

NATIONAL MARINE FISHERIES SERVICE PROCEDURAL INSTRUCTION 02-110-21

March 23, 2017

Protected Resources

02-110 Conservation of Threatened and Endangered Species

Process For Post-Interaction Mortality Determinations Of Sea Turtles Bycaught In Trawl, Net,
and Pot/Trap Fisheries

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Office: F/PR2 (B. Stacy)

Certified by: F/PR (Donna Wieting)

Type of Issuance: Initial

Office: Protected Resources

Signed

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Director, Office of Protected Resources

Date

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Process for Determining Post-interaction Mortality of Sea Turtles Bycaught in Trawl, Net, and Pot/Trap Fisheries

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1. Introduction. The National Oceanic and Atmospheric Administration’s (NOAA) National Marine Fisheries Service (NMFS) Policy Directive 02-110 establishes the framework for NMFS Endangered Species Act (ESA) implementation, including consultation under ESA Section 7 on any Federal actions that may affect a listed species. Actions that require Section 7 consultation include operation of fisheries that are regulated or permitted by NMFS and that may affect sea turtles. A comprehensive accounting of take, including lethal take, is fundamental to determining whether activities jeopardize listed species and whether compliance with take exemptions provided under Section 7 is achieved. Lethal take (mortality) can occur during interaction or after turtles are released alive from fishing gear. The latter is referred to as “post-interaction mortality” and results from delayed effects of physiological disturbances or traumatic injuries caused by capture. To assess the full effects of fishing activity on listed sea turtles, NMFS must use the best available information to estimate what proportion of turtles incidentally captured and released alive will subsequently die. This Procedural Directive (02-110-XX) provides the process and criteria for consistently assessing post-interaction mortality of sea turtles caught by trawl, net,¹ and pot/trap gear. NMFS issues this Procedural Directive to establish national consistency for incorporating post-interaction mortality into Section 7 consultations for fisheries² that incidentally capture sea turtles and defines the process by which post-interaction mortality is determined from information collected by NMFS fisheries observers and other sources that document interactions between sea turtles and fisheries.

This Procedural Directive establishes the following:

- a) Staff in the Regional Offices, Science Centers, and Office of Protected Resources will incorporate post-interaction mortality into assessments of total mortality developed for the purposes of Section 7 consultations and other analyses as appropriate.
- b) Staff within NMFS Office of Protected Resources, Regional Offices, and Science Centers will work with regional fisheries observer and sea turtle response programs to develop

¹ “Net” gear includes all fisheries (e.g., gillnet, pound, purse, seine) that use any type of entangling, gill, or entrapment/encirclement net to harvest target species.

² Post-interaction mortality rates for sea turtles interacting with longline gear are contained in Ryder et al. (2006)

and/or modify information collection methods (i.e., data forms and protocols) that best inform criteria for assigning post-interaction mortality, as defined in Appendix A, and provide consistency in evaluations across similar fisheries and gear types to the maximum extent possible.

- c) Staff within NMFS Office of Protected Resources, Regional Offices, and Science Centers will execute this directive's review and reporting process.
- d) NMFS' Office of Protected Resources, in consultation with staff in the Regional Offices and Science Centers, will review this Procedural Directive(s) every five years. The 5-year review will be based upon the best available scientific information, input from external experts, as appropriate, and experience gained in implementing the Directive. If new information becomes available sooner than the five-year review time frame, NMFS will consider whether revisions are warranted and update the Procedural Directive(s), as appropriate. After completing this review, NMFS Office of Protected Resources will compile the updated, recommended revisions. The Director, Office of Protected Resources, will then once again review, consult with Regional Offices and Science Centers, as appropriate, and then approve the updated Procedural Directive.

2. Basis for the Post-Interaction Mortality Criteria. This section describes the basis for the criteria used to assign percent mortality associated with bycatch of sea turtles in trawl, net, and pot/trap fisheries. These criteria are based on the apparent degree of impairment, severity of physical injury, and relative risk of developing life-threatening conditions as a result of the interaction. The intent of the criteria is to consistently determine, across all NMFS regions, post-interaction mortality based on conditions that diminish survival and must be accounted for in mortality estimates.

Turtles captured in fishing gear that are alive upon discovery exhibit a range of outward effects, from seemingly normal behavior and activity to complete unresponsiveness. Similarly, traumatic injuries of different degrees of severity are encountered, ranging from minor, superficial wounds to those that present an immediate threat to survival and risk of serious complications, such as secondary infections and diminished ability to forage and perform other vital biological functions. There have been relatively few scientific studies of mortality of sea turtles that were released alive from trawl, net, and pot/trap fishing gear. The technical difficulty associated with observing sea turtles after release, limitations in confidently detecting mortality at sea, and rarity of subsequent encounters pose challenges to directly measuring post-interaction mortality. Although specific mortality data are limited, a number of studies have examined physiological and other effects of bycatch in various fisheries (Stabenau et al. 1991; Harms et al. 2003; Stabenau and Vietti 2003; Snoddy et al. 2009; Wilson et al. 2014; García-Párraga et al. 2014; Phillips et al. 2015). In addition, there is considerable veterinary medical experience with disorders and injuries resulting from capture by fisheries or those that are similar in nature (and thus directly relevant) to conditions and injuries sustained as a result of fisheries interactions. For instance, physiological effects and attendant clinical deficits associated with physical exertion and oxygen deprivation; blood loss, secondary infections, and other complications caused by traumatic injuries; and immediate and delayed consequences of drowning are not limited to fisheries interactions and are regularly encountered by veterinarians practicing in sea turtle care/treatment facilities. Moreover, many of these effects and their implications on post-interaction mortality are not unique to the specific types of gear or fishing practices used in

