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# Franciscana calls for help: the short and long-term effects of Marianas disaster on small cetaceans of South-eastern Brazil

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# Franciscana calls for help: the short and long-term effects of Mariana's disaster on small cetaceans of South-eastern Brazil

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## Abstract

In November 5, 2015, one tailing dam holding at least 34 million cubic meters of iron-mining waste, construction material and water, collapsed, releasing a torrent of mud into the Doce River, South-eastern Brazil. The contaminated river waters went downstream 650 km and reached the Atlantic Ocean at Regência, in November 21, eliminating the aquatic life of this river basin on their way. This river mouth is known by its extreme ecological significance which includes the two most endangered cetaceans of the Southwestern Atlantic Ocean: Guiana dolphin (*Sotalia guianensis*) and Franciscana dolphin (*Pontoporia blainvillei*). this report is to briefly introduce the potential short and long-terms impacts of the Mariana's dam disaster on these two endangered dolphin species. Examining Landsat 8-derived images, we demonstrate that the plume spread over 2,580 km$^2$ in surface waters, that is, two times the natural plume observed two months before the incident. The high concentrations of dissolved metals, including heavy metals, also represent a sound mischaracterization of the habitat, which may distort or/and require adaptations of the biosonar system under such conditions. Bycatch in coastal gillnets and habitat degradation already represent continuing threats to Guiana dolphins and Franciscana dolphins along the northern coast of Espírito Santo. Therefore, this catastrophic incident may significantly increase the threat level of the northern Franciscana population.

## Introduction

In November 5, 2015, one tailing dam (Fundão) holding at least 34 million cubic meters of iron-mining waste, construction material and water, collapsed, flowing over the Santarém dam, and releasing a torrent of mud into the Doce River, South-eastern Brazil (ANA, 2016). This toxic mud buried Bento Gonçalves village, in Mariana Municipality, state of Minas Gerais, located some 5 km from the dams, causing the death of at least 18 people and catastrophic biodiversity losses long way off. The contaminated river waters went downstream 650 km and reached the Atlantic Ocean at Regência, in November 21, eliminating the aquatic life of this river basin on their way. The iron ore mine was operated by Samarco Mineração SA, a joint venture between Vale SA and BHP Billiton Brasil Ltda. On the afternoon of January 27, 2016, a new leak of tailings occurred in the same dam, in Mariana, further affecting life downstream. This time, the volume of displaced waste reached 1 million cubic meters. This new event evidenced that the break has not ceased and there is considerable remaining, approximately 20 million cubic meters, within the Fundão Dam (minesandcommunities.org/article.php?a=13235).

## Objectives

The Doce River mouth is known by its extreme ecological significance due to its high biological productivity, followed by an impressive diversity of aquatic species (Ramsar Convention, 2016) which includes the two most endangered cetaceans of the Southwestern Atlantic Ocean: Guiana dolphin (*Sotalia guianensis*) and Franciscana dolphin (*Pontoporia blainvillei*) (Figure 1). The beaches along the mouth of Doce River are important nesting sites for sea turtles, including leatherbacks (Baptistotte et al., 2003, Thomé et al., 2007).

Although such catastrophe has impacted all living organisms which depends on the Doce River, the main objective of this report is to briefly introduce the potential short and long-terms impacts of the Mariana's dam disaster on these two endangered dolphin species.

