Intra-interspecific traumatic interactions in stranded cetaceans in the Canary Islands (2018-2023)

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SUMMARY

With the study of different cetacean populations worldwide, numerous aggressive encounters have been described, which we refer to as traumatic interactions. These are classified as intraspecific, if they occur between individuals of the same species, and interspecific, if they occur between different species. With this study we want to update the cases compatible with this pathological entity and expand the information on the injuries that occur in these encounters in the Canary Islands between 2018 and 2023. In this period 262 cetaceans stranded in the archipelago and 19 of them presented lesions compatible with traumatic interactions. All the cases presented multifocal severe vascular changes, 68,4% (13/19), bone fractures affecting mainly the thoracic region, 89,5% (17/19), acute tooth-rake marks, 31,6% (6/19), undigested food in the stomach and 10,5% (2/19) had lung perforation. The inter-tooth distance allowed us to identify the aggressor species. Six cases were compatible with killer whales (*Orcinus orca*) affecting four species: pigmy sperm whale (*Kogia breviceps*), dwarf sperm whale (*Kogia sima*), Atlantic spotted dolphin (*Stenella frontalis*) and short-finned pilot whale (*Globicephala macrorhynchus*). Another finding was postmortem shark bites in 26,3% (5/19) of the affected animals. In addition, we found signs of predation by sharks on two Atlantic spotted dolphins (*Stenella frontalis*). These animals presented semi-circular parallel multifocal tooth marks with inflammatory or vascular changes. Microscopically, skeletal muscle displayed acute degenerative changes in 89,5% (17/19), the cardiac muscle presented degeneration in 78,9% (15/19) of the cases, and skin tearing, with suppurative inflammatory infiltrate, necrosis and bacteria in 36,8% (7/19). Also hemorrhages and congestion in kidney, 36,8% (7/19), adrenal glands, 21,1% (4/19), brain, 42,1% (8/19) and liver, 15,8% (3/19) was observed. Shallow divers, with a good body condition and between Tenerife and La Gomera were more prone to these fatal interactions. Additionally, in this period, one animal died due to an accident during predation: a bottlenose dolphin (*Tursiops truncatus*) presented disinsertion of the larynx because of struggling while predating eels.

INTRODUCTION:

The Canary Islands are a worldwide reference point for biodiversity of terrestrial and aquatic fauna and flora, including numerous species of cetaceans that inhabit the archipelago throughout the year and share the ecosystem resulting in numerous encounters of different species, where in some cases they can cooperate with each other (Möller et al., 2001; Syme et al., 2021), but in other cases they can result in physical injury to at least one of the individuals involved, which can lead to stranding or death at high seas. It is important to know more about these types of encounters between species, as the current information is very scarce and diffuse due to the difficulty of obtaining information at the time of the aggressions due to the environment in which they take place and the low probability of seeing any of them live. For this reason, the best method to study these interactions between cetaceans is through observation and analysis of lesions compatible with this complex etiology in necropsies of marine mammals stranded or found dead adrift. Although it is often difficult to diagnose as there is no specific protocol and a presumptive diagnosis is always made in which intra-specific interactions are the most likely cause of death. For this reason, the aim of this study is to classify the necropsy cases of cetaceans stranded or found adrift between 2018 and 2023 with lesions compatible with traumatic intra-interspecific interactions in order to better understand the cetaceans that inhabit our archipelago and to expand the information available from a veterinary point of view.

In the different ecosystems of the animal kingdom, different interactions occur between individuals of the same or different species. Interactions between animals are usually defined by the direction in which they affect the interactors. These can range from cooperation to competition or predation, directly affecting the dynamics of the ecosystems and populations of the animals involved (Pringle, 2016).

Within these interactions we highlight the agonistic interactions. We can define these behaviors as behavioral adjustments associated with threaten, to cause or seek to reduce physical damage, which includes attack, escape, threat, defense, and appeasement. Agonistic behavior consists of threats, aggression and submission. The major difference between offensive and defensive attack is that defensive attack occurs in sequence with escape, avoidance or fear behaviors (Mcglone, 1986). In top predators, competition can take different forms: avoidance (that can result in shifts in habitat use), exploitative competition (when predators share the same food resources), food stealing or competitor killing (Caro & Stoner, 2003).

When resources are limited and many individuals exploit the same limited ecosystem, they become competitors resulting in an increase of these aggressive behaviors. One of the most common causes is the competition for a territory with rich resources, like the Canary Islands, so the winner gets the access to develop its life cycle in a favorable habitat, then the loser may still get to live, feed and breed in a poor habitat. So, the value of winning the contest is the difference between the life and reproductive success in the good and poor habitats. When the value of the resource is similar to, or greater than the value of the future, we would expect individuals to risk more in contests, even at the cost of serious injury or death (Mcglone, 1986.; Pringle, 2016).

Traumatic interactions among cetaceans are defined as aggressive acts directed towards individuals of the same species (Intraspecific), or aggressive behaviors directed towards individuals of another species (Interspecific) (Volker& Herzing, 2021). These interactions are characterized by being diverse, complex, highly violent and non-consumptive apart from the killer whale (*Orcinus orca)*, which has been observed attacking or harassing over 20 different species of cetaceans with feeding purposes (Ross & Wilson, 1996; Díaz-Delgado et al., 2018). Differentiating between intraspecific and interspecific is complex and requires experience, with a large degree of subjectivity. However, assessment of cutaneous dental markings (interdental spacing and depth) and comparison with the individual, sightings of social interactions and published scientific literature can help distinguish between these two types of interactions between cetaceans.

These behavioral displays and physical attacks occur in the context of competition for food or interference with feeding activity, territorial dispute and/or social dominance/rank in a group (establishing and maintaining rank often involves displays of strength and aggression). It has also been related to competition over mates, female access for copulation, sexual frustration and intraspecific infanticide. When the breeding season begins, the males can compete to mate with the females, leading in aggressions between males or aggressions of the female rejecting the male. It has been described alliances of males responsible for the "kidnapping" of non-pregnant females to increase their chances of mating. The infanticide occurs because female dolphins become sexually attractive to males within a few days of losing a calf. Interactions also occur protecting ill members of the group or young calves from intraspecific infanticide and play or practice fighting. In the latter situation, these interactions are not usually serious injuries, it is just a play behavior or a training for hunting or future dominance and mate competition (Crespo-Picazo et al., 2021; Barnett et al., 2009; Spitz et al., 2006; Connor et al., 1992; Volker & Herzing, 2021).

However, the most common explanation for these interactions is that they are influenced by competition for food and resources. Especially in the Canary Islands where there exists a habitat overlap of multiple species. If there is overlap in the ranges of different species, there is also potential for competition for food resources. A marine predator's diet is the combination of resource availability and foraging strategies. The former is determined by a combination of spatially defined characteristics of the environment such as depth and slope. If several predators develop the same foraging technique and so exploit the same resource, they are in a context where competition could occur (Spitz et al., 2006).

In the open ocean, cetaceans rarely display territorial behavior due to the lack of spatially defined environmental features that may promote individuals or groups to demarcate their territories and patrol or defend them (Crespo-Picazo et al., 2021). However, as the Canary Islands are a world biodiversity hotspot where 31 species of cetaceans have been reported (Banco de datos de Biodiversidad de Canarias, 2024), we can find different species of cetaceans coexisting in such a small space as the archipelago. Here it has been seen mixed-species groups that coexist for some time within the same area, sharing and partitioning resources and providing reciprocal benefits in foraging techniques. But, on the contrary we can find competitions resulting in these kinds of aggressions (Ascheri et al., 2024).

These traumatic interactions can be classified in:

- Unidirectional aggression: it is observed when a dominant individual attacks a subordinate one. This can occur during mating attempts, in cases of infanticide, or as an act of predation in killer whales. The dominant individual asserts his position in the social hierarchy through these aggressive interactions.

- Bidirectional aggression: occurs when both individuals actively engage in attacking one another. This can happen as a means of establishing dominance within the social hierarchy of their group, defending territorial boundaries, competing for food resources, or even as a form of play fighting. Such bidirectional aggressive interactions have been observed across various cetacean species (Barnett et al., 2009).
- Involvement of multiple individuals: in some cases, cetacean aggression involves coordinated attacks by groups of individuals. For instance, groups of male cetaceans have been observed attacking a female to mate, or different species have been known to coordinate attacks for the same reasons mentioned previously, such as establishing dominance within the social hierarchy, defending territorial boundaries, or competing for food resources (Connor et al., 1992).

Some of the attack techniques observed in aggressors, especially in dolphins, have been described but can be extrapolated to all cetaceans (Cotter et al., 2012):

- **Sandwiching:** it consists in squeezing the target between the left and right flank of two aggressors in a forceful movement that lifts the victim's body out of the water. The intensity and power of this maneuver may cause bilateral hematomas of varying severity and bilateral rib fractures.
- **Drowning:** repeatedly lifting the aggressor's upper body out of the water and letting it forcefully drop on top of the target's head, pushing it underwater. It has also been seen that dolphins position their rostrum underneath the flukes of the victim and then they lift their head out of the water, effectively keeping the head of the victim underwater. Both techniques are effective in tiring and disorienting the injured cetacean, and in preventing it from breathing.
- **Tossing:** partially or completely throwing the affected cetacean out of the water with fast and violent maneuvers, using either the rostrum or the fluke to hit it. This tactic produces loud noises as the attacked is violently hit on both sides, and often sends the victim somersaulting out of the water.

- **Ramming:** hitting the target at fast speed with the rostrum and the side of the body, often repeatedly and sometimes by multiple animals at the same time.

These interactions can take the form of direct strikes, for example lunging or finning, but also biting, choking, etc. The most common lesions observed are known as tooth rakes marks, external, mild, multifocal, linear and parallel erosions on the skin inflicted by teeth. These lesions are frequently associated with vascular changes like focally extensive to suffusive hemorrhage, hematomas and myonecrosis. These lesions can also be seen in subcutis, axial musculature, and in internal viscera. Pulmonary fat emboli and myo-/hemoglobinuric nephrosis have been occasionally observed, as well as underlying inflammatory infectious disease. Bone fractures, especially of the skull and spine, are also very common in these types of encounters (Arbelo et al., 2013; Díaz-Delgado et al., 2018). The location of injuries can indicate the nature of the interaction. Lesions in the skull and flank area may be indicative of a direct conflict while injuries in the caudal fin area may be indicative of a chase, especially if we observe lesions in the form of tears due to bites.

The main differential diagnosis for this pathological entity is the strike/collision with surfaces of boats and vessels that cause a blunt trauma. This can often be confused with intra- or interspecific traumatic interactions, as the origin of the lesions is typically unknown. As a result, only a presumptive diagnosis can be made, with a definitive diagnosis being possible in some cases.

What differentiates these strikes/collisions from intra-specific interactions is that those caused by cetaceans are frequently bilateral/multilateral with different directions in nature, which is indicative of an attack by other animals, whereas those caused by boats/vessels used to be unilateral in nature. We can also observe direct aggressions by fishermen on cetaceans with heavy blunt objects (Cotter et al., 2012).

Finally, it is worth considering how interspecific cetacean interactions could affect the risk of infectious disease transmission. Firstly, open wounds can lead to infectious diseases and septicemia that can debilitate the affected cetaceans, making them an easy prey for predators and other marine mammals that will take advantage of their poor health condition. Also, close contact from aggressive interactions can increase the possibility for infection via body fluids or tissues exposition (blood, urine, secretions, etc.) (Crespo-Picazo et al., 2021).

This pathological entity has been previously investigated in the Canary Islands. Studies conducted by Arbelo et al., (2013) between 1995 and 2005 concluded that 4.3% (6/138) of necropsied cetaceans were affected by this etiology, including 5 different species of cetaceans (2 striped dolphins, 1 rough-toothed dolphin, 1 pilot whale, 1 sperm whale and 1 Gervais' beaked whale). They found superficial parallel skin marks due to intraspecific interaction and severe traumatic lesions such as fractured ribs and subcutaneous and pulmonary hemorrhages. In addition, they clarified that in some cases the causal species could not be identified due to the non-specificity of the lesions. In these cases, other possible causes like vessel collisions could not be definitively ruled out.

On the other hand, Díaz-Delgado et al., (2018) updated the available information covering the period from 2006 to 2012. They reported cases of infanticide and predation by killer whales. Also, they detected a higher intra-interspecific interaction prevalence than the previous study by Arbelo et al., (2013), 17,8% vs 4,3%, involving a wider range of species. In this study 13 species were affected while in the previous study only 5 species were affected. The short-finned pilot whales were the most prevalent. Apart from the lesions already described by Arbelo et al., (2013), this study reported evidence of traumatic events and concomitant infectious inflammatory disease, largely involving the CNS or systemic diseases.

