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Biological Data of Pygmy Killer Whale (*Feresa attenuata*) from a Mass Stranding in New Caledonia (South Pacific) Associated with Hurricane Jim in 2006

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Abstract

Despite its distribution throughout the tropics and subtropics, the pygmy killer whale (*Feresa attenuata*) is one of the most poorly known species of odontocetes (Cetacea: Delphinidae). We used the opportunity of a mass stranding of six animals in New Caledonia (early February 2006) to gather information about their biology. Four animals, including three males and one female, were found dead, and morphometrics, including dental counts, were collected. Two live mature males of 236 and 246 cm total length (TL), respectively, were closely monitored and sampled via blood analysis. As it was not likely to survive, the second animal was euthanized and necropsied. Following the euthanasia of the larger animal, the smaller one, which was probably staying out of social solidarity, returned on its own to the open sea. The necropsy revealed the presence of cardiopulmonary collapse and enlarged and congested testes. Blood parameters confirmed a deteriorating health status for both animals, enhanced by starvation. Some of the relative morphometric measurements of all six stranded pygmy killer whales seemed to be larger for these animals living in the southwest Pacific as compared to the literature for this species. We hypothesize that this group of pygmy killer whales was probably pushed through the Coral Sea toward the New Caledonian lagoon by Hurricane Jim, which occurred in the area from 26 January until 2 February. These observations reveal January as a potential part of the mating season in this area for this rare, elusive, and unknown species. It also supports the notion that early sacrifice of distressed, terminal animals could be a way to improve the survival rate of other less traumatized individuals during cetacean mass strandings.

Key Words: hematology parameters, cetacean, blood chemistry, odontocete, gregarious, climate event, mortality mitigation, mating season

Introduction

Pygmy killer whales (*Feresa attenuata*; Gray, 1874) are toothed whales from the family Delphinidae, with body lengths ranging from 2.1 to 2.6 m (for a complete description, see Donahue & Perryman, 2009). Maximum known weight is 225 kg (Jefferson et al., 2008). This species can be easily confused with other large, black-colored odontocetes, even by experts such as in Ecuador, Southeast Tropical Pacific (Castro, 2004), which was later correctly identified as false killer whales by Baird (2010). Despite distribution throughout the tropics and subtropics, pygmy killer whales are rare throughout their range and considered as "Data Deficient" in the *IUCN Red List* (Taylor et al., 2008); the species is listed in Appendix II of CITES. It is one of the most poorly known species of odontocetes (McSweeney et al., 2009).

In the western Pacific Ocean, at least 10 reliable sightings (between 1968 and 1995) of pygmy killer whales and five individuals identified at stranding (between 1990 and 2009) are known from the eastern coast of Australia (Atlas of Living Australia [AOLA], 2012), but only two sightings have been recorded in New Caledonia (Garrigue & Poupon, 2013). The presence of the pygmy killer whales is better documented in the eastern Pacific Ocean with several observations in the Hawaiian archipelago where a 22-y study described a small population of island-associated individuals around the main Hawaiian Islands (McSweeney et al., 2009). These animals only represented 1.2% of odontocete sightings through 40,709 km of trackline during 386 d (McSweeney et al., 2009). Two small groups of pygmy killer whales were recently observed in the western half of the Hawai'i Range Complex (HRC), and two animals were satellite tagged in October 2010 and displayed movement around O'ahu Island for 1 mo (Baird et al., 2011).

Following Robson (1984), the concept of *mass stranding* for marine mammals can be used when the process concerns three or more adult animals all together in a given area, not necessarily the same site; it is, however, commonly accepted (as we do) to include temporal and geospatial groupings of animals spread along several days and sometimes tens of km (Frantzis, 1998; D'Amico et al., 2009). Large groups of pygmy killer whales often strand together, and such mass strandings were described in Hawaii (Mazzuca et al., 1999), in Taïwan (Wang & Yang, 2006), and in the British Virgin Islands (Mignucci-Giannoni et al., 1999). These strandings are opportunities to learn more about these elusive animals, in particular about their physiology and anatomy. In February 1997, a male pygmy killer whale stranded alive on a beach of Puerto Rico and was transported for treatment in provisional facilities. Rodriguez-Lopez & Mignucci-Giannoni (1999) collected blood samples and a nasal swab to assess the health of the animal. Despite hydration and care, the animal died within 1.5 d after stranding and was necropsied. In June 2008, two pygmy killer whales stranded live near Boca Grande, Florida, and were taken into rehabilitation. Montie et al. (2011) examined the peripheral anatomy of the auditory system and hearing sensitivity. Although both animals died after several months, one appeared healthy enough to provide relatively normal values for comparison purposes (C. Manire, previously unpub. data, 2008).

