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Effects of recreational scuba diving on Mediterranean fishes: evidence of involuntary feeding?

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Abstract

Despite a large body of literature assessing the impacts of recreational scuba diving on marine habitats, little attention has been paid to the potentially harmful effects this has on fishes. The aim of this study was the assessment of the immediate response of different fish species to divers' activities. A decrease of fishes' natural diffidence towards divers is shown, probably due to an enhanced availability of their prey as a result of divers' contacts with the substrate.

Keywords: Scuba diving, fish behaviour, short-term effect, Mediterranean Sea.

In the past few decades, a large number of papers dealt with the impact evaluation of recreational scuba diving worldwide (Di Franco *et al*., 2009; Luna *et al*., 2009; Di Franco *et al*., 2010 and references therein). The great majority of these studies assessed the potential disturbance to benthic sessile assemblages (Di Franco *et al*., 2009; Luna *et al*., 2009), and only very few of them focused on the effects on motile species (e.g., fishes, Hawkins *et al*., 1999).

Despite the general belief that the presence of humans could lead to changes in the "natural" behaviour of fish (see Kulbicki, 1998; Dickens *et al.*, 2011 and references therein) only a few studies assessed the effect that human leisure activities have on fish behaviour, with fishes exhibiting a human-approaching behaviour when additional resources are made available (i.e., recreational fish-feeding, Milazzo *et al.*, 2005; Milazzo *et al*., 2006), or differences in escape responses as a result of spearfishing (Guidetti *et al*., 2008; Gotanda *et al.*, 2009). The only two studies formally investigating the effects of recreational scuba diving (Hawkins *et al*., 1999) and snorkelling (Claudet *et al*., 2010) on fishes evaluated the long-term (i.e., in terms of weeks/months) disturbance, that potentially affects the entire composition and distribution of fish assemblages. In this study, we focus on short-term responses (i.e., in terms of minutes after human disturbance has occurred) of fishes as a result of a diver's activity (i.e., divers' contact with the benthic substrate) as an immediate disturbance potentially affecting fishes. We hypothesised that when a diver makes contact with whatever substrate, in addition to potentially causing immediate damage to benthic organisms (see Di Franco *et al*., 2009), release of a prey may also be caused, which likely decreases the instinctive diffidence of fishes towards humans (Kulbicki, 1998). This could be particularly true for those species of fish that eat small invertebrates associated with benthic organisms (e.g., phytal fauna).

Sampling was done at two marine protected areas (MPAs) in Sicily (SW Mediterranean): the Ustica MPA (Ustica, summer 2003) and the Capo Gallo – Isola delle Femmine MPA (CGIF, summer 2005–2006). MPAs attract tourists, and often represent the reason for which scuba divers choose to visit an area, with diving pressure (i.e., number of dives per year in one particular site) largely increasing after the MPA was implemented.

At the time of sampling, Ustica was already enforced (Guidetti *et al*., 2008) with high densities of fishes, while CGIF was a paper-park due to weak levels of enforcement (Di Franco, pers. obs.). Despite this, both MPAs attracted a larger number of divers than did the flanking and proximal areas (Di Franco *et al*., 2009), with diving pressure in Ustica notably higher than in CGIF (i.e. ~10,000 dives/year *vs*. ~1,000 dives/year).

During a total of 53 experimental dives (n = 25 at

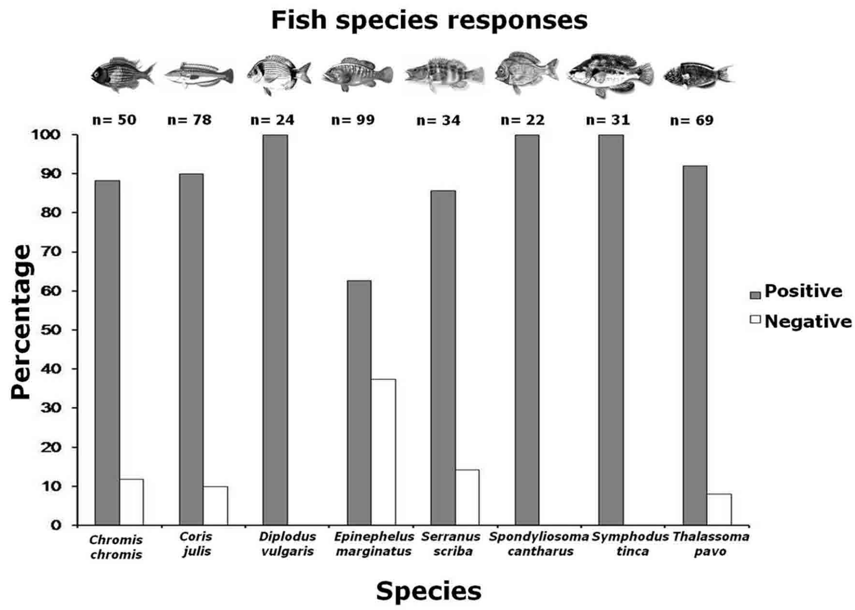

Fig. 1: Percentage of positive and negative response to SCUBA divers for each species. Data from different habitats were pooled for each fish species.

