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**Modelling the drift of bycaught dolphin stranded carcasses help identify involved fisheries: an update of recent stranding data and in progress analyses**

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## OBJECTIVES

This paper gives an update of recent data and analyses of cetacean strandings from the Bay of Biscay in the aim of identifying candidate fisheries involved in the associated bycatch. Firstly, it provides a short synthesis of recent stranding data in the Bay of Biscay for the years 2016-2019 compared to the period 1990-2015. Secondly, an analysis of spatial co-occurrence of mortality areas, obtained by dolphin carcass reverse drift calculation, and fishing effort distributions split by *métiers* (fishing gear/target species) is given for the multiple stranding event of the year 2017, and further extended over the period 2006-2015.

## RECENT STRANDING RECORDS IN PERSPECTIVE

From December 1, 2018, to April 16, 2019, a total of 1170 cetaceans have been reported stranded along the French Atlantic coasts (Figure 1). 90% of those were examined by the national stranding scheme of which 93% were identified as common dolphins, 85% of them being diagnosed as bycatches (provisional figures subject to validation in forthcoming months). These events occurred along the whole Atlantic seaboard, with higher numbers south of the river Loire, *i.e.* in the Bay of Biscay proper.

Even if these figures are still in the process of being fully validated, it already appears that the year 2019 would set a new record of total cetacean stranding along the French Atlantic seaboard. An examination of yearly totals recorded from 1990 to present (Figure 2), suggest that the 2019 partial count is already close to the maximum yearly total ever recorded (year 2017), and that the years 2016-2019 (data for 2018 and 2019 still to be fully validated and completed) would represent the period of highest stranding numbers since the beginning of the French stranding scheme in the 1970's. The common dolphin represents approximately 50-75% of these total counts and follow the same trend, with maximum figures in the most recent years (Figure 2).

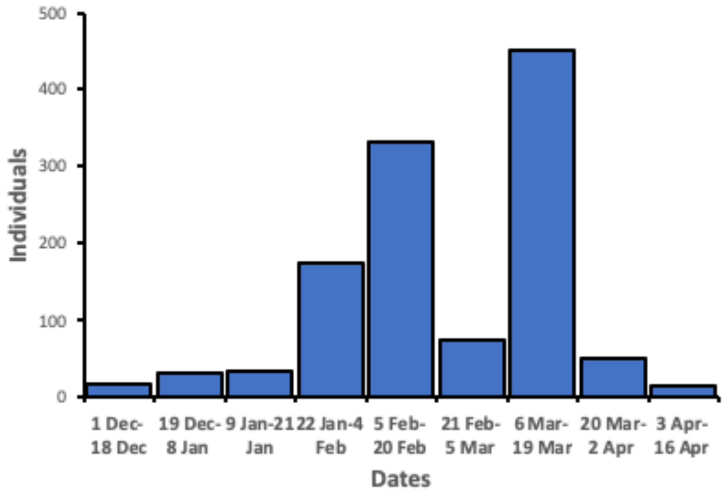


*Figure 1: Temporal distribution of stranded cetaceans along the French Atlantic coasts from December 2018 to April 2019.*

