Northeast Fisheries Science Center Reference Document 11-04

Proration of Loggerhead Sea Turtle (*Caretta caretta*) Interactions in US Mid-Atlantic Bottom Otter Trawls for Fish and Scallops, 2005–2008, by Managed Species Landed

by Melissa L. Warden

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PURPOSE

Warden (in review) estimated an annual average of 292 observable (i.e., via standard fisheries observer protocols) loggerhead sea turtle (*Caretta caretta*) interactions with bottom otter trawl gear for fish and scallops during 2005–2008, with an additional estimated annual average of 61 loggerhead interactions that were unobservable but quantifiable (i.e., they were estimated to have passed through a turtle excluder device [TED] at depth). To support Endangered Species Act Section 7 consultations for Fishery Management Plans (FMPs), the Northeast Regional Office (NERO) has requested information on these estimated loggerhead interactions in relation to all managed species landed on the commercial bottom trawl trips. This document provides the supplemental information requested.

Fisheries observer sampling and analysis of sea turtle interactions are not normally done at the FMP level. Fishing vessels are selected randomly for observer coverage, which is typically allocated by month and port in proportion to fishing effort. Estimation of turtle interaction rates and magnitude is most often done by gear type, taking into account temporal and spatial patterns of fishing, environmental factors, and fishing gear characteristics. The resulting estimates need to be reported in a manner consistent with the needs of Section 7 consultations on FMPs.

Reporting turtle interactions by all individual species landed differs from the previous approach for trawl fisheries (Murray 2008), in which interactions were assigned to the single species (or species group) with the largest amount (by weight) landed on a trip. That approach may underrepresent landed species that do not account for the largest share of the landed weight on a trip. The weight-based approach used in this report is similar to that for Mid-Atlantic gillnet fisheries (Murray 2009) and accounts for all managed species landed on a trip, regardless of their quantity.

METHODS

Warden (in review) used 1996–2008 Northeast Fisheries Observer Program (NEFOP) data from the Mid-Atlantic (i.e., south of Cape Cod, Massachusetts, to the North Carolina/South Carolina border) to develop a generalized additive model (GAM) describing loggerhead interaction rates (i.e., loggerheads per day fished, which is 24 hours with nets in the water) as a function of latitude, sea surface temperature, and bottom depth. These interaction rates were applied to Vessel Trip Report (VTR) days fished to estimate total interactions on each VTR trip. In the present report, the total loggerhead interactions on each trip were assigned to the individual managed species that were landed on the trip, as reported in VTR data. If multiple species were landed, the estimated interactions per trip were prorated across the managed species based on the proportion (by weight) of the species landings on the trip. If unmanaged species were landed, estimated interactions were apportioned among only the managed species on the trip, effectively distributing the contribution of unmanaged species (which are often retained nontarget catch) among the managed species. If only unmanaged species were landed, then estimated interactions were apportioned to the unmanaged species as an aggregate "other" group. (Managed species with total landings <0.5 metric tons [t] for 2005–2008 also contributed to the "other" group.) For instance, if a vessel landed 800 pounds of monkfish, 150 pounds of skate, and 50 pounds of bluefish, the estimated number of loggerheads for that trip would be apportioned among the three species, with monkfish receiving 80% (100*800/1000) of the total. If the final 50 pounds instead represented an unmanaged species (e.g., sea robins) then the estimated loggerhead interactions for the trip would be distributed among the two managed species, with monkfish receiving 84% (100*800/950). If the entire 1000 pounds was comprised

of unmanaged species, then the "other" group would receive 100% of the estimated loggerhead interactions. This quantitative method incorporates NERO's request to allocate all estimated loggerhead interactions to species with federal or state management plans whenever possible.

Total estimated interactions in the present report are based on VTR days fished as reported by fishers, and on VTR landings that were adjusted for underreporting according to dealer-reported landings in the Commercial Fisheries Database System (CFDBS). For species-level records that matched between the two databases according to the vessel permit number, the VTR serial number, and the species, CFDBS landings replaced reported VTR landings if the VTR and CFDBS landings differed.

