PRELIMINARY RESULTS OF MODELING FISHING EFFECTS ON EXPLOITED MARINE ECOSYSTEMS IN NW MEDITERRANEAN SEA

Marta Coll [1] *, Sergi Tudela [2], Francesc Sardà [1], Isabel Palomera [1],
[1] Institut de Ciències del Mar (CMIMA – CSIC), Barcelona, Spain - * mcoll@icm.csic.es
[2] WWF Mediterranean Program Office, Barcelona, Spain

Abstract
A mass-balance model of the NW Mediterranean Sea was used as a baseline to explore ecosystem effects of fishing under different combinations of bottom-up and top-down control situations and under different changes in fishing effort. Preliminary results of main ecosystem effects are explored.

Keywords: Effects of fishing, Ecosim, NW Mediterranean

Introduction

The dynamic simulation tool Ecosim (1, 2) has extended Ecopath initial capabilities by providing a temporal dimension and spread out its applications for exploring ecosystem effects of changes in fishing efforts and fishing policies (3, 4). Preliminary results of an attempt to apply Ecosim to a case study from the NW Mediterranean Sea (5) are presented and ecosystem effects of fishing accounting for ecosystem trophic interactions under different combinations of bottom-up and top-down control situations and under different theoretical fisheries regimes are explored.

Methodology

The Ecopath model constructed for the exploited ecosystem associated with the Delta of Ebro River, NW Mediterranean (5), settled the baseline to apply Ecosim (1, 2). All simulations assumed default values from the model, with the exception of flow controls in the ecosystem determining the type of control between functional groups. An initial period of five years without changing fishing scenario was established to reach stability of the ecosystem prior to perturbation and simulations were settled for an additional 45 years.

Three scenarios of flow control were explored by changing the vulnerability values of groups: (1) bottom-up control, prey control of zooplanktivorous fishes by zooplankton preys; (2) wasp-waist control, top-down control of zooplankton by small pelagic fishes and bottom-up control of pelagic predators by small pelagic fishes; and (3) mixed control, neither bottom-up nor top-down control. Three different fishing scenarios were also considered related with all functional groups of the ecosystem and with sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*) and adult and juvenile hake groups (*Merluccius merluccius*), all important groups in terms of biomass and catches. Scenarios were related with (a) the definitive closure of fishing activities; (b) a quick and permanent increased of fishing activity (4 times higher that its original level); and (c) a temporary increase in fishing activity for a period of 5 years (4 times higher), after which fishing activity was restored to its original level.

Results and discussion

Globally, fishing effects on the ecosystem were deeply dependent on the configuration of interactions of the groups in the ecosystem. All simulations showed that under wasp-waist control fishing effects were wider and major perturbations propagated thought the system. Mixed control situation showed intermediate results, while under bottom-up control fishing impacts were narrow and frequently had shorter propagated effects. Similar results had been previously achieved from the upwelling ecosystem of Southern Benguela (4).

Important **effects of closing the fishing activities** were related with a decrease of jellyfish biomass under bottom-up and wasp-waist control and the collapse of seabirds under all control situations, probably due to their dependence on discards. On the contrary, bonito, tuna and swordfish showed deep increases, mainly related with an increase of prey availability and a decrease of fishing mortality. **The closure of** the **sardine-anchovy** fishery had positive impacts on most of the pelagic and demersal top predators, as well as on themselves. However adult hake, blue whiting and fin whale were strongly depleted. **The closure of** the **adult hake fishery** had positive impact on itself under bottom-up and mixed control, while an initial increase turning to a notable decrease of biomass was observed under wasp-waist control. Juveniles were permanently depleted under all control situations, possibly due to adults' predation on juveniles and resource competition. **The closure of juvenile hake fishery** had some important negative impacts on target species were seen under wasp-waist control.

The permanent increased of fishing resulted in a collapse of octopus, various demersal fishes and small and large pelagics under all situations. Notable decreases on adult hake under wasp-waist and mixed control and on juvenile hake under bottom-up and mixed control were also shown. Seabirds increased under bottom-up and wasp-waist control, while demersal sharks increased under all situations and dolphins and turtles were notably depleted. Total catch showed a stable increase of 50% under bottom-up control, but were depleted around 60% from its initial value under wasp-waist and mixed control. **The permanent increase of sardine-anchovy catches** had a higher depletion on total catches (≈ 75%) under wasp-waist and mixed control and jellyfish significantly increased, while numerous target and not target groups were negatively impacted. Sardine and anchovy collapsed under wasp-waist and mixed control. **The increase of adult hake catches** had slightly higher impact on total catches (≈ 10%) under all control situations and important decreases were shown by juvenile hake and sardine. Adult hake collapsed under all situations and significant increases were shown by pelagic top predators. An **increase of juvenile hake** catches had little positive impacts on total catch (≈ 5%), important increases on pelagic top predators and decreases on hake and small pelagic fishes.

Temporary increase of total fishing had a negative impact on total catches when fishing effort was reestablished after intensive activity. The lowest ecosystem recovery was under wasp-waist control and total catches took ≈ 35 years to achieve initial values after reestablishing initial fishing effort. The highest ecosystem recovery was under bottom-up control. Under mixed control 10 years were necessary to achieve initial catches. **The temporary increase of sardine-anchovy** showed similar patterns of ecosystem and catches recovery. However, under wasp-waist control catches were not recovered after 40 years, intense changes on the ecosystem were shown and sardine-anchovy collapsed. **The temporary fishing increase on juvenile and adult hake** had non significant impacts on total catches, with highest positive impact under wasp-waist control of ≈ 10%, but intense changes on ecosystem functional groups were shown under wasp-waist control.

Therefore, the results underline differences under different settled control situations for different fishing scenarios. This stresses the importance of understanding internal controls between ecosystem components to correctly predict ecosystem effects of fishing while applying dynamic modeling techniques. This agrees with the results from the Southern Benguela upwelling ecosystem (4).

References

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