Ustica, and n = 28 at CG), we followed recreational scuba divers to collect data on the immediate effects their dives had on fish species. The number of contacts made with different substrates was recorded (see Di Franco *et al*., 2009 for further details). Eight different benthic habitats of the Mediterranean infralittoral were considered at Ustica: horizontal photophilic algae (HPA), vertical photophilic algae (VPA), coralline barrens (BA), *Posidonia oceanica* meadow (PO), sciaphilic walls (SW), submersed caves (CA), sandy bottoms (SA) and pebbles (PE). Seven habitats were considered at CGIF, because coralline barrens were not present (Di Franco *et al*., 2011; Milazzo *et al*., unpublished data). When a diver's contact occurred, the immediate effects of each contact were assessed by recording the response of coastal fish taxa present within a range of 5 metres around the point of contact (defined as the distance at which fishes usually react to a diver's presence, Guidetti *et al*., 2008). Two behavioural categories were considered: positive reaction (when a fish moved towards the point of contact) and neutral-negative reaction (when a fish did not show any response or reaction to the human contact, or moved away from the point of contact). Category of "no reaction" was not considered by itself as, after preliminary observations, it appeared very uncommon. For the dusky grouper *Epinephelus marginatus*, due to its piscivorous feeding habits (distinguishing this species from the more abundant invertebrate feeders) that could disentangle it from a restrictive habitat selection (i.e., referring to habitat as previously listed), and to the larger size than the other fish species considered, the behavioural responses were recorded, apart from considering any classification of its habitat.

At Ustica, seven taxa reacted after divers' contacts: the small invertebrate feeders *Thalassoma pavo*, *Chromis chromis*, *Coris julis*, *Diplodus vulgaris*, *Symphodus tinca*, *Serranus scriba*, *Spondyliosoma cantharus*, and the piscivorous *E. marginatus*. At CGIF, only the following three species were recorded: *C. chromis*, *C. julis* and *D. vulgaris*. No differences in responses (i.e., the frequency of positive and neutral-negative responses) were detected among the two MPAs (χ^2 Yates corrected = 0.29, $p>0.05$). The positive responses were significantly higher than neutral-negative (χ^2 Yates corrected = 98.06, $p<0.01$) for all species (Fig. 1). Most of the total responses per number of contacts was recorded on the BA habitats at Ustica (Fig. 2), and all these were positive. On the contrary, a low or null frequency of both total and positive responses was recorded in CA, SW, and PE.

In general, most of the total responses were recorded on HPA. This evidence was caused by the higher permanency of divers in this habitat, compared against other habitats considered (Di Franco *et al.*, 2009), and probably to the higher density of fishes on HPA (Guidetti, 2000). Considering the most abundant species (i.e., the ones with higher frequencies of total responses, *T. pavo*, *C. julis*, *C. chromis*, and *E. marginatus*), differences were recorded among *E. marginatus* and other fishes in behavioural responses (χ^2 = 27.86, $p<0.01$) with grouper showing the highest neutral-negative responses among all species, with this evidence partially matching with the available one from tropical areas (Dickens *et al*., 2011). It was impossible to test for formal differences among responses in different habitats due to the low number of observations in most of them. This study shows a predominance of positive responses of fishes towards the divers'