Finally, Puig-Lozano et al., (2020), conducted a more in-depth study, focusing on this pathological entity and covering from 2000 to 2017. In this study, in addition to reporting more cases of traumatic interactions between cetaceans, three cases of fatal interactions with other species were also described. These consisted of a traumatic death due to an accident during predation. The first one was a false killer whale that presented an intralesional stingray spine in the tongue causing severe chronic perforating glossitis and stomatitis. The other two cases consisted of two Risso's dolphins that presented fatal interaction with large squids and died from decompression sickness. The dolphins presented evidence of struggling/fighting with the squid. In this study more cases of infanticide between cetaceans and about predation by killer whales were also described. In addition, they provided a list with the interdental space of different species to improve this pathological entity's diagnosis (TABLE 3).

OBJECTIVES

With this study we will cover 5 main objectives:

Objective 1:

Update the available information on traumatic intra-interspecific interactions of cetaceans in the Canary Islands.

Objective 2:

Improve the classification and identification of the most common lesions associated with this pathological entity.

Objective 3:

Perform an epidemiological study of intra-interspecific traumatic interactions cases in animals necropsied between 2017 and 2023 in the Canary Islands, analyzing the characteristics of the affected individuals (species, sex, age, body condition, previous pathologies, etc.).

MATERIALS AND METHODS

The animals included in this study consist of cetaceans stranded in the Canarian archipelago with lesions compatible with intra-interspecific traumatic interactions from 2018 to 2023. In this period 442 cetaceans belonging to 19 different species stranded in the waters of the Canary Islands, and 262 out of the 442 (59,3%) belonging to 17 species, were submitted for postmortem studies. Those were animals stranded dead or alive and dead shortly after the stranding, whose carcasses could be recovered and presented a decomposition code suitable for necropsy (codes 1-5).

Information about the location and date of the strandings, life history data (species, age class, sex, sexual maturity) and body condition were systematically recorded following standardized protocols (Geraci & Lounsbury, 1993).

Age class was classified based on total body length, and gonadal examinations in the following categories: neonate, calf, juvenile, subadult, and adult.

Assessing the body condition state is an important metric as it provides an indicator for the ante-mortem health of the animal. We estimated the body condition based on the external physical conformation analyzing the degree of epaxial concavity or convexity, nuchal depression, the visibility of the ribs and vertebral transverse processes, as well as the presence or absence of nuchal and internal fat. It was classified in the following categories: very poor, poor, fair and good body condition (Ijsseldijk et al., 2019; Joblon & Pokras, 2014):

- **Good body condition**: the animal's outlining on a cranial perspective is convex; round appearance caudal to the skull and lateral to the dorsal fin visible; subcutaneous, pleural and other visceral fat present; blubber layers are thick.
- **Fair body condition**: the animal's outline on a cranial perspective is not fully round; a slight hollow appearance caudal to the skull and lateral to the dorsal fin is visible (slightly hollow or almost flat); no internal fat is observed.
- **Poor body condition**: the animal's outline on a cranial perspective shows moderate concavity, and outline of lateral aspects of the vertebrae; a hollow appearance caudal to the skull and lateral to the dorsal fin is visible; scapula's can be observed sticking out.
- **Very poor body condition/Emaciated:** the animal's outlining on a cranial perspective is very concave and the lateral aspects of the vertebrae are easily palpable; an extremely hollow appearance caudal to the skull and lateral to the dorsal fin is visible; scapula can be observed sticking out; blubber layers are minimal.

For carcass decomposition categorization we applied the following classification: very fresh (code 1), fresh (code 2), moderate autolysis (code 3), advanced autolysis (code 4), and very advanced autolysis (code 5) (Ijsseldijk et al., 2019):

- **Code 1:** Extremely fresh carcass. Usually live stranded and died/ euthanized cases or those stranded right after death; exhibiting no postmortem changes; fresh smell; clear, glassy eyes; blubber firm and white; muscles firm, dark red, well-defined; viscera intact and well-defined; gastrointestinal tract contains no to little gas (unless pathologic); brain firm with no discoloration, surface features distinct, easily removed intact.

- **Code 2:** Fresh carcass. Normal appearance, fresh smell, minimal drying and wrinkling of skin, eyes and mucous membranes; carcass not bloated, tongue and penis not protruded; blubber firm and white, occasionally tinged with blood.
- **Code 3:** Moderate decomposition. Bloating evident, with tongue and penis often distended; skin cracked and started sloughing; characteristic mild odor can be expected; mucous membranes dry, eyes sunken. Blubber blood-tinged and oily; muscles are softer and poorly defined; gut segments contain gas; brain has soft consistency. Organs are largely intact, still distinguishable and can be easily removed and assessed, although color is more uniform throughout thoracic and abdominal cavity and consistency, particularly kidneys and pancreas is soft and increasingly friable.
- **Code 4:** Advanced decomposition. The carcass may be intact but collapsed; skin sloughing; epidermis may be largely missing, exposing underlying blubber. Strong odor; blubber soft, often with pockets of gas and pooled oil; muscles nearly liquefied and easily torn, effortless separation from the bones; blood thin and black; viscera often identifiable but friable, easily torn, and difficult to dissect; gut gas-filled; brain liquified, dark red, containing gas pockets, with decreased consistency.
- **Code 5:** Very advanced decomposition. The skin may be draped over skeletal remains; any remaining tissues are desiccated. Organs partially or totally disappeared, or if present not completely identifiable.

The necropsies were performed following international protocols, where the carcass, previously placed in right lateral decubitus, was dissected. One or more skin windows were created depending on the size of the animal, following lines perpendicular and parallel to its longitudinal axis, from the nuchal area, and in front of the pectoral fin, to the area immediately caudal to the anogenital region. Once the main muscle bundles were dissected and partially extracted from the nuchal region to the retroabdominal area, the abdominal cavity was opened. Before opening the thoracic cavity, the existence of negative pressure was checked. The ribs were then removed to expose the thoracic cavity and its organs. Next, the upper digestive tract (tongue, oropharynx, esophagus), respiratory system (larynx, trachea and lungs) and cardiovascular system (heart and great vessels) were dissected and removed. The gastric compartments and intestinal loops, pancreas, spleen, liver, adrenal glands, kidneys, urinary bladder, and genital system were then removed and examined systematically (Kuiken & García Hartmann, 1991; Ijsseldijk et al., 2019)

During the necropsy, every external and internal lesion was described, photographed and sampled. Systematically, samples of approximately 2-3 cm^3 were taken from skin and blubber, skeletal muscle, larynx and laryngeal tonsil, pharynx and pharyngeal tonsil, thyroid, thymus, trachea, bronchi, lung, heart and great vessels, diaphragm, tongue, esophagus, stomach compartments, intestine, pancreas, liver, kidney, urinary bladder, adrenal glands, spleen, prescapular, mediastinal, pulmonary, mesenteric and retroperitoneal lymph nodes, testis/ovaries, uterus/epididymis, mammary gland/prostate, brain, cerebellum, brainstem, spinal cord, pituitary gland, eyes, mucosa of pterygoid sacs and nasal sacs, acoustic melon and mandibular fat, and the tympano-periotic complexes.

Each tissue sample collected for histological studies was fixed in 10% buffered formalin, routinely processed, embedded in paraffin and sectioned at 5µm. Later they were dyed with hematoxylin and eosin staining for the posterior analysis following rutinary procedures.

Samples of selected organs (skin, blubber, muscle, heart, lung, lymph nodes, liver, kidney, adrenal glands, spleen, and CNS) were also taken and conserved at -80 ºC for microbiological, molecular and toxicological studies.

For diagnosing traumatic intra-interspecific interactions, we followed a cautious methodology based on previous research, excluding cases where other possible causes of traumatic death could not be ruled out, such as interaction with fisheries, vessel collisions, or alive strandings (Arbelo et al., 2013; Ascheri et al., 2024; Barnett et al., 2009; Cotter et al., 2012; Díaz-Delgado et al., 2018; Jepson & Baker, 1998; Ross & Wilson, 1996).

RESULTS

Between January 2018 and December 2023, 262 cetaceans stranded in the Canary Islands were necropsied. Of these, 19 cases (7.4%) presented severe lesions compatible with intra-specific traumatic interactions.

In 93.7% (18/19) of the cases, traumatic interactions between cetaceans of the same or different species produced injuries which led to the death of the animal. In 6.3% (1/19) of the cases, the death (case nº1) occurred due to a fatal accident while feeding on potential prey (eels). Only 1 of the 19 affected animals was found stranded alive (case nº7) (TABLE 1).

Gross Findings

All the animals diagnosed with intra-interspecific trauma (19/19) presented multifocal severe vascular changes such as hemorrhages in the blubber, subcutaneous and muscular hematomas; 68,42% (13/19) presented hemorrhages and/or congestion in the central nervous system; 21,05% (4/19) had hemoabdomen and 15,78% (3/19) hemothorax.

Other common findings were healed tooth-rake marks (linear non-severe parallel superficial lesions in the skin). These are non-fatal lesions compatible with previous intra-interspecific interactions, that were observed in 89,5% (17/19) of the cases. We also found severe intraspecific acute multifocal tooth-rake marks in 36,84% (7/19). On the other hand, 57,9% (11/19) of the cases presented acute interspecific tooth-rake marks. In six cases the interspecific tooth-rake marks were compatible with killer whale interaction, and the species affected were *Kogia breviceps* (cases 3, 17 and 19), *Kogia sima* (case 2), *Mesoplodon densirostris* (case 10) and *Stenella frontalis* (case 13). We also found signs of predation by sharks in two *Stenella frontalis* (cases 7 and 16), characterized by semi-circular parallel multifocal tooth marks with inflammatory or vascular changes associated.

In relation to the above-mentioned, we also found postmortem shark-inflicted tooth marks in 26,3% (5/19) of the animals, with the same semi-circular parallel multifocal pattern but without vascular or inflammatory reaction associated. These lesions were described in *Kogia breviceps* (cases 3 and 17), *Stenella frontalis* (cases 7 and 17) and in *Mesoplodon densirostris* (case 10). The distribution of the lesions varied from case to case but mainly the dorsal and ventral area of the abdominal and peduncle region was affected (TABLE 2) (FIGURE 2).

In addition, 68,42% (13/19) of the animals presented bone fractures. Also, in all these cases multiple bones were affected by this pathologic entity and 6 of the cases had fractures with a bilateral presentation.

The most affected body region was the thorax, with 7 of the cases presenting fractures in the ribs (cases 2, 4, 5, 10, 11, 17 and 18) and 4 cases affecting thoracic vertebrae (cases 5, 11, 14 and 15). We also found fractures in the lumbar and caudal vertebrae in 6/13 of the studied cetaceans (cases 8, 9, 10, 12, 14 and 19). Another bone frequently affected was the mandible in 5 cases (4, 10, 12, 14 and 15), in which 3 were multiple fractures and in the 2 remaining presented single fractures. Lastly, cranium fractures were found in 3 animals (cases 4, 12 and 15) affecting bones like occipital, parietal, temporal and lacrimal bones (FIGURE 3).

Other macroscopic findings observed were non-digested or partially digested food in the stomach in 31,6% (6/19) of the animals (cases 1, 2, 3, 5, 10 and 16) and pulmonary perforation or laceration in 10,5% (2/19, cases 4 and 5) (TABLE 2).

Histological Findings

Histologically, skeletal muscle displayed acute degenerative and/or necrotic changes (loss of cross striations, segmental degeneration, hyalinization, hypercontraction, hypereosinophilia and pyknotic nuclei) in 89,5% (17/19) of the affected animals. These lesions were severe in 5,3% (1/19) of the cases, moderate in 63,2% (12/19) and mild in 21,1% (4/19). In the cardiac muscle, degenerative and/or necrotic changes such as fibrillar rupture, cardiomyocyte cytoplasmic and juxtanuclear vacuolization and intracellular vacuolization with loss of sarcoplasmic boundaries, hypereosinophilia, hypercontraction and pyknotic nuclei, were found in 78,9% (15/19) of the cases. The lesions were severe in 5,2% (1/19), moderate in 42,1% (8/19) and mild in 31,6% (6/19) of the cases (FIGURE 6).

