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Modelling Hazards in Fisheries and Aquaculture Activities in the Mediterranean Sea and the Risk of their Transmission and Dispersion. Is it Feasible?

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Abstract

Modelling approaches in marine science is a controversial issue as no model is, or can be, a perfect representation of nature. Models can provide useful information for the dynamics of ecosystems and inform us about the likely consequences of human activities in fisheries and aquaculture. Applying a suite of dynamic models can be valuable predictive tools for modelling hazards transmission in fisheries and aquaculture activities in the Mediterranean Sea. These should include

a. A low trophic level ecosystem model and sub-models to describe the ecosystem functioning of the sea for the background physical information and a biogeochemical sub-model which simulates functional groups.

b. A pelagic fish individual-based model (IBM) to describe the bio-accumulation of chemical and biological hazards.

c. An aquaculture integrated model, a mass balance model, to calculate the input of effluents into the environment as a result of the fish farm operations and feeding regimes.

d. A dynamic energy budget (model for cultured bivalve species to predict the bioaccumulation of hazards such as heavy metals or toxins from harmful algal blooms.

These dynamic models can contribute to develop and/or improve systems ensuring process efficacy and validation for hazard control by identifying "hot spot" zones and concentrations of hazard agents above certain limits, improve the effectiveness and efficiency of the controls performed by food safety Competent Authorities along the seafood chain, identify areas of hazard agents accumulation and contribute to the transparency and reliability of food safety in the Mediterranean fisheries and aquaculture production sites.

Keywords: Hazards; Aquaculture; Fisheries; Lower Trophic Level (LTL) Model; Individual Based Model (IBM); Aquaculture Integrated Model; Dynamic Energy Budget (DEB) Model; Micro-Plastics; Nano-Plastics; Dispersion Risk

Abbreviations: CAS: Competent Authorities; FAO: Food and Agriculture Organization of the United Nations; EFSA: European Food Safety Authority; ERSEM: European Regional Seas Ecosystem Model; HABS: Harmful Algal Blooms; IBM: Individual Based Model; LTL: Lower Trophic Level; MPs: Micro-Plastics; NPs: Nano-Plastics; STECF: Scientific, Technical and Economic Committee for Fisheries; POM: Princeton Ocean Model

Introduction

The term "hazard" (the intrinsic potential to cause harm) is often confused with the term "risk" (the probability of harm occurring at a given exposure) and often the public do not generally differentiate between these two terms [1]. The microbiological definition of hazard in Codex Alimentarius [2] is "inherent property of an agent or situation having the potential to cause adverse effects when an organism, system, or (sub)population is exposed to that agent" whereas of risk is "the probability of an adverse effect in an organism, system, or (sub)population caused under specified circumstances by exposure to an agent". Aquaculture and fisheries are important activities in the Mediterranean Sea entailing significant socioeconomic implications [3,4]. Both activities face some potential hazards including natural, anthropic or both causes. Aquaculture hazards include diseases in both fish and shellfish whereas high stocking densities may lead to chronic stress that has important implications for fish immuno-competence [5-9], but relationships with infection levels are variable [10]. In addition, marine litter and especially micro-plastics (MPs - 0.1 to 5,000 μm) and nano-plastics (NPs - 0.001–0.1 μm) concerns for potential toxicity of the plastic particles towards human health are growing, as they could potentially induce physical damages through particles themselves and biological stress through MPs/NPs alone or leaching of additives (inorganic and organic) [11,10].

Is it feasible to model hazards in fisheries and aquaculture activities in the Mediterranean Sea and the risk of their transmission and dispersion? The use of modelling approaches in marine science is a controversial issue as no model is, or can be, a perfect representation of nature [12]. However, as predictive modelling can provide a better understanding and potentially either prevent hazardous events or identify hotspot areas or describe the spread patterns and concentration of hazards (pollutants, infectious diseases etc), their transmission and dispersion needs to be integrated in dynamic models but in an environmentally realistic manner [13,7]. Therefore, a suite of dynamic models can be valuable predictive tools for modelling hazards transmission in fisheries and aquaculture activities in the Mediterranean Sea.