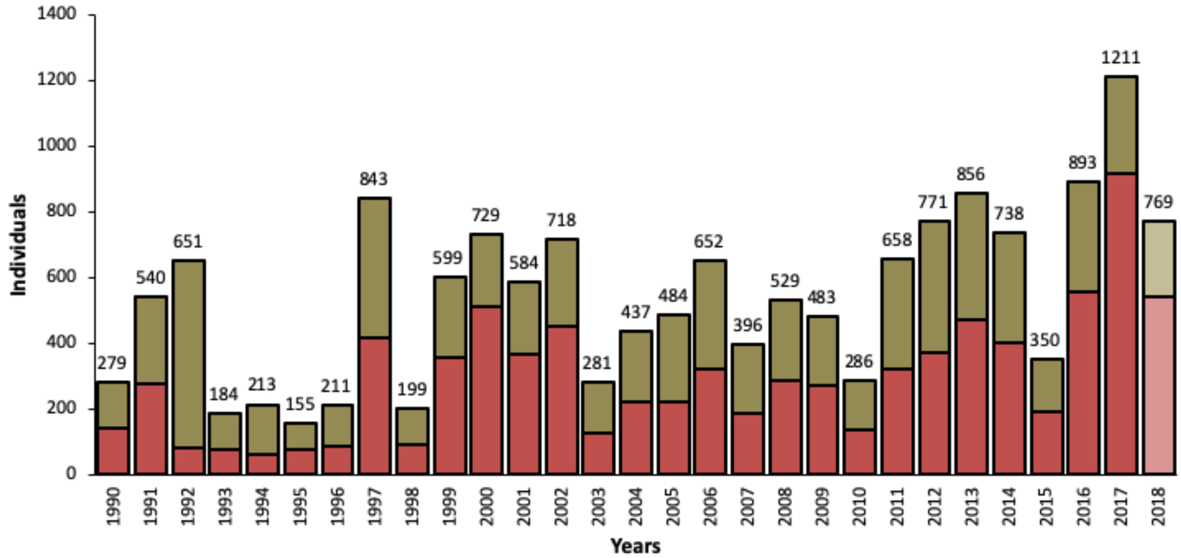


*Figure 2: number of cetacean stranding per year along the French Atlantic coast from 1990-2018. All species in brown, common dolphin in red. Figures for the year 2018 are incomplete because validation was still going on at the time of preparing this document. From Dars et al., 2018.*

The monthly pattern of common dolphin stranding averaged over the period 1990-2015 show a winter maximum from January-March and low figures the rest of the year (Figure 3). Compared to this average pattern, the years 2016-2018 display outstanding record numbers of stranded common dolphins in February or March or in both months (Figure 3) and the year 2019 (Figure 1) is going to follow the same trend with figures well above long term average in January, February and March.

In addition to the winter season, a secondary seasonal peak is also visible in late summer, which had not been detected in the average pattern of the period 1990-2015.

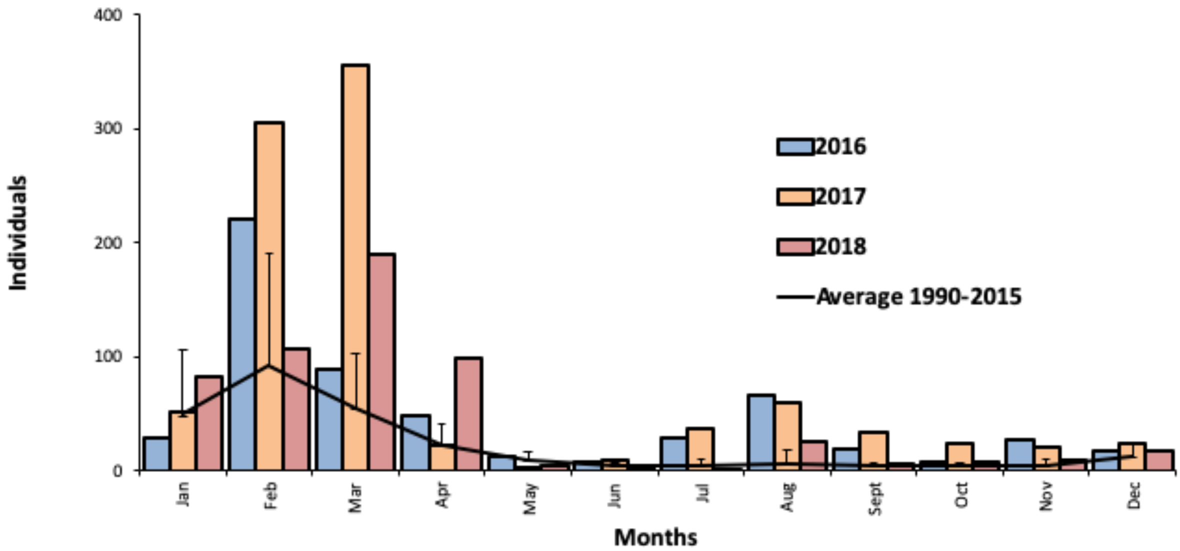


*Figure 3: numbers of common dolphins found stranded per month along the French Atlantic coast for the years 2016-2018 compared to average figures for the years 1990-2015. Figures for the year 2018 are incomplete.*

The winter maxima are often related with short (1-3 weeks) and acute (50-350 carcasses) multiple stranding events (Figure 4). Such events have been documented in 23 of the last 30 winter seasons (Figure 4, with the years 2018-2019 added to the series) and generally contribute to more than half of the yearly total counts of stranded common dolphins.