Estimated interactions by managed species landed

For each VTR fishing trip *i*, Warden (in review) estimated total loggerhead interactions (B_i) for the trip. For the present report, loggerhead interactions for managed[1] species *j* on trip *i* (B_{ij}) were determined by multiplying B_i by the proportion of adjusted landings of managed species *j* caught on trip *i*:

$$B_{ij} = B_i * T_{ij}/T_i \qquad (1)$$

where T_{ij} is the metric tons of managed species *j* landed on trip *i*, and T_i is the total metric tons of managed species landed on trip *i*.

Total estimated loggerhead interactions for species *j* over all bottom trawl trips for fish and scallops from 2005 to 2008 (N=86,819) was then:

$$B_j = \sum_{i=1}^{N} B_{ij} \quad , \qquad (2)$$

which was done separately by year to obtain annual estimates and divided by 4 to obtain an average annual estimate.

Bootstrap resampling was used to derive a coefficient of variation (CV) and 95% confidence intervals (CI) for the average annual interactions during 2005–2008. Bootstrap replicates were generated by sampling hauls with replacement 1000 times from the original observer dataset, and the replicate datasets were used to reparameterize the preferred model. Each model was then applied to the VTR effort data to estimate total interactions, which were then apportioned among the managed species landed on the trip. A CV for each species was computed by dividing the standard deviation of the replicate interaction estimates by the mean, while the 95% CI was the middle 95% of the distribution of the interaction estimates.

This process was done for 1) the collective group of observable plus unobservable but quantifiable interactions, and 2) for observable interactions only.

RESULTS

From 2005 to 2008, fishers reported on Vessel Trip Reports approximately 135 fish and invertebrate species landed. Unmanaged species (or managed species with 2005–2008 landings <0.5 t) (Appendix) constituted approximately 0.4% of total landings (with an annual average of 270 t; Table 1). Nearly all (98.5%, or 266 annual average t) unmanaged landings occurred on trips that also landed managed species, resulting in the apportioning of 4 total (observable +

[1]or "other" species (which includes unmanaged species) if no managed species were landed

unobservable but quantifiable) loggerhead interactions from unmanaged species to managed species (2 to summer flounder, 1 to croaker, and 1 to horseshoe crab). For observable interactions only, 3 loggerheads were apportioned from unmanaged species to managed species (2 to summer flounder and 1 to croaker). No estimated loggerhead interactions were associated with the small portion (1.5%, or 4 annual average t) of unmanaged landings that were reported on trips with no managed species landed.

The largest proportion of estimated total loggerhead interactions was attributed to VTR landings of summer flounder (22%), followed by scallops (20%) and croaker (14%) (Table 1). The largest proportion of the estimated observable loggerhead interactions was attributed to VTR landings of scallops (25%), followed by croaker (18%) and summer flounder (15%). An annual average of 3 loggerhead interactions were assigned to trips reported in the VTR data as having no landed catch, which constituted 0.16% of the reported days fished.

DISCUSSION

Loggerhead interaction rates in Mid-Atlantic bottom trawl gear for fish and scallops are correlated with the bottom depth, sea surface temperature, and latitude fished, with the highest interaction rates associated with shallow, warm, southern waters (Warden in review). Fisheries operating in times and areas having some likelihood of loggerhead interactions may have no documented interactions due to little or no observer coverage (Murray 2008) or the effect of random sampling of rare events. However, the approach taken in Warden (in review) explicitly recognizes that environmental factors are correlated with estimated interaction rates on individual fishing trips, and the present paper apportions the estimated loggerhead interactions among the individual species on each trip. This approach accounts for all managed species landed on a trip, rather than merely the target (or principal) species landed. As a weight-based approach, it could potentially assign a large portion of estimated interactions on a trip to a species with a single heavy individual landed (e.g., a shark). Similarly, on any given fishing trip, the primary species by weight might be different from the primary species in terms of value to the fisher.

During 2005–2008, approximately 1% of total VTR days fished occurred on trips with TED requirements. In the Mid-Atlantic study area, TEDs were required only in the summer flounder fishery prosecuted between Cape Charles, Virginia, and the North Carolina/South Carolina border (with an exemption from 15 January to 15 March for trawlers north of Oregon Inlet, North Carolina). Trips for which the primary species landed by weight was summer flounder accounted for about 24% of total VTR days fished, and among those trips, approximately 4% of days fished occurred on trips with TED requirements. The number of estimated TED-passed loggerheads is reflected in the difference between total and observable interactions attributed to the summer flounder fishery. Species that are commonly landed along with summer flounder, such as croaker, bluefish, and horseshoe crab, also show differences between estimated total and observable loggerhead interactions.