These should include the following:

A low trophic level (LTL) ecosystem model

The low trophic level (LTL) ecosystem model must be fully dynamic and to consist mainly of two sub-models: a hydrodynamics sub-model that describe the ecosystem functioning of the sea area and will provide the background physical information e.g. a Princeton Ocean Model – POM [14] or MICOM [15] or ROMS etc, to a second biogeochemical sub-model which simulates functional groups. The LTL ecosystem model shall provide the dynamics of biological functional groups that consist of population processes (growth and mortality) and physiological processes (ingestion, respiration, excretion and egestion). The biotic system is subdivided into three functional types, producers (phytoplankton), decomposers (pelagic and benthic bacteria) and consumers (zooplankton and zoobenthos). These broad functional classifications are usually subdivided, according to their trophic level (derived according to size classes or feeding method) to create a food web. The plankton pool should have the functional groups based on size and ecological properties like diatoms, nanophytoplankton, picophytoplankton, and dinoflagellates. Bacteria, heterotrophic nano flagellates and microzooplankton represent the microbial loop. All groups in the phytoplankton and the microbial loop have dynamically varying C:N:P ratios. The chemical dynamics of nitrogen, phosphorus, silicate and oxygen are coupled with the biologically driven carbon dynamics.

A pelagic fish individual-based model (IBM)

The health benefits associated with seafood consumption are coupled with concerns about potential health risks associated with the presence of hazards (chemical and biological contaminants), both those occurring naturally and those resulting from human activities, in seafood. As the bio-accumulated hazards sooner or later will end up in our plates through the consumption of seafood, there is a need to understand this process and what is transferred from one trophic level to the other. In the Mediterranean, landings continued to increase until 1994, reaching 1,087,000 tonnes, and subsequently declined irregularly to 787,000 in 2013, with a group of 13 main species accounting for some 65 percent of landings, with anchovy (393,500 tonnes) and sardine (186,100 tonnes) being by far the dominant species [16]. Pelagic species catches are higher than the ones of demersal and 30 species contribute to 90 percent of the landings in all Mediterranean subareas.

For pelagic fish, the fish model must be on-line coupled with the LTL model (described above). Currently, it has been developed and is a full-life cycle, individual based model (IBM) that includes two species, the European anchovy (Engraulis encrasicolus) and the European sardine (Sardina pilchardus) [17]. Early larvae feed on microzooplankton, late larvae start consuming mesozooplankton and juveniles/adults interact only with the mesozooplankton compartment of the LTL model. The plankton biomass (micro- and mesozooplankton) that is consumed by the fish is removed in the LTL model, while fish bio-products from egestion, excretion and specific dynamic action are directed to the LTL particulate organic matter and dissolved inorganic nutrient pools.

The above two models (LTL & IBM) can be further developed to include potential hazards (microplastics, oil spill particles, etc)

That exist in the marine environment [10]. These hazards may be attached to phytoplankton, which subsequently may be consumed by zooplankton groups. In addition, they might be attached to zooplankton organisms and these will eventually be grazed by small pelagic fish. Also, the fish may randomly attach fibres, microplastics, oil spill particles on their gills and body. Small-scale lab experiments will be needed to quantify the above processes in order to describe some parameters and to customize the models.

An aquaculture integrated model

In order to calculate the input of effluents into the environment as a result of the farm operations and feeding regime, a mass balance model should be applied for the fish farms. Mass balance models have been developed based on nutrition (feed type) and conditions for salmonids [18,19], sea bream and sea bass among others [20-23]. Input of nitrogen and phosphorus supplied in fish feed can be used to calculate the amount harvested as fish, excreted in dissolved form (Urea, NH_4, PO_4) and excreted in particulate form (uneaten feed, faeces). Tsapakis et al. [23] and Lupatsch and Kissil [21] calculated that the largest portion of nitrogen supplied is excreted in the dissolved form as Urea (41%) and ammonium (26%), while phosphates losses account for 22% of phosphorus supplied. Conversely particulates released consist mainly of organic phosphorus accounting for 44% of phosphorus supplied whereas particulate nitrogen losses account for 10% of the nitrogen supplied. It is also estimated that approximately 5% of feed is settling uneaten, either being

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consumed by wild fish or contributing to the organic load of the underlying sediment [24,25].

