From species to function: Using the tool of biological traits analysis to detect the effects of small-scale fisheries on the functioning of fish assemblages

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Summary
An emerging issue in fisheries ecology is the effect of living resources exploitation not only on population dynamics, but also on ecosystem functioning. We used biological traits analysis (BTA) to examine whether small-scale fisheries target specific functions of the fisheries resources assemblages. A total of 21 traits encompassing elements of the species life cycle, distribution, population ecology and behaviour were examined for 86 species dominating the small-scale fisheries catch of the Patraikos Gulf (Greece). Standardized species composition abundance data from 145 fishing operations (11 métiers) were combined with a presence-absence matrix of trait categories/modalities to construct a dataset of traits by fishing operation. A PERMANOVA indicated differences in traits composition among métiers; however a cluster and an MDS analysis did not reveal any clear métier distinctions. A SIMPER analysis of the modalities within each trait showed a few fragmented associations of métiers with trait categories. The absence of strong associations, indicates that the multi-species character of small-scale fisheries results to a balanced removal of functions from the assemblage. The application of the traits approach in large datasets, examining all the fleets of a geographic area, could provide crucial information on the fisheries effects on ecosystem functioning.

Introduction
In recent years the importance of small-scale fisheries has been gradually identified (e.g. Tzanatos et al. 2006). Small-scale fisheries are generally believed to have small impact on the marine environment in comparison with industrial fisheries. A variety of tools exist evaluating the ecosystem effects of fishing (e.g. Rice 2000), but to date only a few works have studied the effects of fishing on the functioning of fish assemblages even though the Ecosystem Approach to Fisheries Management underlines the need to take the entire ecosystem into account for successful fisheries management (e.g. FAO 2003). The various aspects of functioning are examined in biological traits analysis approaches Somerfield et al. 2008) and despite some recent attempts to evaluate the effects of fisheries on assemblage traits (Bremner 2005, de Juan et al. 2007) no studies on the functions removed by small-scale fisheries exist. The aim of this work is the evaluation of different fishing tactics considering the biological traits of the catches in order to detect whether there are métiers that remove specific functions from the assemblage.

Materials and Methods
The dataset that was examined, included the catch biomass by species from 145 fishing operations (assigned to 11 métiers) of the small- scale fishing fleet in Patraikos Gulf (Greece) collected in 2003-2004 (Tzanatos *et al*. 2006). As a proxy of the species functioning within the assemblage we used elements of the species life cycle (e.g. longevity and fecundity), distribution (e.g. habitat type and depth), population ecology (e.g. trophic level) and behaviour (schooling, mobility). From the available bibliography, we created a matrix (presence-absence) of biological traits (21 traits with 2-6 trait categories/modalities each) by species for 86 of the most common species in the catches of the area. The biomass of the examined species comprised on average 94,4% of the total catch biomass per fishing operation. Multiplying the traits-by-species and the species catch-biomass-by-fishing-operation matrices we created a matrix of traits by fishing operation.

A Mantel test was carried out using the similarity matrices of catch-biomass-by-fishing-operation and traits-by-fishing-operation in order to detect whether the species composition of métiers is reflected in the traits composition of these métiers. In the standardized traits-by-fishing-operation matrix a PERMANOVA was carried out in order to detect whether there are differences in traits between métiers. A cluster and MDS were carried out on the traits by fishing operation matrix to discern fishing operations removing specific modality combinations. For the association of métiers with specific modalities within a trait, a SIMPER analysis was carried out for each of the 21 traits. All analyses were carried out in PRIMER 6 (Clarke & Gorley 2006, Anderson *et al.* 2008).

Results and Discussion

The Mantel test indicated that the similarity matrices of species and traits composition were related but the relationship was not very strong (ϱ= 0508, α=0.05, p=0.001); thus the catch and trait matrices are not identical and the trait matrix includes information not depicted in the catch matrix. The PERMANOVA indicated significant differences between métiers for the traits by fishing operation (pseudo-F= 9.1764, α=0.05, p=0.001) in Patraikos Gulf. However, no specific métier was unambiguously distinct from the rest, either in the cluster analysis or the MDS, perhaps due to the multitude of traits used. The SIMPER analysis carried out on the trait level provided insight to whether trait categories (modalities) are associated with specific métiers and indicated some rather scattered associations of 5 métiers. A longline métier targeting *Dentex dentex* and *Epinephelus marginatus* in autumn was associated with high (> 1 m) maximum length of the catches. Winter trammel net tactics targeting *Solea solea* and *Sepia officinalis* were related to modalities concerning low mobility and ambushing way of feeding (the former) and fecundities at the scale of 1000 eggs, soft seabed species and rounded body forms (the latter). A small mesh-size trammel net tactic operating in autumn targeting *Mullus barbatus* was related with species of life-spans of 5-10 years, while a similar spring one targeting *Melicertus kerathurus* with species of low (<20 cm) maximum length. Overall, however, no clear distinction of métiers was found or strong associations indicating specialization in certain trait characteristics.

In general, it seems that small-scale fisheries result in a balanced removal of biological traits, exactly because of their multi-specific nature; however the need to implement detailed estimations of the functions that fishing may remove from the ecosystem in wider scales and incorporating industrial fisheries is obvious. In data-poor fisheries, like the majority of small-scale fisheries, the traits approach can be a useful alternative in fisheries management optimization.

References

Anderson, M.J., Gorley, R.N., and Clarke, K.R. 2008. PERMANOVA + for PRIMER Guide to Software and Statistical Methods. PRIMER-E,Plymounth, UK

Bremner, J., Frid, C.L.J., and Rogers, S.I. 2005. Biological traits of the North Sea benthos: does fishing affect benthic ecosystem function? American Fisheries Society Symposium, 41, 477: 477-489.

Clarke, K.R., and Gorley, R.N. 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E. Plymouth. 192pp.

de Juan, S., Thrush, S.F., and Demestre, M. 2007. Functional changes as indicators of trawling disturbance on a benthic community located in a fishing ground (NW Mediterranean Sea). Marine Ecology Progress Series, 334: 117–129.

FAO. 2003. Fisheries management 2. The ecosystem approach to fisheries. FAO Technical Guidelines for Responsible. Fisheries 4. 112 pp.

Rice, J. C. 2000. Evaluating fishery impacts using metrics of community structure. ICES Journal of Marine Science, 57: 682–688.

Somerfield, P. J., Clarke, K. R., Warwick, R. M., and Dulvy, N. K. 2008. Average functional distinctness as a measure of the composition of assemblages. ICES Journal of Marine Science, 65: 1462-1468.

Tzanatos, E., Somarakis, S., Tserpes, G., and Koutsikopoulos, C. 2006. Identifying and classifying small-scale fisheries métiers in the Mediterranean: A case study in the Patraikos Gulf, Greece. Fisheries Research, 81: 158–168.