different regions of the U.S. This combination of available studies and clinical experience provides a considerable basis for expert opinion on mortality associated with various degrees of impairment and injury observed in sea turtles that are incidentally captured in fisheries. The criteria defined herein were developed using the outcomes of two multidisciplinary workshops that convened veterinarians, physiologists, and biologists with expertise in sea turtles and fisheries to discuss the effects of capture by trawl, net, and pot/trap fisheries and implications on post-interaction mortality (Upton 2011; Stacy et al. 2016).

Because the survival or death of sea turtles that are captured in fisheries and subsequently released cannot be directly measured in most instances, the likelihood of mortality is primarily based on activity level and the presence or absence of any abnormal behavior or injuries. This information is largely collected by observers on board commercial fishing vessels; observers are trained to document the condition of bycaught sea turtles amid a number of other duties. Sea turtles caught in pot/trap gear may also be documented and assessed by personnel that are specifically trained and permitted to disentangle and release animals. In the vast majority of cases involving fishery observers, turtles are visually assessed when brought aboard vessels, while on board, and upon release. Observers are provided with datasheets that cue specific observations and facilitate consistent documentation. There is inherent variability in the conditions under which observations are made and the amount of time turtles are available for examination due to factors such as fishery operations and environmental conditions. Information collected by observers, including written notes, photographs, and videos, is later evaluated by individuals with specific sea turtle expertise (see Section 3). The criteria defined in this Procedural Directive will be used for this evaluation. These criteria consider the nature of information obtainable by observers and were developed to allow assessment of the majority of observed interactions.

In the criteria, each observation is categorized as low risk of mortality (Category 1), intermediate risk of mortality (Category 2), or high risk of mortality (Category 3). Each mortality risk category is associated with percentages that reflect the proportion of sea turtles that are estimated to later die following release. In addition, injuries or conditions that are incompatible with survival are considered deaths (100% mortality). The mortality percentages applied to these risk categories are provided in Table 1 and were derived from a combination of expert opinion and available studies pertinent to sea turtle post-interaction mortality. Defining the three categories and the associated mortality percentages initially began as the product of an expert workshop convened by the Greater Atlantic Regional Fisheries Office (GARFO) in 2009 (Upton 2011). This approach was subsequently revisited by a second expert workshop assembled in 2015 to re-evaluate post-interaction mortality in the context of trawl, net, and pot/trap fisheries operating throughout the U.S., and in light of new information that became available following the 2009 workshop (Stacy et al. 2016). The key elements of the outcome of the 2015 workshop and basis for the mortality determination criteria are explained in the following paragraphs.

Table 1. Mortality percentages assigned to risk categories

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

^a1A-fisheries at minimal risk of causing decompression sickness (DCS).

^b1B-fisheries at risk of causing DCS.

Under the criteria, the lowest mortality risk category (Category 1) assigned for any fisheries interaction includes apparently uninjured sea turtles that exhibit indications of normal behavior and activity, those with slight alterations in behavior or activity that may still be considered within the bounds of normal, and turtles with minor, non-life threatening traumatic injuries. A mortality rate of 20% was assigned to Category 1 observations following the 2009 GARFO workshop and was strongly supported by individual expert opinions conveyed in the 2015 workshop. In both efforts, veterinarians and physiologists provided available evidence of effects of interaction on bycaught turtles, limited ability of fisheries observers to detect subtle, yet significant effects of capture, and effects that cannot be detected in sea turtles by visual observation alone. Available empirical data for sea turtles caught in shallow-set gillnets in North Carolina also support concerns that some sea turtles later die despite appearing to be relatively unaffected upon capture. Mortality of turtles released from gillnets was confirmed in 1 of 7 turtles that were observed to be in a condition compatible with Category 1 observations; death of a second turtle was suspected based on satellite telemetry data (Snoddy et al. 2009; Snoddy and Williard 2010). In addition, recent studies of decompression sickness (DCS) in sea turtles caught in gillnet and trawl fisheries, and information provided by one of the key researchers that discovered its occurrence indicate that 25.9% (29/112) of loggerheads initially observed to be active and behaving normally upon capture developed life-threatening gas embolism (formation of gas bubbles within the bloodstream; the cause of DCS) over a period of hours (García-Párraga pers. com. 2016; Stacy et al. 2016). In light of this information, multiple experts felt that DCS could be an important contributing cause of mortality assigned to Category 1 observations and that fishing parameters and risk for DCS should be taken into account. Evidence also reflected uncertainty that post-interaction mortality of animals exhibiting Category 1 observations could be especially variable and dependent on a number of different factors, such as duration of submergence or entrapment, depth of capture, turtle size, life phase, and water temperature.