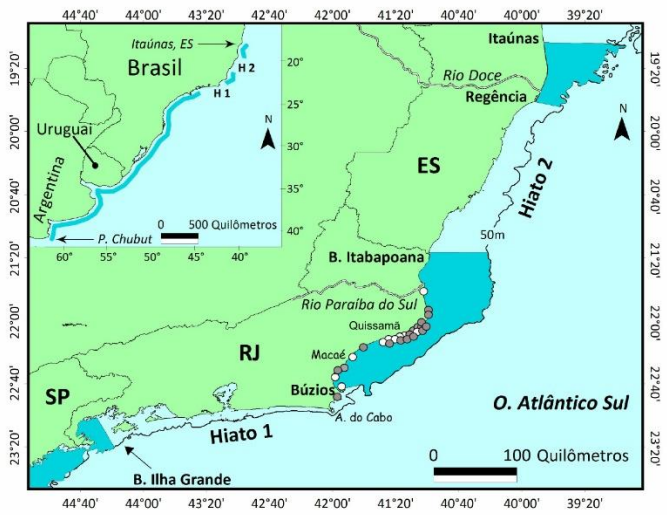


Figure 1. Franciscana dolphin (*Pontoporia blainvillei*) range along South-eastern Brazil, corresponding to the northern distribution limit of the species. Note the two isolated sub-populations: one in the northern coast of Espírito Santo State (Franciscana Management Area 1a – FMA 1a) and one in the northern coast of Rio de Janeiro (Franciscana Management Area 1b – FMA 1b). The Doce River is also indicated in the figure. Prepared by J.F. de Moura (GEMM-Lagos).

## Results and Discussion

Two small cetaceans inhabit the mouth of Doce River and adjacent waters: the Guiana dolphin (*Sotalia guianensis*) and the Franciscana dolphin (*Pontoporia blainvillei*) (Moreno et al., 2003, Frizzera *et al.*, 2007, Pinheiro, 2014). Both are known to interact with local artisanal fishing nets (Siciliano, 1994, Netto and Siciliano, 2007, Frizzera et al., 2012). Rupil (2016) examined stomach contents of coastal dolphins found stranded along southern Bahia and Espírito Santo states (54 *S. guianensis*, 18 *P. blainvillei* and one *Tursiops truncatus*). Small bottom-dwelling fishes, mainly Sciaenidae associated to estuaries, were indicated as important preys of Franciscana dolphins along the northern coast of Espírito Santo.

Based on a recent report from the Brazilian Navy, the torrent of mud was observed reaching more than 15 Km offshore the Doce River mouth (Brazilian Navy, 2016)**.** The tailing ponds were basically filled with silica, iron oxide, aluminum, construction materials and additional water from the rainfall (FAPEMIG,

2015, ANA, 2016). These mineral composts would certainly change turbidity and concentration of dissolved iron in the water column, as well as total iron, aluminum, manganese and solids in the streams directly affected (ANA, 2016).

Examining Landsat 8-derived images with 30 meters of resolution (bands 4 and 2), we demonstrate that the suspended sediment plume has reached 80 km southward the Doce River mouth by May 2016 (Figure 2). From the date of the incident on 05 November 2015 to 12 May 2016 the plume spread over 2,580 km$^2$ in surface waters, that is, two times the natural plume observed two months before the incident (Figure 2). The potential impacts of the sediments loads during the Mariana's disaster deserve high priority in view that the sediment plume overlaps an extensive area inhabited by *P. blainvillei*, within the Franciscana Management Area 1 (FMA 1a) (Siciliano *et al.*, 2002). It is known that this population is restricted to shallow coastal waters between Regência and Itaúnas, northern Espírito Santo, and is considered the most vulnerable among the four FMA's due to a relatively low number of individuals and low genetic diversity (Rocha-Campos *et al.*, 2010)

