FISH : shapes and swimming styles

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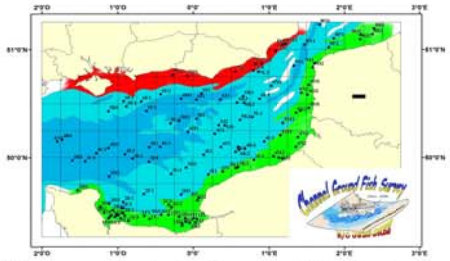
Introduction

Fishes compose one of the most morphologically diverse taxon.
Their body morphology varies between and within species, and is conditioned by several developmental paths and functions depending on multitude behaviours.
Notably, body shape has been shown to be associated with fish swimming and foraging abilities. For instance, trade-offs in body morphology may occur between traits favouring swimming performances and those facilitating manoeuvres to escape from predators or to predate on preys.
We propose to study and compare shapes of different fish species to evaluate the relationship between form and functions such as swimming or movement capability, the ultimate goal being to characterize fish functional diversity through morphology.

Material and methods



Map representing the CGFS survey with 3 different areas
UK offshore FR

Species were collected in October 2009 during the Channel Ground Fish Survey, an annual scientific survey conducted by IFREMER in the Eastern English Channel. 22 homologous landmarks were determined and digitized on numerical pictures to describe the morphology of 9 exploited fish species (seabass, whiting, red mullet, plaice, thornback ray, horse mackerel, mackerel, gurnard and searobin) based on roughly 90 individuals each.
Generalized Procrustes Analysis (GPA) were performed on seven focused species : seabass, whiting, red mullet, horse mackerel and mackerel, red gurnard and searobin.


Red mullet
(Mullus surmuletus)


Seabass
(Dicentrarchus labrax)


Red gurnard
(Aspitrigla cuculus)


Whiting
(Merlangius merlangus)


Sea robin
(Chelidonichthys lucerna)


Mackerel
(Scomber scombrus)


Horse mackerel
(Trachurus trachurus)

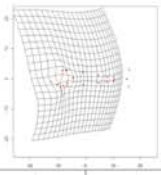
Both inter- and intra-specific morphological variations were considered. At the inter-specific level, a Principal Component Analysis (PCA) combined with Thin Plate Spline Deformation Grids was performed after the GPA using individual warps scores. In addition, mean shape differences between species were tested. At the intra-specific level, differences in mean shape were tested between 3 pre-defined size classes (small, medium and large) and between geographical locations (U.K, offshore, FR).

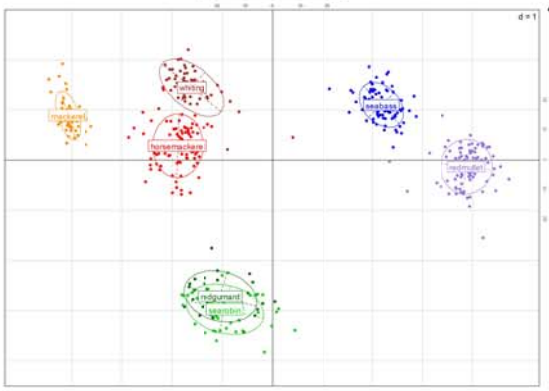
inter-specific : PCA + TPS deformation grid + test mean shapes
intra-specific : PCA + TPS deformation grid + test mean shapes size class & test mean shapes geographical locations

Results

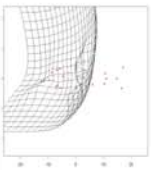
The seven species differ significantly in their shape ($p<0.001$).

On the first axis we observe mackerel, horse mackerel and whiting aggregated together because they share a slender body form with a strong but thin caudal peduncle supporting a hydrodynamic tail, which all contribute to fast cruise swimming. In contrast, red mullet and seabass are both characterized by a thicker body form that allow them to produce rapid punctual acceleration and manoeuvring.



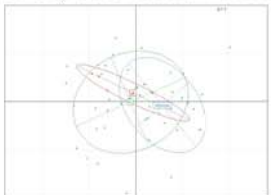


PCA after GPA on individuals warps scores

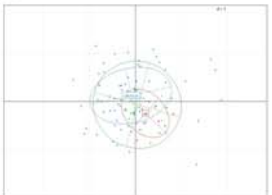


Red gurnard and searobin are isolated along the second axis, which is associated with a typical triglidae (fish family of these two species) deformation grid.
Distinct morphological traits observed are a square-shaped head and a slender body with a thin caudal peduncle. When swimming, sea robins used their fan-like pectoral fins for gliding and their caudal fin for propulsion. As benthic species, they can also use their pelvic fins to "walk" along sandy sea floors.

Size class:
Many species, just like the human being, exhibit ontogenic changes in their body's proportions with age due to development. This phenomenon can be observed in fish species, particularly when sexual maturation is reached. Despite this expectation, no size class effect is detected in all seven species, which may reflect the absence of ontogenic changes in their morphology during development. Due to the low number of juveniles in our samples, it was difficult to infer any potential ontogenic changes in morphology specifically related to sexual maturation.

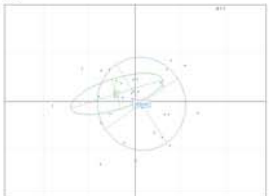


Sea robin PCA by location

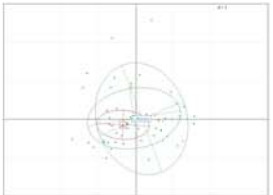


Red mullet PCA by location

Locations:
In the context of fisheries management and biodiversity conservation, it is important to be able to discriminate (partially) distinct populations of the same fish species. Differences in morphology have been already used to show the existence of different fish populations that were genetically differentiated. Based on intra-specific mean shape comparisons between geographical locations, we observe that whiting, red mullet, red gurnard and sea robin have significantly different shapes between individuals caught along the French coasts and those captured offshore, which may indicate that different sub-populations of these species co-exist in the Eastern English Channel.



Red gurnard PCA by location



Whiting PCA by location

Discussion, conclusion and perspectives

Fish exhibit a wide diversity of shapes in the Eastern English Channel. The morphological variation observed was in traits which are mostly related to swimming capacities and predation ability, including particularly the head and the caudal areas. Different body and caudal morphologies are related to different swimming styles, which have been observed to affect the search rates and foraging success. Different head shapes have also been shown to be related to handling and ingestion capability of different prey types.
Future aspect that will be dealt with in our study is to link the diet to morphological traits related to fish dispersal or movement capabilities and predation ability. Ultimately, our work intends to define species' functional diversity through geo-morphometrical analyses of fish anatomy and shape in the context of biodiversity conservation.

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