



Commentary: Fishing Without a Trace? Assessing the Balanced Harvest Approach Using EcoTroph

Shijie Zhou^{1*}, Serge M. Garcia², Jeppe Kolding^{2,3} and Michael J. Plank^{4,5}

¹ Commonwealth Scientific and Industrial Research Organization Oceans and Atmosphere, Brisbane, QLD, Australia,

² International Union for Conservation of Nature Commission of Ecosystem Management, Fisheries Expert Group (IUCN-CEM-FEG), Gland, Switzerland, ³ Department of Biological Sciences, University of Bergen, Bergen, Norway, ⁴ School of Mathematics and Statistics, University of Canterbury, Christchurch, New Zealand, ⁵ Te Pūnaha Matatini, Auckland, New Zealand

Keywords: productivity, production, ecosystem structure, EcoTroph, balanced harvest

A Commentary on

Fishing Without a Trace? Assessing the Balanced Harvest Approach Using EcoTroph

by Rehren, J., and Gascuel, D. (2020). *Front. Mar. Sci.* 7:510. doi: 10.3389/fmars.2020.00510

INTRODUCTION

Balanced harvest (BH) aims to reduce fishing impact on ecosystems while supporting sustainable fisheries (Garcia et al., 2012). The concept has been examined by various modeling techniques and limited empirical evidence (Zhou et al., 2019). Recently, Rehren and Gascuel (2020, hereafter RG20) used the trophic-level-based model EcoTroph to investigate the effects of BH on the catch, biomass, and trophic spectra of a virtual ecosystem. We applaud the use of a new tool to study BH as this is an effective way to identify properties that are model-independent. In addition, their proposed new fishing strategy, balanced structure harvest or BSH, is very welcome. The results from EcoTroph are generally consistent with existing studies, confirming the core advantages of BH. Unfortunately, some of the modeling results were misinterpreted, leading to distorted conclusions. The readers should be aware of some misleading statements in RG20.

It is well-recognized that any fishing strategy, like any other mortality, will have some impacts on marine ecosystems. In the real world, it is impossible to fish (or eat) without a trace. One of the BH goals is to fish with smaller impacts (traces) on ecosystems than presently generated with conventional fishing and management strategies. To achieve this while producing high fishery yields, BH has alternative technical expressions. The BSH strategy proposed by RG20 is another promising form of BH. Different fishing strategies, either with mortality proportional to productivity, production, or biomass structure, may have different outcomes in terms of ecosystem effects or fisheries yields. When assessing or criticizing BH as an alternative to present fisheries and asserting that it has a “strong” impact, it is essential to have something (e.g., status quo) to compare with. We will examine each of the following RG20 sections.

KEY CONCLUSIONS

The abstract of RG20 provides some concise results of EcoTroph. The simulation shows that a BH fishing pattern does not fully maintain unfinished ecosystem structure but results in small structural changes and a large total yield. The resulting catch was dominated by low trophic levels. These findings are in line with studies on BH using other models. The results that fishing mortality cannot be fully aligned to productivity of all species simultaneously and that fishing can increase unexploitable biomass are consistent with earlier BH studies. Even the result that

OPEN ACCESS

Edited by:

Athanassios C. Tsikliras,
Aristotle University of
Thessaloniki, Greece

Reviewed by:

Simone Libralato,
National Institute of Oceanography
and Experimental Geophysics
(OGS), Italy

*Correspondence:

Shijie Zhou
Shijie.Zhou@csiro.au

Specialty section:

This article was submitted to
Marine Fisheries, Aquaculture and
Living Resources,
a section of the journal
Frontiers in Marine Science

Received: 25 September 2020

Accepted: 10 December 2020

Published: 18 January 2021

Citation:

Zhou S, Garcia SM, Kolding J and
Plank MJ (2021) Commentary: Fishing
Without a Trace? Assessing the
Balanced Harvest Approach Using
EcoTroph. *Front. Mar. Sci.* 7:610216.
doi: 10.3389/fmars.2020.610216

protecting lower trophic levels can limit the impact of fisheries on the highest trophic levels is not surprising. However, these results in no way imply the conclusion that “*given our inability to align fishing mortality to the productivity of each species, BH could lead to strong adverse impacts on the ecosystem.*”

EFFECTS OF BALANCED HARVEST ON BIOMASS AND CATCH TROPHIC STRUCTURE

RG20 found that under $BH_{P/B}$, the resulting biomass structure deviated from the virgin ecosystem, with a relatively stronger biomass depletion of higher TLs than under BH_P . It appears that the P/B ratio was assumed a constant function of TL while in fact the ratio is also a function of mortality rate (natural and fishing mortalities) (Gasche et al., 2012). Nevertheless, these results were consistent with earlier studies (e.g., Zhou and Smith, 2017; Plank, 2018). Comparison between $BH_{P/B}$, BH_P , and BSH showed that BSH was close to BH_P and had less impact on ecosystem structure but lower total catch than $BH_{P/B}$. It is a pity that there was no comparison of these BH strategies with current practices. Earlier studies showed that when heavy fishing mortality occurs at high trophic levels, the impact is much more severe than BH (Bundy et al., 2005; Zhou and Smith, 2017).