Following review and consideration of the individual experts' comments and the available data, a mortality percentage of 10% is assigned to sea turtles exhibiting Category 1 observations and that are caught by fisheries for which current data do not indicate a high risk of DCS. This percentage is the central value between no resulting mortality (0% mortality), which is not supported by available scientific information, and the approximate percent mortality reported in turtles caught in shallow-set gillnets that exhibited Category 1 observations (1-2 out of 7; 14.3-28.6% mortality) (Snoddy and Williard 2010). There is insufficient information available at this time on which to base an alternative percentage within or outside of this range (0-20%). This approach acknowledges the limitations of both the currently available data on post-interaction

mortality across different trawl, net, and pot/trap fisheries and visual assessments by fisheries observers, but also considers the direct evidence of significant effects of capture in some animals within this category, as well as a considerable body of expert opinion that effects of capture can be significant and diminish survival despite the condition apparent to observers while on board vessels.

A higher mortality rate of 20% is assigned to Category 1 observations for sea turtles caught by fisheries operating at a depth of 40 m (22 fathoms) or greater. The actual depth of the interaction is used for this purpose if known. If the depth of interaction is unknown, the following are used in order of preference: 1) the maximum depth reached by the gear during an observed set that resulted in the interaction; 2) maximum best available measure of gear depth for the specific deployment or trip in which interaction occurred; or 3) maximum best available measure of depth of gear use for the same fishery in which interaction occurred. As previously described, DCS represents an additional threat beyond the effects of physiological derangement, exertion, and forced submergence. This mortality rate is lower than the actual percent occurrence of clinically significant gas embolism (25.9%) observed in turtles meeting Category 1 observations based on findings in gillnet and trawl fisheries operating in the Mediterranean. The mortality rate of 20%, as applied following the 2009 GARFO workshop, is retained instead of using a higher rate because of the degree of uncertainty regarding the pathophysiology and occurrence of DCS under different conditions. Twenty percent mortality was initially assigned to Category 1 observations to account for a variety of poorly understood effects of interaction. In consideration of all of these factors, this rate remains consistent with these concerns, including those related to DCS, and reflects the current level of understanding.

The threshold fishing depth of 40 m was selected based on analysis of data from sea turtles bycaught in trawlers operating in the Mediterranean region (Fahlman et al. 2016). Turtles were evaluated by veterinarians for the presence of gas embolism. The analyses most relevant to the assigned 40 m depth threshold focused on those turtles with relatively severe embolism that were unlikely to survive if untreated. Although the relationship between depth and risk of mortality from DCS is complicated by a number of factors, the best available information indicates that probability of mortality likely exceeds 10% at around 40 m (shown in Figure 4 in Fahlman et al. 2016). This threshold is an analytically conservative application of these data because 1) it applies the lower bound of the 95% confidence interval for estimated mortality and 2) it does not attempt to interpret the limited available data for turtles caught at shallower depths. This cautious approach was elected because of the variability in the available data. Decompression sickness likely occurs at shallower depths, especially in animals submerged for longer intervals; however, there is insufficient data available at this time to inform additional incorporation into mortality estimates. In addition, the data suggest that mortality resulting from DCS actually may be higher than 20%; however, this concern arguably is accounted for to some degree because at least some animals affected by DCS may exhibit behavioral abnormalities included in the higher risk categories.

The intermediate mortality risk (Category 2) and high mortality risk (Category 3) categories include observations where direct measurements of mortality are lacking; thus, mortality rates are based almost entirely on clinical experience and expert opinion. Mortality rates of 50% and 80% were assigned to intermediate and high risk categories, respectively, following the initial

2009 GARFO workshop and were further supported in expert opinions solicited in the subsequent 2015 workshop. Observations under these risk categories include anomalous behaviors and injuries that are much more obvious compared to Category 1 observations, and thus medical assessment of significance and implications on survival can be more directly extrapolated from observations of animals treated in rehabilitation facilities or encountered in the field. For example, experience with injuries and complications such as blood loss or risk of secondary infection provided a specific basis for mortality estimates applied to some injuries. Likewise, impaired neurological function and inability to surface present a clear and obvious threat associated with certain observations. Fisheries parameters and risk of DCS are not used to assign different mortality percentages for observations within Categories 2 and 3. The reason for this is three-fold: 1) mortality percentages applied to these categories reasonably include some risk of DCS (among other complications); 2) there is insufficient data available to warrant cumulative assignment of mortality risk; and 3) expert opinion regarding risk of DCS and relevance to the assigned mortality percentage was most strongly expressed for Category 1 observations. Additional detail on specific rationale and observations for each criterion is provided in Appendix A.

3. Annual Process for Determining Post-Interaction Mortality. Each region will convene a designated group of reviewers for the purpose of examining records of incidental captures in trawl, net, and pot/trap fisheries to determine post-interaction mortality. This group will be composed of one staff member from the primary³ NMFS Regional Office, one staff member from the Regional Science Center, one staff member from an outside Science Center or Regional Office, and a NMFS veterinarian or contract veterinarian. All members should have experience with sea turtles and be familiar with sea turtle behavior and the criteria used for assessment. This group composition will promote consistency in application across regions and ensure that the necessary expertise is represented within the group. Following establishment of an initial reviewer group for each region, when feasible, new prospective reviewers must participate in a minimum of one complete review cycle as a non-scoring observer prior to serving as an actual reviewer. This requirement will promote consistency and continuity in the process. The general annual process for determination of post-interaction mortality is as follows:

3.1 Initial injury determination. Annually, NMFS Regional Office staff will compile all available information on observed incidental captures in trawl, net, and pot/trap gear. This information will be made available by the Regional Office to the reviewer group members, who will independently determine whether the observations are attributable to the current fishing interaction; assign a mortality risk category of low (1A or 1B), intermediate (2), high (3), or deceased (D) based on the criteria; and provide a brief explanation of each determination. For sea turtles that are brought on board dead, the group will evaluate whether mortality is attributed to the current interaction based on postmortem condition and other evidence, such as entanglement in gear or concurrent abnormalities. Any apparent decomposition will be evaluated in light of duration of gear deployment and water temperature. The participant from the primary Regional Office will collate results and comments, and provide them to the entire group for discussion.