Herein, we document the first stranding record of pygmy killer whales in New Caledonia in the western South Pacific, where a mass stranding occurred in early 2006 during Hurricane Jim. Data were collected on six animals from the stranding event. Two that were found alive were examined more closely, providing data on the physiology and insight into the social behavior of this species, including the identification of a potential part of their mating season in the South Pacific.

Methods

Study Site

New Caledonia (21° 30' S, 165° 30' E) is located approximately 1,200 km east of Australia in the South Pacific, within the Tropic of Capricorn. Between 1968 and 1997, the South Pacific region was hit by 117 hurricanes (average 4.03/y) of which 71 (60.6%) reached the New Caledonian Exclusive Economic Zone (EEZ) (data retrieved from www.cyclonextreme.com). A yearly average of more than two hurricanes suggests that dramatic climate events are quite frequent in this area. The main island, Grande Terre, is just over 400 km long and about 50 km wide. It is surrounded by more than 1,600 km of barrier reef that delineates a lagoon of almost 25,000 km^2 with a mean depth of 24 m (Figure 1A). The Southwestern Lagoon encompasses a relatively closed area with several sections reaching 30 m depth in a radius of 18 km from the main city, Nouméa. This part of the lagoon also includes several islets and intermediate reefs. Cetaceans such as delphinids (*Stenella longirostris* and *Tursiops aduncus*) and more

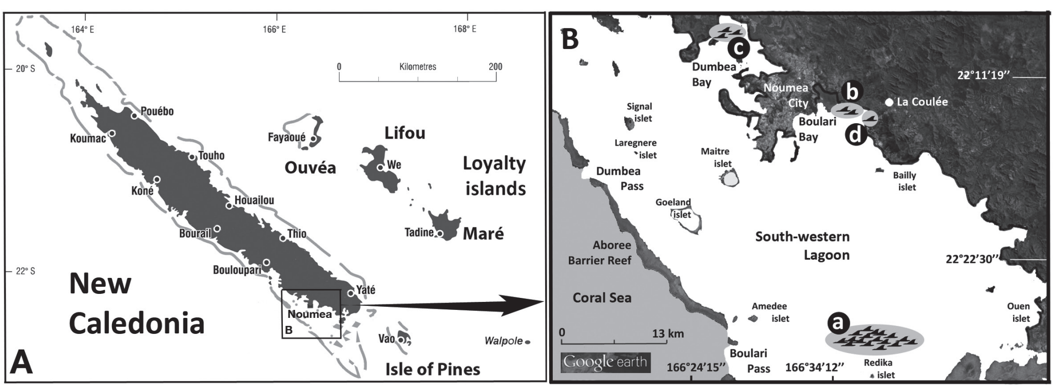

Figure 1. (A) General view of the main island of New Caledonia showing the delineation of its great lagoon, including a large southwestern component; and (B) portion of the southwestern lagoon where the herd of pygmy killer whales (*Feresa attenuata*) was probably first sighted near Redika Islet on 29 January 2006 (a), before the first stranding of two live animals around La Coulée area on 31 January (b), then the second stranding of three dead animals in Dumbea Bay on 4 February (c), and the last single stranding of a dead animal again in La Coulée area on 8 February (d).

scarcely *Balaenoptera acutorostrata* and other *Balaenoptera* spp. utilize the shelter with relatively easy access to the open ocean provided by several reef passages (Figure 1A).

Data Collection

Based on the testimony of passengers on a recreational boat, a group of about 20 animals described as "black dolphins" (species unidentified at this stage) was first spotted in the vicinity of Redika Islet on 29 January 2006 (Anonymous, 2006). At 1400 h on 31 January, three black and elongated animals were found live-stranded in a mangrove area at the end of Boulari Bay (east of the capital city of Nouméa) by fishers who pushed the animals back into deeper surrounding waters (Figure 1B). When these three whales stranded again a few hours later, the local firemen were called at 1800 h to repeat the same rescue effort. This effort also failed, and two animals restranded. The third animal did not restrand with them. A team composed of two veterinarians (including one co-author, EC) and two members of Operation-Cétacés (including one co-author, CG) was informed and arrived on site at 0900 h on 1 February. Biometric measurements and skin samples were taken on the two animals (hereafter referred to as #1 and #2), which were about 100 m from each other. After sample collection, both animals were pushed into deeper water and left in water about 1 m deep (at low tide) to maximize their probability of survival.