Summer flounder, sea scallops, and croaker accounted for the bulk of the fishing effort in shallow (≤50 m), warm (>15 °C), southern (≤39°N) waters in terms of both days fished and metric tons landed. On VTR trips in these waters with the highest loggerhead interaction rates, 52% of days fished occurred on trips for which the main species landed by weight was summer flounder, 24% on trips for which the main species was sea scallops, and 12% on trips for which the main species was croaker. In terms of metric tons landed, croaker comprised 71%, summer flounder 10%, and scallops 8% of total landings. Scallop landings decreased by about half from

2005 to 2008, and the decline in fishing effort is reflected in the decline in loggerhead interactions that were attributed to the fishery.

Predicted loggerhead interactions attributed to the horseshoe crab fishery might be underestimated because horseshoe crab landings are underrepresented in VTR data. For biomedical use, horseshoe crabs are captured, bled, and released with no VTR reporting requirement. The effort in terms of days fished on trips landing horseshoe crabs would be required to be reported if a federally managed species was also landed on the trip, but it is difficult to determine how much effort was unreported. To characterize the size of the biomedical fishery, in 2007 and 2008, about 500,000 horseshoe crabs annually were brought to biomedical facilities coastwide, with >400,000 harvested for biomedical purposes only (the remainder were then used for bait) (ASFMC 2010).

The blue crab fishery is an example for which no loggerhead interactions were recorded on observed tows landing that species, but a very small portion of the fishery was observed (<0.001% of landings), likely due to low observer coverage in inshore waters (i.e., nonoceanic coastal fishing waters). VTR trips landing blue crabs were primarily operating in North Carolina inshore waters in the fall and winter. The loggerhead interactions attributed to the blue crab fishery in 2005, however, are much higher than in other years because most of the VTR trips in 2005 occurred during the summer, when waters were warmer and loggerheads were more likely to be present.

Confidence intervals for each species landed are relevant to the average annual loggerhead interactions from 2005–2008. Since the variability of estimated loggerhead interactions attributed to an individual species in any given year is likely to be higher than that associated with the average, the confidence intervals for annual estimates would likely be wider than the confidence interval for the annual average. Thus, annual estimates would not necessarily be expected to fall within the average annual confidence interval 95% of the time. For instance, the average annual total interaction estimate attributed to the croaker fishery is 70 loggerheads (95% CI 51–91), although in 3 of 4 years, the annual estimates fell outside that average annual confidence interval. If these interaction estimates are updated approximately every five years, then future levels of loggerhead interactions can be evaluated by comparing the average annual estimates and CIs reported in this paper to the future average annual estimates and CIs.

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Table 1. Estimated total (observable + unobservable but quantifiable) loggerhead sea turtle (*Caretta caretta*) interactions as attributed to managed species landed. For species that were rarely or never landed on trips with turtle excluder device (TED) requirements, observable interactions will be equal to observable + unobservable but quantifiable interactions. For species that were sometimes landed on trips with TED requirements, the observable interactions only are also shown (the difference being the estimated number of loggerheads that passed through TEDs at depth). CC = *Caretta caretta*, CV = coefficient of variation, CI = 95% confidence interval. Note: due to rounding, columns might not sum to reported column totals.