³ Refers to the region documenting the interaction.

3.2 Reviewer group discussion and determination. The reviewer group will be convened annually as a management action by the Regional Office and focus discussion on any interactions that were categorized differently among group members. The group will review the available information as necessary and attempt to reach consensus. The final assigned mortality category will reflect this consensus determination. The veterinarian member will make the determination if consensus is not reached. If the group concludes that insufficient information is available for a case evaluation, the justification for the decision will be noted and then it will be excluded from further analysis. Mortality estimates will only be derived from those interactions in which sufficient data exist to assign mortality. However, if the observer's ability to collect information pertinent to an animal's condition was deliberately obstructed by the captain or crew, a determination of deceased (100% mortality) may be assumed. Individual case summaries explaining the final determination for each interaction will be prepared by the participant from the primary Regional Office.

3.3 Report Preparation. Results of the determinations will be compiled by the primary Regional Office participant into an annual report. While the format of these written reports may vary depending on the needs and clearance processes of each region, each report will include: 1) a summary of determinations by gear type and/or fishery⁴ and species; 2) a compilation of individual case summaries; and 3) justification for any departure from the criteria (e.g., if the outcome of interaction is known or information was used in the assessment that is not specifically considered in the criteria).

3.4 Report Clearance. The injury determination reports follow the formal review and clearance processes specific to each Regional Office. Final reports will be posted to the appropriate Region website.

4. Fishery-wide extrapolation of mortality for Section 7 purposes. Mortality determinations for observed interactions will be used to calculate total mortality attributed to a given gear type and/or fishery. Because depth of interaction determines the mortality rate assigned to Category 1 interactions, estimates of total mortality should apply the lower (A) and higher (B) rates to Category 1 interactions based on the proportion of the fishery that fishes above or below the 40 m threshold, respectively. For example, observed interactions are assigned into the appropriate categories based on the criteria in Appendix A. The number of total interactions is estimated for the entire fishery and is proportionally allocated across the Categories 1 through 3 (and deceased) based on these observed interactions. For a fishery in which 70% of effort occurs in depths shallower than 40 m, 70% of total estimated captures in Category 1 will be assigned 10% mortality and 30% of captures will be assigned 20% mortality.

5. Interactions Included in this Procedural Directive. The process and criteria defined in this Procedural Directive apply to evaluation of fisheries observer information collected from any trawl, net, or pot/trap fishery. In addition, this Directive may also be applied to data collected on incidental sea turtle interactions with these types of fishing gears that are deployed for other purposes under conditions that are similar to commercial fisheries (e.g., recreational use, fisheries-independent monitoring, scientific research). The criteria defined in this

⁴ Excludes fisheries with confidentiality considerations due to limited participants.

procedural directive are not intended to apply to interactions with gear that meet certain specific conditions. The exceptions are as follows:

- 1) Interactions that are characterized by capture situations where a turtle has the ability to freely swim, dive, and reach the surface without any obstruction (including entanglement in netting, twine, or other material) and where release occurs on a regular basis (e.g., live captures within the head/pound portion of pound nets). Physiological effects have been shown to be relatively mild following these interactions (Harms et al. 2003), and there is no equivalent basis for the various concerns reflected in the criteria unless an interaction clearly entails a complicating element, such as entanglement, underwater entrapment, or other injury.
- 2) Interactions followed by escapement or release within minutes of capture (i.e., trawl nets equipped with properly installed, functioning, certified turtle excluder devices - TEDs). Although such interactions induce physiological derangements that can be further worsened in animals that undergo multiple encounters (Stabenau et al. 1991; Stabenau and Vietti 2003), the period of submergence and interaction nonetheless is typically much shorter than the fisheries interactions considered in the development of these criteria.
- 3) Directed capture of sea turtles authorized under NMFS Section 10(a)(1)(A) permits or biological opinions (e.g., relocation trawling). These interactions are exempted because of protective measures inherent to these activities, including strict adherence to gear deployment requirements, regular gear monitoring, and other measures that maximize sea turtle survival (e.g., veterinary consultation and assistance, training, review of operational protocols).

All of these types of interactions may result in post-interaction mortality under some conditions; however, for these reasons inclusion under the process identified herein is not currently warranted.

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APPENDIX A - Criteria Used To Assign Likelihood of Post-interaction Mortality of Sea Turtles Caught in Trawl, Net, and Pot/Trap Gear

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1. **Introduction.** This Appendix presents the National Criteria in 3 tables followed by an itemized description that explains the basis for each observation and the assigned mortality risk. The rationale provided in these descriptions summarizes information and individual expert opinions obtained from the 2015 workshop and is found in additional detail in Stacy et al. (2016). Unless specifically noted, these criteria apply to all species and life phases. In addition, mortality determined for any animals with multiple behavioral anomalies or injuries will be based on the highest category present. Reviewers have the discretion to assign a higher category if there is a reasonable expectation that multiple abnormalities will pose an additive risk of mortality. As described in Section 3.3, justification for any deviation from the criteria must be provided during the review process.