On 2 February at 1400 h, EC and CG returned to the site and found both animals still alive in the same area, surrounded by several children who were holding them and preventing them from stranding again. From a vessel, blood samples were taken from the fluke of both animals; and samples for cell counts and hemoglobin determinations were collected in anticoagulant tubes. Dorsal fins were photographed on both occasions. As there was no available place to rehabilitate the animals, several attempts were made to push the animals to deeper water, but they immediately returned to shore. Animal #2 was in very poor condition and respiratory distress. Based on recommendations in Geraci & Lounsbury (2005) and given that it had lost palpebral and corneal reflexes, the animal was euthanized under veterinary supervision by an intravenous injection of T61^{MD}. It was then pulled onto the beach and a necropsy was performed (focusing on the peritoneal cavity, heart, and lungs).

On 4 February, the firemen informed scientists that three additional animals (animals #3, #4, and #5) stranded in Maisonneuve Bay near Dumbea Bay. Four days later on 8 February, fishers reported a single dead animal (animal #6) stranded for several days at Saint Louis in Boulari Bay, near the area where the first live animals had been found (Figure 1B). Examination of these latter four individuals was conducted, but the state of decomposition prevented the collection of blood samples. Biometric measurements and skin samples were taken from all stranded animals (N = 6). Stomach contents were examined, and tooth counts were performed on the five animals that died.

Data Analysis

Blood samples from animals #1 and #2 were sent to the veterinary laboratory of New Caledonia for assessing routine hematology and chemistry parameters. Their results were compared to similar data from a live-stranded pygmy killer whale (animal #7) from the Caribbean (Rodriguez-Lopez & Mignucci-Giannoni, 1999) and to average blood parameters taken from a rescued live pygmy killer whale (animal #8) in rehabilitation at Mote Marine Laboratory and Aquarium in Florida (unpub. data from case reported in Montie et al., 2011). This adult male stranded on 16 June 2008 with a second male (animal #9) and underwent rehabilitation for 5 mo. Although the pygmy killer whale eventually died from parasites in the brain, blood values appeared to be normal for a period when the animal was stable. Those values from a 2-wk time period are included here for comparison. In addition, values taken from this pygmy killer whale upon admission and those taken from the second male from the same stranding are provided (animal #9).

Results

Morphology, Color, and Behavioral Patterns of Animals #1 and #2

The body color of animals #1 and #2 was dark grey to black with a greyish flank and a whitish pink area around the genital region. The tip of the snout and the lips were white, and numerous white oval scars attributed to *Isistius* sp. were observed on the ventral surface of both animals (Figure 2a). A few parallel scars, likely from tooth rakes, were present on the back and flanks. Animal #1 had almost no coral reef scars on the body, but some recent abrasions were found on animal #2, probably caused by contact with coral reefs in shallow water. In addition, several barnacles were attached to the front teeth of the upper mandible of animal #2. When found on 31 January, both animals were beached and appeared physically exhausted. Animal #1 was in slightly better shape than animal #2, which appeared older (as confirmed by its total length; see below) and in a more precarious state of health. The following day, the health status had deteriorated for both animals, more so for animal #2. The abrasions on their bodies were significantly more numerous. Animal #2 was in respiratory distress, almost drowning each time the children released their hold at the surface. At this point, it was decided to conduct a humane euthanasia, and it is important to note that immediately after the euthanasia and removal of animal #2 from the water, animal #1 started swimming toward the open ocean on its own.

Sex, Total Length (TL), and Dental Count

External measurements were obtained from most of the specimens (Table 1). The advanced decomposition of the last stranded animal did not allow for the collection of all biometric information as its fluke was not present. TLs ranged from 218 to 247 cm (Table 2). Five of the stranded animals were males and one was a female. Dental counts were noted (Table 2). The stomachs of all five dead individuals were empty.

Necropsy of Animal #2

The necropsy performed on animal #2 mainly revealed an abnormal congestion of the lungs, associated with traces of foam in the airways and alveoli, evidence of edema and/or drowning. The testes were congested (with apparent and

