

Protocols for Categorizing Sea Turtles for Post-release Mortality Estimates

NMFS, Southeast Fisheries Science Center

75 Virginia Beach Dr.
Miami, FL 33149

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The following are the protocols established by the Southeast Fisheries Science Center for categorizing sea turtles taken using the final tables of Ryder et al. (2006), which synthesized the information provided by individual experts at a January 2004 workshop. Epperly and Boggs (2004) were the first to use these criteria, then in draft form. They discovered that not every hooking situation encountered in the data could be accounted for by the draft criteria. They were instructed to make decisions grounded in science when interpretations of the draft table were necessary. Thus, they drafted a set of protocols that are outlined in their report and incorporated herein, also. Since, additional protocols have been added by the SEFSC for subsequent analyses. As a result of the 2004 workshop the SEFSC modified the Sea Turtle Life History Form so that more detailed data on hook location and release condition of the turtles could be recorded. Table 1 details the assignment of codes currently in use by the SEFSC to the categories established by the structure of the table for post-release mortality.

There are 3 situations where these protocols differ with the final criteria in the table presented by Ryder et al. (2006) and those are highlighted below.

Beak internal, unknown; beak internal, lower jaw; beak internal, upper jaw –

The draft criteria did not address hooking in the beak internally. The SEFSC and PIFSC made the decision to place these animals in Category I (hooked externally) because (1) the rhamphotheca (beak) is both external and internal; (2) the rhamphotheca are keratinous beaks and are hard, and in most Cheloniid species (except green turtles) are moderately to heavily constructed (Wyneken, 2001). Hooks generally only lightly penetrate it, and the observers generally report that these hooks require little effort to remove. Removal is most often done by hand, and with little or no bleeding (NMFS unpublished data); (3) the rhamphotheca is at best minimally innervated and vascularized, although the underlying tissue between the rhamphotheca and the bone is innervated and moderately vascular (Wyneken, 2001; personal communication; Harms, personal communication); and (4) post-workshop communications from several participants have recommended that beak-hooked turtles be placed in the category with externally hooked turtles (Category I).

In Feb. 2004, S. Epperly polled the small subgroup of 4 scientists who developed the structure of this table. Epperly noted that observers reported there is no or little blood when a hook is removed from the beak. Three of the 4 responded that the beak, internal and external, should be

grouped in Category I (hooked externally). One suggested it should be in Category II (hooked in upper or lower jaw). Hooking in the beak was described thus:

- "... the hook in the horny beak would be similar to external hooking. It is minimally vascularized, though just as with the carapace, it does seem to be innervated as they do have some tactile sensation through it. Considering what they use it for, it can't be terribly sensitive to sharp objects"
- "The tissue underlying the beak, between the beak and the bone is innervated and moderately vascular. The beak itself (properly the rhamphotheca) is not vascular"
- "... it is not heavily vascularized, nor innervated"

Based on this input, Epperly and Boggs (2004) placed all beak-hooked animals in category I and reported the issue to OPR, who had issued the draft guidance and was writing the final report. The rationale for this decision is detailed in the Epperly and Boggs report. Furthermore, placement of beak hooked turtles with externally hooked turtles is consistent with the former (2001) post-hooking mortality criteria (sic "lip-hooked"). Note that *Dermochelys* do not have rhamphotheca and, thus, never should be coded as beak-hooked.

Mouth lower jaw, other; mouth, side, other –

The draft criteria were silent about hooks in the side/corner of the mouth/jaw, except to indicate that animals hooked in the jaw joint should be placed in Category III (hooked in cervical esophagus, glottis, jaw joint, soft palate, tongue, and/or other jaw/mouth tissue parts not categorized elsewhere). Hooking in the side/corner of the mouth happens frequently in loggerheads, but it is a location where hooks can be removed easily. Usually the barb or eye of the hook is cut away and then the hooked backed out without further damage. Generally, we believe that animals hooked in the corner of the mouth should be placed in Category II (hooked in upper or lower jaw). Since it was not noted whether the jaw joint was involved on the data sheets, for the original NED analysis, Epperly and Boggs (2004) placed all animals hooked in the corner of the mouth in Category III (hooked in cervical esophagus, glottis, jaw joint, soft palate, tongue, and/or other jaw/mouth tissue parts not categorized elsewhere), assuming the worst (jaw joint involvement). After the workshop SEFSC revised the forms and asked the observer to indicate whether the hook, if in the mouth, was in the jaw joint, tongue, or glottis and to indicate whether it was in the upper or lower jaw, or the side, if not in those locations. Unless the hook was in the jaw joint, glottis or tongue, the SEFSC continued to include animals hooked in the mouth in Category II (hooked in upper or lower jaw).