Table A-1 includes observations related to behavior, activity level, responsiveness, and findings other than traumatic injuries. Greater risk of mortality is assigned for behaviors that indicate impairment or aspiration of seawater during the interaction, especially any abnormalities that are evident when a turtle is returned to the water. Any deficits present at the time of release or abnormal behavior upon release are considered to be associated with high risk of mortality.

Table A-2 includes descriptions of various types of injuries involving different parts of the body and of different severities. Injuries included in this table are relatively acute; therefore, assigned risk of mortality primarily considers immediate effects of damage to vital anatomy and blood loss. Delayed effects, such as secondary infection or loss of function, are also taken into account. Greater mortality is assigned to those injuries that are more likely to be associated with life-threatening internal trauma.

Table A-3 is a more complex matrix that specifically considers trauma involving the neck and appendages and takes into account a combination of injury location(s), degree of injury, and species in the assigned mortality category. This table includes two general categories of injuries: 1) those resulting from entanglement, including chronic wounds; and 2) acute traumatic injuries such as fractures, dislocations, and amputations. Entanglements in some types of gear (e.g., pot/trap) are often discovered after prolonged interaction with longer intervals of survival relative to other types of interactions. Acute fractures, dislocations, and amputations are

associated with an immediate threat of blood loss as well as delayed complications from secondary infection and loss of fitness. In the Table 3 matrix, there is a general trend of increasing risk of mortality associated with injuries involving multiple flippers or the neck and its vital structures. Injuries involving combinations of flippers are weighted differently with regard to risk of mortality. Specifically, injuries affecting both front flippers or both flippers on the same side are associated with the most significant impairment of swimming. The matrix also incorporates likelihood of loss of the flipper or flipper function as determined by the degree of tissue injury or loss of tissue vitality, which are frequent complications of entanglement wounds that cut into tissues or compress the blood supply. With regard to mortality assigned to different species, leatherbacks are assigned a higher risk of mortality for injuries associated with loss of a front flipper. Although amputations reduce the fitness of hard-shelled (cheloniid) sea turtles and may cause life-threatening complications, individuals missing single front flippers are encountered in the wild. Observations of subadult and adult leatherbacks with equivalent injuries are seemingly rare; thus, loss of a front flipper is considered incompatible with survival in the wild for this species based on available data.

1.2 **Table A-1.** Behavioral criteria for determination of post-interaction mortality. Observations categorized as “D” are incompatible with survival and are considered deceased (100% mortality).

Observations	Category
1-A. Vigorously crawls around when brought on board ^a	1
1-B. Moves little or remains stationary when brought on board ^a , but actively responds and/or crawls if moved, handled, or tagged ^b	1
1-C. Dives or swims deliberately away from vessel within 1 minute of release	1
1-D. Remains at surface and/or does not swim deliberately away from vessel for greater than 1 minute ^c	2
1-E. Movements generally appear or become slow, sluggish, or weak (may be described as lethargic or dull) ^a , but becomes active before release	2
1-F. Movements generally appear or become slow, sluggish, or weak (may be described as lethargic or dull) AND water or froth discharges from mouth or nares	3
1-G. Exhibits an episode at any time where consciousness/responsiveness (does not move voluntarily) is not apparent ^d when moved, handled, or tagged, but subsequently becomes conscious/responsive prior to release	3
1-H. Exhibits abnormal neurological signs, including any of the following: circling, not using all four flippers appropriately, eyes are continuously closed for several seconds or more at a time, persistent tilting of the head, listing/rolling, or inability to right itself in the water	3
1-I. Movements generally appear slow, sluggish or weak (lethargic) at the time of release (just prior to placing back in water)	3
1-J. Does not appear conscious/ responsive (does not move) upon release; and/or sinks (exhibits no swimming motions)	D

^aThis behavior refers to general level of activity when turtles are first brought on board. It is not considered abnormal behavior if turtles calm down after crawling into a corner and/or after being placed onto tires or other devices as part of safe handling measures.

^bActive response includes vigorously crawling, lifting the head, or flapping or withdrawing flippers in response to being moved, handled, or tagged.

^cObservations less than 1 minute will be evaluated on a case-by-case basis.

^dRegardless of responsiveness to reflex stimulation including: touching the eyelid or eye, pinching the flippers, or touching the cloaca/vent.

1.3 Table A-2. General traumatic injury criteria for determination of post-interaction mortality

Observations	Category
2-A. No apparent injuries	1
2-B. Superficial abrasions, chips, or scuffs to carapace or plastron	1
2-C. Minor or superficial injuries to skin ^a	1
2-D. Fractures of shell margin involving <50% width of marginal or pygal ^b	1
2-E. Injuries to cornea, sclera, and/or globe of one eye	2
2-F. Fractures of shell margin involving >50% width of marginal or pygal ^b	2
2-G. Any shell fracture involving bones other than the marginals/pygals ^b , but not involving the dorsal midline; any shell fracture in leatherbacks not involving dorsal midline	2
2-H. Any shell fracture that crosses the dorsal midline	3
2-I. Fractures or wounds penetrating the body cavity OR exposing visceral organs	3
2-J. Skull or mandibular fracture	3
2-K. Evidence of bleeding from cloaca, nares, eyes, or oral cavity, unrelated to superficial wounds ^a	3
2-L. Injuries to cornea, sclera, and/or globe of both eyes	3

^aIncluding abrasions involving nasal planum, eyelid or cloacal skin.

