

Reply to Roopnarine: What is an apex predator?

Roopnarine (1) suggests that the significance of the human trophic level (HTL) (2) is reduced because it defines the position of humans in the food web by diet and is not representative of our functional role in the ecosystem. He is concerned that humans are compared with low trophic level omnivores and asserts that we are apex predators because in marine systems, our extraction of wild fish is linked to high trophic level species.

Our report demonstrates that humans are low trophic level omnivores because globally we eat more plant than meat. This fact remains, regardless of the functional role of humans in the ecosystem. Apex predators are most commonly defined by trophic dynamics and are species that occupy the highest trophic levels and are crucial in maintaining ecosystem health (3). Less commonly, apex predators are defined as species that have no predators themselves, in which case, we could be considered apex predators regardless of what we eat. However, we assert that our ecosystem function is more complex than that: we have no predators, we are key in maintaining (or threatening) ecosystem health, but we do not occupy the highest trophic level. We fully agree that humans have significant and wide-ranging ecosystem impacts because of our sheer numbers, which are ultimately linked to high levels of food consumption, and because of, e.g., pollution and land use change. For example, the total nonfood-related primary production used by humans (e.g., forestry, biofuels) presently represents three times the primary production

required for food (4). However, these impacts are not a result of our being apex predators, and we feel that the fact that we are not apex predators is a useful observation with consequences for our ability to reduce our impacts.

To consider humans as trophic components of ecosystems was the key objective of our paper. Roopnarine's (1) point regarding marine systems is indeed interesting, and we believe that the exploration of the functional role of humans in specific food webs is an exciting topic for future research. For example, human impacts related to food production vary widely between marine and terrestrial ecosystems, as Roopnarine notes (1). In general, resource exploitation in terrestrial systems is caused by agricultural practices, leading to a large harvest of plants and prey species with trophic levels close to 2, giving humans a consequently low trophic level. In marine systems, resource exploitation is primarily because of wild harvest (including that of forage fish used for fishmeal and oil), with minimal direct extraction of primary productivity, and large extraction of high trophic level prey species, ~3.1–3.3 (5). If an HTL were calculated as by Roopnarine (1), based on the trophic levels of extracted resources in marine ecosystems rather than on direct food consumption, humans would indeed have a much higher trophic level than 2.21. However, this brings us back to the previous issue of predator definitions. In general, predators ingest what they kill (6); thus, can fishermen really

be considered apex predators as they do not consume the total quantity of their catch?

Anne-Elise Nieblas^{a,1}, Sylvain Bonhommeau^a, Olivier Le Pape^b, Emmanuel Chassot^c, Laurent Dubroca^c, Julien Bardé, and David M. Kaplan^c

^aInstitut Français de Recherche pour l'Exploitation de la MER, Unité Mixte de Recherche (UMR) Exploited Marine Ecosystems (EME-212), 34203 Sète Cedex, France; ^bEcologie et santé des écosystèmes (UMR985 ESE) Agrocampus Ouest-Institut National de la Recherche Agronomique, F-35042 Rennes, France; and ^cInstitut de Recherche pour le Développement, UMR EME-212, Centre de Recherche Halieutique Méditerranéenne et Tropicale, 34203 Sète Cedex, France

1 Roopnarine PD (2014) Humans are apex predators. *Proc Natl Acad Sci USA* 111:E796.

2 Bonhommeau S, et al. (2013) Eating up the world's food web and the human trophic level. *Proc Natl Acad Sci USA* 110(51):20617–20620.

3 Elton C (1927) *Animal Ecology* (Sidgwick and Jackson, London).

4 Imhoff ML, et al. (2004) Global patterns in human consumption of net primary production. *Nature* 429(6994):870–873.

5 Branch TA, et al. (2010) The trophic fingerprint of marine fisheries. *Nature* 468(7322):431–435.

6 Heupel MR, et al. (2014) Sizing up the ecological role of sharks as predators. *Mar Ecol Prog Ser* 495:291–298.

Author contributions: A.-E.N., S.B., O.L.P., E.C., L.D., J.B., and D.M.K. wrote the paper.

The authors declare no conflict of interest.

¹To whom correspondence should be addressed. E-mail: anne.elise.nieblas@gmail.com.