% (28%)	14% (11%)	24% (36%)		
Dead turtles (total × % mortality)	2.1	12.5	8	18 (32)	40.6 (54.6)	**55% (62%)**

^ The combined percentages do not equal 100% because of rounding.

2012-2021

Out of the 279 entanglement cases reviewed from 2012 to 2021, we made post-interaction mortality determinations for 199 cases. The resulting mortality rate is 54% (Table 11). An additional 32 cases (30 leatherbacks, one loggerhead, one unidentified turtle) were assumed dead. When those cases are included, the mortality rate increases to 61%. Several interactions (n=33) had insufficient information to make a determination, with all but one case (unidentified species) involving leatherbacks. The cases with low confidence were not included in the estimated mortality rate; from 2012-2021, six leatherbacks scored as LC1, nine leatherbacks as LC2, and one leatherback and one loggerhead as LC3.

Table 11. Mortality rate assessment for sea turtles found entangled in vertical fishing line gear from 2012 to 2021. The number in parentheses includes the "assumed dead" cases.

	Category 1 10% mortality	Category 2 50% mortality	Category 3 80% mortality	100% mortality	**TOTAL**	**Estimated Mortality Rate**
Loggerhead	3	1	1	8 (9)	**13 (14)**	
Leatherback	60	54	31	40 (70)	**185 (215)**	
Unidentified	0	0	0	1 (2)	**1 (2)**	
TOTAL	**63**	**55**	**32**	**49 (81)**	**199 (231)**	
Percentage of turtles in each category^	32% (27%)	28% (24%)	16% (14%)	25% (35%)		
Dead turtles (total × % mortality)	6.3	27.5	25.6	49 (81)	108.4 (140.4)	**54% (61%)**

^ The combined percentages do not equal 100% because of rounding.

Fish Trap Gear

2017-2021

We reviewed nine pound net and two weir records. Out of the 11 records reviewed, three cases (two leatherbacks, one Kemp's ridley) had insufficient information to make a determination and were excluded from the mortality rate estimate. All of the interactions with mortality determinations involved leatherbacks. No entanglements were reported in 2018, 2020, or 2021. The results for 2017-2021 are included in Table 12.

Table 12. Mortality rate assessment for sea turtles found entangled in fish trap gear from 2017 to 2021.

	Category 1 10% mortality	Category 2 50% mortality	Category 3 80% mortality	100% mortality	TOTAL	Estimated Mortality Rate
Leatherback	4	2	1	1	**8**	
TOTAL	**4**	**2**	**1**	**1**	**8**	
Percentage of turtles in each category^	50%	25%	13%	13%		
Dead turtles (total × % mortality)	0.4	1	0.8	1	3.2	**40%**

^ The combined percentages do not equal 100% because of rounding.

2012-2021

From 2012 to 2021, the STDN documented 26 interactions with fish trap gear. Twenty-two cases involved pound net leaders, and four cases involved weirs. There were five cases (four leatherbacks, one Kemp's ridley) with insufficient information to make a PIM determination that were excluded from further analysis. An additional two leatherbacks scored as a Less Confident Category 2 and were excluded from the mortality rate estimate. The resulting overall mortality rate for fish trap gear from 2012-2021 is 56% (Table 13).

Table 13. Mortality rate assessment for sea turtles found entangled in fish trap gear from 2012 to 2021.

	Category 1 10% mortality	Category 2 50% mortality	Category 3 80% mortality	100% mortality	TOTAL	Estimated Mortality Rate
Loggerhead	0	0	0	3	**3**	
Leatherback	6	5	2	2	**15**	
Kemp's ridley	0	0	0	1	**1**	
TOTAL	**6**	**5**	**2**	**6**	**19**	
Percentage of turtles in each category^	32%	26%	11%	32%		
Dead turtles (total × % mortality)	0.6	2.5	1.6	6	10.7	**56%**

^ The combined percentages do not equal 100% because of rounding.