On the other hand, in the skin, lesions attributable to intra-interspecific interaction were loss of continuity, laceration and tearing of the skin layers, associated with abundant suppurative inflammatory infiltrate, necrosis and bacteria in 36,8% (7/19) of the cases, being in 15,8% (3/19) severe, and moderate in 21,1% of the cases (FIGURE 7).

Regarding other organs such as the kidney, we observed interstitial lymphoplasmacytic nephritis in 36,8% (7/19) of the cases, being moderate in 26,3% (5/19) and mild in 10,5% (2/19) of the cases. Hemorrhages and congestion were present in 21,1% (4/19) of the cases, severe in 5,2% (1/19) and moderate in 15,8% (3/19) of the cases.

Hemorrhages and congestion were also found in adrenal glands, in 21,1% (4/19) of the animals, being severe in 5,2% (1/19), moderate in 5,2% (1/19) and mild in 10,5% (2/19) of the cases.

In the liver, congestion and diffuse hemorrhage were found in 15,8% (3/19) of the cases, being severe in 10,5% (2/19) and moderate in 5,2% (1/19) of the cases. Another finding was multifocal macrovacuolar and microvacuolar degeneration in 10,5% (2/19) of the cases, classified as severe in 5,2% (1/19) of the cases and moderate in 5,2% (1/19). Moderate ischemic periportal necrosis was also found in 10,5% (2/19) of the cases and moderate hyaline globules inside the hepatocytes in 5,2% (1/19) of the cases.

Regarding the brain, the most common finding was hemorrhages and congestion. These lesions were found in 42,1% (8/19) of the cases, being severe in 5,2% (1/19), moderate in 31,6% (6/19) and mild in 5,2% (1/19) of the cetaceans studied (FIGURE 8).

Species

Eight different species showed lesions compatible with traumatic intra-interspecific interaction. The most affected species was the Atlantic spotted dolphin (*Stenella frontalis*) with 36,8% of the cases (7/19), followed by the pygmy sperm whale (*Kogia breviceps*) with the 21,0% of the cases (4/19), striped dolphin (*Stenella coeruleoalba*) with 15,78% (3/19) and bottlenose dolphin (*Tursiops truncatus*), dwarf sperm whale (*Kogia sima*), Blainville's beaked whale (*Mesoplodon densirostris*), common delphin (*Delphinus delphis*) and short-finned pilot whale (*Globicephala macrorynchus*) with 5,26% each (1/19) (TABLE 1).

Location

The prevalence of strandings per island in 2018-2023 was 29% in Tenerife (76/262), 27,1% in Fuerteventura (71/262), 26,33% in Gran Canaria (69/262), 11,06% in Lanzarote-La Graciosa (29/262), 3,05% in La Palma (8/262), 1,9% in El Hierro (5/262) and 1,52% in La Gomera (4/262).

Regarding cases of traumatic intra-interspecific interactions, the island with the highest number of affected animals was Tenerife, 36.84% (7/19), followed by Gran Canaria, 26.31% (5/19), Fuerteventura, 21.05% (4/19), Lanzarote-La Graciosa, 10.52% (2/19) and La Palma, 5.26% (1/19). None of the animals stranded on El Hierro and La Gomera were affected by this pathological entity (FIGURE 1).

Age class

The percentage of necropsied animals for each age class was 50,76% adults (133/262), 20,61% juveniles/subadults (54/262), and 25,57% neonates/calves (67/262). The age class of eight animals could not be determined.

If we analyze only the cases of traumatic intra-inter-specific interactions, we can see that adults were also the most affected group with 63,15% (12/19), followed by neonates-calves and juveniles-subadults with 15,78% (3/19) each. The age class of one animal could not be determined (TABLE 1).

Body condition

The body condition of the cetaceans analyzed between 2018 and 2023 was 43.89% good/fair (115/262) and 32.06% poor/very poor (84/262). In 63 animals the body condition could not be determined because of advanced decomposition state. In the context of traumatic interactions 57,89% (11/19) of affected cetaceans were in good/fair body condition and 31,57% (6/19) presented poor/very poor body condition. The body condition of two animals could not be determined (TABLE 1).

Sex

The percentage of necropsied animals in the period studied for each sex were 47,32% of females (124/262) and 50,38% of males (132/262). The sex of six animals could not be determined.

In our study, the females represent 79% of the total cases of traumatic intra-interspecific interactions (15/19). In contrast, the males only represented the 21% (4/19) of the affected animals (TABLE 1).

Seasonality

Regarding the seasonality of stranding events, 73,68% of the strandings of our cases (14/19), occurred in spring-summer seasons (from March to September). On the contrary, 26,31% (5/19) stranded in autumn-winter seasons (from October to February).

The annual average occurrence of intra-interspecific interactions cases was 3-4 stranded cetaceans per year (19 cases over 6 years).

Traumatic Death Due to an Accident During Predation: Gross and Histological Findings

In one case, interspecific interaction with potential prey resulted in the death of the cetacean. A juvenile bottlenose dolphin (case 1) in poor body condition died because a fatal interaction with eels.

The main necropsy finding was the disinsertion of the larynx from its anatomical position. In this location, two intact fish specimens were observed, compatible with eels, in the esophagus, close to the larynx and reaching the entrance of the keratinized stomach. Partially digested food content was also detected in the stomach compartments. In addition, a focal, reddish, hemorrhagic lesion was found in the subcutaneous musculature in the ventral area of the caudal part of the left mandible deepening to the remaining adjacent musculature that may have been caused by this interspecific interaction (FIGURE 5).

Histologically the musculature showed acute degenerative changes such as hypercontraction and hypereosinophilia.

On the other hand, in the lung, multifocal presence of muscle fibers in bronchial, bronchiolar and alveolar lumina and laryngeal crypts was found, suggestive of food aspiration. In addition, a moderate multifocal lymphoplasmacytic inflammatory infiltrate was observed in bronchial and bronchiolar submucosa.

Furthermore, in case 3 several small circular lesions, around 3 mm in diameter, with a hyperemic halo in regions close to the oral cavity were found. These lesions were compatible with interspecific interaction with a cephalopod that, when preyed upon, generates these lesions in the cetacean with its tentacles. These lesions were not related with the death of the animal (FIGURE 5).

DISCUSSION

Gross Findings

In this study, we focused on 19 cases with traumatic lesions compatible with intra-interspecific interaction. The diagnosis was based on previously reported cases (Ascheri et al., 2024; Barnett et al., 2009; Crespo-Picazo et al., 2021; Puig-Lozano et al., 2020). The main findings were multifocal blunt traumas with fractures and contusions along the cetacean's body (FIGURE 3). These injuries were bilateral and in most of the cases associated with multiple severe tooth-rake marks (FIGURE 2). Other findings were undigested or partially digested food in the stomach, pulmonary perforation or laceration, hemothorax and hemoabdomen (FIGURE 4).

It is important to clarify that none of these described lesions are pathognomonic for this pathological entity, except for the acute tooth-rake marks as they are a clear indicator of intra-interspecific interaction between cetaceans. However, the absence of tooth rake marks does not rule out this entity as some cetaceans may attack another by collision, tossing, drowning or sandwiching, without the use of the teeth, as we described earlier.

Some differential diagnoses include vessel strikes, fishing interactions or alive strandings. These pathologic entities can cause blunt trauma that can confuse the diagnosis of specific interactions. Vessel strikes cause blunt and/or sharp trauma from the impact. Either or both may be present, depending on the nature of the collision. These lesions are unidirectional and typically found on the dorsal surface of the animal, affecting at least the skin, subcutaneous and deep muscular tissues and bone fractures and exposure of cavities in severe cases. Some common lesions from fishing interactions are entanglement in gillnets, which causes lacerations and indentations from the net. In injured cetaceans we can find unhealed, narrow, linear lacerations or indentations in the epidermis, most commonly around the head, dorsal fin, flukes and flippers. Other common findings are the presence of undigested food in the stomach or esophagus, red eyes, and disseminated gas bubbles (Arbelo et al., 2013; de Quiros et al., 2012; Read & Murray, 2000). Some common findings in live strandings are small, superficial lacerations in the ventral thorax, abdomen, flanks and head. Hemorrhages and subcutaneous hematomas of the rectus abdominis due to the physical trauma of stranding are also observed, as well as hemodynamic changes characterized by petechiae, diffuse congestion and edema in organs such as the brain, liver or kidney (Herráez et al., 2013).

In our study we excluded all the cases in which other traumatic etiologies other than intra-interspecific interactions could not be ruled out.

If we compare our study with the previous one by Puig-Lozano et al., (2020) we find similar results, but the main differences are:

- A higher prevalence of intraspecific tooth-rake marks (36,84%, 7/19) while Puig-Lozano et al. found only 8,3% (2/24) between 2000 and 2017. Also, we found a higher prevalence of interspecific tooth-rake marks, 57,9% (11/19), vs. 33,3% (8/24).
- A higher percentage of skin erosion and laceration in our study 63,2% (12/19) vs. 25% (6/24).
- The number of fractures reported were similar in both studies. The main differences are that in our study the spine was the most affected region with 9/19 cases while Puig-Lozano et al. found 3/24. On the other hand, the most affected region in their study was the ribs with 11/24 while in our case, 7/19 had these lesions. Also, they found fractures of the scapula while in our study any of the studied cetaceans presented this injury.

- Another main difference between the studies is that in the Puig-Lozano et al. study 50% (12/24) of the animals necropsied had hemothorax and in our study only 15,8% (3/19) of the cetaceans presented it. Regarding hemoabdomen, the differences are not as notable, with a prevalence of 29,2% (7/24) in Puig-Lozano et al. study, and 21,1% (4/19) in our study. Also, in our study we did not find any cases of hemopericardium while in the previous study, 1 case presented this lesion.

Histological Findings

In the cetaceans diagnosed with traumatic intra-interspecific interactions we found a high prevalence of acute degenerative and/or necrotic changes of the skeletal muscle and cardiac muscle such as loss of cross striations, segmental degeneration, hypercontraction, hypereosinophilia, pyknotic nuclei, fibrillar rupture and vacuolization (FIGURE 6).

Although we found interstitial lymphoplasmacytic nephritis in the kidney of 7 cetaceans, this is a common non-specific lesion found in chronic pathologies associated mainly to infections or parasitism, so this lesion is not related to this pathological entity.

In the kidney, adrenal glands and brain, hemorrhages and congestion were frequently observed. In the liver, congestion and diffuse hemorrhage was also described, along with multifocal macrovacuolar and microvacuolar hepatocellular degeneration, ischemic periportal necrosis and hyaline globules inside the hepatocytes (FIGURE 8).

All these histological findings have been previously reported in stressful agonal events such as severely polytraumatized animals, capture myopathy and live strandings (Díaz-Delgado et al., 2018; Herráez et al., 2013; Jaber et al., 2004; Sierra et al., 2017).

Another finding was the loss of continuity, laceration and tearing of the skin with abundant suppurative inflammatory infiltrate and necrosis. These lesions are associated with intra-interspecific lesion that include bites, tooth-rake marks and lacerations that cause the tearing of the skin layers, the inflammatory reaction and the tissue necrosis (FIGURE 7).

Species

According to the Banco de Datos de Biodiversidad de Canarias (2024), 31 species of cetaceans have been found in the island's waters. In our study, the most affected species was the Atlantic spotted dolphin (*Stenella frontalis*). They inhabit the waters of all the Canary Islands with more sightings in the waters between Tenerife and La Gomera, in the south of Gran Canaria, the west of La Palma and the south of Fuerteventura (Herrera et al., 2021). They inhabit shallow waters between 0-250 meters and are often seen in water depths of less than 20 m (Ministerio para la Transición Ecológica y el Reto Demográfico, 2006).

Atlantic spotted dolphin (*Stenella frontalis*) and bottlenose dolphins (*Tursiops truncatus*) are known to travel and forage together but they also engage in aggressive interactions (Volker & Herzing, 2021). Some of these aggressive behaviors and vocalizations include head-to-head postures, open-mouth behaviors, squawking, pushing out of the water, and chasing. Side-mounts by male bottlenose dolphins to male spotted dolphins have also been described; spotted dolphins are smaller than bottlenose dolphins, so they often sexually harass male spotted dolphins in the form of side-mounting behavior. Side-mounting usually involves one or more male bottlenose dolphins attempting to force their erect penis into the genital slit of the spotted dolphin. This aggressive sexual behavior is believed to be a dominance display by the bottlenose dolphins over the spotted dolphins (Herzing & Johnson, 1997; Volker & Herzing, 2021).