	Average annual adjusted VTR	Estimated CC interactions				Average annual		
Managed species	landings (t)	2005	2006	2007	2008	CC	CV	CI
Blue Crab	48	59	0	0	9	17	0.5	3-35
Bluefish	418	5	3	4	3	4	0.15	3-5
observable only		2	3	3	3	3	0.17	2-4
Coastal Migratory Pelagics	1	0	0	0	0	0	0.13	0
Croaker	3220	37	96	55	93	70	0.14	51-91
observable only		34	93	49	88	66	0.15	47-86
Dolphin/Wahoo	<0.5	0	0	0	0	0	0.45	0
Flounder (other)	45	2	1	3	4	2	0.13	2-3
Herring	2365	0	0	0	0	0	0.53	0
Highly Migratory Species	13	0	0	0	0	0	0.18	0
Horseshoe Crab	136	19	4	4	2	7	0.16	5-9
observable only		4	3	2	2	3	0.22	2-4
Invertebrates	8	0	0	0	0	0	0.15	0
Lobster	22	0	0	0	0	0	0.39	0
Mackerel, Squid, Butterfish	29 736	13	26	32	28	25	0.24	13-37
Mackerel	4140	0	0	0	0	0	0.55	0
Squid (Illex)	12 928	2	0	0	1	1	0.44	0-2
Squid (Loligo)	12 252	10	24	29	26	23	0.25	12-33
Squid (Unc)	2	0	0	0	0	0	0.21	0
Butterfish	414	1	1	2	1	1	0.22	1-2
Menhaden	50	0	0	0	1	0	0.3	0
Monkfish	938	2	2	3	2	2	0.21	1-3
NE Multispecies	4602	4	5	7	6	5	0.3	3-9
Red Crab	<0.5	0	0	0	0	0	1.18	0
Red Drum	1	0	0	0	0	0	0.23	0
Sea Scallop	5643	172	153	31	25	95	0.22	60-140
Seatrout	34	0	0	0	0	0	0.29	0
Shad & River Herring	31	0	0	0	0	0	0.42	0
Shrimp, Northern	4	0	0	0	3	1	0.46	0-1

Table 1, continued. Estimated total (observable + unobservable but quantifiable) loggerhead sea turtle (*Caretta caretta*) interactions as attributed to managed species landed. For species that were rarely or never landed on trips with turtle excluder device (TED) requirements, observable interactions will be equal to observable + unobservable but quantifiable interactions. For species that were sometimes landed on trips with TED requirements, the observable interactions only are also shown (the difference being the estimated number of loggerheads that passed through TEDs at depth). CC = *Caretta caretta*, CV = coefficient of variation, CI = 95% confidence interval. Note: due to rounding, columns might not sum to reported column totals.

	Average annual adjusted VTR landings	Estimated CC interactions				Average annual		
Managed species	**(t)**	**2005**	**2006**	**2007**	**2008**	**CC**	**CV**	**CI**
Skates	6290	8	10	6	5	7	0.23	4-11
Smooth Dogfish	70	1	1	2	1	1	0.18	1-2
Snapper/Grouper	8	0	1	2	0	1	0.15	0-1
observable only		0	1	1	0	0	0.16	0
Spiny Dogfish	112	0	0	0	0	0	0.34	0
Spot	1	0	0	0	0	0	0.17	0
Striped Bass	62	0	0	1	1	1	0.27	0-1
observable only		0	0	1	0	0	0.28	0-1
Summer Flounder, Scup, Black Sea Bass	7799	130	115	117	79	110	0.13	83-139
observable only		83	59	65	32	60	0.14	44-77
Summer Flounder	4957	128	112	115	78	108	0.13	81-136
observable only		81	56	63	31	58	0.14	42-74
Scup	2447	2	2	2	1	1	0.37	1-3
Black Sea Bass	394	1	1	1	0	1	0.26	0-1
Tautog	17	0	0	0	0	0	0.35	0
Tilefish	12	0	0	0	0	0	0.25	0
Weakfish	82	1	1	0	0	1	0.15	0-1
Other	270	0	0	0	0	0	0.23	0
No catch	0	0	3	0	0	1	0.27	0-1
Total	62 039	455	422	268	265	352	0.12	276-439
observable only		386	361	207	211	292	0.13	221-369

APPENDIX

List of unmanaged species (or managed species with <0.5 m tons landed) reported on Vessel Trip Reports for 2005–2008 Mid-Atlantic bottom otter trawls for fish and scallops

bonito, Atlantic
cunner
cusk
cutlassfish (ribbonfish)
dogfish, chain
eel, American
eel, conger
eel, unclassified
escolar
fish, other
hagfish
harvestfishes
john dory
lumpfish
mackerel, chub
mackerel, frigate
mullets
mummichog
perch, white
puffer, northern
quahogs
rosefish, black bellied
salmon, Atlantic
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sea robins
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