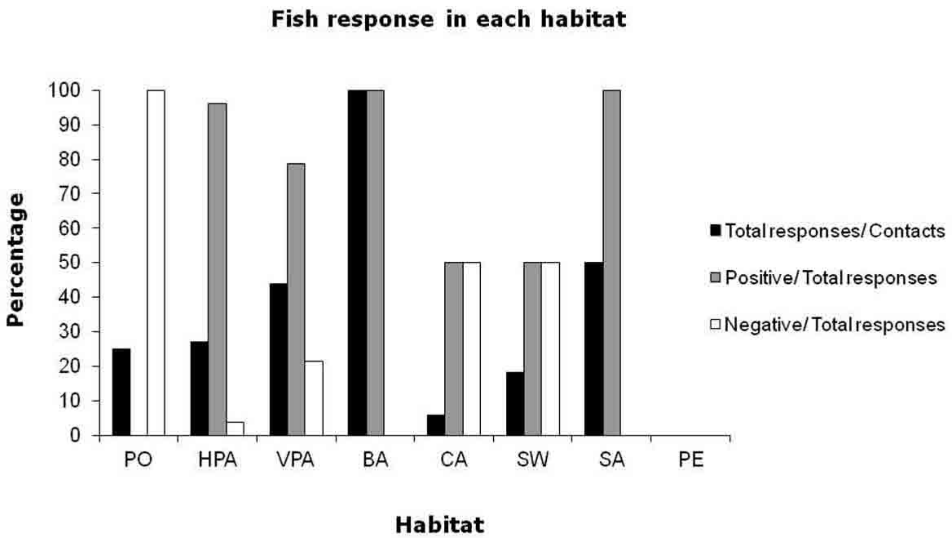

Fig. 2: Percentage of responses to SCUBA divers (total responses/number of contacts, positive responses/ total responses, negative responses/ total responses) in each habitat considered. Horizontal photophilic algae (HPA), vertical photophilic algae (VPA), coralline barrens (BA), *Posidonia oceanica* meadow (PO), sciaphilic walls (SW), submersed caves (CA), sandy bottoms (SA) and pebbles (PE).

contact point, and provides evidence for an effect of recreational scuba diving on fishes, not highlighted by others approaches (i.e., Hawkins *et al.*, 1999; see Di Franco *et al.*, 2009 for further discussion). Most fish actively followed divers, waiting for any contacts with the substrate (Di Franco, pers. obs.). Previous studies have examined learning patterns in fish, and have found that fish can improve their foraging performance with experience (Shettleworth, 1984). However, no studies have been focused on the learning response of fish as a result of a human disturbance. Rapid behavioural responses of fish occur frequently in areas where they are fed (Milazzo, 2011) or hunted (Kulbicki, 1998; Guidetti *et al.*, 2008), but in the absence of these stimuli, the presence of divers should not normally cause any significant changes in fish behaviour. An exception to this might occur when single individuals get accustomed to the presence of divers after their repeated visits (like at popular diving sites), with no stimulus other than habituation, or when – as in our case – divers involuntarily alter fish behaviour through contact with the substrate. The habitat-differential responses observed causing aggregation of fishes in the short term (i.e., within seconds) may be as a result of a different prey being available. At present, it has not been demonstrated that availability of prey (i.e., small invertebrates) is enhanced by contacts, but it is very likely that prey can be dislodged, or made more accessible to predators by divers' contacts (i.e., involuntary fish-feeding). Indeed, availability of prey may differ across different subtidal habitats. Erect macroalgae on rocky substrates are a suitable habitat for a wide range of phytal organisms (mainly crustaceans, gastropods and polychaetes, Giangrande *et al.*, 2003 and references therein), and most of the invertebrate biomass is located on the algal canopy, where divers' contacts occur. A similar pattern would be for seagrasses, like *Posidonia oceanica*, but in this case, the majority of the associated fauna potentially available for fishes is concentrated underneath the leaves in the lower accessible *matte* layer (Orth *et al.*, 1984). In the barren habitat overgrazed by sea urchins, encrusting coralline algae mainly host small-sized polychaetes and gastropods (Micheli *et al.*, 2005), and the lack of macroalgal canopy indeed makes these prey more visible to predator fishes. In addition to increasing predation rates on low mobile and sessile invertebrate fauna, other potential indirect effects may occur on local scale, as this unnatural aggregations of fishes may enhance the probability of predatory attacks on the benthic nests of other fish species (Milazzo *et al.*, 2006). Beyond the potential ecological fallouts previously discussed, the diver's positive behaviour, highlighted in the present study, could affect the analysis of the distribution and abundance of fish through the use of underwater visual census. This problem was extensively investigated, resulting in contrasting evidences (see Dickens *et al.*, 2011 and references therein). Provided, that under comparable conditions, just the estimates of absolute numbers of fish, and not relative comparison within a single study, can be affected (Dickens *et al.*, 2011), the effect of the presence of scuba divers' on the fish environment should be carefully tackled, particularly in the case of comparing fish assemblages inhabiting areas where fishes can potentially show different responses to scuba divers' presence (e.g., protected *vs.* unprotected areas). From this perspective, further studies assessing fish responses under different protection conditions are required to be conducted.