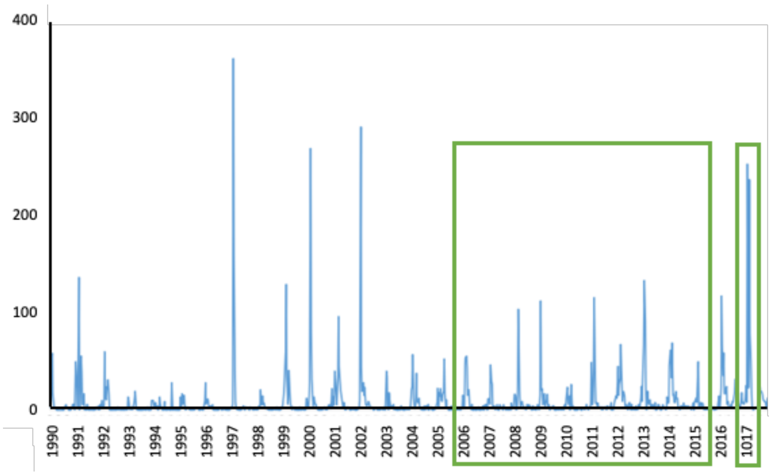


*Figure 4: number of common dolphins and unidentified small delphinids found stranded per 10-days periods along the French Atlantic coast for the period 1990-2017 showing typical winter multiple stranding events, except for the years 1993-1996, 1998 and 2010. The two green frames indicate years for which spatial co-occurrence of bycatch mortality with fishing effort was analysed. Adapted from Dars et al., 2018.*

## USING A DRIFT MODEL TO IDENTIFY CANDIDATE FISHERIES

Peltier et al (in revision, ForInfo X) aimed at developing an approach to identify the fisheries potentially involved in multiple stranding events related with bycatch and tested it on the events of January-March 2017. They examined how the likely distributions of mortality of bycaught dolphins inferred from carcass drift modelling coincide with fishing effort statistics in the same area and at the same dates for different fleets defined by fishing gear and vessel flag. The likely mortality areas at sea of common dolphins stranded diagnosed as bycaught were predicted using a reverse drift modelling methodology based on the drift model MOTHY where the two main drivers of the drift are winds and tidal currents (Daniel et al., 2002; Peltier et al., 2012, 2014, 2016; Peltier and Ridoux, 2015). Fishing effort maps were generated by Ifremer from Vessel Monitoring System (VMS) data, that automatically collects positional data of fishing vessels, along with other sources of data, to inform fishing gears and target species (Leblond et al., 2008); fishing effort was agregated by fishing gear and vessel flag. These two independent data sets, mortality areas and fishing effort, were analysed under a General Additive Model framework.

The spatial distribution of mortality areas for stranded bycaught dolphins was found to be significantly correlated with fishing effort distribution during the weeks associated with the different stranding events (from two weeks before onset of multiple stranding event to the end of it) for French midwater pair trawlers, Spanish otter bottom trawlers and French Danish seiners. Gillnets and trammel nets were not identified as candidate gears potentially involved in these bycatch-related multiple stranding events, although field evidences accumulate suggesting the contrary (amputation observed on carcasses would mostly be related to disentangling dead dolphins from nets rather than from trawls; carcasses with piece of nets attached on; oral reporting by some fishermen).

In a subsequent step, the analyses were refined by investigating spatial relationships between fishing effort and mortality areas with fishing effort data split by *métier* (fishing gear/target species). The mortality areas for all multiple stranding events have been obtained by using the same drift model MOTHY (Daniel et al., 2002) as described in Peltier et al. (in revision, ForInfo XX) on the assumption that carcasses in DCC-1 or 2 and carcasses in DCC-3 had been drifting for 1-5 days and 5-15 days respectively before stranding (Appendix 1). Fishing effort was determined by Ifremer from VMS data with vessel speed < 4.5 knots being the principal criteria to discriminate actual time spent fishing from transit time (Leblond et al., 2008). We extracted fishing effort data for the dates corresponding to drift duration before each multiple stranding event as described above for the gear/flag analysis of 2017. Only target species representing >10% of the catch by a given fishing gear were considered. A spike-and-slab regression approach was used to deal with the large number of possible predictors compared to the number of observations (Scheipl, 2011). All combinations of variables were tested and the results were expressed by the percentage of combinations in which a given fishing gear-target species pair (*métier*) was selected. Twelve *métiers* selected in at least 25% of the combinations were finally retained (codes and definitions in Table 1; selected *métiers* for each year in Table 2).