Aquaculture

Only one record in the STDN database from 2012 to 2021 involved aquaculture gear. The interaction occurred in 2014 and involved a leatherback, but the information was insufficient to make a PIM determination and therefore was given an unknown determination.

Summary of Interactions 2012-2021

Figure 1 presents the estimated sea turtle mortality rates for each gear type as rolling 5-year periods as well as the entire time series (2012-2021). All of the combined NEFOP, IFS, ASM, and STDN data with determinations are included. Mortality rate calculations for the previous 5-year periods can be found in Upite et al. (2019) and memoranda from Upite to Anderson (2020, 2021a, 2021b).

For trawl gear, the 5-year mortality rates range from 43 to 48%. The number of trawl determinations range from a low of 33 cases in 2017-2021 to a high of 89 in 2012-2016; between those time periods, the mortality rate only varies by 1%. As stated previously, the number of interactions in 2020 and 2021 were influenced by the limited observer coverage due to the COVID-19 pandemic. For the longer time period of 2012-2021, the trawl mortality rate is 47% with a sample size of 122 cases. The number of gillnet records is smaller than for trawl gear, even with the longest time series of 2012-2021 (n=62). The range of cases varies from 17 interactions in 2017-2021 to 45 in 2012-2016. In general, as the 5-year sample sizes decrease over time, so does the mortality rate. The gillnet mortality rate varies among the years, with several 5-year periods recording mortality percentages above 70%, and other years ranging around 62-65%. The longer time series mortality rate (74%) falls slightly above the middle of that range. For dredge gear, the estimated mortality rates range from 28 to 40%, with a 35% rate from 2012-2021. The small sample sizes (three to six) need to be taken into consideration when applying these results.

For vertical fishing line interactions, the mortality rate from 2012-2021 is 61% when including those cases assumed to be dead. Overall, the 5-year periods are similar with a range of 59 to 64% mortality rate. Without the assumed dead cases, the mortality rate ranges from 53% in 2012-2016 to 60% in 2014-2018, and 54% in the longer time series (2012-2021). There is an average 6% increase in the mortality rate when the assumed dead cases are included. The vertical fishing line sample sizes show more variance, ranging from a high of 139 interactions in 2012-2016 to a low of 88 in both 2015-2019 and 2017-2021. Fish trap records are much fewer, as there were only 19 in total during the longest time series. Accordingly, the mortality rates for fish trap gear vary significantly (range 40-68%, with the 2012-2021 mortality rate falling near the middle).

