FOLLOWING THE FOOD CHAIN - AN ECOSYSTEM APPROACH TO PELAGIC PROTECTED AREAS IN THE MEDITERRANEAN BY MEANS OF CETACEAN PRESENCE

Maurizio Wurtz [1] * and François Simard [2]
[1] Biology Department, University of Genova, Italy - wurtz-ge@unige.it
[2] IUCN Center for Mediterranean Cooperation, Spain

Abstract
Based on the correlation between cetacean distribution patterns and oceanographic features, this paper opens discussions about possibilities to define multidimensional pelagic habitats in order to link these discussions to the ongoing debate about the efficiency of Marine Protected Areas as a tool for conservation, and proposes ways to proceed towards marine biodiversity conservation.
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The effectiveness of the IWC pelagic protected areas for whales has been recently questioned by Gerber et al. [1]. On the basis of existing knowledge about marine protected areas and cetacean biology, they point out four main limitations: arbitrary boundaries, narrow focus, lack of an adaptive population design and needs for baseline. The multidimensional nature of the problems related to marine environment protection needs a multidimensional approach to be understood and solved [2]. The typical solution in the ocean governance is to establish boundaries, mainly from legal perspective, because the clarity of boundaries would improve governance. Unfortunately, from an ecological point of view, this is a frustrating task due to the high variability of the omni-directional relationships among ocean habitats, species, land and atmosphere. These aspects are enhanced in the pelagic environment because its stability can be evaluated only through long term global scale measures of its dynamic structured habitats.

One possible solution could be to identify one or more species which food web can summing up the results of all the derived effects from the natural and anthropic induced variability of the pelagic environment. Obviously this group of species have to be long living, high-level predators, high biomass consumers with high energy budget needs: cetaceans seems to be the most suitable group of marine organism for this purpose. To evaluate this hypothesis, the relatively small pelagic domain of the Mediterranean Sea because of its oceanographic features, large cetacean populations and strong human impact, could be a reliable test to establish dynamic pelagic protected areas for several reasons.

The total area of the Mediterranean is more than 3.000.000 km^2(including the Black Sea). Because of the limited extension of the continental slope, the pelagic domain covers about 70%, corresponding to 96% of the total water volume. The Mediterranean Sea is a mid-latitude partially enclosed sea but, even if semi-isolated, can be considered an oceanic system. Processes which are fundamental to the general circulation of the world ocean also occur within the Mediterranean, identically or by analogous mechanisms.

The Mediterranean Sea exchanges water, salt, heat and other properties with the North Atlantic Ocean, which is known to play an important role in the global thermohaline circulation. The effects encompass the Atlantic, Southern, Indian, and Pacific Oceans [3], thus the salty water of Mediterranean origin may affect water formation processes and even the stability of the global thermohaline equilibrium state. The picture of the Mediterranean general circulation which is now depicting is complex, even if the Atlantic water jet is the main basin scale feature, from Gibraltar to the Levantine, with its instabilities, bifurcations, and multiple pathways, also cold wind stress, intermediate heat fluxes and other hydrodynamic movements, due to freshwater income and to evaporation loss, contribute to the general circulation pattern [4].

Too rough generalisations on oligotrophy of this flow affected the general believe on the trophic potential of the Mediterranean Sea: nevertheless the presence and abundance of large predators such as cetaceans drives to reconsider the oligotrophy paradigm [5]. Rather recently the classic scheme of marine food webs has been revised and the role of microorganisms has been reconsidered under various aspects: CO2, organic into inorganic, but also as food when they aggregate as rods or in a synergetic action with jelly macroplancton through the water column [6]. Now it is recognised that in some oligotrophic sea bacteria can constitute 70-80% of the biomass.

The abundance of cetaceans in the pelagic Mediterranean incites other consideration related to upper trophic levels than the primary production, particularly about the timing of the energy turn over through the biomass formation and transportation from the surface to the deep bottoms and vice-versa. Hundred thousands tonnes per year of euphausid krill can be consumed by the Mediterranean fin whales and ten thousands tonnes of various pelagic and bathy-pelagic cephalopods are eaten by odontocetes. Thus new ideas about the trophic potential of the pelagic ecosystem have to be developed not only to explain the top predator biomass but also the prey biomass formation and turnover in a relatively short time period.

The bottom morphology and hydrodynamic features of the Mediterranean Sea explain the organic matter flow from the coastal zone to the pelagic one, from the surface to the bottom and from deep waters to the entire water column, but the reasons why the energy flow through the biomass formation is so fast have, in turn, to be sought within the food webs. Mediterranean cetaceans show various degrees of prey selection but, in general, the most abundant species, such as striped dolphin and fin whale, seem to be rather opportunistic, they fully exploit this potential, moving and concentrate time by time where food is abundant. Nevertheless their *opportunism* has to be better defined because all the Mediterranean cetaceans, with the only exceptions of bottle-nose dolphin (*Tursiops truncatus*) and common dolphin (*Delphinus delphis*), feed on short living species such as ammoniacal cephalopods (*Histioteuthis*), myctophids (*Diaphus*) and glass shrimps (*Pasiphaea*) moving from the bathyal grounds up to the surface [7]. The effect of the very fast biomass formation by these prey on the energy flow is enhanced through the space by the amplitude of their daily vertical migrations.

These factors affecting the cetacean distribution patterns can be relatively well defined, but are not constant on the time-space domain, as is generally believed. Not always and not everywhere the crossing over of strong temperature gradient (frontal zone) and depth or bottom morphology (slope gradient, canyons, sea-mounts) determine the prey presence and abundance, but when this happens the cetaceans are there, as indicators of a past or actual particular oceanographic and biological condition. Based on the above, to define ephemeral pelagic habitats suitable for protection could be more efficient for conservation than permanent Marine Protected Areas and a way to proceed towards marine biodiversity conservation.

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