

## TRENDS IN TROPHIC LEVEL OF FARMED FISH IN MEDITERRANEAN COUNTRIES

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### Abstract

The mean trophic level ( $\tau$ ) of the Mediterranean farmed fishes (i.e. excluding crustaceans, cephalopods and bivalves) was estimated on a country basis for the period 1950-2004. Overall,  $\tau$  increased from a mean value ( $\pm$ SD) of 2.68 ( $\pm$ 0.044) for 1950-1959 to 3.21 ( $\pm$ 0.031) for 2000-2004, thus confirming that the Mediterranean food webs, overall, are being farmed up. However, the pattern was not uniform across countries; France, Italy Turkey and Israel are farming progressively higher trophic level fishes, while the mean trophic level of farmed fish is declining in Greece, Egypt and Croatia. The overall trend toward farming farming up should be reversed, because it implies non-sustainable pressures on Mediterranean ecosystems.

**Keywords:** *Aquaculture, Fisheries, Fishes, Food Webs*

**Introduction** The trophic level ( $\tau$ ) of fisheries landings and mariculture production has been used to evaluate both their status and that of their supporting ecosystems, notably by testing whether marine food webs are fished down [1] or farmed up [2]. The selective removal of large, high trophic level organisms by fishing lowers their relative contribution to the landings, which are progressively dominated by small fishes, while their mean trophic level declines. The opposite occurs when the contribution of large, high-trophic level organisms produced by mariculture operations increases, and hence the mean trophic level of their aggregate output increases. Both processes are indicators of absent sustainability and ecosystem health; the latter poses additional economic and ethical concerns [2]. The aim of the present work was to assess the extent of farming high-trophic level fishes across the Mediterranean and identify which countries and species contribute to the overall farming up trend of the Mediterranean aquaculture, recently demonstrated to occur based on aggregated data [2].

**Materials and methods** The marine and brackish water aquaculture production of fishes (i.e., excluding crustaceans, cephalopods and bivalves) of the Mediterranean and the Black Seas was extracted from the GFCM (General Fisheries Commission for the Mediterranean) dataset for the period 1950-2004 [3]. The mean weighted  $\tau$  [4] for each year was calculated for the Mediterranean part of each of the countries with such production, based on specific estimates of  $\tau$  taken from the literature, or from FishBase (www.fishbase.org).

**Results and Discussion** Overall,  $\tau$  increased from an average value ( $\pm$ SD) of 2.68 ( $\pm$ 0.044) for 1950-1959 to 3.21 ( $\pm$ 0.031) for 2000-2004, thus confirming that the Mediterranean food webs are being farmed up and that farming up is the result of culturing high trophic level fishes. This confirms the trend established by an earlier analysis of the farming-up effect in the Mediterranean [2]. However, the absolute values of  $\tau$  are not straightforwardly compared, as their pertained to a shorter time period (1970-2004), and were based on more aggregated data. The main fish culturing Mediterranean countries for 2004 were Greece (65000 t), Turkey (47000 t), Egypt (43000 t), Italy (14000 t), France (5000 t), Croatia (4000 t) and Israel (3000 t). From these countries, Turkey (mean  $\tau \pm$ SD=3.46 $\pm$ 0.001), France (mean  $\tau \pm$ SD=3.50 $\pm$ 0.015), Italy (mean  $\tau \pm$ SD=3.36 $\pm$ 0.116) and Israel (mean  $\tau \pm$ SD=3.45 $\pm$ 0.005) are progressively culturing higher trophic level fishes, whereas Greece (mean  $\tau \pm$ SD=3.44 $\pm$ 0.001), Egypt (mean  $\tau \pm$ SD=2.40 $\pm$ 0.204) and Croatia (mean  $\tau \pm$ SD=3.48 $\pm$ 0.007) are not (Figure 1, mean  $\tau$  refers to 2000-2004). The rate of  $\tau$  increase is higher in Italy (0.15 per decade) and Turkey (0.05 per decade) compared to France (0.015 per decade) and Israel (0.02 per decade) and is mainly attributed to the increasing percentage of cultured seabass (*Dicentrarchus labrax*) and seabream (*Sparus aurata*). The declining percentage of low trophic fishes in the Mediterranean aquaculture may enhance this trend in the future. It should be noted that the effect of bluefin tuna (*Thunnus thynnus*) fattening [5] was not yet identifiable in the 2004 dataset. As noted earlier [2], the farming of seabass and seabream, and the fattening of bluefin consume far more fish (sardine, anchovies, etc.) for feed than these operations produce, which thus contribute to reducing the net supply of fish available for human consumption. Along with the many environmental problem caused by the farming of carnivorous fish, this argues for a need to return to more sustainable forms of mariculture, notably bivalve aquaculture, which has a long tradition in the Mediterranean.

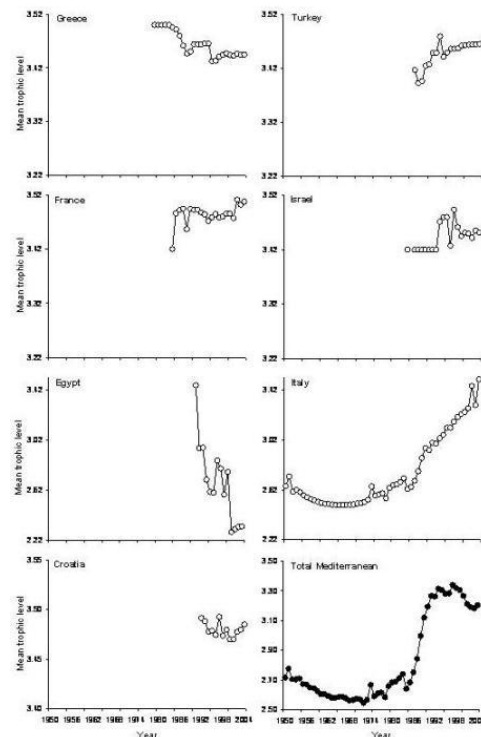


Fig. 1. Mean weighted trophic level variability of the Mediterranean cultured fishes for the main producing countries (1950-2004). The four bottom panels (Egypt, Italy, Croatia and Total Mediterranean) are not in the same scale.

### References

- 1 - Pauly D., Christensen V., Dalsgaard J., Froese R. and Torres F. Jr, 1998. Fishing down marine food webs. *Science*, 279: 860-863
- 2 - Stergiou K.I., Tsikliras A.C. and Pauly D., 2009. Farming up the Mediterranean food webs. *Conserv. Biol.*, 23: 230-232
- 3 - FAO Fishery Information, Data and Statistics Unit. 2006. Aquaculture production 1950-2004. FISHSTAT Plus - Universal software for fishery statistical time series. Food and Agriculture Organization of the United Nations
- 4 - Gascuel D. and Pauly D., 2009. EcoTroph: Modelling marine ecosystem functioning and impact of fishing. *Ecol. Model.* 220: 2885-2898
- 5 - Ottolenghi, F., 2008. Capture-based aquaculture of bluefin tuna. In: Lovatelli, A., Holthus, P. F., (Eds.), Capture-based aquaculture. Global overview. *FAO Fisheries Technical Paper*. No. 508. FAO, Rome. pp. 169-182