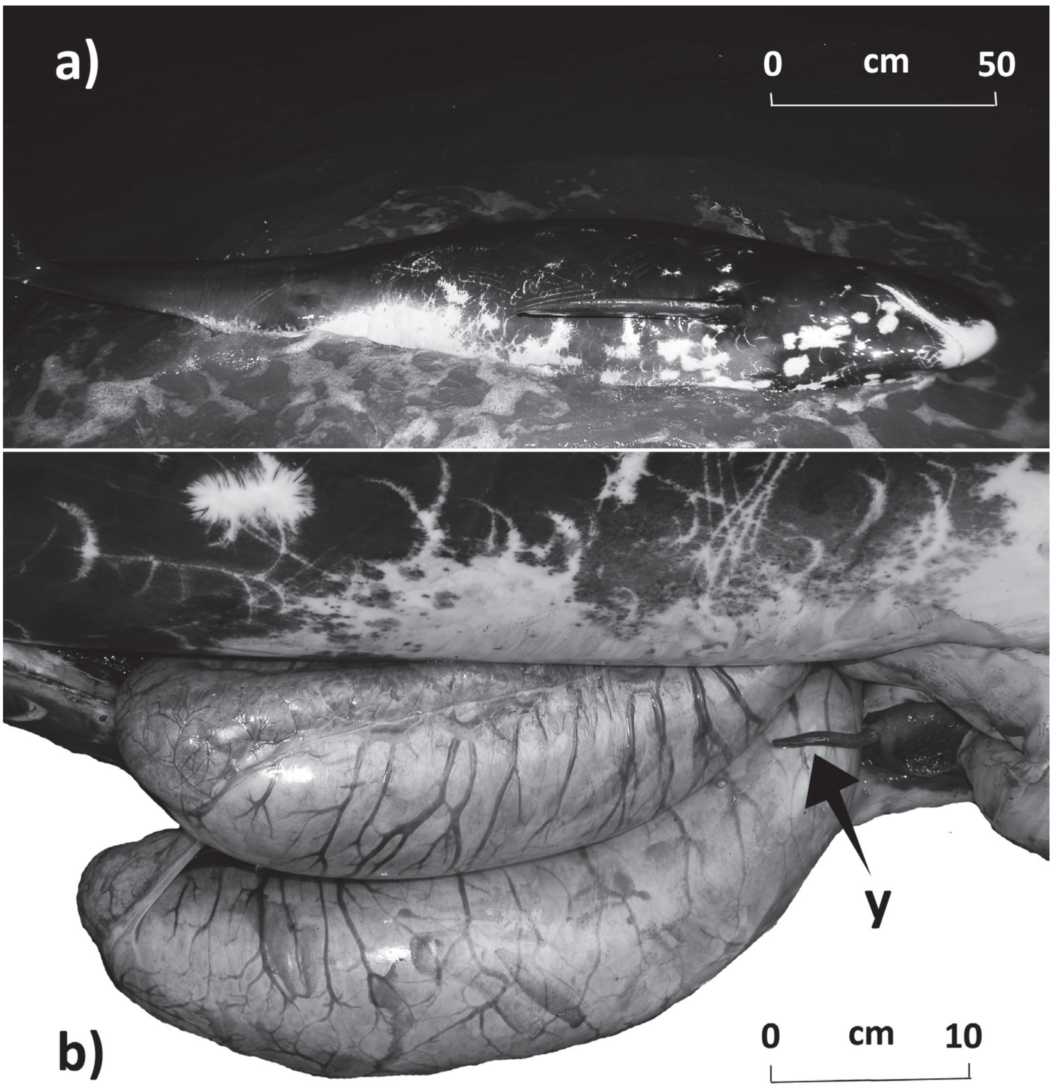

Figure 2. Photographs of animal #2 showing (a) the ventral body coloration, including the several oval and whitish scars probably following *Isistius* sp. bites; and (b) details of the two hypertrophied testes with a developed vascular system and the penis in a posterior position (Y) as observed through the necropsy.

Table 1. External measurements (cm) of the six stranded pygmy killer whales (*Feresa attenuata*) (A) compared with the values for the species (B) presented in Ross & Leatherwood (1994)

	New Caledonia		In Ross & Leatherwood (1994)	
Measurements	Mean (range)	% of TL: Mean (range)	Mean (range)	% of TL: Mean (range)
Total length	233.7 (218-247)	--	225.6 (207-259)	--
Snout to eye	27.7 (26-29)	11.9 (11.0-12.4)	22.9 (18.0-28.0)	10.2 (8.1-12.0)
Snout to blowhole	27.3 (26-29)	11.7 (10.6-12.9)	21.6 (15.0-25.5)	9.6 (6.7-11.9)
Snout to gape	23.3 (21-25)	10.0 (9.3-11.0)	15.5 (12.0-21.2)	7.2 (5.4-9.4)
Snout to anterior insertion of flipper*	47.8 (46-49)	20.0 (19.1-20.8)	44.4 (38.5-53.5)	19.6 (16.8-21.9)
Snout to tip of dorsal fin	131.3 (108-154)	56.2 (43.9-62.2)	131.0 (120.0-147.0)	58.4 (54.3-63.6)
Flipper, anterior insertion to tip**	46.4 (42-49)	19.6 (19.1-20.9)	45.1 (40.0-50.5)	21.1 (18.2-22.1)
Flipper, max width	17.2 (16-19)	7.4 (6.9-8.7)	14.5 (13.0-16.3)	6.5 (5.8-7.0)
Dorsal fin, height	24.7 (22-29)	10.6 (9.7-12.6)	23.7 (20.0-29.5)	10.5 (9.4-12.3)
Width of flukes, tip to tip**	67.6 (64-70)	28.6 (25.9-31.1)	57.6 (49.5-66.0)	25.5 (23.8-28.4)

