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1 **Amazon aquatic biodiversity imperiled by oil spills**

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51 **ABSTRACT**

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53 Oil exploitation poses a significant threat to freshwater biodiversity, and future plans to
54 develop petroleum leases in the Amazon Basin should be seen with caution. A series of
55 oil spills have significantly affected biodiversity and human activities in some
56 Amazonian basins, indicating that disturbances by petroleum activities will increase in
57 the region, particularly in upper basins and river headwaters. Measures are needed to
58 reduce the risk of spills and to minimize their impacts. More fundamentally, changes in
59 decision making are needed that give proper weight to these impacts.

60

61 **KEYWORDS:** Petroleum, Pollution, Fish kill, Environmental impact, Freshwater,
62 Development policy

63

64 The remarkable biodiversity of Amazon Rivers is imperiled by a growing
65 number of threats such as hydropower expansion (e.g. the Belo Monte dam) (Lees et al.
66 2016; Val et al. 2016; Winemiller et al. 2016), deforestation (e.g. Brazil's newly
67 weakened Forest Code) (Soares-Filho et al. 2014), mining (Meira et al. 2016), and
68 direct pollution by petroleum activities (Kimerling 2013). This last threat, in particular,
69 has been largely overlooked by authorities.

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71 Recently, the leakage of 3,000 barrels of oil in the Peruvian Amazon
72 contaminated the Marañón River, a major tributary of the Amazon River (Mega 2016).
73 This is far from an isolated case; for instance, an oil spill in 2014, in the same region,
74 caused significant biological and water deterioration, affecting the well-being of local
75 people (Fraser 2014). Other parts of the Amazon region have been affected by oil spills,
including the Texaco/Chevron oil projects in Ecuador that released oil over a period of

76 almost 30 years (e.g. Jochnick et al. 1994; Kimerling 2006). Ecuador continues to be a
77 major source of oil pollution in Amazonia, including spills from ongoing oil projects in
78 the Yasuni National Park (Kimerling 2013) and a spill on an Amazon tributary in
79 Ecuador that carried oil to both Peru and Brazil (BBC News 2013). Large areas are
80 slated for future oil development (Finer et al. 2008; Castello and Macedo 2016),
81 indicating that disturbances by petroleum activities will increase in the region,
82 particularly in upper basins and river headwaters. This is troubling because the
83 connectivity and unidirectional water flow in lotic environments will spread the
84 disturbance across downstream sections of the system (e.g. wetlands).

85 Oil spills have high potential to negatively affect freshwater aquatic ecosystems
86 and can severely affect biodiversity (Steen et al. 1999). Oil affects aquatic invertebrate
87 and vertebrate fauna both directly by toxicity and indirectly by decreasing oxygen
88 diffusion (Lytle et al. 2001; Couceiro et al. 2006). In the 2014 oil spill in the Marañon
89 River, a massive amount of fish was killed immediately (Fraser 2014). This fish kill
90 probably affected other organisms, since fish are common prey for caimans, birds and
91 mammals. Community and food web structure may remain disrupted for years as a
92 result of spills (Kingston 2002). Spilled oil has multiple consequences for humans,
93 including severe impacts on health (see review by Chang et al. 2014). Disturbances like
94 these, therefore, can compromise water resources and services, including drinking water
95 and fisheries.

96 These impacts imply a need for changes at many levels in Amazonian countries.
97 Measures are needed to provide alerts to environmental authorities and development
98 planners. Implementing a system to monitor water quality and pollution levels is a
99 minimum first step towards promoting policy action. Amazonian countries must
100 establish sustainable limits to the geographical expansion of petroleum activities.

101 Development plans should avoid oil leases in hydrographic basis and river stretches that
102 provide essential services (e.g. fisheries, wetlands, nutrient cycling) or that have high
103 endemic biodiversity. In addition, inspection of existing leases must be carried out on a
104 permanent basis, and irregular activities must be effectively repressed.

105 Most importantly, fundamental changes are needed in the decision-making
106 process to arrive at rational decisions on oil development (or on any other form of
107 development). These decisions need to be made with information on environmental and
108 social impacts in hand and with institutional mechanisms for democratic discussion of
109 the issues involved *before* the decision to implement a project is made in practice.
110 Unfortunately, this is not yet the case in any of the Amazonian countries. The recent
111 history of Amazonian hydroelectric dams provides clear examples of the lack of such a
112 procedure and order of events in Brazil (Fearnside 2014; 2015). The same applies to
113 other Amazonian countries, such as Peru (Vega 2010). Authorities in the Amazonian
114 countries must reconsider the unprecedented development schemes planned for the
115 Amazon Basin, which will cause extensive changes in hydrology, land use and water
116 quality. The international community could and should be actively engaged in these
117 agendas, particularly because the Amazon provides services at the global scale (e.g.
118 climate).

119 The Amazon Basin is home to a rich biodiversity with many rare, endemic and
120 unknown species, and this diversity is extremely vulnerable to large-scale human
121 actions (Castello et al. 2013; Lees et al. 2016; Val et al. 2016; Winemiller et al. 2016).
122 Expansion of petroleum leases will aggravate this scenario (Castello et al. 2013;
123 Castello and Macedo 2016). If the current trend continues, Amazonian aquatic
124 biodiversity – probably the richest on Earth – will experience large-scale and
125 irreversible losses in a short time period.

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