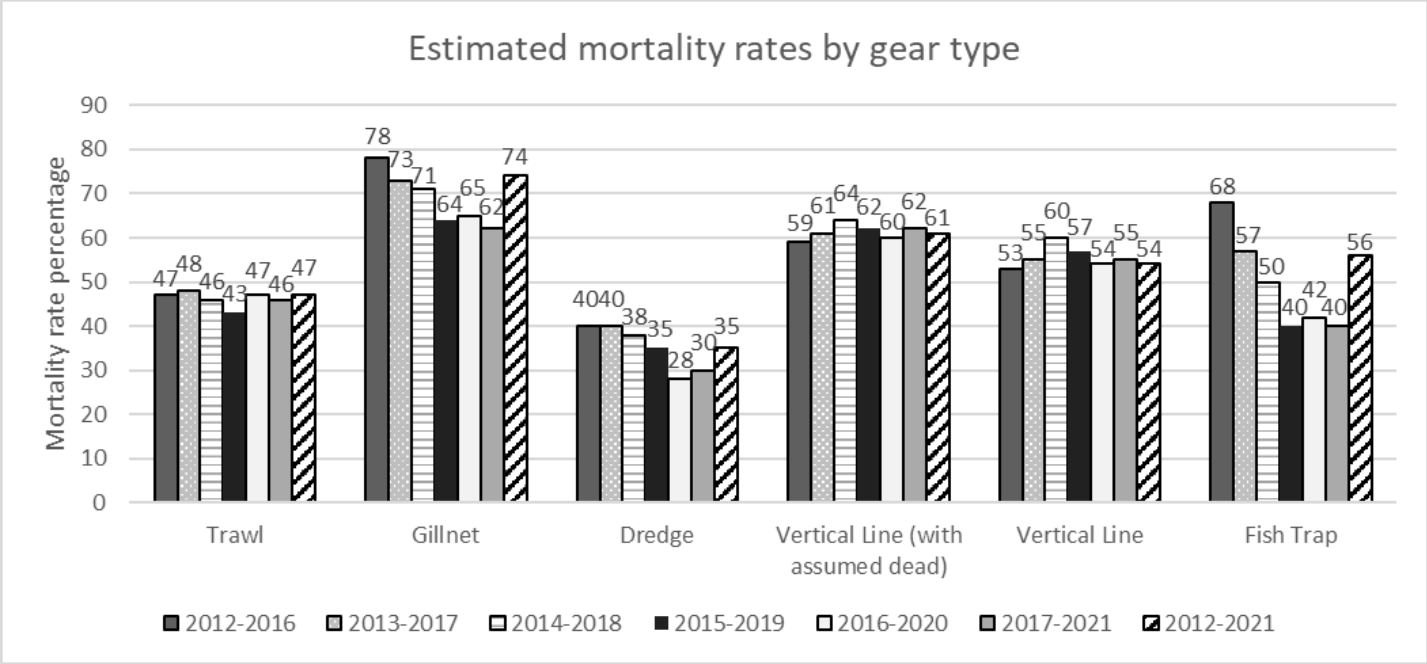

Figure 1. Overall estimated mortality rate by gear type in rolling 5-year increments, as well as the total time series from 2012 to 2021 (in diagonal striped bar). The mortality rates are included above the columns.

Discussion

NOAA Fisheries is required to evaluate the impacts of federal actions on listed species under the ESA, and these estimates of sea turtle mortality are important pieces of information that can assist in the assessment of federal fishery impacts. For example, a recent Biological Opinion on ten federal fisheries in the Greater Atlantic Region (NMFS 2021) used previously estimated turtle mortality rates in trawl, gillnet, and vertical fishing line gear to anticipate the numbers of lethal takes occurring in those fisheries. In future consultations, managers may choose to use the mortality rates in this document to compare long term versus specific 5-year periods depending on the time period of the action under consideration.

In some years, the numbers of documented or reported sea turtle interactions are fewer than in other years. This could be a result of changes in turtle distribution or fishing effort, changes in observer effort (e.g., as a result of COVID-19), or fewer people out on the water to document entangled sea turtles. In the years with fewer interactions, the sample sizes by gear type will be smaller, even with a 5-year time series. That was the case with the most recent 5-year time period, as there were no observed turtle interactions in 2020 and only four trawl interactions in 2021. Further, bycatch reduction measures in the Atlantic sea scallop dredge fishery (i.e., chain mats, Turtle Deflector Dredges) were enacted to reduce turtle mortality, but also reduce the number of takes observed onboard the dredge vessel and preclude the ability to assess injuries or mortalities of sea turtles deflected on the bottom. As such, the small observed sample size is likely to continue in this fishery. In this document, we continued to calculate the 5-year rolling estimate for consistency with previous years but

also combined all records from 2012-2021. This provided a shorter and longer time series to evaluate and compare results. This is the first time a mortality rate for Northeast/Mid-Atlantic fishing gear has been calculated for a time series longer than five years.