The aquaculture modelling tool could be based on the above-described LTL model and can be used for ecosystem monitoring of the dispersion of parameters, including bacteria biomass and bacterial production and can be used to model the spread of diseases from farms. It can also be adopted to predict the dispersion of parasites. This will allow the creation of zones that might get infected and therefore might trigger the use of antibiotics and other chemoprophylaxis treatments. If such treatments are not properly followed, the fish that will be harvested and directed to the value/market chain might include those chemicals and all this is a potential hazard. This mapping of the zones, can be evolved to a DSS tool that will identify critical zones of potential hazards and prioritise the controls of the Competent Authorities to identify contaminants, pathogens etc.

A dynamic energy budget (DEB) model for cultured bivalve species

The bivalve mollusc model in combination with the LTL model can be useful to predict the bioaccumulation of hazards such as heavy metals, toxins from harmful algal blooms (HABs) etc. A dynamic energy budget (DEB) model for bivalve molluscs should investigate the growth and reproduction of cultured bivalve species raised under different environmental conditions (varying phytoplankton carbon biomass, particulate organic carbon and temperature) and can be tuned against field data. The interested reader may refer to Zaldívar [8] and Casas & Bacher [26] for a full description of the model equations used. Such model has been described by Hatzonikolakis et al. [6, 27-29].

Conclusion

Models can bridge the gap of the complex links between existing environmental variation and hazards presence and risk of transmission although responses of hazards over and above natural variation might be challenging. There are tools available that can be further improved to describe the most important physical and biochemical processes that, combined together, determine the dynamics of the ecosystem. Given the complexity of these processes and their interactions, mathematical models can be regarded as unique tools to deliver integrated approaches and better understand the mechanisms of hazards transmission and risk of dispersion and inform about the likely consequences of human actions.

The above-described dynamic models can contribute to:

a. Develop and/or improve systems ensuring process efficacy and validation for hazards control by identifying “hot spot” zones and concentrations of hazard agents above certain limits.

b. Improve the effectiveness and efficiency of the controls performed by the food safety Competent Authorities (CAs) along the seafood chain by direct and guide their sampling effort to detect contaminants (Decision Support Tool that will identify critical zones of potential hazards) and prioritise the controls of the CAs to identify contaminants, pathogens etc.

c. Identify areas of hazard agent’s accumulation (e.g. microplastics and Nano plastics, HABs, areas that antibiotics and chemicals are used etc).

d. Assist activities that will develop detection and monitoring tools that will allow for the data collection, integration, validation and analysis.

e. Contribute to the transparency and reliability of food safety in the Mediterranean production sites.

f. Future research should evaluate trophic transfer of hazards with their associated risks through the marine food web for humans. Models that describe the evolution of hazards are in progress and will be published in the near future.

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References

1. Barlow SM, Boobis AR, Bridges J, Cockburn A, Dekant W, et al. (2015) The role of hazard- and risk-based approaches in ensuring food safety. Trends in Food Science & Technology 46(2): 176-188.
2. Codex Alimentarius (1999) Principles and guidelines for the conduct of microbiological risk assessment CAC/GL-30. Food and Agriculture Organization Corporate Document Repository.
3. Nielsen R (2018a) Scientific, Technical and Economic Committee for Fisheries (STECF) – Economic Report of the EU Aquaculture sector (STECF-18-19). In: Publications Office of the European Union, German.
4. Scientific, Technical and Economic Committee for Fisheries (STECF) – The 2018 Annual Economic Report on the EU Fishing Fleet (STECF-18-07). In: Publications Office of the European Union, German.
5. Athanassopoulou F, Bitchava K, Pappas IS (2009) An overview of the treatments for parasitic disease in Mediterranean aquaculture.
6. Hatzonikolakis Y, Tsiaras K, Theodorou JA, Petihakis G, Sofianos S, et al. (2017) Simulation of mussel Mytilus galloprovincialis growth with a dynamic energy budget model in Maliakos and Thermaikos Gulfs (Eastern Mediterranean). Aquaculture Environment Interactions 9: 371-383.
7. Pernet F, Lupo C, Bacher C, Whittington RJ (2016) Infectious diseases in oyster aquaculture require a new integrated approach. Philos Trans R Soc Lond B Biol Sci 5: 371(1689).
8. Zaldívar J (2008) A general bioaccumulation DEB model for mussels. JRC Scientific and Technical Reports.
9. Sadhu N, Sharma SRK, Joseph S, Dube P, Philipose KK (2014) Chronic stress due to high stocking density in open sea cage farming induces variation in biochemical and immunological functions in Asian seabass (*Lates calcarifer*, Bloch). Fish Physiol. Biochem 40(4): 1105-1113.
10. Revel Messika, Amelie Chatel, Catherine Mouneyrac (2018) Micro(na-

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no)plastics: A threat to human health? Current Opinion in Environmental Science & Health 1: 17-23.