*N = 4, **N = 5

Table 2. Sex, individual length (cm), and dental count of the six stranded pygmy killer whale stranded in New Caledonia in 2006

Animal #	Date of stranding	TL (cm)	Sex	Dental formula: UR/UL/LR/LL
1	31/1/2006	236	Male	NA
2	31/1/2006	246	Male	9/9/9/11
3	4/2/2006	230	Female	11/10/12/12
4	4/2/2006	247	Male	9/9/11/11
5	4/2/2006	225	Male	10/11/11/11
6	8/2/2006	218	Male	10/10/13/13

NA: Not available

numerous blood vessels) and enlarged (Figure 2b). It therefore was assumed to be an adult male. The cardiac muscle appeared slightly soft and distended. The stomach was empty with a small parietal ulcer (diameter of 2.7 cm). It contained many free parasites in the peritoneal cavity as well as some embedded in the blubber. No evidence of visible infectious lesions or trauma from injuries was found internally.

Hematology and Chemistry Parameters of Animals #1 and #2

For animal #1, the hemogram showed the mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) to be slightly elevated and the red blood cell (RBC) count to be slightly decreased compared to baseline figures such as those for rehabilitated animal #8 (Table 3). Additionally, animal #1's blood sample showed the white blood cell (WBC) count to be somewhat decreased (slight leukopenia) as were the lymphocytes (lymphopenia) and slightly decreased levels of platelets (thrombocytopenia). The blood chemistry for this animal showed it to have slightly elevated alanine aminotransferase (ALAT), aspartate aminotransferase (ASAT), total serum bilirubin, and creatinine as well as lowered calcium, alkaline phosphatase (AP), and phosphorus.

For animal #2, the hemogram showed the RBC, hemoglobin, and MCH to be slightly elevated and the WBC and lymphocytes to be slightly decreased. The blood chemistry for this animal showed ALAT, ASAT, total serum bilirubin, and creatinine to be elevated, and the calcium, AP, and phosphorus to be decreased.

Discussion

In the context of very scarce information available about this species, our observations allowed us to gather some interesting data about the anatomy, biology, and social behavior of pygmy killer whales in the South Pacific.

Additional Morphometric and Anatomic Data on Pygmy Killer Whales

The external morphology and color patterns of the two pygmy killer whales that live-stranded fit the description found in the literature (Jefferson et al., 2008). As revealed by their length, the six stranded

Table 3. Hemogram and blood chemistry values of animals #1 and #2 compared with values of animal #7, stranded alive in Puerto Rico (Rodriguez-Lopez & Mignucci-Giannoni, 1999); of animal #8, a rescued live pygmy killer whale undergoing rehabilitation at Mote Marine Laboratory and Aquarium in Florida (unpub. data from case reported in Montie et al., 2011); and of animal #9, a second male from the same stranding event