The trawl mortality rate remained relatively consistent through the years, regardless of sample size. Given the lack of variability between the respective 5-year periods and the entire time series, we consider 47% to be an accurate reflection of the level of lethal take resulting from trawl fisheries. The 5-year and longer term estimates for dredge gear also were similar, but as stated, these rates are less informative due to the low numbers of observed interactions. Gillnet mortality rates were more variable. This variation is not surprising as gillnet interactions often present as either alive and uninjured or dead. For instance, the highest percentage of gillnet cases are in the dead category (Table 6). As such, a year with a substantial number of cases with 100% mortality determinations (that may occur due to one particular set, for example) would notably increase the overall 5-year mortality rate. Sample sizes also should be considered when evaluating gillnet mortality rates; there were no observed gillnet interactions in 2020 and 2021 and only 4 in 2019. The longer time series may be more reflective of the overall gillnet mortality rate (74%), as there are more cases to consider.

The calculation of mortality rates for vertical fishing lines and fish traps uses a different set of data (e.g., STDN reports), which are opportunistically collected. The STDN and NOAA Fisheries are consistently engaged in outreach efforts in order to increase reporting, but the decision to report an interaction remains with an individual boater or fisherman. While there is no specific reason why an individual's reporting would vary by year, there are also no controls for effort and reporting and no insights into why the reported entanglement sample sizes fluctuated by a 5-year time period. As stated previously, the variance may be a result of turtle distribution in the area, fishing effort, or the number of vessels on the water to detect entanglements. Regardless, the mortality rates for vertical fishing line have remained relatively constant over time. There is also a somewhat even split between Category 1, 2, 3, and dead cases with this gear type. Given this consistency, the longer time series rate of 61% appears to be a reliable assessment of sea turtle mortality in vertical fishing lines. The 2012-2021 mortality rate is lower when the assumed dead cases are removed (i.e., 54%), so managers can choose the more or less conservative mortality rate depending on the management action and confidence in the caveats surrounding the assumed dead cases as mentioned previously.

Leatherback turtles comprised most of the reported interactions in vertical fishing lines and fish trap gear. This is different from the other gear types like trawls, gillnets, and dredges, where loggerheads were most commonly observed. This is likely a function of where or how the respective gears are fished, but could also be related to leatherbacks being easier to detect in vertical fishing lines by the public given their large size. Further, leatherback turtles may be more susceptible to vertical fishing line interactions given their pelagic foraging behavior and long flippers that could easily snag on a nearby line. The benthic foraging behavior of loggerheads may result in more interactions with bottom otter trawls, dredges, and anchored gillnets.

While the sampling and reporting methods differ between data collected by observers (trawl, gillnet, and dredge) and data collected by the STDN (vertical fishing line and fish trap), we are comparing the gear type results for the purposes of this discussion. When considering the longer time series of 2012-2021, mortality rates are highest in gillnet gear (74%), followed by vertical fishing lines (61%, when assumed dead cases are included), fish trap (56%), and trawls (47%). Dredge gear has the lowest documented mortality rate (35%), but again, this rate should be interpreted with caution given the small sample size and because dredge takes deflected on the bottom would not be observed. Vertical fishing lines have the highest number of cases with

PIM determinations (n=231), followed by trawls (n=122) and gillnets (n=62). These overall mortality results and the number of observed interactions should be taken into consideration when prioritizing bycatch reduction measures, gear research, and sea turtle recovery actions in the future.

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Literature Cited

Memorandum from Carrie Upite, Sea Turtle Recovery Coordinator, to Jennifer Anderson, Assistant Regional Administrator for Protected Resources. 2020. 2014-2018 sea turtle mortality determinations. February 26, 2020. NOAA National Marine Fisheries Service Greater Atlantic Regional Fisheries Office. 6 p.

Memorandum from Carrie Upite, Sea Turtle Recovery Coordinator, to Jennifer Anderson, Assistant Regional Administrator for Protected Resources. 2021a. 2015-2019 sea turtle mortality determinations. April 26, 2021. NOAA National Marine Fisheries Service Greater Atlantic Regional Fisheries Office. 6 p.