CONSEQUENCES OF BALANCED HARVEST UNDER LIMITED EXPLOITABILITY

The limited exploitability scenario, accounting for the fact that part of the ecosystem trophic structure might not be exploitable for various reasons, is analogous to the “partial balance” strategy suggested in Zhou et al. (2019). Again, this section only compared impacts of different types of BH ($BH_{P/B}$ vs. BSH). Both strategies reduced the total catch from the full-exploitability scenario and increased the relative amount of unexploitable biomass, which is consistent with preceding studies on BH.

EFFECTS OF PROTECTING LOWER AND INTERMEDIATE TROPHIC LEVELS

In this scenario, conserving ecosystem structure and maximizing catch were dealt with separately. Such a treatment is inappropriate as both objectives are simultaneously fundamental for fisheries management. For example, with a mean trophic level at first catch of 4 ($\tau_{50} > 4$), the catch was reduced by 82–98% compared to no protection of species at lower trophic levels. This is clearly unacceptable for management that strives to sustainably harvest a high proportion of biomass. According to the RG20’s method and their Figure 1, mean $\tau_{50} > 4$ also included a large proportion of species at lower trophic levels. The total catch would have been very low (i.e., <2% of catch under their full exploitability scenario) if the trophic level at first catch (not the mean TL) was 4. Such a small catch suggests that the

fishing strategy that would generate the lowest possible impact is to stop all fishing activities (a conclusion that does not need to be demonstrated).

From the modeling results, the authors gave a compelling statement: “*For a given total catch, harvesting all exploitable trophic levels without any protection (full $BH_{P/B}$ or full BSH) has the least impact on the overall ecosystem structure but induces the highest increase in the relative unexploitable biomass.*” Unfortunately, the first part of these results (least impact on ecosystem) was not in the Abstract and Conclusion, while the positive effect of inducing a high unexploitable biomass was regarded as an adverse impact. Unexploitable biomass is a food source for exploitable species. From a big picture, unexploitable biomass at low TLs plays a key role in carbon dioxide storage and a critical biological carbon pump (Buesseler et al., 2020), clearly a desirable by-product of BH.

Harvesting all exploitable trophic levels without protection of low TLs will reduce biomass at high trophic levels. This is true for fishing at any TL. The modeling showed that to ease the impact on the high trophic indicator (HTI, the percentage of consumer biomass from trophic levels above 4 in the ecosystem) and predator biomass, the trophic level at first catch should be between 1.8 and 2.6 depending on the amount of total catch. However, TLs between 1.8 and 2.6 are sufficiently low and well in line with BH as BH does not require full and perfect implementation (i.e., catching every component in the ecosystem exactly in proportion to its productivity or production; Zhou et al., 2019).

A τ_{50} around 3.5 was considered as a proxy of the current fisheries situation and used to analyze the effects of expanding fisheries toward lower trophic levels. The results showed: “*... to get the largest predatory catch, fishing mortality should be balanced with productivity and trophic level at first capture should be delayed to τ_{50} 3.7. Contrasting to maximizing total catch it induces a lower impact on the amount of unexploitable biomass and biomass structure but reduces total catch by 71% compared to its maximum.*” We note three messages here. First, τ_{50} 3.5 or 3.7 is a mean TL at first catch, which encompasses a significant proportion of lower TLs (see RG20’s Figure 1). Second, a reduction of 71% catch is a substantial loss of fisheries yields, which is one of the adverse impacts BH aims to avoid. Third, their “*lower impact on the amount of unexploitable biomass*” refers to not increasing relative unexploitable biomass at low trophic levels. However, as discussed above, increasing unexploitable biomass is a positive thing. The performance measure of biomass structure is therefore inappropriate when including unexploitable biomass in the calculation of disturbance index D (Bundy et al., 2005), because the larger the unexploitable biomass, the higher the D -value.

The final Results section provides the following statements. “*To keep both (total catch and predatory catch) as high as possible (72% and 60% of the maximum total and predatory catch, respectively), while keeping total and predator biomass above 60%, trophic level at first catch should be delayed to 2.6 at an exploitation rate of 0.3 while setting fishing mortality proportional*

to productivity ($BH_{P/B}$).” TL 2.6 is significantly lower than current mean τ_{50} 3.7, and again is in line with the concept of BH.