	Parameter	Animal #1 (New Caledonia)	Animal #2 (New Caledonia)	Animal #7 Stranded *F. attenuata*	Animal #8 Stranded *F. attenuata*	Animal #8 Rehabilitated *F. attenuata*	Animal #9 Stranded *F. attenuata*	Units
Hemogram	Red blood cell (RBC) count	3.53	4.46	4.2	4.8	3.8	4.59	Millions/mm^3
	Hemoglobin	17.9	17.5	16.4	17.3	13.1	16.7	g/dl
	Hematocrit	45	45	47.9	52.7	40.8	51.1	%
	Mean corpuscular volume	127	100.9	113	109.8	107.9	111.3	fl
	Mean corpuscular hemoglobin concentration (MCHC)	39.78	38.89	34.2	32.8	32.2	32.7	g/dl
	Mean corpuscular hemoglobin	50.71	39.24	38.7	36.0	34.8	36.4	fl
	White blood cell (WBC) count	6.6	5.6	8.9	2.1	8.9	4.4	0.000
	Neutrophils	91	83	81	56	65	70	%
	Eosinophils	1	0	3	3	12	3	%
	Basophils	0	0	0	0	0	0	%
	Lymphocytes	7	13	13	34	19	22	%
	Monocytes	1	4	1	7	2	5	%
	Platelets	0.35	1.25	NP	1.60	NP	NP	10exp11/l
Blood chemistry	Alanine aminotransferase (ALAT)	62	38	115	8.0	28.7	60	UI/l
	Albumin	39	42	40	37	44	43	g/l
	Aspartate aminotransferase (ASAT)	349	229	1,150	160	149	359	UI/l
	Total serum bilirubin	23.5	35.1	30	44.2	8.5	35.3	Micro mole/l
	Calcium	7.2	7.2	8.6	9.3	9.7	8.8	mg/dl
	Creatine kinase (CK)	317	679	416	NP	NP	NP	UI/l
	Creatinine	2.99	3.74	1.4	3.2	1	2.4	mg/dl
	Alkaline phosphatase (AP)	102	110	32	64	209	29	UI/l
	Phosphorus	5.88	5.26	5.2	8.6	6.3	4.2	mg/dl
	Total protein	86	74	71	79	89	85	g/l
	Urea	57.4	54.3	NP	33	64.3	32	mg/dl

NP: Not provided

pygmy killer whales were mature; males of this species are considered sexually mature when they reach 200 cm in length (Wang, 1999). The state of wear of teeth confirmed this fact. Most of the biometric measurements were within the range(s) found in the literature (Ross & Leatherwood, 1994), but some relative values seemed to be greater (Table 1). The main differences are the distances between the snout and the eye, snout and blowhole, snout and gape, maximum width of the flipper, and width of the fluke. Some of the external relative measurements seemed to be larger in the animals living in the western South Pacific compared to those presented by Ross & Leatherwood (1994).

The dental counts noted for these stranded animals are consistent with those reported for the species (Table 2; Ross & Leatherwood, 1994). The last stranded animal was very putrefied and was located in the same area as the first two (see Figure 1B[d]); we hypothesize that it could be the third animal that was part of the original group sighted and manipulated on 31 January by the fishers and firemen. Still, we cannot confirm ID as that third animal because the scientific team did not observe it. And, if it was the third animal, it stranded and died several hundred meters from its two conspecifics, probably on 1 or 2 February.

Analysis of Hematology and Chemistry Parameters

The most interesting finding is that WBC levels were low for animals #1 and #2, which is a symptom of leukopenia or rather pseudoleukopenia (Table 3). Pseudoleukopenia can develop at the onset of infection. The leukocytes (predominantly neutrophils) start migrating toward the site of infection and can be seen at the infection site. Their migration causes bone marrow to produce more WBCs to combat infection and to restore the leukocytes in circulation, but as the blood sample was likely taken upon the onset of infection, it contains a low amount of WBCs, which is why it is called *pseudo*leukopenia. For both animals, this hypothesis is confirmed by low levels of leucocytes that are mobilized by the fight against a starting infection, either viral or bacterial, probably facilitated by the stress of the strandings. Eosinophils deal with parasitic infections, and their depletion could be explained by the high concentration of parasites that were found during the necropsy of animal #2; animal #1 would likely host the same level of infection and also show a decrease in eosinophils. However, a drop in eosinophils could also be observed in the context of stress, which would be an additional contributing factor in this case.

The RBCs of animal #1 seemed low, likely due to a thrombopenia (low level of platelets). This could be interpreted as the commencement of anemia following several days of starvation. Hemoglobin and hematocrit are slightly superior between stranded animals and the captive animal (Table 3); this could be linked to the fact that wild animals need greater diving capacities (correlated to hematocrit and capacity to store O_2) than animals residing in shallower depths.