Another common aggressive sexual interaction is the competition for females between the Atlantic spotted dolphins (*Stenella frontalis*) and bottlenose dolphins (*Tursiops truncatus*). These sexual interactions are usually initiated by subadults bottlenose dolphins as they are not able to copulate with females due to their lower position in the social ranking, so they alternatively attempt to copulate with female Atlantic spotted dolphins, by aggressively separating individual females from groups (Möller et al., 2001; Melillo et al., 2009). For this reason, we can see males of both species fighting for access to copulate with females.

In our study 7 Atlantic spotted dolphins were affected by intra-interspecific interactions, of which 6 were females. This aggressive behaviors of both species against the females spotted dolphins could justify the high prevalence of females affected by this pathological entity, as well as defend the calves from infanticide, as will be discussed in more detail later.

By studying the inter-tooth spacing of the rake marks (TABLE 3) we could diagnose fatal interactions with killer whales in 6 animals of four cetacean species: 3 pigmy sperm whales (*Kogia breviceps*), 1 dwarf sperm whale (*Kogia sima*), 1 Atlantic spotted dolphin (*Stenella frontalis*) and 1 Blainville's beaked whale (*Mesoplodon densirostris*). In previous studies they found killer whale aggressive interactions in three cetacean species in the Canary Islands: Cuvier's Beaked whale, pygmy sperm whale and short-finned pilot whale (Puig-Lozano et al., 2020).

Killer whales has been recorded preying on *Mesoplon spp.* in Australia (Wellard et al., 2016), dwarf sperm whale (Dunphy-Daly et al., 2008) and pigmy sperm whales in the Bahamas (Dunn & Claridge, 2014) and sperm whales in California, in this population it has been observed that sperm whales have very tough hides and when killer whales bite them, they had difficulty removing the flesh (Pitman et al., 2001). This may have caused the killer whales to avoid feeding on these cetaceans and go hunting other species (Pitman et al., 2001). Based on these reports *Kogia sp.* appears to be a target species in these locations for the killer whales as they have no problems removing the flesh in comparison with sperm whales. Pygmy sperm whales are also a target for killer whales in the Canary Islands, but according to our study, the purpose of this predation is not for feeding. In all the cases of pygmy sperm whales with signs of interaction with killer whales that we studied, there were no signs of predation. Apparently killer whales hunted pygmy sperm whales but did not use them as food. Some reasons for these interactions may be territorial defense, calf training, competition for food or that pygmy sperm whales are not a dietary preference of the killer whales that inhabit the archipelago, unlike in other killer whale populations in other parts of the world such as the one in the Bahamas mentioned above.

In spring and summer, killer whales have been sighted in the Canary Islands, associated with the presence of tuna and there are records of them having aggressive encounters with short-finned pilot whales and beaked whales. In our study, all the cases compatible with killer whale predation occurred in this period.

We also found evidence of two shark attacks on two Atlantic spotted dolphins. They presented semi-circular parallel multifocal tooth marks with inflammation, vascular changes in the tissue and tearing of the skin. These lesions were located mainly in the dorsal peduncle. One of the affected dolphins had a poor body condition and the other one was an old individual. This could have affected these two cetaceans in a negative manner, as they may be weakened, facilitating the shark predation (FIGURE 2).

These interactions have already been described in the Bahamas (Melillo-Sweeting et al., 2014). They found that 15% of the studied spotted dolphins (15/92) presented healed shark-induced lesions. This indicates that shark attacks are more common than we thought but these predation attempts often fail, leaving the dolphin injured but not dead. This could also be the case in the Canary Island, although this type of interaction has not been described before, shark attacks could be common in the seas of the archipelago.

Diving behavior

Previous investigations by Puig-Lozano et al., 2020 showed that deep divers are more prone to intra-interspecific interactions than shallow divers. However, our study showed that shallow divers are more likely to suffer traumatic intra-interspecific interactions. Deep divers require a prolonged period of recuperation at the surface after one or more apneas, for this reason they are more susceptible to suffering ship collisions (Arbelo et al., 2013). But this recuperation time could also leave them exposed to suffer from intra-interspecific interactions as well as killer whale predations affecting pigmy sperm whales, dwarf sperm whales and short-finned pilot whales, like we mentioned before.

However, shallow divers might suffer for traumatic interactions for many reasons as we have already mentioned: territorial defense, food competition, competition over mates, female access for copulation, sexual frustration, intraspecific infanticide and defending of the calves, or social dominance in a group (Crespo-Picazo et al., 2021; Barnett et al., 2009; Spitz et al., 2006; Connor et al., 1992; Volker & Herzing, 2021).

Location

The incidence of the cases of intra-interspecific interactions was higher between Tenerife and La Gomera. It has been confirmed by sightings in the open sea that there are populations of different species of cetaceans living in the sea that separates La Gomera from Tenerife. These species are: Atlantic spotted dolphin, short beaked common dolphin, rough-toothed dolphins, bottlenose dolphins and short-finned pilot whales (Herrera et al., 2021; Ritter et al., 2010). This high number of populations of different cetacean species inhabiting this reduced space may be the reason for the high prevalence of intra-specific interactions due to disputes over territory or access to food. In a previous study (Puig-Lozano et al., 2020), a higher prevalence of intra-specific interactions was also observed on the coasts of Tenerife and La Gomera, suggesting that this is an area with an abundant population in which numerous territorial or food disputes occur (FIGURE 1).

We also found a high prevalence of these interactions on the coasts of Gran Canaria and the north-east of Fuerteventura. Although there is evidence of a high number of cetaceans living in the south of both islands (Herrera et al., 2021), only one case was diagnosed in the south of Gran Canaria and none in the south of Fuerteventura. Similar results were found in the study of Puig-Lozano et al.

Age class

In our study, 63% of the cetaceans analyzed were adults and juveniles/subadults and calves were 16% each. We can see a correlation between the total cetaceans necropsied between 2018 and 2023 and the ones affected by intra-interspecific interactions (TABLE 1).

In the previous study by Puig-Lozano et al., 50% of the cetaceans affected were calves and neonates, 33% were adults and 15% were juveniles/subadults.

If we compare both studies, there has been an increase in the adult cases reported and a notable decrease in the number of cases of calves. However, the juveniles/subadults cases have remained constant. This data suggests a decrease in the prevalence of infanticide cases.

Infanticide, defined as the killing of dependent calves by males, is considered one of the most notable expressions of sexual conflict between males and females of mammalian groups (Díaz López et al., 2018). It has been observed in primates, equids, rodents, carnivores and cetaceans. In these species the lactation is longer than the gestation period and females have lactational amenorrhea (temporary infertility after birth) so postpartum mating does not occur (Palombit, 2015). In this situation, males try to kill the calves, to force the female to return to the normal reproductive cycle and try to have a chance to reproduce in the next female's estrus. This is because if a female loses her calf prematurely, she will become sexually receptive within a short period of time. Females can become pregnant within two months after losing a newborn, but conception takes much longer, up to a year or more. Therefore, to improve their chances of mating, the male's strategy is to reduce the time between births (Díaz López et al., 2018; Robinson, 2014).

The affected species in our study were 1 striped dolphin and 2 Atlantic spotted dolphins. The striped dolphin presented tooth-rake marks with a separation of 5 millimeters, compatible with an intraspecific interaction (TABLE 3). The spotted dolphins did not have any tooth rake marks but only blunt trauma, so it is not possible to determine if it was an intra or an interspecific interaction. It has been reported that the most common finding is calves without any external lesions, but with internal injuries such as bone fractures, muscle damage and damage to cavities and organs (Dunn et al., 2002).

Direct observations of this aggressive behavior at the open sea are rare. In a study on bottlenose dolphins in Scotland, a group of adult males were observed attacking an adult female and her male calf. After fighting, the infant was severely injured (Robinson, 2014).

Body condition

There was a higher number of cetaceans with good body condition affected by this pathological entity than those with a poor body condition. Previous studies obtained the same results, and the reason is still unknown. One explanation could be that cetaceans with poor body condition may be affected by some systemic disease, such as infections or massive parasitism and therefore do not engage in fights for social rank, food or territory but these disputes are made by animals with a good body condition. On the other hand, cetaceans with a poor nutritional status may be targeted by other cetaceans with better body condition, so they suffer traumatic injuries despite trying to avoid these aggressions.

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Sex

According to Puig-Lozano et al., between 2000 and 2017 the percentage of males and females were 58,3% and 41,7% respectively. However, in our study we found that the percentage of females affected by this pathological entity has increased drastically (15 out of 19 total affected animals). In the deep divers we found an equal male-female proportion. However, in the dolphins there was a higher prevalence for these interactions in females.

An explanation for this event may be an increase of the sexual frustration, where access to females or other resources is limited. Sexual arousal may be triggered by physiological responses related to stress or may be an expression of dominance, with no reproductive purpose. Another reason that may be related to the above is an increase in infanticide by males to gain access to females, reducing the inter-birth time as was explained before. In these cases, females may be injured in their attempts to defend the calf, resulting in serious lesions and death. First-time mothers might further be targeted in view of their lack of parental experience (Methion & Díaz López, 2021; Robinson, 2014; Syme et al., 2021).

As we explained before, these sexual interactions can also be initiated by subadults dolphins as they are not able to copulate with females because of their lower position in the social ranking, so alternatively they try to copulate with female dolphins of smaller species by aggressively separating them from groups (Möller et al., 2001; Melillo et al., 2009).

Some counter-strategies employed by females to avoid infanticide has been described by Agrell et al., (1998). These strategies include choosing the most dominant male, polygamous behavior, faking estrus, actively defending the offsprings, avoiding unfamiliar males, and associating with other conspecifics for protection.

Although these aggressive interactions directed towards females by males are not uncommon, as it is a documented phenomenon, it is interesting and important to highlight this increase in the incidence of these attacks and to try to better understand the cause.

Traumatic death due to an accident during predation

In the necropsy of the case nº1, a juvenile bottlenose dolphin presented a fatal interaction with live prey. A disinsertion of the larynx (goosebeak) from the upper airways was observed with the presence of two elongated fish (compatible with eels) in the pharynx, esophagus and reaching the entrance of the keratinized stomach. In addition, muscle fibers were observed in alveolar spaces and laryngeal crypts, suggestive of food aspiration. The dislocation of the larynx by eels has been reported before in a long-finned pilot whale. In this case, the eel occupied the entire trachea and the main bronchial lumen. Also, severe pulmonary edema, subpleural and intraparenchymal hemorrhages, as well as severe pulmonary atelectasis were found (Fernández-Maldonado et al., 2015) (FIGURE 5).

- Other similar cases of laryngeal disinsertion caused by other prey include black margate (*Anisotremus surinamensis*) (Miagnucci-Giannoni et al., 2009) and a beheaded sheepshead (*Archosargus probatocephalus*) (Watson et al., 2005) in bottlenose dolphins. Also, a flounder (*Platichthys stellatus*) has been reported in belugas (Rouse et al., 2017) or in an Indo-Pacific bottlenose dolphin (*Tursiops aduncus*) by interaction with an octopus (*Macroctopus maorum*) (Stephens et al., 2017) or two Risso's dolphins that died of suffocation while fighting with squids (Puig-Lozano et al., 2020). In Puig-Lozano et al. (2020), it was described a fatal interaction between a false killer whale with a stingray. The cetacean presented an intralesional stingray spine in the tongue causing severe chronic perforating glossitis and stomatitis.

Although in our study only one case presented this traumatic death while predation, these interactions has been documented around the world and they are more common than we thought.

CONCLUSIONS

This retrospective study is an update of traumatic intra-specific interactions cases in cetaceans in the Canary Islands. There has been an increase in the number of cases compatible with this pathologic entity from 1–2 animals per year (24 cases between 2000 and 2017) to 3-4 cases per year (19 cases between 2018 and 2023). Also, there has also been a very marked decrease in the cases of infanticide and at the same time a very remarkable increase in the cases of females affected by this pathological entity. On the other hand, we have obtained more data on predation by killer whales, seeing which are their preferred prey as well as the most common lesions in their victims. Furthermore, this is the first time that shark predation towards cetaceans has been registered. We have also obtained more data about traumatic death due to an accident during predation, however, there has been a decrease in the cases reported.

We must take into consideration that stranding numbers represent only a small fraction of the animals that actually die at sea, as strandings are estimated to be an order of magnitude lower than the number of individuals dying at sea. Therefore, they may be more common than stranding data alone would suggest.

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ANNEXES:

TABLE 1| Nineteen cetaceans died due to intra-interspecific traumatic interactions in the Canary Islands (from January 2018 to December 2023).