Memorandum from Carrie Upite, Sea Turtle Recovery Coordinator, to Jennifer Anderson, Assistant Regional Administrator for Protected Resources. 2021b. 2016-2020 sea turtle mortality determinations. October 7, 2021. NOAA National Marine Fisheries Service Greater Atlantic Regional Fisheries Office. 8 p.

Memorandum from Shannon Bettridge, Marine Mammal and Sea Turtle Conservation Division Chief, to Kim Damon-Randall, Office of Protected Resources Director. 2022. Procedural Directive 02-110-21: Process for Post-Interaction Mortality Determinations of Sea Turtles Bycaught in Trawl, Net, and Pot/trap Fisheries: 5-Year Review. March 18, 2022. NOAA National Marine Fisheries Service Office of Protected Resources. 11 p.

National Marine Fisheries Service (NMFS). 2021. Endangered Species Act Section 7 Consultation on the: (a) Authorization of the American Lobster, Atlantic Bluefish, Atlantic Deep-Sea Red Crab, Mackerel/Squid/Butterfish, Monkfish, Northeast Multispecies, Northeast Skate Complex, Spiny Dogfish, Summer Flounder/Scup/Black Sea Bass, and Jonah Crab Fisheries and (b) Implementation of the New England Fishery Management Council's Omnibus Essential Fish Habitat Amendment 2 [Consultation No. GARFO-2017-00031]. May 27, 2021, 583 p. https://repository.library.noaa.gov/view/noaa/30648

National Marine Fisheries Service (NMFS). 2022. Process for Post-Interaction Mortality Determinations of Sea Turtles Bycaught in Trawl, Net, and Pot/Trap Fisheries. National Marine Fisheries Service Procedural Instruction *02-110-21,* March 23, 2022, 22 p. https://media.fisheries.noaa.gov/2022-03/02-110-21_renewal_March%202022_kdr_0.pdf

Stacy, B.A., J.L. Keene, and B.A. Schroeder. 2016. Report of the Technical Expert Workshop: Developing National Criteria for Assessing Post-Interaction Mortality of Sea Turtles in Trawl, Net, and Pot/Trap Fisheries. U.S. Dep. Commerce, NOAA Technical Memorandum NMFS-OPR-53, 116 p. https://repository.library.noaa.gov/view/noaa/15880

Upite, C.M. 2011. Evaluating Sea Turtle Injuries in Northeast Fishing Gear. U.S. Dep. Commerce, NEFSC Reference Document 11-10, 26 p. https://www.nefsc.noaa.gov/publications/crd/crd1110/

Upite, C.M., K.T. Murray, B.A. Stacy, S.E. Weeks, and C.R. Williams. 2013. Serious Injury and Mortality Determinations for Sea Turtles in U.S. Northeast and Mid-Atlantic Fishing Gear, 2006-2010. NOAA Tech Memo NMFS NE 222; 18 p. https://repository.library.noaa.gov/view/noaa/4378

Upite, C.M., K.T. Murray, B.A. Stacy, and S.E. Weeks. 2018. Post-interaction Mortality Determinations for Sea Turtles in U.S. Northeast and Mid-Atlantic Fishing Gear, 2011-2015. NOAA Tech Memo NMFS NE 248; 27 p. https://repository.library.noaa.gov/view/noaa/22903

Upite, C.M., K.T. Murray, B.A. Stacy, L. Stokes, and S.E. Weeks. 2019. Mortality Rate Estimates for Sea Turtles in Mid-Atlantic and Northeast Fishing Gear, 2012-2017. Greater Atlantic Region Policy Series 19-03. NOAA Fisheries Greater Atlantic Regional Fisheries Office; 15p. https://www.greateratlantic.fisheries.noaa.gov/policyseries/index.php/GARPS/article/view/13/12

Warden ML, Murray KT. 2011. Reframing protected species interactions with commercial fishing gear: Moving toward estimating the unobservable. Fish. Res. 110:387-390. https://www.sciencedirect.com/science/article/abs/pii/S0165783611002049?via%3Dihub