Levels of calcium for animals #1 and #2 are significantly lower than those of animals #7 and #8. This could be explained by a potential alkalosis due to hyperventilation that both stressed animals were displaying while they were held at the surface. Animal #2 showed a high level of creatinine kinase (CK), which can be an indicator of acute stress disorder and kidney deficiency. These results are consistent with its general health status on 1 February. Animal #1 survived after maintaining normal levels of CK compared to moribund animals #2 and #7 (Table 3). Compared to animal #8, which underwent rehabilitation, the slightly increased level of total blood protein in animals #1 and #2 is likely due to dehydration linked to starvation. Levels of alkaline phosphatase (AP) for both animals #1 and #2 were higher than for animal #7 and lower than for animal #8 in rehabilitation. Low levels of AP are generally due to nutritional deficiencies. We can hypothesize that both of the New Caledonian animals #1 and #2 had more substantial energetic reserves as compared to animals #7 and #9. However, an AP depletion generally signals impending death in other odontocetes, confirming the negative prognosis for animal #2, which justified its euthanasia. Both levels of ALAT and ASAT of animals #1 and #2 were significantly lower than animal #7 and higher than animal #8; an increase of these enzymes is probably due to the effect of gravity on the liver at stranding. It increases for a week or two and then gradually returns to normal with almost every rehabilitated cetacean (C. Manire, pers. obs., 2008).

From a general perspective, blood and chemistry parameters of animals #1 and #2 undoubtedly reflected their deteriorating conditions. Based on animal #2's necropsy, both lung and heart status suggested a marked cardiovascular insufficiency, probably associated with the repetitive strandings. The size and congested testes of this animal should be considered as normal, probably linked to an ongoing mating period, logically concerning a mature male such as animal #2. This is an interesting point as there was so far no available information regarding the mating period for this species, but it seems to include January in the South Pacific.

Cause of the Mass Stranding

The causes of cetacean strandings remain largely unknown, although many hypotheses have been advanced; examples include magnetic navigation anomalies (Klinowska, 1985), confused navigation linked to bathymetric conditions (Brabyn

& McLean, 1992), distraction by activities such as foraging (Wood, 1979), or even regression to ancient instinctive behaviours (Cordes, 1982). Disease and parasitism are often stated as a cause of both single and mass cetacean strandings (Dailey & Walker, 1978). In addition to these natural causes, human activities can also lead to strandings. The accidental entanglement or bycatch in fishing gear combined with marine litter and vessel collisions are major sources of cetacean mortality (Parsons et al., 2007). Sound pollution from anthropogenic sources such as shipping, explosions, seismic surveys, military sonar, and harassment devices make a large contribution through impairment of the cetaceans' auditory abilities (Gordon & Tyack, 2001; Nowacek et al., 2007; Perrin & Geraci, 2009). In early 2004 and in 2005, several unusual stranding events occurred in Taiwan during a period of large-scale naval exercises. Examination of the partial remains of a pygmy killer whale revealed internal injuries due to structures associated with or related to acoustics or diving, suggesting that those nearby naval exercises may have contributed to the death of the animal (Wang & Yang, 2006).

Natural causes of strandings remain dominant in the South Pacific as strong and persistent storm events may cause animals to strand because of disorientation or additional energetic costs (Evans et al., 2005). Hurricane Jim was in the Coral Sea from 26 January until 2 February 2006; we strongly believe that the mass stranding of this group of pygmy killer whales is related to the severe weather. Our hypothesis is supported by a previous record of a mass stranding of this same species in the British Virgin Islands (Mignucci-Giannoni et al., 1999); the stranding was associated with meteorological and oceanographic disturbances from Hurricane Marilyn, which devastated the Virgin Islands a day prior to the stranding (see also Geraci & Lounsbury, 2005). In our case, the first strandings were observed on 31 January when the trajectory of the hurricane was at its minimum distance from New Caledonia (Figure 3). Thus, the deteriorated health status of both animals #1 and #2 can be attributed to a huge physical effort likely related to escaping through the Coral Sea from the approaching hurricane. Their physical deterioration may have been worsened by their inability to feed properly in lagoon waters as