For the year 2017 the areas of mortality were those described in the previous analysis conducted on fishing effort aggregated to gear and flag level (Figure 4 of Peltier et al., in revision, or ForInfo XX), with fresh carcasses originating from the inner shelf and the others from the outer shelf and slope areas. The same exercise conducted for each year presenting a multiple stranding event during the period 2006-2015 shows that mortality areas can change considerably from one year to the next (Figure 5). Mortality areas could be mostly over the continental shelf (years 2006-8 and 2015), a restricted region of the shelf (2011, 2012), along the slope (2013), a combination of shelf and slope (years 2009 and 2011) or scattered across the whole study area (2014).

*Table 1: List of* métiers *used in the present work (Codes and definitions for gears and target species).*

| | |
|---|---|
| PTM_BSS | Pelagic pair trawl; sea bass |
| PTM_MAC | Pelagic pair trawl; mackerel |
| PTM_HKE | Pelagic pair trawl; hake |
| OTB_BSS | Bottom otter trawl; sea bass |
| OTB_MAC | Bottom otter trawl; mackerel |
| OTB_CTC | Bottom otter trawl; cuttlefish |
| OTB_CTL | Bottom otter trawl; cuttlefish |
| GTR_MNZ | Trammel net; monk fish |
| GNS_HKE | Set gillnet; hake |
| GNS_MNZ | Set gillnet; monk fish |
| GN_SOL | Gillnet; sole |
| OTM_HOM | Pelagic otter trawl; horse mackerel |

Quite in agreement with the year-to-year variations observed in mortality areas, the selected *métiers* also changed considerably from one year to the next (Table 2). No *métier* was found to be clearly correlated with mortality areas in 2014 and 2015, possibly because the spatial pattern of mortality was not well defined. From 1-4 *métiers* were identified for each of the 8 remaining years. Pair trawls targeting either seabass, hake or mackerel were found to be associated with mortality areas in 6 of these years; otter trawls for seabass, mackerel, horse mackerel and cuttlefish were involved in 5 of these years; gillnets and trammel nets targeting hake, monk fish or sole were retained in 3 of these years. It must be noted that although gillnets in general were not identified in the gear/flag analysis for the year 2017 (see Peltier et al., in revision, ForInfo XX), gillnet for hake was selected in the *métier* analysis for that same year, suggesting that the *métier* approach would be more discriminating that the gear/flag approach.