Specifically, the subgroup of scientists who developed the structure of the table was asked about the corner of the mouth, with no jaw joint involvement. Two of the four responded that the side of the mouth, with no joint involvement, should be placed in Category II (hooked in upper or lower jaw). One dissented and suggested Category III (hooked in cervical esophagus, glottis, jaw joint, soft palate, tongue, and/or other jaw/mouth tissue parts not categorized elsewhere) instead. The fourth qualified their response, based on depth of penetration (e.g., mucosa vs. jaw joint), but when asked specifically about the location, excluding jaw joint (not adnexa), answered unequivocally, indicating it should be grouped with the lower jaw (the definition of Category II in the draft criteria, which was the only criteria available at the time of their response). Hooking in the side of the mouth, excluding jaw joint was described thus:

- "... there isn't much else to the side of the mouth"
- "If the point violates the joint space, it could lead to septic arthritis and ultimate inability to use the jaw. If it only penetrates superficially into the mucosa and immediately underlying structure, it may go into a category of 'ext hook". Considering the 'potentials' I'd probably put it closer to the 'glottis, tongue, soft palate category"
- "for a hook in the corner of the mouth, not penetrating the joint, I think it would go in the lower jaw category"

Based on this input and the detailed comments of the observers (which were not yet part of the codes), Epperly and Boggs (2004) placed "mouth, corner" interactions in Category III (hooked in cervical esophagus, glottis, jaw joint, soft palate, tongue, and/or other jaw/mouth tissue parts not categorized elsewhere) because the observers had not been instructed yet to identify the jaw joint. Because tongue and glottis were locations noted at the time, all "mouth, lower" (indicating other than glottis or tongue) were placed in Category II (hooked in upper or lower jaw) by Epperly and Boggs. The rationales for their decisions are detailed in their report. The issue was reported to OPR, who had issued the draft guidance and was writing the final report. As a result of the 2004 workshop, the SEFSC modified the Sea Turtle Life History Form so that more detailed data could be collected and the distinction could be made for those side mouth hooks in the jaw joint, separating them from "mouth, side, other". Identification of the tongue, glottis, and upper jaw (all Category III) always have been distinguished, even before the form modification. Epperly et al. (2009) since revisited the NED analysis; the detailed comments of the observers and the photos were scrutinized, and the data were re-coded to reflect current coding detail. When the distinctions could not be made based on comments, the animals were placed in Category III (hooked in cervical esophagus, glottis, jaw joint, soft palate, tongue, and/or other jaw/mouth tissue parts not categorized elsewhere. The reanalysis of Epperly et al. (2009) placed "mouth, side, other" and "mouth, lower" in Category II (hooked in upper or lower jaw) per the recommendations of the majority of the subgroup.

Swallowed, cervical –

The draft criteria distinguished between hooks in the cervical esophagus and those at the level of the heart or lower. At the workshop, cervical esophagus was defined to be when any portion of the hook was visible with tension on the line. However, the draft criteria defined cervical esophagus as only when the insertion point of the hook was visible and that is maintained in the final criteria. Of the small subgroup of scientists polled, two were in agreement with the definition of cervical esophagus including hooks that were visible, but the insertion point was not visible. A third dissented and the 4th either did not respond or the response was lost. Epperly and Boggs (2004) did not have hook visibility available for their analysis and instead used a surrogate to make the distinction between a cervical esophagus category and deeper: if all the line was removed then the hook's eye had to be accessible and thus visible. Epperly and Boggs reported the issue to OPR, who had produced the draft guidance and was writing the final report.

As a result of the 2004 workshop the SEFSC modified the Sea Turtle Life History Form so that more detailed data on hook and insertion point visibility could be collected and the distinction could be made between hooks in the cervical esophagus (Category III - hooked in cervical esophagus, glottis, jaw joint, soft palate, tongue, and/or other jaw/mouth tissue parts not

categorized elsewhere) and deeper (Category IV – hooked in esophagus at or below level of the heart). If the hook is visible, it is in the cervical esophagus; if it is not visible then it is at the level of the heart or lower. The visibility of the insertion point is relevant only to guide a decision about whether to attempt to remove the hook (if the insertion point is not visible, our guidance to the fishers is to not remove the hook, but to remove as much line as possible.) In the SEFSC's analyses for 2004 and 2005 they continued to include all hooks partially visible in Category III (hooked in cervical esophagus, glottis, jaw joint, soft palate, tongue, and/or other jaw/mouth tissue parts not categorized elsewhere), regardless of whether the insertion point was visible or not. They did this because they expected the final criteria to resolve the conflict between the definition discussed at the workshop and the definitions in the draft and final criteria.