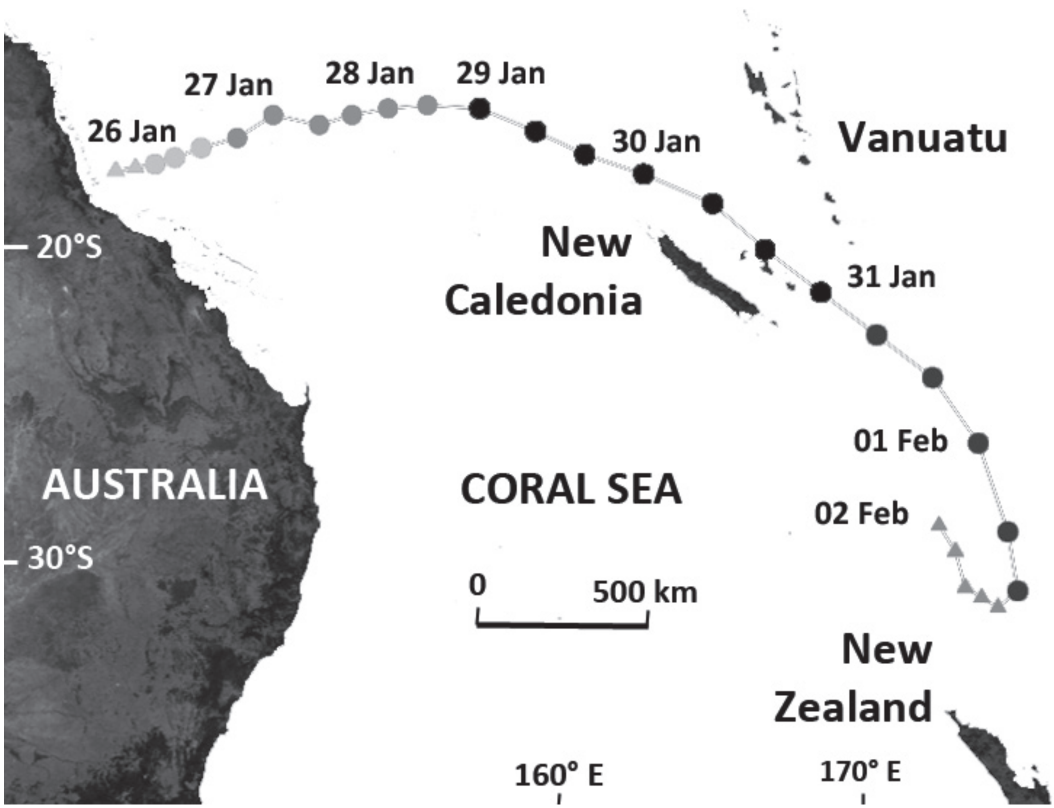

Figure 3. Chronological trajectory of Hurricane Jim from 26 January until 2 February 2006 (Source: Wikipedia)

suggested by the empty stomachs of animal #2 and all of the other dead stranded animals. Pygmy killer whales seem to primarily feed on cephalopods (Santos & Haimovici, 1998; Williams et al., 2002) and smaller cetaceans (Madsen et al., 2004) that are not available in the lagoon of New Caledonia.

Mitigation of Mass Strandings

Frequently, it has been documented that a whole group of cetaceans could strand around a sick companion, refusing to leave it until it died. It is thought that the other members of the group follow due to cohesive social bonds. This is confirmed by the fact that mass stranding events usually involve highly social odontocetes such as pilot whales (*Globicephala* sp.) (Berta et al., 2006). A particularly dramatic example has been recorded of 30 false killer whales (*Pseudorca crassidens*) that semi-stranded in very shallow water in the Dry Tortugas in 1977. The group included a large male that was moribund due to illness and the other whales that clustered around it without moving. Every time the assembled people tried to save them, they obstinately returned to restrand around the wounded male. Only when it died 3 d later did the other false killer whales go back to the open sea (Odell et al., 1980). On 17 April 1994, five Risso's dolphins (*Grampus griseus*) stranded off the Ebre Delta (Mediterranean Sea) around a female suffering from serious respiratory difficulties. Once the female was withdrawn, to be taken to a care center, the other cetaceans went back to the open sea without any problem (Alegre et al., 1995). In rare circumstances, such strandings can involve multiple species at the same time. This was the case on the Atlantic coast of the U.S., with bottlenose dolphins (*Tursiops truncatus*) showing solidarity with a group of black pilot whales (Duignan et al., 1996).

Regarding our case, we could consider that following the stress induced by the hurricane, animal #2 was exhausted enough to be unable to move back to the open ocean and that the younger animal #1 was showing solidarity by remaining in close contact. Right after the withdrawal of animal #2 from the water, animal #1 swam away from the area. As it was not found restranded in the days following, and given its better health status compared to animal #2, we can hypothesize that it may have survived. This hypothesis is supported by the example of the false killer whales in Florida and recent demonstrations through satellite tracking and monitoring of the successful release of stranded animals in Australia and the U.S., in spite of their poor conditions (Gales et al., 2012; Sampson et al., 2012). The withdrawal of animal #2 on 1 February was artificial, but we can hypothesize that its natural death would have had the same consequence of releasing animal #1. An early release can be considered to be a critical factor for optimizing the survival of animal #1 whose health status was declining through the multiple strandings imposed by its dying companion. Based on the documented examples cited above and our experience, the sacrifice of one or several animals, in keeping with their respective health status, should be considered as a potential strategy for managing the survival rate during cetacean mass strandings (Geraci & Lounsbury, 2005; Dierauf & Gulland, 2010).

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