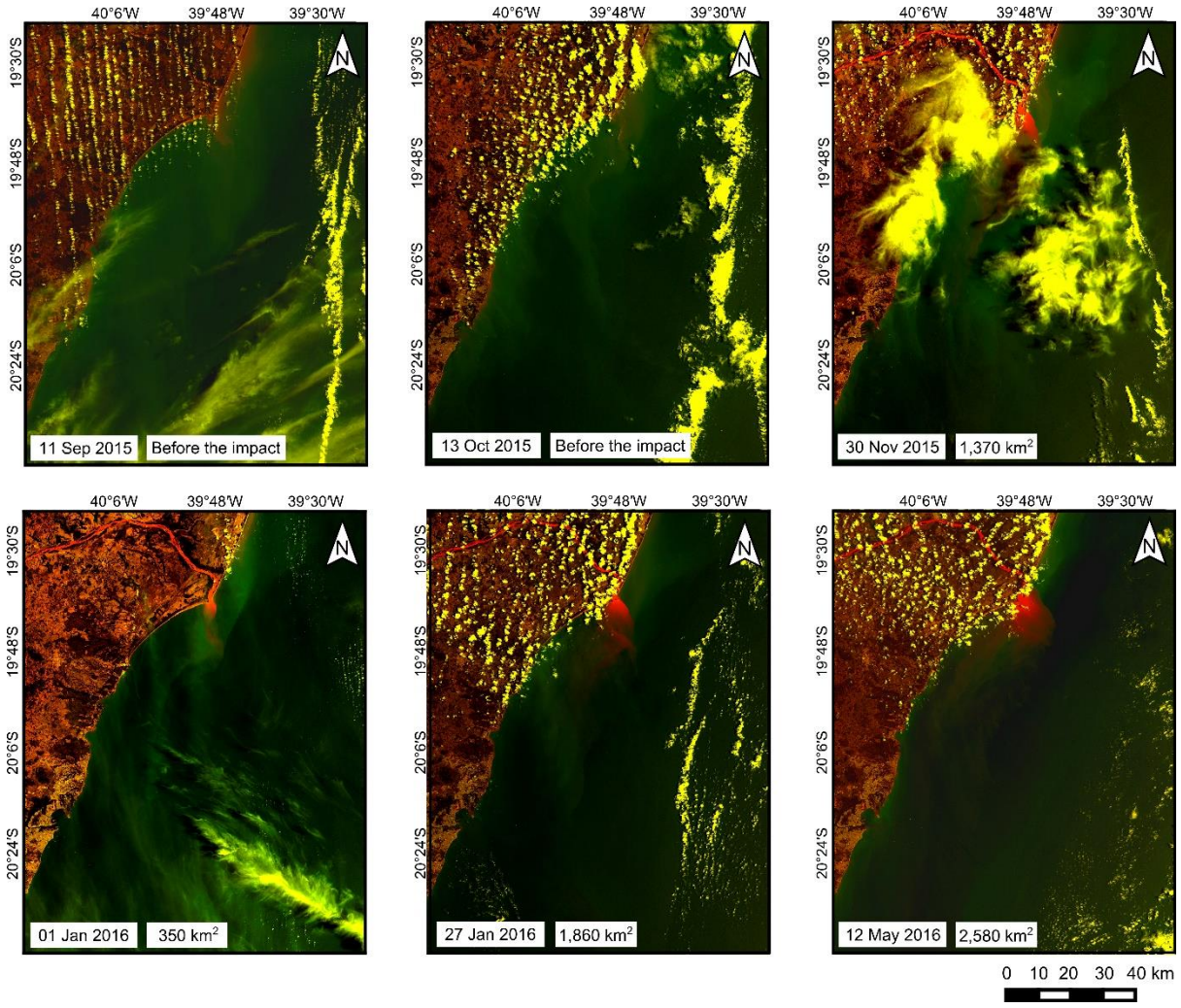


Figure 2. Landsat 8-derived images of the River Doce, South-eastern Brazil, a month before-and-after the impact of Mariana's disaster. Reflectance bands 4 and 2 were selected for a better contrast between the suspended sediment plume and non-contaminated waters.