Nº	Species	DB	Stranding Date	Island	State	Sex	Age	BC	DS	Traumatic behavior
1	*Tursiops truncatus*	S	13/03/18	GC	D	F	Juvenile	1	4	P
2	*Kogia sima*	D	23/08/18	LZ	D	F	Adult	2	4	S
3	*Kogia breviceps*	D	04/09/18	TF	D	M	Adult	NE	3	S
4	*Stenella coeruleoalba*	S	05/01/19	FV	D	F	Calf	2	3	S
5	*Stenella coeruleoalba*	S	06/05/20	GC	D	M	Subadult	2	4	S
6	*Stenella frontalis*	S	30/06/20	FV	D	F	Adult	1	3	S
7	*Stenella frontalis*	S	28/07/20	LP	A	F	Adult	1	2	S
8	*Stenella coeruleoalba*	S	28/09/20	TF	D	F	Adult	2	2	S
9	*Stenella frontalis*	S	21/03/21	GC	D	F	Juvenile	2	3	S
10	*Mesoplodon densirostris*	D	04/04/21	FV	D	F	Adult	2	3	S
11	*Stenella frontalis*	S	17/04/21	TF	D	F	Calf	2	2	S
12	*Kogia breviceps*	D	17/08/21	TF	D	F	Adult	1	3	S
13	*Stenella frontalis*	S	28/01/22	LZ	D	F	Adult	1	2	S
14	*Delphinus delphis*	S	16/03/22	TF	D	F	Adult	1	3	S
15	*Stenella frontalis*	S	16/12/22	GC	D	F	Calf	2	3	S
16	*Stenella frontalis*	S	27/01/23	FV	D	M	Adult	2	3	S
17	*Kogia breviceps*	D	17/03/23	TF	D	M	Adult	2	3	S
18	*Globicephala macrorynchus*	D	24/03/23	TF	D	F	NE	2	4	S
19	*Kogia breviceps*	D	19/09/23	GC	D	F	Adult	NE	4	S

The table shows every species diving behavior (DB) (D, deep diver; S, shallow diver), Stranding Date (day /month/year), Location Island (GC, Gran Canaria; LNZ, Lanzarote; TNF, Tenerife; FV, Fuerteventura; LP, La Palma), the state of the animal when the stranding event occurred (D, death; A, alive), Sex (F, female; M, male); Age class (calf, juvenile, subadult, adult) of each case (n=19). Postmortem studies allowed us to know the following data: Body Condition (BD) (1: poor/very poor; 2: good/fair), Decomposition State (DS) (2: fresh; 3: moderate autolysis; 4: advanced autolysis), and the traumatic behavior that caused the death of the animal (S: social traumatic interaction between cetaceans of the same species or other; P: death due to an accident during predation). NE: Not Evaluated

TABLE 2 | Macroscopic findings in cases of social traumatic intra-interspecific interaction between cetaceans (n=19).								
Case	Species	Interspecific rake marks	Intraspecific rake marks	Healed rake marks	Skin erosion/ laceration	Skin vascular changes	Postmortem shark bites	Hematomas
1	*Tursiops truncatus*	N	N	N	N	Y	N	Y
2	*Kogia sima*	Y	N	Y	Y	Y	N	Y
3	*Kogia breviceps*	Y	Y	Y	Y	Y	Y	N
4	*Stenella coeruleoalba*	N	Y	N	N	Y	N	Y
5	*Stenella coeruleoalba*	N	Y	Y	N	Y	N	Y
6	*Stenella frontalis*	Y	N	Y	Y	Y	N	Y
7	*Stenella frontalis*	Y	N	Y	Y	Y	Y	Y
8	*Stenella coeruleoalba*	N	Y	Y	N	Y	N	Y
9	*Stenella frontalis*	N	Y	Y	N	Y	N	Y

10	*Mesoplodon densirostris*	Y	N	Y	Y	Y	Y	Y
11	*Stenella frontalis*	N	Y	Y	Y	Y	N	Y
12	*Kogia breviceps*	Y	N	Y	N	Y	N	Y
13	*Stenella frontalis*	Y	N	Y	Y	Y	N	Y
14	*Delphinus delphis*	N	Y	Y	Y	Y	N	Y
15	*Stenella frontalis*	N	N	Y	N	Y	N	Y
16	*Stenella frontalis*	Y	N	Y	Y	Y	N	Y
17	*Kogia breviceps*	Y	N	Y	Y	Y	Y	Y
18	*Globicephala macrorynchus*	Y	N	Y	Y	Y	Y	Y
19	*Kogia breviceps*	Y	N	Y	Y	Y	N	Y
TOTAL		11	7	17	12	19	5	18

The table shows the number of the case, the species, and the presence (Y, yes) or the absence (N, no) of intra-interspecific tooth rake marks, healed rake marks, skin erosion/laceration, vascular changes in the skin, postmortem shark bites, subcutaneous and muscle hematomas. In the end, the table shows the total number of cases presenting the different lesions.

TABLE 2 | Macroscopic findings in cases of social traumatic intra-interspecific interaction between cetaceans (n=19).										
Case	Species	Fractures				Hemo-thorax	Hemo-abdomen	Lung perforation	Non-digested food
		Cranium	Mandible	Spine	Ribs				
1	*Tursiops truncatus*	N	N	N	N	N	N	N	Y
2	*Kogia sima*	N	N	N	M (L: 3º, 4º, 5º, 6º)	N	N	N	Y
3	*Kogia breviceps*	N	N	N	N	N	N	N	Y
4	*Stenella coeruleoalba*	Right parietal and temporal	S (R)	N	M (L: 4º, 5º, 6º, 7º, 8º, 9º, 10º; R: 6º)	N	N	Y	N
5	*Stenella coeruleoalba*	N	N	T	M	Y	N	Y	Y
6	*Stenella frontalis*	N	N	N	N	N	N	N	N
7	*Stenella frontalis*	N	N	N	N	N	N	N	N

8	*Stenella coeruleoalba*	N	N	L and Ca (aprox. 14 fractures)	N	N	Y	N	N
9	*Stenella frontalis*	N	N	L (from 8º to 14º and from 17º to C8)	N	N	Y	N	N
10	*Mesoplodon densirostris*	N	S (R)	L	M (R: 8º, 9º, 10º, 11º, 12º)	N	Y	N	Y
11	*Stenella frontalis*	N	N	T: 10º, 11º, 12º, 13º, 14º	M (L: 10º, 11º)	Y	N	N	N
12	*Kogia breviceps*	Neurocranium and lacrimal bone	M (L and R)	L	N	N	N	N	N
13	*Stenella frontalis*	N	N	N	N	N	N	N	N
14	*Delphinus delphis*	N	M (L)	T: 7º, 8º, 9º, 10º, 11º. L: 1º, 2º, 3º, 4º, 5º and 6º	N	N	N	N	N

15	*Stenella frontalis*	Y	M (L and R)	T	N	N	Y	N	N
16	*Stenella frontalis*	N	N	N	N	N	N	N	Y
17	*Kogia breviceps*	N	N	N	M (R)	N	N	N	N
18	*Globicephala macrorynchus*	N	N	N	M (L and R)	Y	N	N	N
19	*Kogia breviceps*	N	N	L and Ca	N	N	N	N	N
TOTAL		3	5	9	7	3	4	2	6

The table shows the number of the case, the species, and the presence (Y, yes) or the absence (N, no) of fractures [cranium, mandibles (S, single; M, multiple; R, right; and L, left), vertebrae (T, thoracic, L, lumbar and Ca, caudal), ribs (the exact number of fractures is given in case it was recorded, also the side)], hemothorax, hemoabdomen, hemopericardium, lung perforation/ laceration, and non-digested or partially digested food.

TABLE 3 | Distance between teeth of Odontocetes	
Species	**Intertooth spacing (mm)**
Tursiops truncatus	7-12
Globicephala macrorhynchus	20-33
Stenella coeruleoalba	4-6
Stenella frontalis	5-6
Orcinus orca	28-43
Data obtained from Puig-Lozano et al., 2020 study.	

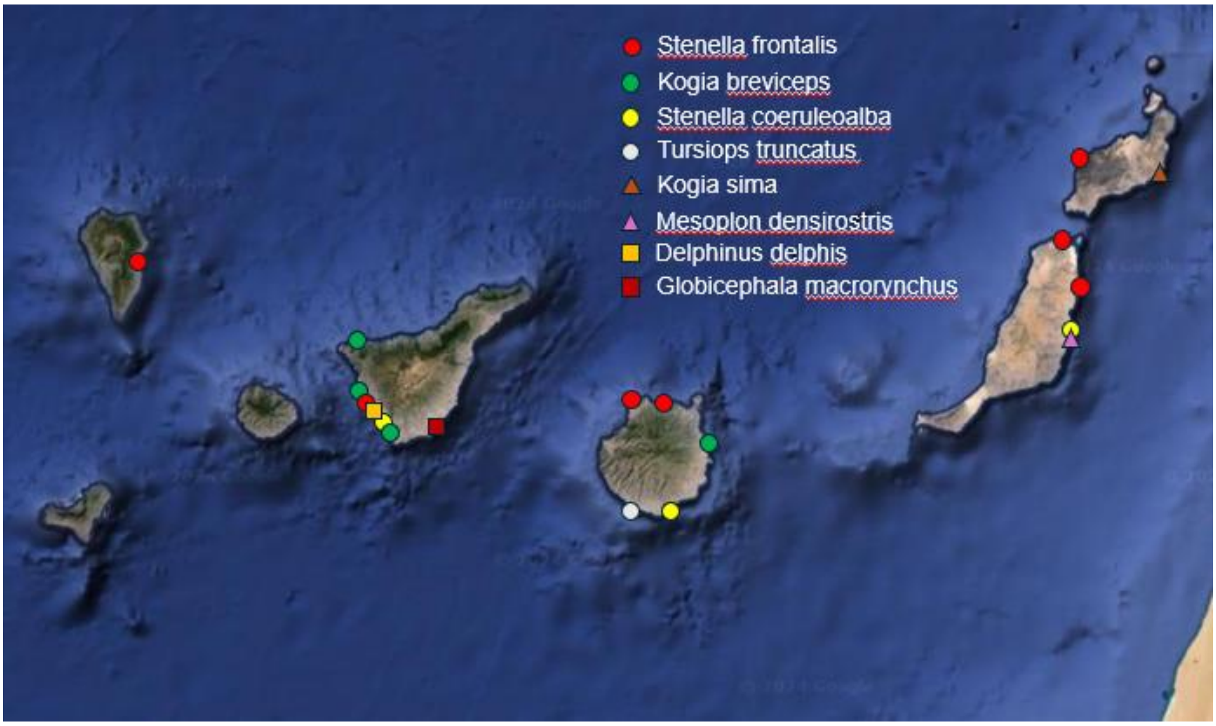

FIGURE 1 | Locations (dots) of cetaceans stranded in the Canary Islands with a diagnosis compatible with traumatic intra-interspecific interaction (n=19).