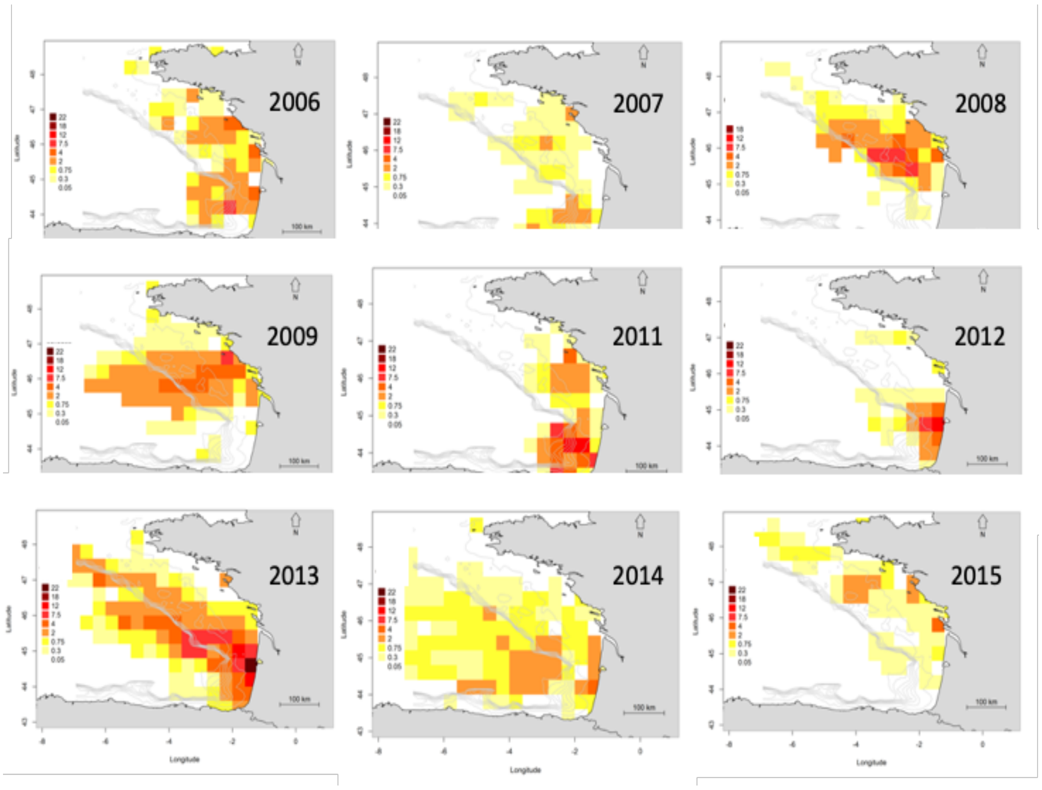


*Figure 5: mortality areas for each by-catch related multiple stranding events reported from 2006-2015. Colour codes depict the number of stranding originating from each cell of the grid.*

*Table 2:* Métiers *spatially correlated with mortality areas. Figures give the percentage of combinations in which a given* métier *was selected for a given year.*

| YEARS | PTM_BSS | PTM_MAC | PTM_HKE | OTB_BSS | OTB_MAC | OTB_CTC | OTB_CTL | GTR_MNZ | GNS_HKE | GNS_MNZ | GND_SOL | OTM_HOM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2018 | analysis in progress | | | | | | | | | | | |
| 2017 | 26 | | 40 | | | | | | 28 | | | |
| 2016 | analysis in progress | | | | | | | | | | | |
| 2015 | | | | | | | | | | | | |
| 2014 | | | | | | | | | | | | |
| 2013 | 96 | 54 | | | | 75 | | 74 | | | | |
| 2012 | 24 | | | | 90 | 99 | | | | | | |
| 2011 | | 51 | | | | | | | | | | |
| 2010 | no multiple stranding event | | | | | | | | | | | |
| 2009 | | | | 70 | | | | | | | | |
| 2008 | 85 | | | | | | | | | 91 | 91 | 35 |
| 2007 | | 30 | | | | | | | | | | |
| 2006 | | | | | | | 60 | | | | | |

## DISCUSSION

At this stage, the work presented here for discussion is very much a work in progress and a lot remains to be done before it can be properly submitted. Nevertheless, several comments can be done at this stage.

- Reverse drift analysis of cetacean carcasses diagnosed as bycaught allows bycatch mortality areas to be mapped. A key element in this exercise is the duration of the drift. Here we assumed that carcasses in DCC-1 or -2 would have been drifting for 5 days before stranding, and carcasses in DCC-3 15 days (Appendix 1). Hence, the origin at sea of a carcass is not a single location, but instead is a stretch of drift trajectory of either 5 or 15 days respectively. Consequently, uncertainty in death-to-stranding time tends to blur the spatial pattern of mortality areas, in particular for carcasses in DCC-3; this may explain the lack of spatial correlation with fishing effort distributions observed some years.
- Comparing mortality areas with fishing effort by gear or by *métier* allows candidate fisheries to be identified. In this respect the typology of gear types and FAO gear codes can sometimes be misleading. For instance, OTB (bottom otter trawl) includes High Vertical Opening and Very High Vertical Opening Trawls alongside the more typical bottom trawls but their potential impact in terms of cetacean bycatch should be very different. Working at the *métier* level appears a useful development since incorporating target species in the definition of the fisheries allows a more specific, potentially more discriminating, analysis to be conducted.
- Candidate gears (PTM, OTB, GNS, GTR) and target species (CTC, CTL, MNZ, HKE, BSS, MAC, HOM) are diversified. If confirmed in further analyses, the *métiers* identified should be submitted to reinforced observer or Remote Electronic Monitoring programs. The diversity of potentially involved *métiers* suggests that mitigation is going to be complex as it should be adapted to each case.
- Stranding monitoring programs, fisheries monitoring programs and studies on the short-term mobility of the common dolphin should be conducted at the scale of the species distribution in the North-East Atlantic to better understand the spatiotemporal dynamics of the bycatch issue.

- It would be interesting to conduct the same analyses during the late summer period when more strandings have been recently reported and diagnosed as bycatches. Similarly, out of the bycatch-related multiple stranding events, a significant percentage of the animals found stranded are also diagnosed as bycaught, in particular for the harbour porpoise and the spatial correlation of these mortality areas with fishing effort at the métier level should be investigated as well.