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References

Claudet, J., Lenfant, P., Schrimm, M., 2010. Snorkelers impact on fish communities and algae in a temperate marine protected area. *Biodiversity & Conservation*, 19 (6), 1649-1658.

Di Franco, A., Ferruzza, G., Baiata, P., Chemello, R., Milazzo, M., 2010. Can recreational scuba divers alter natural gross sedimentation rate? A case study from a Mediterranean deep cave. *ICES Journal of Marine Science*, 67 (5), 871-874.

Di Franco, A., Graziano, M., Franzitta, G., Felline, S., Chemello, R. *et al.,* 2011. Do small marinas drive habitat specific impacts? A case study from Mediterranean Sea. *Marine Pollution Bullettin*, 62 (5), 926-933.

Di Franco, A., Milazzo, M., Baiata, P., Chemello, R., 2009. Evaluation of scuba divers' behaviour and of its effects on the biotic component of a Mediterranean MPA. *Environmental Conservation,* 36, 32-40.

Dickens, L.C., Goatley C.H.R., Tanner J.K., Bellwood D.R., 2011. Quantifying relative diver effects in Underwater Visual Censuses. *PLoS ONE*, 6 (4), e18965. doi:10.1371/journal.pone.0018965.

Giangrande, A., Delos, A.L., Fraschetti, S., Musco, L., Licciano, M. *et al.,* 2003. Polychaete assemblages along a rocky shore on the South Adriatic coast (Mediterranean Sea): patterns of spatial distribution. *Marine Biology*, 143, 1109-1116.

Gotanda, K.M., Turgeon, K., Kramer, D.L., 2009. Body size and reserve protection affect flight initiation distance in parrotfishes. *Behavioral Ecology & Sociobiology*, 63 (11), 1563-1572.

Guidetti, P., 2000. Differences among fish assemblages associated with nearshore *Posidonia oceanica* seagrass beds, rocky–algal reefs and unvegetated sand habitats in the Adriatic Sea. *Estuarine Coastal & Shelf Science,* 50 (4), 515-529.

Guidetti, P., Vierucci, E., Bussotti, S., 2008. Differences in escape response of fish in protected and fished Mediterranean rocky reefs. *Journal of the Marine Biological Association of the U.K.*, 88 (3), 625-627.

Hawkins, J.P., Roberts, C.M., Van't Hof, T., De Meyer, K., Tratalos, J. *et al.,* 1999. Effects of recreational scuba diving on Caribbean coral and fish communities. *Conservation Biology*, 13 (4), 888-897.

Kulbicki, M., 1998. How the acquired behaviour of commercial reef fishes may influence the results obtained from visual censuses. *Journal of Experimental Marine Biology & Ecology*, 222 (1-2), 11-30.

Luna, B., Valle Pérez, C., Sánchez-Lizaso, J.L., 2009. Benthic impacts of recreational divers in a Mediterranean Marine Protected Area. *ICES Journal of Marine Science*, 66 (3), 517-523.

Micheli, F., Benedetti-Cecchi, L., Gambaccini, S., Bertocci, I., Borsini, C. *et al.,* 2005. Cascading human impacts, marine protected areas, and the structure of Mediterranean reef assemblages. *Ecological Monographs*, 75 (1), 81-102.

Milazzo, M., 2011. Evaluation of a behavioural response of Mediterranean coastal fishes to novel recreational feeding situation. *Environmental Biology of Fishes*, 91 (1), 127-132.

Milazzo, M., Anastasi, I., Willis, T.J., 2006. Recreational fish feeding affects coastal fish behaviour and increases frequency of predation on damselfish (*Chromis chromis*) nests. *Marine Ecology Progress Series*, 310, 165-172.

Milazzo, M., Badalamenti, F., Vega-Fernandez, T., Chemello, R., 2005. Effects of fish feeding by snorkellers on the density and size distribution of fishes in a Mediterranean marine protected area. *Marine Biology*, 146, 1213-1222.

Orth, R.J., Heck, K.L., van Montfrans, J., 1984. Faunal communities in seagrass beds: A review of the influence of plant structure and prey characteristics on predator-prey relationships. *Estuaries*, 7, 339-350.

Shettleworth, S.J., 1984. Learning and behavioural ecology. p. 170-194. In: *Behavioural ecology: an evolutionary approach*. Krebs, J.R., Davies, N.B. (Eds), 2nd ed., Sinauer Associates, Sunderland.