Because our guidance instructs fishers not to remove hooks where the insertion point is not visible, the final criteria did not account for situations where the hook was swallowed with the insertion point not visible, but where all gear was removed. Although per veterinary recommendation, these hooks would not be removed, this has occurred and must be accounted for. Therefore, values were interpolated for turtles in Category IV with all gear removed (Column D) based on veterinary and expert opinion. In February 2012, a subgroup of 4 scientists and veterinarians were polled for their opinion on this cell's value. All were generally in agreement that the value of this cell should be higher than if the turtle were released with the gear remaining, due to the risk of esophageal tears, hemorrhage, and potential damage to major vessels and organs (e.g., heart, liver, lungs) if deeply swallowed hooks are removed. Because there would be no way to tell whether a tear in the esophagus, vessel or organ had occurred, one expert estimated the value at 75% (85%), and 2 others agreed. The other placed the value at 25% if there was no attached tissue on the hook or visible hemorrhage, and the gear was removed with minimal effort; however, if there is much effort to remove the hook, tissue remaining on the hook, or conspicuous hemorrhage, they estimated the value at 85%. Based on this input, the more conservative values of 75% (85%) were adopted for Category IV Column D.

Note that all turtles for which the hook location was unknown were placed in Category IV (hooked in esophagus at or below level of the heart), the most severe (highest mortality) observed for loggerheads. At the time Epperly and Boggs (2004) analyzed the NED data, the worst for loggerheads was Category IV (hooked in esophagus at or below level of the heart) for hardshell turtles and was Category III (hooked in cervical esophagus, glottis, jaw joint, soft palate, tongue, and/or other jaw/mouth tissue parts not categorized elsewhere) for leatherbacks. Since, observers have reported hooks swallowed by leatherbacks, albeit rare. Thus, we now code Category IV (hooked in esophagus at or below level of the heart) for all such unknown hooks for both hardshell and leatherback turtles. The re-analysis of the NED data by Epperly et al. (2009) is consistent with this change in protocols.

There were additional assumptions for the subsequent analyses:

- (1) If carapace length was not measured (SCL_{min} , SCL_{std} , and/or CCL_{std} in centimeters) or estimated (in feet), the SEFSC assumed that the minimum carapace length of a leatherback was 91.4 cm (3 ft estimated) and that of a hardshell or unidentified turtle was 31.9 cm (based on data collected to date from the fishery).

- (2) In order to determine whether remaining line is less than or greater than $\frac{1}{2}$ the length of the carapace, the following priority order is given to available measurements and/or estimated lengths: SCL_{\min} , SCL_{std} , CCL_{std} , and then $CL_{\text{estimated}}$.
- (3) If the entanglement status at release is unknown the SEFSC always assigned the turtle to Column A of the mortality table (turtle is entangled).
- (4) If line left on the turtle was not estimated and the turtle was not entangled at release, the SEFSC always assigned the turtle to Column B of the mortality table (line left > 50% carapace length).
- (5) If an animal was hooked in an unknown location or an unknown internal locations or it was not known if it was hooked, the turtle always was assigned to Category IV (maximum mortality for a non-comatose hooked turtle released alive), unless all gear was retrieved. The latter is not acknowledged as a possibility in the draft criteria nor in the final criteria. Thus, if all gear was retrieved it was assumed that the turtle likely had not deeply ingested the hook and the SEFSC always assigned the turtle to Category III (hooked in cervical esophagus, glottis, jaw joint, soft palate, tongue, and/or other jaw/mouth tissue parts not categorized elsewhere) and Column D (released with all gear removed).
- (6) Lastly, at the time of the NED analyses (and the 2002-2003 fishery analyses), there was not a distinction between an animal entangled at capture and an animal released entangled. However, after the workshop the form was modified to make this distinction because only the latter matters. Using the comments on the forms and information on the amount of gear released, the SEFSC recoded all the historical data, including NED data, to identify when an animal was released still entangled. Before the time that the form was changed or the data were recoded, the analyses were based on the entangled condition at capture, not release. The recoded data were used in the Epperly et al. (2009) analysis.

Table 1. Criteria for assessing marine turtle post-interaction mortality, after release from longline gear. Percentages are shown for hardshelled turtles (i.e., loggerhead, Kemp's ridley, olive ridley, hawksbill, and green turtle), followed by percentages for leatherbacks (in parentheses). Table modified from Ryder et al. (2006) to include hook location codes utilized by SEFSC and their characterization in this table; column order has been modified from Ryder et al. 2006. Two situations are not listed in the table: (1) the post-release mortality of any animal released unresponsive, comatose, or dead is assumed to be 100%; (2) Turtles not hooked and not entangled, but just holding the bait, are assumed to have 0% mortality.