11. EFSA publication (2016) Presence of microplastics and nanoplastics in food, with particular focus on seafood. European Food Safety Authority 14(6): 1-30.

12. Dickey-Collas Mark, Mark R. Payne, Verena M. Trenkel, et al. (2014) Hazard warning: model misuse ahead. ICES Journal of Marine Science 71(8): 2300-2306.

13. Anderson RM, May RM (1979) Population biology of infectious diseases: part I. Nature 280: 361-367.

14. Blumberg AF, Mellor GL (1987) A description of a three-dimensional coastal ocean circulation model. Advance Earth and space science 4: 1.

15. Bleck R, Boudra D (1981) Initial testing of a numerical ocean circulation model using a hybrid (quasi-isopycnic) vertical coordinate. J Phys Oceanogr 11: 755-770.

16. FAO (2016) The State of Mediterranean and Black Sea Fisheries. In: General Fisheries Commission for the Mediterranean. Rome, Italy.

17. Schismenou E, Giannoulaki M, Tsiaras K, Triantafyllou G, Somarakis S (2014) Environmental effects on anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) early growth in the North Aegean Sea (eastern Mediterranean). Johan Hjort Symposium on Recruitment Dynamics and Stock Variability, Bergen, Norway.

18. Holby O, Hall POJ (1991) Chemical fluxes and mass balances in a marine fish cage farm. II. Phosphorus. Marine Ecology Progress Series 70(3): 263-272.

19. Hall POJ, Holby O, Kollberg S, Samuelsson MO (1992) Chemical fluxes and mass balances in a marine fish cage farm. IV. Nitrogen. Marine Ecology Progress Series 89(1): 81-91.

20. Kaushik S (1998) Nutritional bioenergetis and estimation of waste production in non-salmonids. Aquatic Living Resources 11(4): 211-217.

21. Lupatsch L, Kissil GW (1998). Predicting aquaculture waste from gilthead seabream (*Sparus aurata*) culture using a nutritional approach. Aquatic Living Resources 11(4): 265-268.

22. Lemarie G, Martin JL, Dutto G, Garidou C (1998) Nitrogenous and phosphorus waste production in a flow-through land-based farm of European sea bass (*Dicentrachus labrax*). Aquatic Living Resources 11(4): 247-254.

23. Tsapakis M, Pitta P, Karakassis I, (2006) Nutrients and fine particulate matter released from sea bass (*Dicentrachus labrax*) farming. Aquatic Living Resources 19(1): 69-75.

24. Petihakis G, Triantafyllou G, Korres G, Tsiaras, Theodorou A (2012) Ecosystem modeling: Towards the development of a management tool for a marine coastal system Part-II: Ecosystem processes and biogeochemical fluxes. Journal of Marine Systems 94: S49-S64.

25. Petihakis G, Triantafyllou G, Allen JI, Hoteit I, Dounas C (2002). Modelling the spatial and temporal variability of the Cretan Sea ecosystem. Journal of Marine Systems 36(3-4): 173-196.

26. Casas S, Bacher C (2006) Modelling trace metal (Hg and Pb) bioaccumulation in the Mediterranean mussel, *Mytilus galloprovincialis*, applied to environmental monitoring. Journal of Sea Research 56: 168-181.

27. Baretta JW, Ebenhoh W, Ruardij P (1995) The European regional seas ecosystem model, a complex marine ecosystem model. Netherlands Journal of Sea Research 33(3-4): 233-246.

28. Haidvogel DB, Arango HG, Hedstrom K, Beckmann A, Malanotte-Rizzoli P, et al. (2000) Model evaluation experiments in the North Atlantic Basin: Simulations in nonlinear terrain-following coordinates. Dynamics of Atmospheres and Oceans 32(3-4): 239-281.

29. Petihakis G, Tsiaras K, Triantafyllou G, Korres G, Tsagaraki T, et al, (2012) Application of a complex ecosystem model to evaluate effects of finfish culture in Pagasitikos Gulf, Greece. Journal of Marine Systems, 94: S65-S77.

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