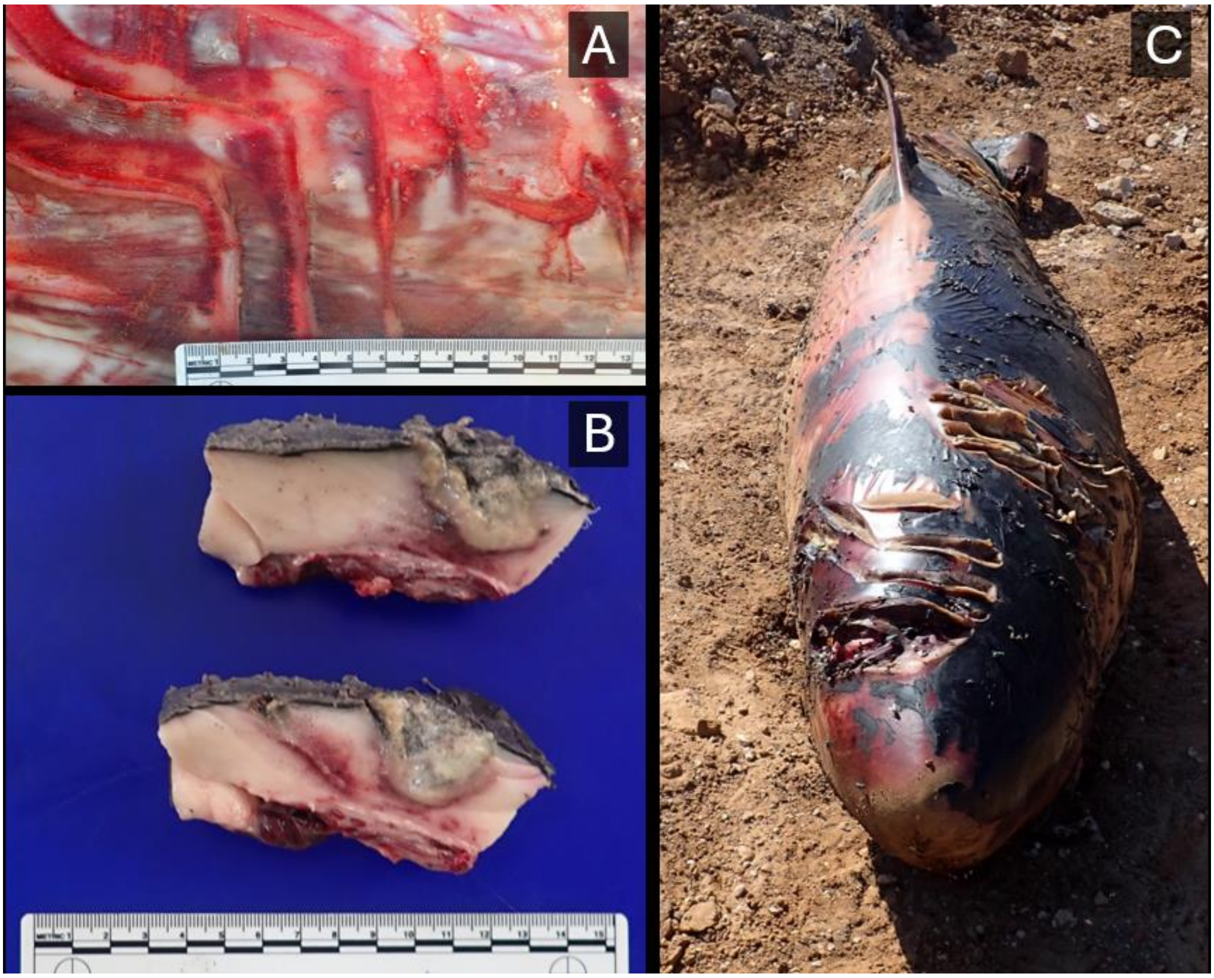

FIGURE 2.1 | Skin gross findings. **(A)** Tooth-rake marks compatible with killer whale predation in the ventral region. Blainville's beaked whale, case 10. **(B)** Transversal cut of puncture wound compatible with killer whale predation with inflammatory reaction associated. Pigmy sperm whale, case 17. **(C)** Dwarf sperm whale carcass with skin lacerations compatible with killer whale predation, case 2.

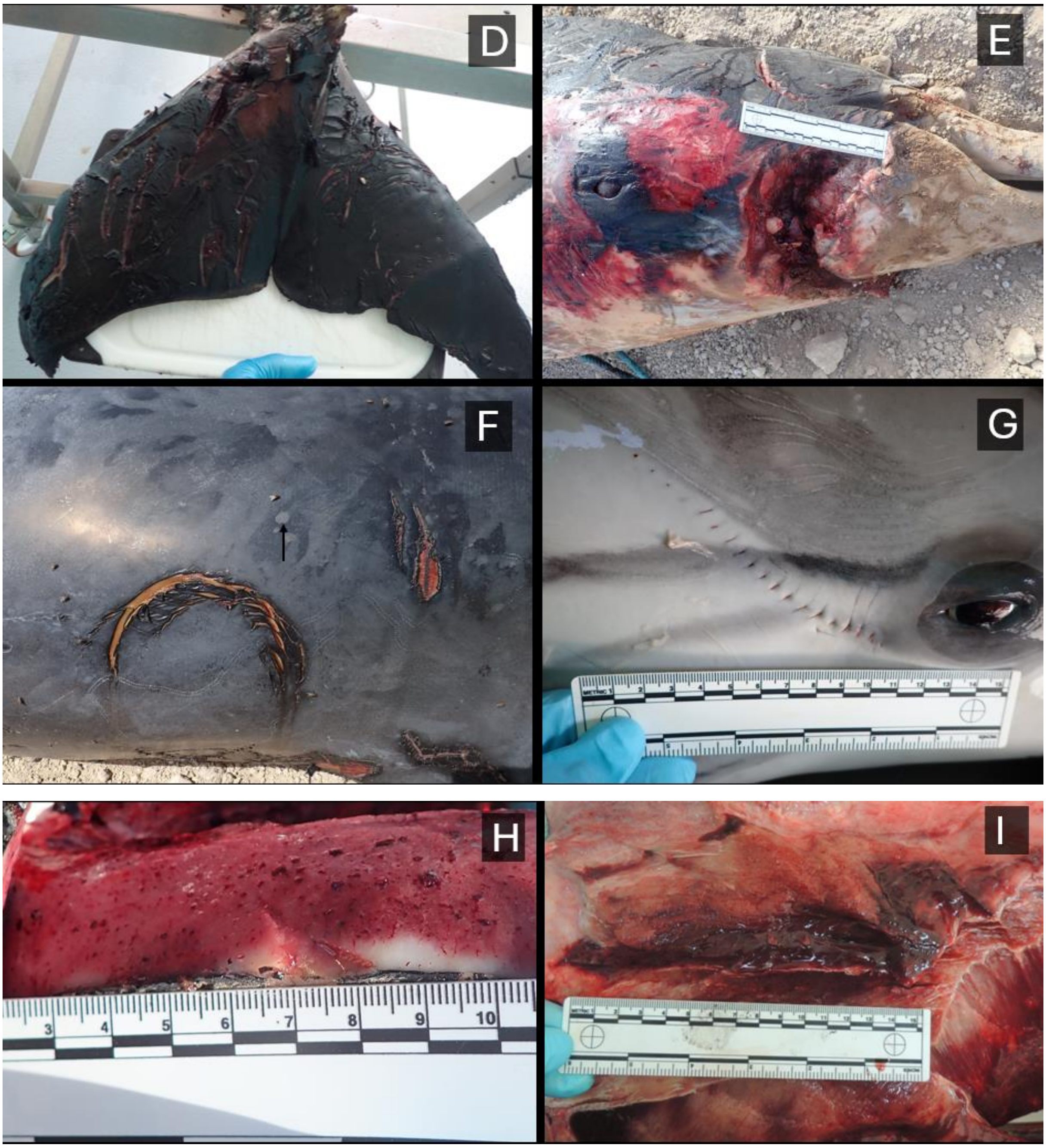

FIGURE 2.2 | Skin gross findings. **(D)** Dorsoventral view of the caudal fin with tooth-rake marks compatible with killer whales and post-mortem shark bites. Pigmy sperm whale, case 3. **(E)** Bite on ventral area of the head with a severe laceration on the skin. Blainville's beaked whale, case 10. **(F)** Postmortem shark bites on the dorsal region. Short-finned pilot whale, case 18. **(G)** Acute tooth-rake mark compatible with intraspecific interaction rostral to the left eye. Striped dolphin, case 8. **(H)** Blubber reddening with presence of petechiae. Blainville's beaked whale, case 10. **(I)** Subcutaneous hematoma in lateral abdomen. Striped dolphin, case 8.

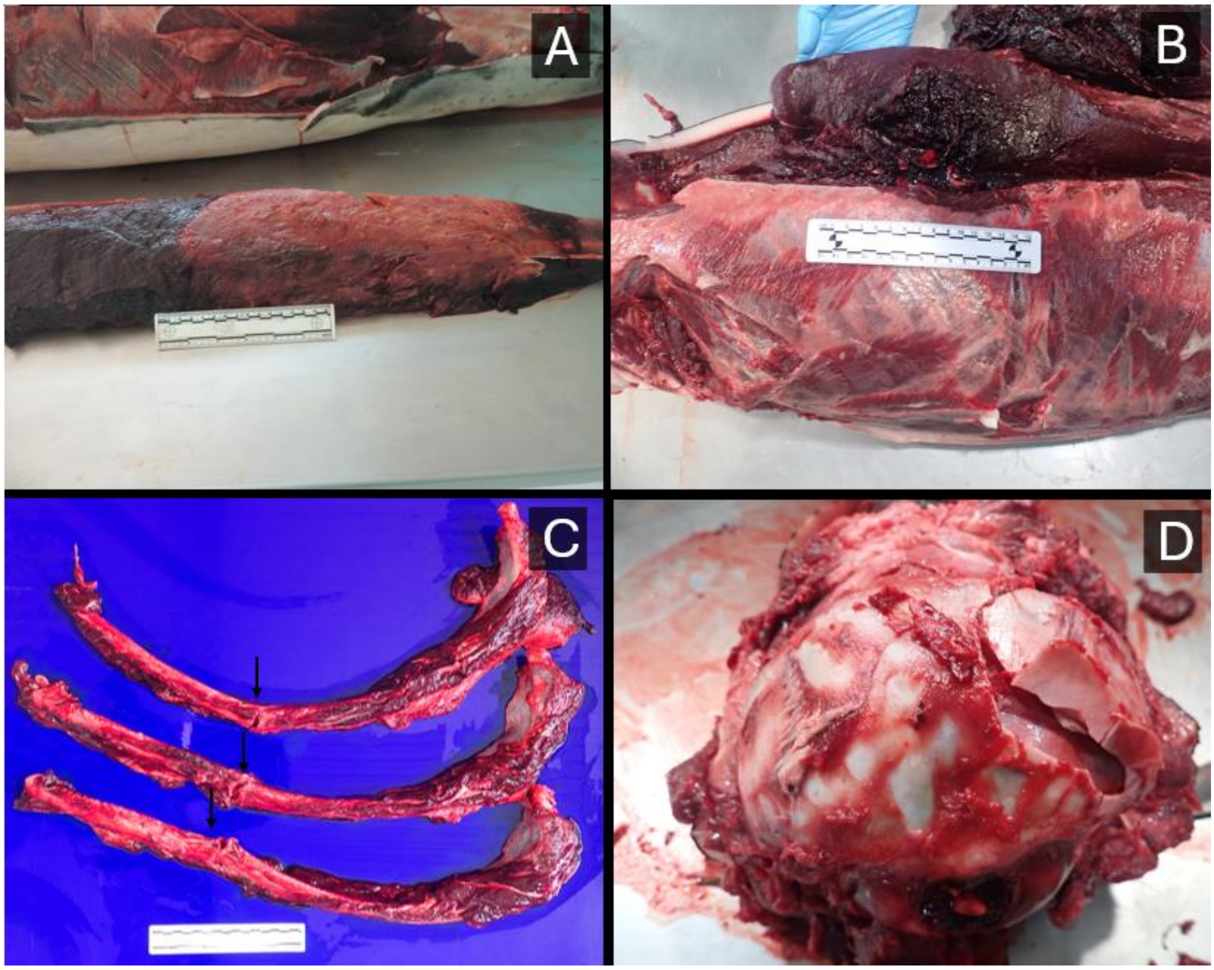

FIGURE 3.1 | Muscle and skeletal gross findings. **(A)** Muscle necrosis and hemorrhages. Striped dolphin, case 8. **(B)** Muscle necrosis hemorrhage and hematoma. Atlantic spotted dolphin, case 15. **(C)** Simple rib fractures. Pigmy sperm whale, case 17. **(D)** Occipital bone multiple fracture. Atlantic spotted dolphin, case 15.