^bThese designations use commonly applied anatomical references and refer to fractures involving peripheral bones (underlying marginal scutes) and pygal bones (underlying postcentral scutes). These descriptors are not applicable for leatherbacks.

1.4 **Table A-3.** Criteria for determination of post-interaction mortality for injuries involving the neck and appendages.^{a,b}

Observations categorized as “D” are incompatible with survival and are considered deceased (100% mortality). Those categorized as “NA” are not applicable because they are incompatible with a live animal interaction.

Observations	Category				Neck
	Single front flipper	Single rear flipper	Both rear flippers OR two flippers on opposite sides	Both front flippers OR two flippers on same side	
3-A. No visible compression or damage to the skin after removal of gear	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
3-B. Ligature impression visible, but skin not damaged	1 (1)	1 (1)	1 (1)	1 (1)	2 (2)
3-C. Skin abraded or ulcerated, but does not expose muscle	1 (1)	1 (1)	1 (1)	1 (1)	2 (2)
3-D. Skin ulcerated with exposure/injury of muscle	1 (2)	1 (1)	1 (2)	2 (3)	3 (3)
3-E. Skin ulcerated with exposure/injury of bone	2 (3)	2 (2)	2 (3)	3 (D)	D
3-F. Swelling distal to entanglement	1 (2)	1 (1)	1 (2)	2 (3)	3 (3)
3-G. Discoloration distal to entanglement	2 (3)	2 (2)	2 (3)	3 (D)	NA
3-H. Necrosis distal to entanglement	2 (3)	2 (2)	3 (3)	D (D)	NA
3-I. Voluntary movement of flippers is slow, absent, or stiff compared to unaffected limbs	2 (3)	1 (1)	2 (3)	3 (3)	NA

^a3-A through 3-I refer to wounds/ligatures involving the proximal flippers (above carpus/tarsus) and neck. Primary involvement of the distal appendages is relatively rare with entanglements and are evaluated case-by-case.

^bRisk for leatherbacks provided in parentheses

Table A-3. Continued.

Observations	Category				Neck
	Single front flipper	Single rear flipper	Both rear flippers OR two flippers on opposite sides	Both front flippers OR two flippers on same side	
3-J. Amputations of less than one third of the flipper (at level of the middle or distal phalanges)	1 (1)	1 (1)	1 (1)	1 (1)	NA
3-K. Amputation of distal one third of the flipper (at level of metacarpals/metatarsals or proximal phalanges)	2 (2)	1 (1)	2 (2)	2(2)	NA
3-L. Amputation of half or more of the flipper (at or above carpus/tarsus)	3 (3)	2 (2)	3 (3)	D (D)	NA
3-M. Any open fracture or dislocation at or above carpus/tarsus	3 (3)	2(2)	3 (3)	D (D)	NA
3-N. Injuries to neck affecting spinal cord, major blood vessels, or airway	NA	NA	NA	NA	3 (3)
3-O. Gear remaining on animal at release	3 (3)	3 (3)	3 (3)	3 (3)	3 (3)

2. Explanatory narrative and rational for each observation used to assign post-interaction mortality.

Table A-1. Behavioral criteria for determination of post-interaction mortality.

1-A. Vigorously crawls around when brought on board – Category 1

This criterion is considered normal behavior for sea turtles following interaction. Placement under Category 1 and the associated mortality rate are based on diminished survival in some animals resulting from effects that are delayed in manifestation or otherwise unapparent within the period of visual observation, including physiological derangement, effects of physical exertion or submergence, and potential for DCS (under some conditions).

1-B. Moves little or remains stationary when brought on board, but actively responds and/or crawls if moved, handled, or tagged – Category 1

This behavior and level of responsiveness also is considered within the bounds of normal behavior following capture but may also reflect relatively mild or early effects of the interaction. Rationale for assignment into Category 1 is as provided under 1-A.

1-C. Dives or swims deliberately away from vessel within 1 minute of release – Category 1

The normal behavior of sea turtles upon release is to dive or swim away immediately from vessels or do so within a short period of time. This criterion is assigned into Category 1 based on the rationale provided for 1-A.

1-D. Remains at surface and/or does not swim deliberately away from vessel for greater than 1 minute – Category 2

Delayed diving or swimming away from the vessel for longer than 1 minute upon release is considered outside of the typical response observed in apparently healthy sea turtles. Placement into Category 2 reflects concerns of impairment from interaction that will negatively affect survival.

1-E. Movements generally appear or become slow, sluggish, or weak (may be described as lethargic or dull), but becomes active before release – Category 2

This behavior is considered reflective of diminished activity or responsiveness attributable to the effects of physical exertion or forced submergence but followed by some degree of apparent compensation or recuperation prior to release. This criterion is placed into Category 2 based on evidence of an uncertain degree of impairment in these animals and concerns that delayed effects can impact survival, as reflected in expert opinion.

