Limited impact of big fish mothers for population replenishment

A recent meta-analysis by Barneche et al. (Science 360(6389): 642) show that fish reproductive output scales hypergeometrically with female weight. This result challenges the common assumption that reproductive output is proportional to weight. The implication made is that current theory and practice severely underestimates the importance of larger females for population replenishment. Their example for cod shows that current practice makes an error of 149%. By properly accounting for fish demography we show that the error is maximally on the order of 10%, and in most other fish stocks likely much less.
Estimating sensitivity of seabed habitats to disturbance by bottom trawling based on the longevity of benthic fauna

Bottom fishing such as trawling and dredging may pose serious risks to the seabed and benthic habitats, calling for a quantitative assessment method to evaluate the impact and guide management to develop mitigation measures. We provide a method to estimate the sensitivity of benthic habitats based on the longevity composition of the invertebrate community. We hypothesize that long-lived species are more sensitive to trawling mortality due to their lower pace of life (i.e., slower growth, late maturation). We analyze data from box-core and grab samples taken from 401 stations in the English Channel and southern North Sea to estimate the habitat-specific longevity composition of the benthic invertebrate community and of specific functional groups (i.e., suspension feeders and bioturbators), and examine how bottom trawling affects the longevity biomass composition. The longevity biomass composition differed between habitats governed by differences in sediment composition (gravel and mud content) and tidal bed-shear stress. The biomass proportion of long-lived species increased with gravel content and decreased with mud content and shear stress. Bioturbators had a higher median longevity than suspension feeders. Trawling, in particular by gears that penetrate the seabed >2 cm, shifted the...
community toward shorter-lived species. Changes from bottom trawling were highest in habitats with many long-lived species (hence increasing with gravel content, decreasing with mud content). Benthic communities in high shear stress habitats were less affected by bottom trawling. Using these relationships, we predicted the sensitivity of the benthic community from bottom trawling impact at large spatial scale (the North Sea). We derived different benthic sensitivity metrics that provide a basis to estimate indicators of trawling impact on a continuous scale for the total community and specific functional groups. In combination with high resolution data of trawling pressure, our approach can be used to monitor and assess trawling impact and seabed status at the scale of the region or broadscale habitat and to compare the environmental impact of bottom-contacting fishing gears across fisheries.

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Estimating sensitivity of seabed habitats to disturbance by bottom trawling based on the longevity of benthic fauna

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Fish community structure from productive shelf systems to open ocean environments

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Growth of teleost fish across marine regions and ecological lifestyles

Spatial distribution of life-history traits and their response to environmental gradients across multiple marine taxa

Trait-based approaches enable comparison of community composition across multiple organism groups. Yet, little is known about the degree to which empirical trait responses found for one taxonomic group can be generalized across organisms. In this study, we investigated the spatial variability of marine community-weighted mean traits and compared their environmental responses across multiple taxa and habitats, including pelagic zooplankton (copepods), demersal fish, and benthic infaunal invertebrates. We used extensive, spatially explicit datasets collected from scientific surveys in the North Sea and examined community composition of these groups using a trait-based approach. In order to cover the key biological characteristics of an organism, we considered three life-history traits (adult size, offspring size, and fecundity) and taxon-specific feeding traits. While many of the traits co-varied in space and notably demonstrated a south–north gradient, none of the traits showed a consistent spatial distribution across all groups. However, traits are often correlated as a result of trade-offs. When studying spatial patterns of multiple traits variability in fish and copepods, we showed a high spatial correlation. This also applied to a lesser extent to fish and benthic infauna, whereas no correlation was found between benthic infauna and copepods. The result suggested a decoupling in the community traits between strictly benthic and strictly pelagic species. The strongest drivers of spatial variability for many community traits are the gradients in temperature seasonality, primary productivity, fishing effort, and depth. Spatial variability in benthic traits also co-varied with descriptors of the seabed habitat. Overall, results showed that trait responses to environmental gradients cannot be generalized across organism groups, pointing toward potential complex responses of multi-taxon communities to environmental changes and highlighting the need for cross-habitat multi-trait analyses to foresee how environmental change will affect community structure and biodiversity at large.
Assessing impact of bottom trawling and hypoxia on seafloor status of the Baltic Sea

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Fish growth in pelagic and benthic food webs across marine ecosystems

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Global patterns in marine predatory fish
Large teleost (bony) fish are a dominant group of predators in the oceans and constitute a major source of food and livelihood for humans. These species differ markedly in morphology and feeding habits across oceanic regions; large pelagic species such as tunas and billfish typically occur in the tropics, whereas demersal species of gadoids and flatfish dominate boreal and temperate regions. Despite their importance for fisheries and the structuring of marine ecosystems, the underlying factors determining the global distribution and productivity of these two groups of teleost predators are poorly known. Here, we show how latitudinal differences in predatory fish can essentially be explained by the inflow of energy at the base of the pelagic and benthic food chain. A low productive benthic energy pathway favours large pelagic species, whereas equal productivities support large demersal generalists that outcompete the pelagic specialists. Our findings demonstrate the vulnerability of large teleost predators to ecosystem-wide changes in energy flows and hence provide key insight to predict the responses of these important marine resources under global change