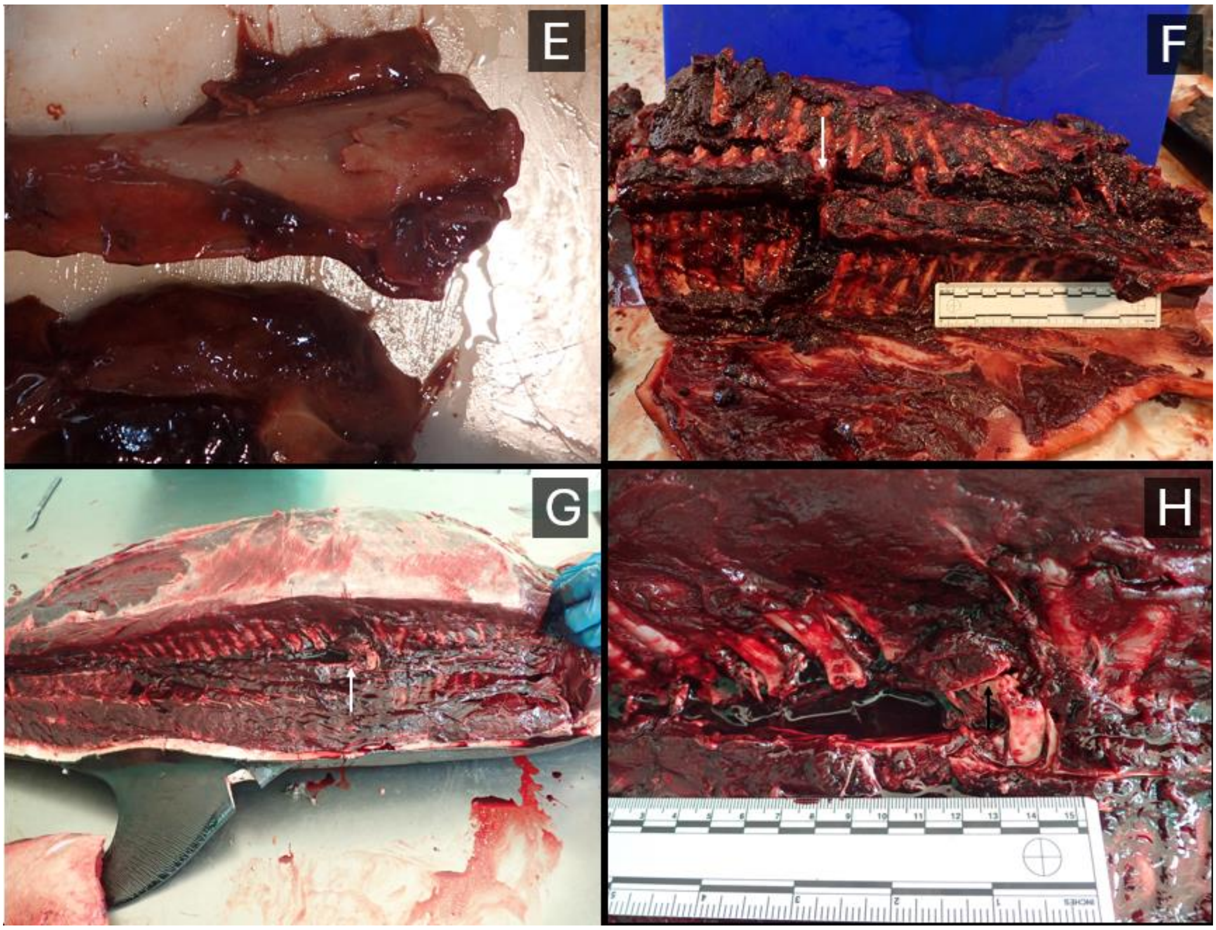

FIGURE 3.2 | Muscle and skeletal gross findings. **(E)** Simple fracture of the right mandible body. Striped dolphin, case 4. **(F)** Spinal dislocation at L27-L28 level. Atlantic spotted dolphin, case 9. **(G)** Multiple comminuted fractures of thoracic vertebrae T10 to T14. Atlantic spotted dolphin, case 11. **(H)** Detail of picture G, multiple comminuted fractures of thoracic vertebrae T10 to T14, affecting the body, spinous and transverse processes. Atlantic spotted dolphin, case 11.

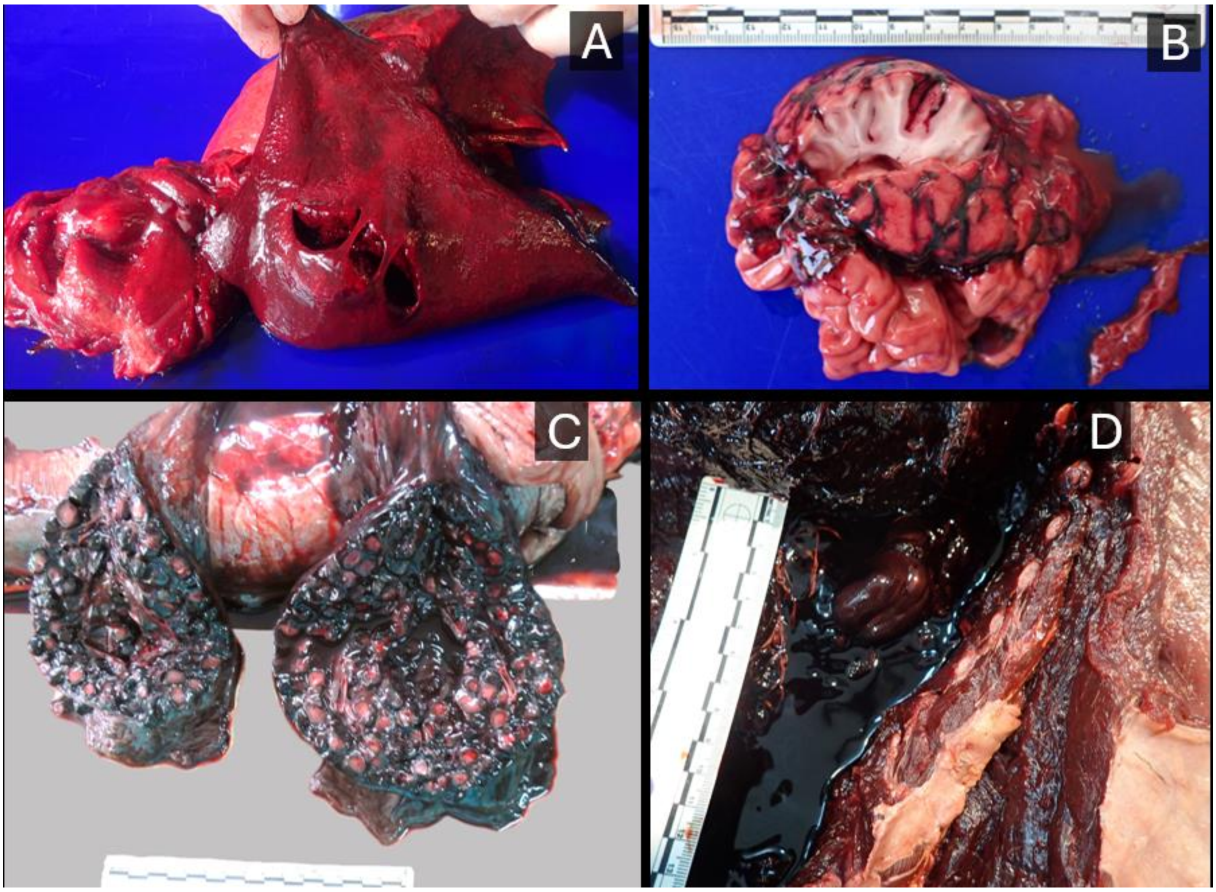

FIGURE 4 | Organs and cavities gross findings. **(A)** Lung perforation. Striped dolphin, case 4. **(B)** Transversal cut of the brain showing vascular changes. Pigmy sperm whale, case 12. **(C)** Subcapsular and interrenicular hemorrhages. Striped dolphin, case 8. **(D)** Hemoabdomen. Atlantic spotted dolphin, case 9.

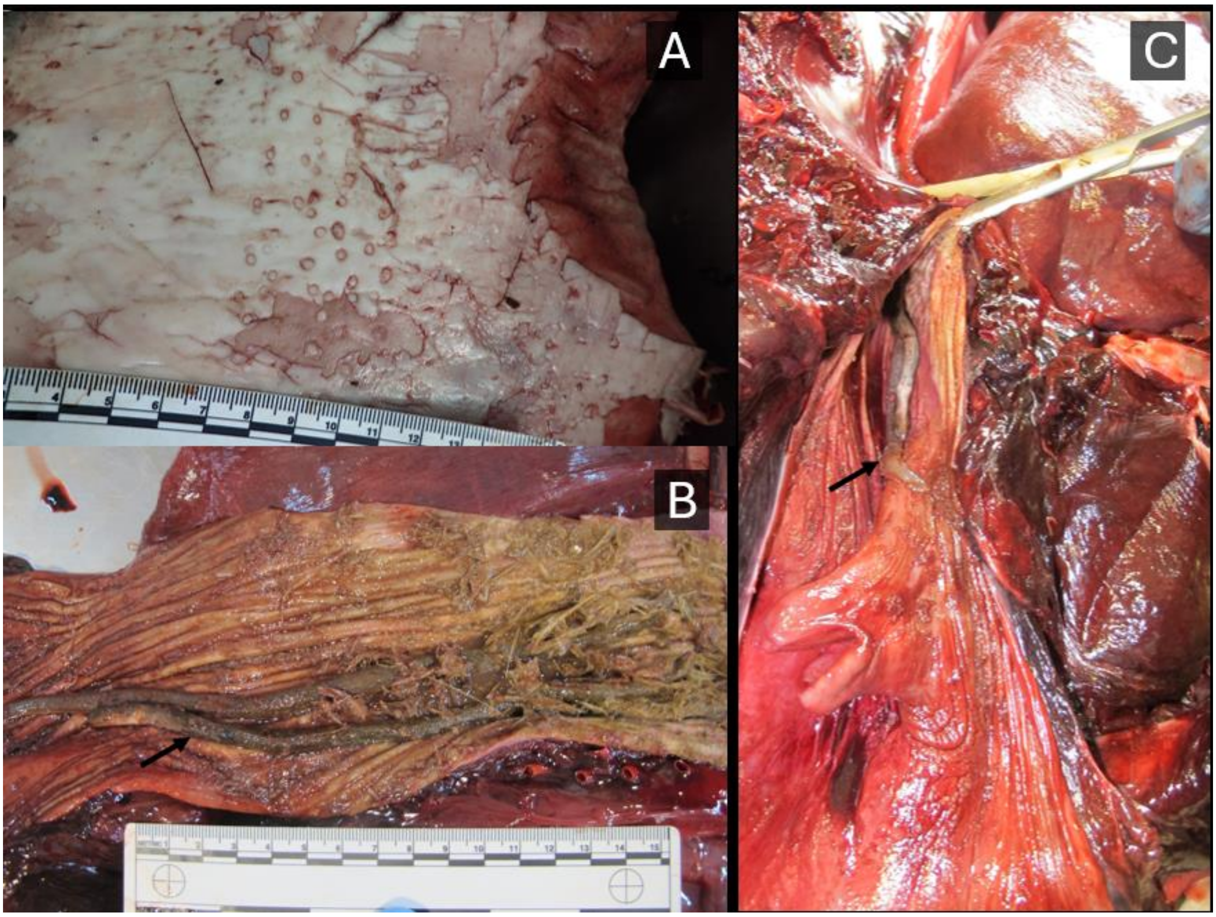

FIGURE 5 | Traumatic death due to an accident during predation, gross findings. **(A)** Cephalopod tentacle marks. Pigmy sperm whale, case 3. **(B)** Two elongated fish, compatible with eels in the esophagus, and remains of semi-digested food, reaching the aperture of the keratinized portion of the stomach. Bottlenose dolphin, case 1. **(C)** Two elongated fish, compatible with eels (arrow) in the transition of the pharynx to the esophagus, disinserting the larynx. Bottlenose dolphin, case 1.