1-F. Movements generally appear or become slow, sluggish, or weak (may be described as lethargic or dull) AND water or froth discharges from mouth or nares – Category 3

Observations within this criterion represent evidence of seawater aspiration during the interaction and are associated with risk of immediate and delayed effects on survival, including impairment of respiratory function and secondary infection.

1-G. Exhibits an episode at any time where consciousness/responsiveness (does not move voluntarily) is not apparent when moved, handled, or tagged but subsequently becomes conscious/responsive prior to release – Category 3

Loss of consciousness or responsiveness is regarded as a sign of significant impairment attributable to hypoxia and other physiological derangements resulting from interaction. This observation is placed into Category 3 due to concerns that animals may suffer continued effects to the degree that jeopardizes survival despite apparent compensation or recuperation prior to release. These effects include complications from seawater aspiration, exertional injury, and incomplete recovery from physiological derangements. This criterion includes sea turtles that have become responsive following any resuscitative measures.

1-H. Exhibits abnormal neurological signs, including any of the following: circling, not using all four flippers appropriately, persistent tilting of the head, listing/rolling, or inability to right itself in the water – Category 3

These observations are an indication of impaired neurological function resulting from traumatic injury or severe physiological derangement. This criterion is placed into Category 3 due to impaired ability to surface to breathe and likelihood of significant effects on other vital functions.

1-I. Movements generally appear slow, sluggish or weak (lethargic) at the time of release (just prior to placing back in water) – Category 3

Obvious impairment upon return to the water is associated with a high risk of mortality (Category 3) due to diminished ability to avoid predators or surface to breathe, as well as potential for worsening of condition if not allowed to recover under protected conditions.

1-J. Does not appear conscious/ responsive (does not move) upon release; and/or sinks (exhibits no swimming motions) – Deceased

These observations are incompatible with life once returned into water despite persistence of any basal biological functions, such as cardiac contraction or responsiveness to reflex testing.

Table A-2. General traumatic injury criteria for determination of post-interaction mortality.

2-A. No apparent injuries – Category 1

Turtles with no apparent injuries are assigned into Category 1 based on the rationale provided for 1-A-C. In addition, the absence of externally visible injuries does not preclude the presence of exertional muscle injury (capture myopathy), which is not externally visible, or more cryptic traumatic injuries that are masked by the resilient nature of the skin of some species. These concerns are also captured within the percent mortality applied to Category 1.

2-B. Superficial abrasions, chips, or scuffs to carapace or plastron – Category 1

Rationale for this criterion is as provided for 2-A. Injuries of this nature are considered minor and do not warrant placement into a higher mortality risk category based on their presence alone.

2-C. Minor or superficial injuries to skin – Category 1

Rationale for this criterion is as provided for 2-A. Injuries of this nature are considered minor and do not warrant placement into a higher mortality risk category based on their presence alone.

2-D. Fractures of shell margin involving <50% width of marginal or pygal (hardshelled species only) – Category 1

Rationale for this criterion is as provided for 2-A. Injuries of this nature are considered minor and do not warrant placement into a higher mortality risk category based on their presence alone.

2-E. Injuries to cornea, sclera, and/or globe of one eye – Category 2

These injuries are associated with high likelihood of loss of vision without treatment. Although survival with unilateral vision impairment is possible, animals with these injuries are placed into Category 2 based on concerns related to the effects of loss of fitness on survival, as expressed by expert opinion.

2-F. Fractures of shell margin involving >50% width of marginal or pygal (hardshelled species only) – Category 2

There is greater risk of significant internal injury or breach of the coelomic cavity associated with fractures that span the majority or entirety of the shell margin. Such internal injuries are not necessarily externally apparent and are associated with life-threatening complications, such as organ dysfunction, blood loss, and secondary infection.

2-G. Any shell fracture involving bones other than the marginals/pygals, but not involving the dorsal midline; any shell fracture in leatherbacks not involving dorsal midline – Category 2

Rationale for this criterion is as provided for 2-F. In addition, any shell fracture that does not involve in midline in leatherbacks is assigned an intermediate risk of mortality due to differences in structure of the shell in this species and potential for internal injuries associated with any fractures.

2-H. Any shell fracture that crosses the dorsal midline – Category 3

Fractures that cross midline present a significant risk of injury to the spinal cord either by direct trauma or destabilization of the surrounding vertebrae. Spinal injury carries a high risk of mortality upon release.

2-I. Fractures or wounds penetrating the body cavity OR exposing visceral organs – Category 3

Injuries that breach the body cavity are likely to result in life-threatening complications, including damage to internal organs, blood loss, and secondary infection.

2-J. Skull or mandibular fracture – Category 3

Skull fractures typically result from trauma involving considerable force and can be associated with damage to the nervous system and delayed complications such as secondary infection. Mandibular fractures also significantly impair the ability to feed.

2-K. Evidence of bleeding from cloaca, nares, eyes, or oral cavity, unrelated to superficial wounds – Category 3

Bleeding from the eyes or orifices is considered a strong indication of severe, life-threatening internal injury.

2-L. Injuries to cornea, sclera, and/or globe of both eyes – Category 3

Bilateral ocular injuries risk impaired vision or blindness and will severely reduce or prevent survival in the wild.