| Injury Category As Defined in Ryder et al. 2006 (with revisions noted in parentheses) | Release Condition ⁱ | | | | Hooking locations as reported by SEFSC observers |
|---|---|--|---|------------------------------------|--|
| | (A) Released entangled (line is trailing or not trailing, turtle is entangled ⁱⁱ) | (B) Released with hook and with trailing line \geq half the length of the carapace (line is trailing, turtle is not entangled) | (C) Released with hook or with hook and with trailing line < than half the length of the carapace (line is trailing, turtle is not entangled) | (D) Released with all gear removed | |
| | Hardshell (Leatherback) | Hardshell (Leatherback) | Hardshell (Leatherback) | Hardshell (Leatherback) | |
| I Hooked externally with or without entanglement. (note: this category now includes all rhamphotheca (beak) hooking locations) | 55 (65) | 20 (30) | 10 (15) | 5 (10) | rear flipper/groin/tail; flipper (front or back); carapace/plastron; carapace; plastron; beak (external)/head/neck; front flipper/shoulder/armpit; front flipper; rear flipper; armpit; groin; head external; beak external, unknown; beak external, lower jaw; beak external, upper jaw; tail; beak internal, unknown ⁱⁱⁱ ; beak internal, lower jaw ⁱⁱⁱ ; beak internal, upper jaw ⁱⁱⁱ ; neck; shoulder; unknown external |
| II Hooked in upper or lower jaw with or without entanglement. Includes rhamphotheca, but not any other jaw/mouth tissue parts (see Category III). (note: this category no longer includes rhamphotheca; it does include jaw/mouth tissue parts not categorized elsewhere) | 65 (75) | 30 (40) | 20 (30) | 10 (15) | mouth, lower jaw, other ^{iv} ; mouth, side, other ^v |
| III Hooked in cervical esophagus, glottis, jaw joint, soft palate, tongue, and/or other jaw/mouth tissue parts not categorized elsewhere, with or without entanglement. Includes all events where the insertion point of the hook is visible when viewed through the mouth. (note: no longer includes other jaw/mouth tissue parts not categorized elsewhere) | 75 (85) | 45 (55) | 35 (45) | 25 (35) | beak (internal)/mouth, unknown; beak (internal)/mouth, lower jaw; beak (internal)/mouth, upper jaw; side jaw joint; mouth, unknown; mouth, lower jaw, unknown; mouth, side, unknown; mouth, upper jaw, unknown; mouth, upper jaw, other; glottis; roof of mouth; tongue; swallowed, hook visible to insertion point; swallowed, cervical (all line removed); swallowed, hook partially visible ^v , not known if hooked (all gear removed) ^{vi} |
| IV Hooked in esophagus at or below level of the heart with or without entanglement. Includes all events where the insertion point of the hook is not visible when viewed through the mouth. | 85 (95) | 60 (70) | 50 (60) | 75 (85) ^{vii} | not known if hooked; unknown location; unknown internal ^{vi} ; swallowed, hook not visible; swallowed, hook visibility unknown |
| V Entangled only, no hook involved. | Released Entangled 50 (60) | n/a ^{viii} | | Fully Disentangled 1 (2) | not hooked |
| VI Comatose/resuscitated | n/a ^{ix} | | 70 (80) | 60 (70) | |

ⁱ Columns have been rearranged from Table 1 in Ryder et al. 2006 in descending order of severity.

ⁱⁱ Length of line, as well as the presence or absence of the hook, is not relevant as turtle remains entangled at release.

ⁱⁱⁱ Inconsistent with final criteria in Table 1 of Ryder et al. 2006, see text for further detail.

^{iv} Inconsistent with final criteria in Table 1 of Ryder et al. 2006, see text for further detail.

^v Inconsistent with final criteria in Table 1 of Ryder et al. 2006, see text for further detail.

^{vi} If the hook location is unknown, if the hook location is known to be internal, but not specifically where, or if it is not known whether the animals was hooked or not, we assume the worst. At the time Epperly and Boggs (2004) analyzed the NED data, the worst for loggerheads was category IV for hook location and was Category III for leatherbacks. Since, observers have reported hooks swallowed by leatherbacks, albeit rare. Thus, we now code Category IV for all such unknown hooks for both hardshell and leatherback turtles. The re-analysis of the NED data by Epperly et al. (2009) is consistent with this change in philosophy. An exception to this is if an animal is not known if hooked, but all gear was retrieved. We assume that if the gear was retrieved it is highly unlikely that the hook had been swallowed completely and the turtle would be coded in Category III Column D (released with all gear removed).

^{vii} Although per veterinary recommendation, hooks would not be removed if the insertion point of the hook if not visible when viewed through the open mouth, this has occurred and must be accounted for. We have interpolated the table's value to insert a value for this cell based on veterinary and expert opinion. Also, there are times when the hook location is unknown, but the hook and line were retrieved. Because these are coded in this row, we must also allow for the removal of all gear.

^{viii} Corrects an error in the table

^{ix} Assumes that a resuscitated turtle will always have the line cut to a length less than half the length of the carapace, even if the hook remains and that the turtle is not released entangled in the remaining line