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Guidelines for setting environmental targets for benthic habitats

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Physical loss and damage to seabed habitats

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Global patterns in the feeding ecology of large marine fish
Spatial structuration of life history traits: congruence between multiple taxa and environmental drivers in the North Sea

Towards a framework for the quantitative assessment of trawling impact on the seabed and benthic ecosystem

A framework to assess the impact of mobile fishing gear on the seabed and benthic ecosystem is presented. The framework that can be used at regional and local scales provides indicators for both trawling pressure and ecological impact. It builds on high-resolution maps of trawling intensity and considers the physical effects of trawl gears on the seabed, on marine taxa, and on the functioning of the benthic ecosystem. Within the framework, a reductionist approach is applied that breaks down a fishing gear into its components, and a number of biological traits are chosen to determine either the vulnerability of the benthos to the impact of that gear component, or to provide a proxy for their ecological role. The approach considers gear elements, such as otter boards, twin trawl clump, and groundrope, and sweeps that herd the fish. The physical impact of these elements on the seabed, comprising scraping of the seabed, sediment mobilization, and penetration, is a function of the mass, size, and speed of the individual component. The impact of the elements on the benthic community is quantified using a biological-trait approach that considers the vulnerability of the benthic community to trawl impact (e.g. sediment position, morphology), the recovery rate (e.g. longevity, maturation age, reproductive characteristics, dispersal), and their ecological role. The framework is explored to compare the indicators for pressure and ecological impact of bottom trawling in three main seabed habitat types in the North Sea. Preliminary results show that the Sublittoral mud (EUNIS A5.3) is affected the most due to the combined effect of intensive fishing and large proportions of long-lived taxa.
Using marine reserves to manage impact of bottom trawl fisheries requires consideration of benthic food-web interactions

Marine protected areas (MPAs) are widely used to protect exploited fish species as well as to conserve marine habitats and their biodiversity. They have become a popular management tool also for bottom trawl fisheries, a common fishing technique on continental shelves worldwide. The effects of bottom trawling go far beyond the impact on target species, as trawls also affect other components of the benthic ecosystem and the seabed itself. This means that for bottom trawl fisheries, MPAs can potentially be used not only to conserve target species but also to reduce impact of these side-effects of the fishery. However, predicting the protective effects of MPAs is complicated because the side-effects of trawling potentially alter the food-web interactions between target and non-target species. These changes in predatory and competitive interactions among fish and benthic invertebrates may have important ramifications for MPAs as tools to manage or mitigate the effects of bottom trawling. Yet, in current theory regarding the functioning of MPAs in relation to bottom trawl fisheries, such predatory and competitive interactions between species are generally not taken into account.

In this paper, we discuss how food-web interactions that are potentially affected by bottom trawling may alter the effectiveness of MPAs to protect (i) biodiversity and marine habitats, (ii) fish populations, (iii) fisheries yield and (iv) trophic structure of the community. We make the case that in order to be applicable for bottom trawl fisheries, guidelines for the implementation of MPAs must consider their potential food-web effects, at the risk of failing management.

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Similar effects of bottom trawling and natural disturbance on composition and function of benthic communities across habitats

Bottom trawl fishing has widespread impacts on benthic habitats and communities. The benthic response to trawling seems to be smaller or absent in areas exposed to high natural disturbance, leading to the hypothesis that natural and trawl disturbance affect benthic communities in a similar way. However, systematic tests of this hypothesis at large spatial scales and with data from sites spanning a large range of natural disturbance do not exist. Here, we examine the effects of trawl and natural (tidal-bed shear stress) disturbance on benthic communities over gradients of commercial bottom trawling effort in 8 areas in the North and Irish Seas. Using a trait-based approach, that classified species by life-history strategies or by characteristics that provide a proxy for their role in community function, we found support for the hypothesis that trawl and natural disturbance affect benthic communities in similar ways. Both sources of disturbance caused declines in long-living, hard-bodied (exoskeleton) and suspension-feeding organisms. Given these similar impacts, there was no detectable trawling effect on communities exposed to high natural disturbance. Conversely, in 3 out of 5 areas with low bed shear stress, responses to trawling were detected and resulted in community compositions comparable with those in areas subject to high natural disturbance, with communities being composed of either small-sized, deposit-feeding animals or mobile scavengers and predators. The findings highlight that knowledge of the interacting effects of trawl and natural disturbance will help to identify areas that are more or less resilient to trawling and support the development of management plans that account for the environmental effects of fishing.