DISCUSSION AND CONCLUSION SECTIONS

The EcoTroph model results are in accordance with previous models investigating BH. Sadly, RG20 dismissed positive outcomes of BH and exaggerated the negative ones. They discussed the adverse effects separately in terms of the goal of increasing fishery production and the goal of reducing ecosystem impacts, ignoring that the two are simultaneously important in fisheries management. There was also a lack of comparison between BH and conventional fishing when criticizing the BH. Some conclusions were inconsistent with the results or contradicted each other. For example, the statement “*While we may better conserve the size or trophic structure of an ecosystem with a BH fishing pattern, the system could experience marked changes in species composition*” is a contradiction. The latter part of the sentence was not supported by the results as there was no comparison between BH and conventional fishing under the condition of equal catch and the study did not examine species composition at the same trophic levels.

The RG20 concluded that the best fishing strategy from a purely ecological point of view was to only harvest a few trophic

levels (>4), although recognizing such a fishing strategy ensured only very limited catches. Their recommended approach was to “*adequately manage those species that are currently harvested beyond their capacity to replenish*,” a solution already included in the BH concept.

In summary, both BH and BSH balance trade-offs between ecosystem structure and yield: BSH tends to be more protective of the ecosystem structure but results in a yield with a greater proportion of lower TLs than BH does. The modeling results are consistent with existing studies and indeed confirms the conclusions on earlier studies on BH. Unfortunately, some results were distorted when making concluding statements. We argue that increasing unexploited biomass is beneficial to fisheries, ecosystems, and even climate changes. It is misleading to call it an adverse effect. Their recommended “*protecting low TLs*” by fishing at mean TL at first catch between 1.8 and 2.6 and their best fishing strategy to achieve both total catch and predatory catch as high as possible by fishing at mean TL at 2.6 are consistent with the BH concept and the recommended TLs are much lower than most current practice (Kolding et al., 2015).

AUTHOR CONTRIBUTIONS

SZ, SG, JK, and MP conceived the idea and wrote the paper. All authors contributed to the article and approved the submitted version.

REFERENCES

- Buesseler, K. O., Boyd, P. W., Black, E. E. and Siegel, D. A. (2020). Metrics that matter for assessing the ocean biological carbon pump. *Proc. Natl. Acad. Sci. U.S.A.* 117, 9679–9687. doi: 10.1073/pnas.1918114117
- Bundy, A., Fanning, P., and Zwanenburg, K. C. T. (2005). Balancing exploitation and conservation of the eastern Scotian Shelf ecosystem: application of a 4D ecosystem exploitation index. *ICES J. Mar. Sci.* 62, 503–510. doi: 10.1016/j.icesjms.2004.12.008
- Garcia, S. M., Kolding, J., Rice, J., Rochet, M.-J., Zhou, S., Arimoto, T., et al. (2012). Reconsidering the consequences of selective fisheries. *Science* 335, 1045–1047. doi: 10.1126/science.1214594
- Gasche, L., Gascuela, D., Shannonb, L., and Shin, Y.-J. (2012). Global assessment of the fishing impacts on the Southern Benguela ecosystem using an EcoTroph modelling approach. *J. Mar. Syst.* 90, 1–12. doi: 10.1016/j.jmarsys.2011.07.012
- Kolding, J., Bundy, A., van Zwieten, P. A. M., and Plank, M. (2015). Fisheries, the inverted food pyramid. *ICES J. Mar. Sci.* 73, 1697–1713. doi: 10.1093/icesjms/fsv225
- Plank, M. J. (2018). How should fishing mortality be distributed under balanced harvesting? *Fish. Res.* 207, 171–174. doi: 10.1016/j.fishres.2018.06.003
- Rehren, J., and Gascuel, D. (2020). Fishing without a trace? Assessing the balanced harvest approach using EcoTroph. *Front. Mar. Sci.* 7:510. doi: 10.3389/fmars.2020.00510
- Zhou, S., Kolding, J., Garcia, S., Plank, M. J., Bundy, A., Charles, A., et al. (2019). Balanced harvest: concept, policies, evidence, and management implications. *Rev. Fish Biol. Fish.* 29, 711–733. doi: 10.1007/s11160-019-09568-w
- Zhou, S., and Smith, A. D. M. (2017). Effect of fishing intensity and selectivity on trophic structure and fishery production. *Mar. Ecol. Prog. Ser.* 585, 185–198. doi: 10.3354/meps12402

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright © 2021 Zhou, Garcia, Kolding and Plank. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC BY). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.