## BIBLIOGRAPHY


Daniel, P., Jan, G., Cabioc'h, F., Landau, Y., Loiseau, E., 2002. Drift Modeling of Cargo Containers. Spill Sci. Technol. Bull. 7, 279–288.

Dars, C., Dabin, W., Demaret, F., Doremus, G., Meheust, E., Mendez-Fernandez, P., Peltier, H., Spitz, J., Van Canneyt, O., 2018. Les échouages de mammifères marinssur le littoral français en 2017 (Rapport scientifique de l'observatoire PELAGIS, Université de La Rochelle et CNRS), Rapport annuel.

Geraci, J.R., Lounsbury, V.J., 2005. Marine mammals ashore: a field guide for strandings, National Aquarium in Baltimore, Inc. ed. Baltimore.

Leblond, E., Daurès, F., Berthou, P., Dintheer, C., 2008. The Fisheries Information System of Ifremer-a multidisciplinary monitoring network and an integrated approach for the assessment of French fisheries, including small-scale fisheries, in: Theme K. Presented at the ICES CM 2008, Halifax, Canada, p. 8.

Peltier, H., Authier, M., Deaville, R., Dabin, W., Jepson, P.D., van Canneyt, O., Daniel, P., Ridoux, V., 2016. Small cetacean bycatch as estimated from stranding schemes: The common dolphin case in the northeast Atlantic. Environ. Sci. Policy 63, 7–18. https://doi.org/10.1016/j.envsci.2016.05.004

Peltier, H., Dabin, W., Daniel, P., Van Canneyt, O., Dorémus, G., Huon, M., Ridoux, V., 2012. The significance of stranding data as indicators of cetacean populations at sea: Modelling the drift of cetacean carcasses. Ecol. Indic. 18, 278–290.

Peltier, H., Jepson, P.D., Dabin, W., Deaville, R., Daniel, P., Van Canneyt, O., Ridoux, V., 2014. The contribution of stranding data to monitoring and conservation strategies for cetaceans: Developing spatially explicit mortality indicators for common dolphins (Delphinus delphis) in the eastern North-Atlantic. Ecol. Indic. 39, 203–214. https://doi.org/10.1016/j.ecolind.2013.12.019

Peltier, H., Ridoux, V., 2015. Marine megavertebrates adrift: A framework for the interpretation of stranding data in perspective of the European Marine Strategy Framework Directive and other regional agreements. Environ. Sci. Policy 54, 240–247. https://doi.org/10.1016/j.envsci.2015.07.013

Scheipl, F. 2011. spikeSlabGAM: Bayesian Variable Selection, Model Choice and Regularization for Generalized Additive Mixed Models in R. Journal of Statistical Soft- ware, 43(14), 1–24.

Van Canneyt, O., Dabin, W., Dars, C., Dorémus, G., Gonzalez, L., Ridoux, V., Spitz, J., 2015. *Guide des échouages de mammifères marins. Cahier technique de l'Observatoire PELAGIS sur le suivi de la mégafaune marine. Université de La Rochelle, CNRS.*

Annex 1: Decomposition codes assigned to stranded cetaceans with criteria, time after death and an examples of carcasses (Van Canneyt et al., 2015, adapted from Geraci and Lounsbury, 2005).

| Decomposition code | Criteria | Time after death (drift) | Example |
|---|---|---|---|
| **1 – < 48 h** | -Seen alive <48h before examination<br>-Unhaemolysed serum<br>-No protrusion<br>-Blood cells intact<br>-Viscera intact<br>-Clear eyes | <2 days |  |
| **2 – Fresh** | -Haemolysed serum<br>-No protrusion<br>-Viscera intact<br>-Glazed eyes | 2 to 5 days |  |
| **3 – Slight decomposition** | -Tongue and penis protruted<br>-Viscera intact<br>-Eyes sunken or missing<br>-Skin cracked and sloughing | 5 to 15 days |  |
| **4 – Advanced decomposition** | -Epidermis can be entirely missing<br>-Viscera friable, difficult to dissect<br>-Gas pockets | 15 to 30 days |  |
| **5 – Skeletal remains or mummified** | -Skin may be draped over skeletal remains<br>-Tissues desiccated | >30 days |  |