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Disentangling physical and biological drivers of phytoplankton dynamics in a coastal system

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This proof-of-concept study integrates the surface currents measured by high-frequency coastal radars with plankton time-series data collected at a fixed sampling point from the Mediterranean Sea (MareChiara Long Term Ecological Research site in the Gulf of Naples) to characterize the spatial origin of phytoplankton assemblages and to scrutinize the processes ruling their dynamics. The phytoplankton community generally originated from the coastal waters whereby species succession was mainly regulated by biological factors (life-cycle processes, species-specific physiological performances and inter-specific interactions). Physical factors, e.g. the alternation between coastal and offshore waters and the horizontal mixing, were also important drivers of phytoplankton dynamics promoting diversity maintenance by i) advecting species from offshore and ii) diluting the resident coastal community so as to dampen resource stripping by dominant species and thereby increase the numerical importance of rarer species. Our observations highlight the resilience of coastal communities, which may favour their persistence over time and the prevalence of successional events over small time and space scales. Although coastal systems may act differently from one another, our findings provide a conceptual framework to address physical–biological interactions occurring in coastal basins, which can be generalised to other areas.

Changes in phytoplankton assemblages at a specific site, such as at Long Term Ecological Research (LTER) ones, may be difficult to interpret, because they result from two main, potentially interplaying key factors, namely: physical transport and biological processes, which are classically indicated as 'allogenic' and 'autogenic' factors, respectively[1,2].

Physical transport may imply either the mixing or the replacement of distinct plankton assemblages. Biology, conversely, determines the local gain and loss of individuals *via* a myriad of processes, such as cell division and life cycle shifts[3], inter-specific differences in growth rates due to different physiological behaviour[4], as well as positive and negative inter-specific interactions, which ultimately result in the succession of species[4]. The interplay of these different processes generates potential biases in interpreting the mechanisms underlying the waxing and waning of phytoplankton blooms[5], some of which are toxigenic and, thus, noxious to human health[6]. This methodological problem is further aggravated in coastal and relatively shallow areas, where horizontal gradients are stronger[7,8]. As a result, the interpretation of the complex spatial-temporal dynamics of plankton communities at LTER sites is often oversimplified, especially in case of single-point sampling sites.

A possible way to overcome these limitations is the integration of the ecological information with that of the surface circulation. The latter may be described with an unprecedented accuracy, resolution and synopticity through land-based remote observations[9], such as those provided by high frequency coastal radars (HFRs)[10]. Protocols for the estimation of hourly surface velocity maps from HFRs are becoming increasingly robust[11]. Not only do HFR data allow following the progress of specific events, but they can also be used to analyze the coastal transport processes by means of consolidated Lagrangian modelling approaches[12–14], such as the backtracking

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