Also, at least three heavy metals were detected in higher concentrations than allowed by the National Environment Council – CONAMA 357/2005 resolution on some points of the mouth of Doce River. The most abundant heavy metals were: manganese (Mn) with 27 times higher than the acceptable by law, followed by lead (Pb) (1.9 x) and selenium (Se) (1.7 x) (Brazilian Navy, 2016)**.** Although high concentrations of toxic elements could be enough to discuss further impacts on such dolphin species, short-term impacts can be predicted when relevant physical properties of water are changed regarding two echolocating species. The high concentrations of dissolved metals, including heavy metals, also represent a sound mischaracterization of the habitat, which may distort or/and require adaptations of the biosonar system under such conditions.

Odontocetes are known to inhabit coastal, pelagic, deep and fresh waters, which adaptive convergence regarding biosonar modifications are known for several groups (Madsen *et al.*, 2005). The evolution of a complex high-frequencies sound production in phylogenetically distinct small cetaceans, for example, reflects a potential adaptation for noisy habitats like coastal (e.g. *Phocoena*, *Cephalorhynchus* and *Pontoporia*) (Kyhn *et al.*, 2010, Madsen et al*.,* 2005) and freshwater environments (e.g. *Platanista*) (Jensen *et al.*, 2013). The main feature of high frequency sounds is that the energy loss during the echolocation behavior is more accentuated than low frequencies, leading the individuals to produce clicks with more repetition rates to compensate the energy loss for the target recognition (Au, 2000). Therefore, sounds for target recognition can be influenced by external factors between its emission and reception. The effects on physical properties changes at the environment and how dolphins compensate/adjust their biological sonar systems in dense waters (*i.e.* with heavy metals) remains unknown. Acoustic impacts have been on great attention on dolphins, especially on populations associated to harbors (Perry, 1998). Short and long-terms reactions on dolphin populations, including changes on acoustic behavior (Buckstaff, 2004) and even local habitat avoidance (Thompson *et al.*, 2010), respectively, are well described in the literature. Similarly, effects of oil spill on dolphin populations are known by behavioral changes, which individuals consistently avoid contact with mousse oil, responding by swimming closer together, decreasing respiration rates, and increasing dive times and rates of reorientation (Smultea and Würsig, 1995); as well as by synchronous members losses (Matkin *et al.*, 2008).

Regarding Franciscana dolphins in the FMA1a, the dense mud found at the bottom of the Doce River estuary might also directly disturb its life history aspects. Franciscana dolphins are estuarine-dependent at early years of life, since weaned individuals and calves essentially feed on shrimps and slow moving crustaceans on the transition from milk to solid food (Rodríguez, *et al.* 2002). Frainer *et al.* (2015) pointed out that the diet-shift presented by this species (*i.e.* comparing with the great variability of food items in adults) might be related to limitations of general motor skills as well as of the echolocation system of young individuals. Since the species presents foraging behavior at the benthonic zone and an estuarine-dependence at early years of life, the impacts of the Mariana's dam disaster is immensurable, at the moment, for this species.

**General Conclusions and Recommendations**

Bycatch in coastal gillnets and habitat degradation already represent continuing threats to Guiana dolphins and Franciscana dolphins along the northern coast of Espírito Santo. Therefore, this catastrophic incident may significantly increase the threat level of the northern Franciscana population (FMA 1a). While the long-term effects of the iron mine disaster for these populations and their ecosystem are unclear and may take years to be fully evaluated, their future seems to depend upon implementation of monitoring and conservation actions.

We thus recommend a few actions to be implemented steadily for an in-depth evaluation of the impacts of the mud on these dolphins' populations. They include:

(a) Implement a passive acoustic monitoring in the mouth of the Doce River to ascertain the presence of cetaceans in the impacted area;

(b) Implement short, medium and long term monitoring of heavy metals concentrations in key components of the aquatic biota, including invertebrates, fish, turtles, seabirds and cetaceans. In the case of franciscana and Guiana dolphins, background information on the burden of heavy metals and the use of biomarkers in tissues should be addressed as reference data

(c) Launch an outreach campaign with fishermen and local communities to bring awareness on the potential impacts of the mud to the endangered dolphins.

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