Table A-3. Criteria for determination of post-interaction mortality for injuries involving the neck and appendages

3-A. No visible compression or damage to the skin after removal of gear – Category 1

Turtles with no externally apparent injury following removal of gear are assigned into Category 1 based on the rationale provided for 1-A-C and 2-A-D.

3-B. Ligature impression visible, but skin not damaged – Category 1, 2

Rationale for this criterion is as provided for 2-A. Injuries are considered low risk for persistent effects of tissue injury or loss of blood supply; however, a visible ligature of the neck is considered a Category 2 injury due to likelihood of compression and injury of trachea.

3-C. Skin abraded or ulcerated, but does not expose muscle – Category 1, 2

Rationale for this criterion is as provided for 3-A. Injuries are considered low risk for persistent effects of tissue damage or secondary infection; however, a visible ligature and ulceration of the neck is considered a Category 2 injury as explained under 3-B.

3-D. Skin ulcerated with exposure/injury of muscle – Category 1, 2, 3

A higher risk of flipper loss or loss of function and secondary infection is attributed to wounds with deep ulceration that expose the underlying muscle. The potential for limb loss is reflected in a higher mortality assignment (Category 2) for multiple flipper injuries that would significantly impair swimming. Consequently, such injuries in leatherbacks are placed into Category 3. Neck injuries that expose muscle are also assigned into Category 3 due to likelihood of involvement of the airway and major blood vessels associated with wounds of this depth.

3-E. Skin ulcerated with exposure/injury of bone – Category 2, 3, D

Exposure of bone carries a high risk of flipper loss and secondary infection, and thus Category 2 is the lowest assignment for these injuries. Leatherbacks with front flipper injuries exposing bone are placed into Category 3 and are considered to inevitably die from bilateral front flipper injuries of this severity due to aforementioned evidence of dire consequences in this species. Neck injuries exposing bone also are not expected to be survivable.

3-F. Swelling distal to entanglement – Category 1, 2, 3

Swelling indicates diminished or loss of blood and/or lymphatic flow to and/or from an appendage. The outcome may be eventual resolution following removal of gear or significant tissue damage may have resulted and may not be immediately apparent based on external assessment alone. The assigned percentage mortality is based on relative risk of flipper loss or function in a proportion of turtles according to the matrix parameters. In addition, any injuries involving the neck associated with swelling are likely to affect the vital structures of the neck and head, and are thus assigned into Category 3.

3-G. Discoloration distal to entanglement – Category 2, 3, D

Discoloration is an indication of necrosis (tissue death) and precedes sloughing of tissue that has died due to loss of blood supply. Discoloration also can be caused by gangrene (proliferation of bacteria within dead tissue), which is a life-threatening complication of these types of injuries. Rationale for the assigned mortality category follows the injury matrix and is as explained under 3-E with regard to loss of appendages and secondary infection. This criterion is not applicable to neck injuries as it would be incompatible with life.

3-H. Necrosis distal to entanglement – Category 2, 3, D

Rationale is as provided for 3-G. Necrosis is recognized by sloughing or visible putrefaction of the affected tissues and loss of the limb is expected. Injuries of this severity involving both front flippers or flippers on the same side are considered to be inevitably fatal in all species. This criterion is not applicable to neck injuries as it would be incompatible with life.

3-I. Voluntary movement of flippers is slow, absent, or stiff compared to unaffected limbs – Category 1, 2, 3

This criterion captures the significance of injuries that affect function, but are not necessarily externally apparent as a clearly visible wound or other tissue damage. The effects of loss of function on the ability to swim are weighted equivalently to observations that risk loss of the appendage(s). This criterion is not applicable to neck injuries.

3-J. Fractures of digits (phalanges) or distal amputations of less than one third of a flipper (at level of the middle or distal phalanges) – Category 1

Injuries of this nature are considered relatively minor and do not warrant placement into a higher mortality risk category based on their presence alone. Potential risk of mortality

posed by blood loss from amputation of distal portions of a flipper is captured by the mortality percentage applied to Category 1.

3-K. Amputation of distal one third of the flipper (at level of metacarpals/metatarsals or proximal phalanges) – Category 1, 2

A higher risk of mortality is associated with amputation at this level of the flipper (as compared to 3-J) due to considerable risk of blood loss, as well as secondary infection.

3-L. Amputation of half or more (at or above carpus/tarsus) of one or more flippers – Category 2, 3, D

Acute traumatic amputation of a flipper involves transection of major blood vessels and uncontrolled bleeding, risking life-threatening blood loss and vulnerability to predators. Fitness is reduced for those animals that survive the initial injury.

3-M. Any open fracture or dislocation at or above carpus/tarsus – Category 2, 3, D

Open fractures or dislocations of proximal appendages impair movement and heal poorly without medical care. Secondary infection and blood loss are important considerations with regard to life-threatening complications.

3-N. Injuries to neck affecting spinal cord, major blood vessels, or airway – Category 3

These structures within the neck are essential to vital functions and injuries are very likely to result in death due to inability to move, breathe, or from loss of blood.

3-O. Gear remaining on animal at release – Category 3

A high risk of mortality is attributed to any material remaining on turtles due to complications that are frequently encountered in stranded animals, including strangulation of the neck or appendages, drowning caused by becoming anchored beneath the surface, or obstruction of the digestive tract following ingestion.