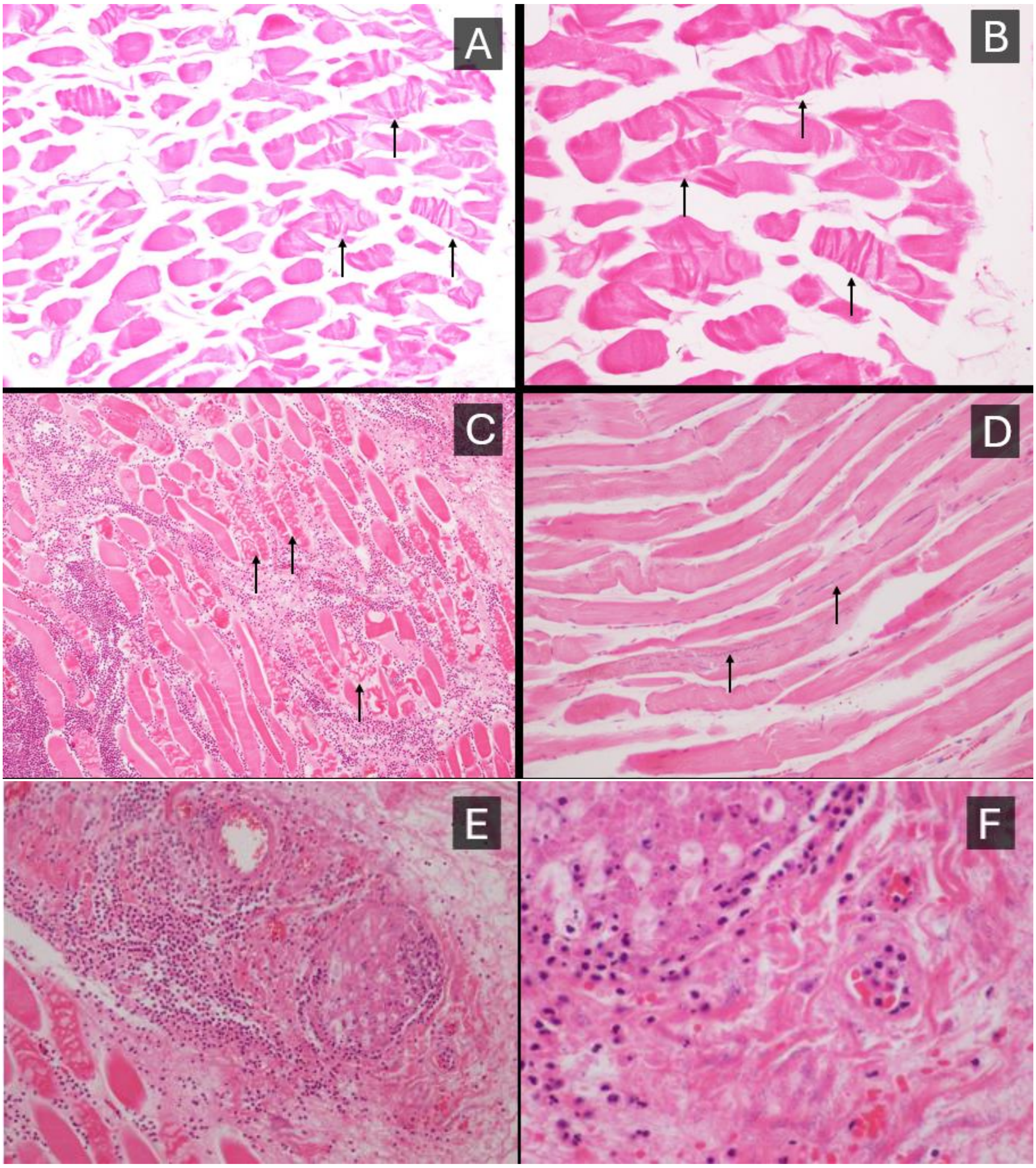

FIGURE 6 | Skeletal muscle. Histological findings. Hematoxylin-eosin stain (HE). **(A)**: Degenerated and necrotic myofibers with partial transversal condensed and disrupted sarcoplasm. Striped dolphin, case 8. HE, x10. **(B)** Detail of A. Degenerated and necrotic myofibers with partial transversal condensed and disrupted sarcoplasm. Striped dolphin, case 8. HE, x20. **(C)** Floccular degeneration and segmental necrosis with neutrophilic infiltration. Atlantic spotted dolphin, case 13. HE, x10. **(D)** Muscle regeneration with a row of internal nuclei. Pigmy sperm whale, case 17. HE, x20. **(E)** Vasculitis and neutrophilic inflammation with presence of bacteria. Atlantic spotted dolphin, case 13. HE, x20. **(F)** Detail of the presence of bacteria admixed with fibrin and neutrophils. Atlantic spotted dolphin, case 13. HE x60.

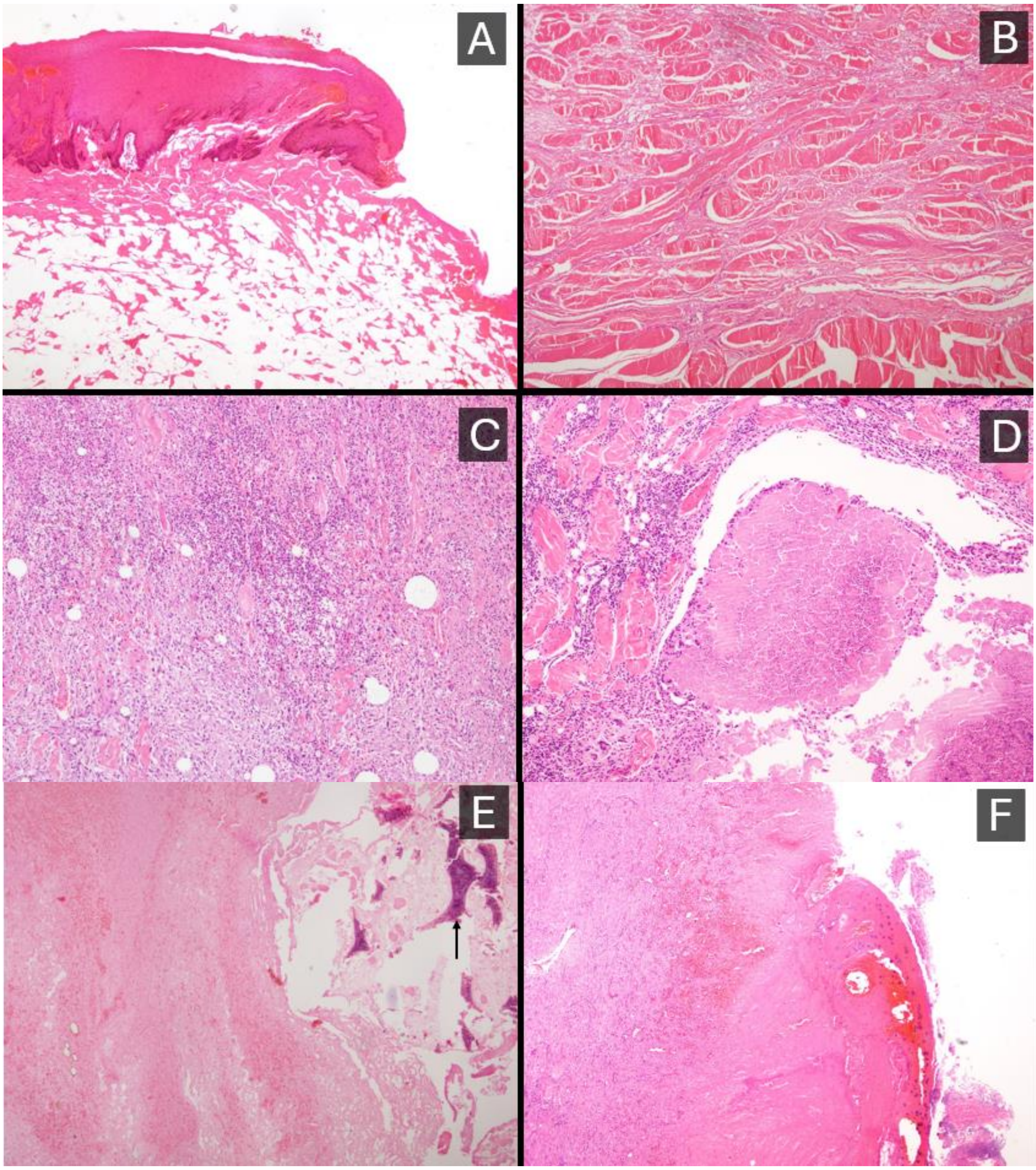

FIGURE 7 | Skin. Histological findings. Hematoxylin-eosin stain (HE). **(A)** Incised wound with loss of epithelium, congestion and hemorrhage. Atlantic spotted dolphin, case 6. HE, x4. **(B)** Necrotic-suppurative dermatitis. Atlantic spotted dolphin, case 6. HE, x10. **(C)** Neutrophilic and histiocytic dermatitis. Atlantic spotted dolphin, case 7. HE, x10. **(D)** Subcutaneous pyogranuloma. Atlantic spotted dolphin, case 13. HE, x4. **(E)** Necrosis, hemorrhages and bone fragments (ribs) in deep dermis. Pygmy sperm whale, case 17. HE, x4. **(F)** Epithelial necrosis, with fibrin, hemorrhages and bacteria. Atlantic spotted dolphin, case 13. HE, x4.

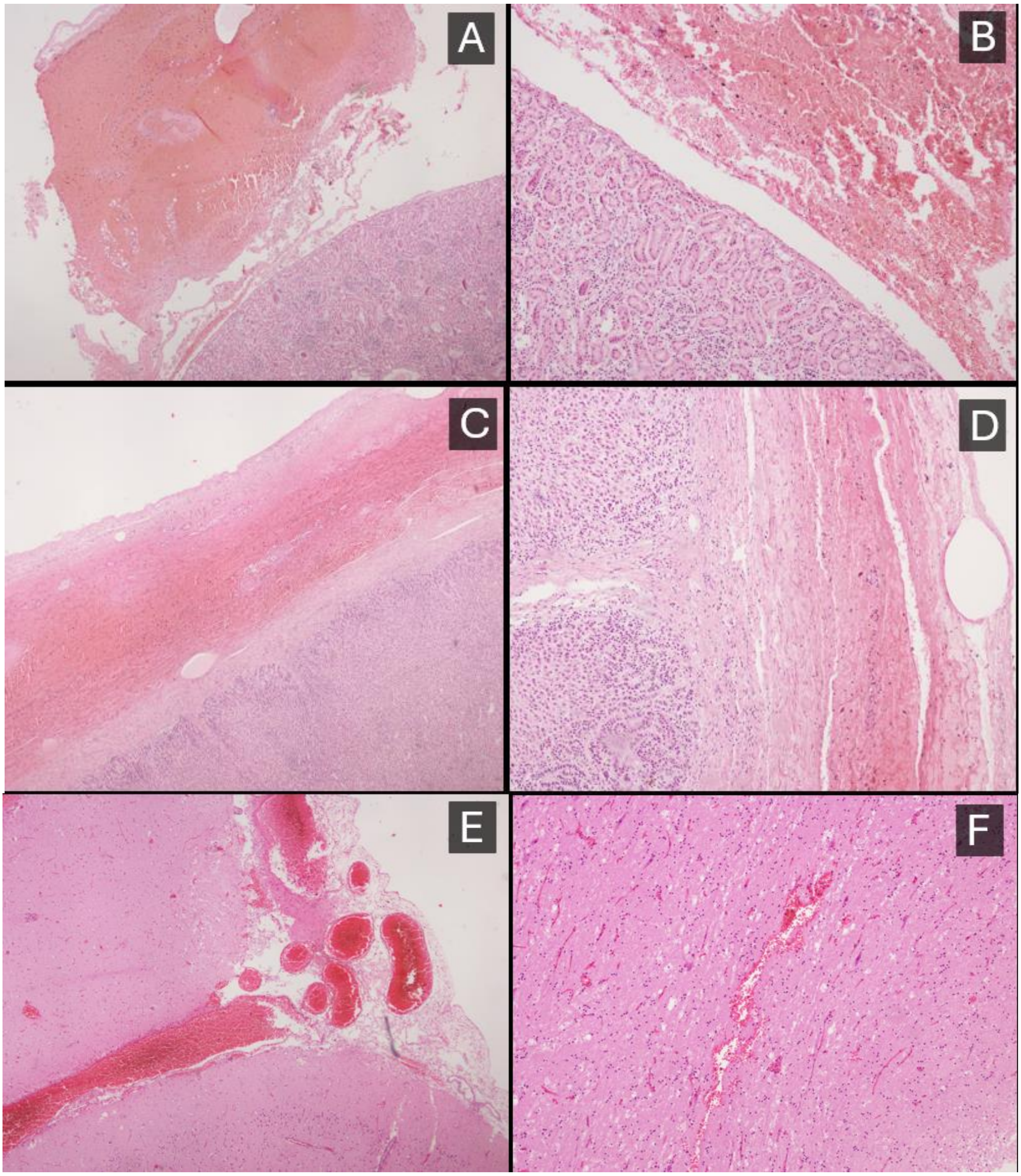

FIGURE 8 | Kidney, adrenal gland and brain histological findings. Hematoxylin-eosin stain (HE). **(A)** Kidney. Subcapsular and interrenicular hemorrhages. Striped dolphin, case 8. HE, x4. **(B)** Kidney. Subcapsular and interrenicular hemorrhage. Striped dolphin, case 8. HE, x10. **(C)** Adrenal gland. Capsular hemorrhage. Striped dolphin, case 8. HE, x4. **(D)** Adrenal gland. Capsular hemorrhage and presence of an intravascular gas bubble. Striped dolphin, case 8. HE, x10. **(E)** Brain. Hemorrhages in leptomeninges. Pigmy sperm whale, case 2. HE, x4. **(F)** Brain. Hemorrhages and vacuolization of neuroparenchyma. Pigmy sperm whale, case 12. HE, x10.