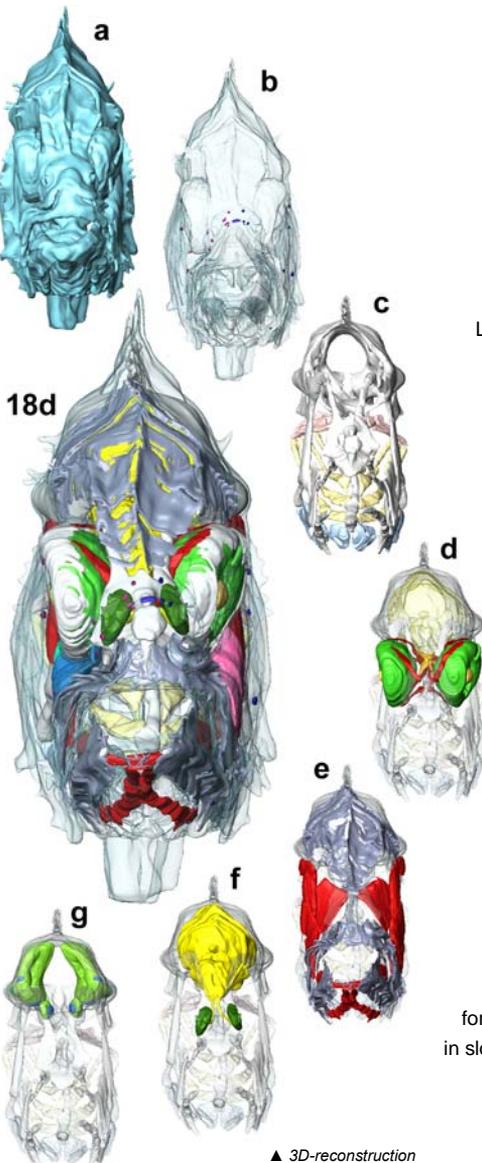


# Pseudo-4D visualization of the flatfish head during metamorphosis in the turbot *Psetta maxima*



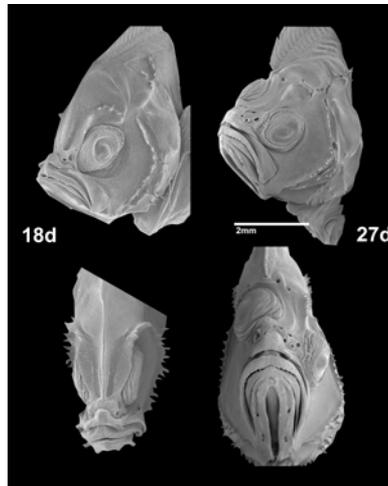
## Introduction

Within the first four weeks of life the vertical body axis of the developing turbot tilts 90° - from an upright swimming larva to a benthic juvenile lying permanently on the right side. Externally the most conspicuous morphological change in this period is the migration of the right eye to the left (future upper) body side. Coherent with this striking phenomenon many more or less serious changes of the inner anatomy are mandatory.



▲ 3D-reconstruction of various organ systems of the 18d old turbot larva (frontal view).

a) Outer surface, b) Neuromasts, c) Chondrocranium, d) Eyes, e) Osteocranium and jaw muscles, f) Brain and olfactory system, g) Labyrinth organ.



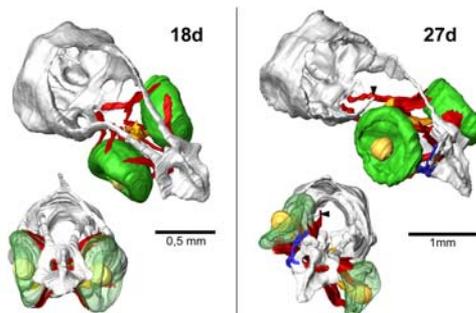
▲ SEM micrographs of turbot larvae (18d post hatching left, 27d right) seen from frontal-left (top) and frontal (bottom)

## Results + Discussion

Like in the sole (DZG abstr 99:137) also in the turbot some organ systems get markedly asymmetric in the course of metamorphosis (e.g. olfactory organs; jaw apparatus; anterior cranium; telencephalon, lateral line system), others retain their bilateral symmetry (bulk of brain and cranium; labyrinth organ). At climax of metamorphosis the right optic nerve is found only 10% longer than the left on, the right telencephalon is considerably smaller than the left one.

The cartilaginous arch of the right taenia marginalis is partially resorbed, preparing the way for the migrating eye and its supporting structures. The frontalia both are deformed towards the left side and the right lateral ethmoidal bone is shaped to form the ventro-nasal quadrant of the orbita.

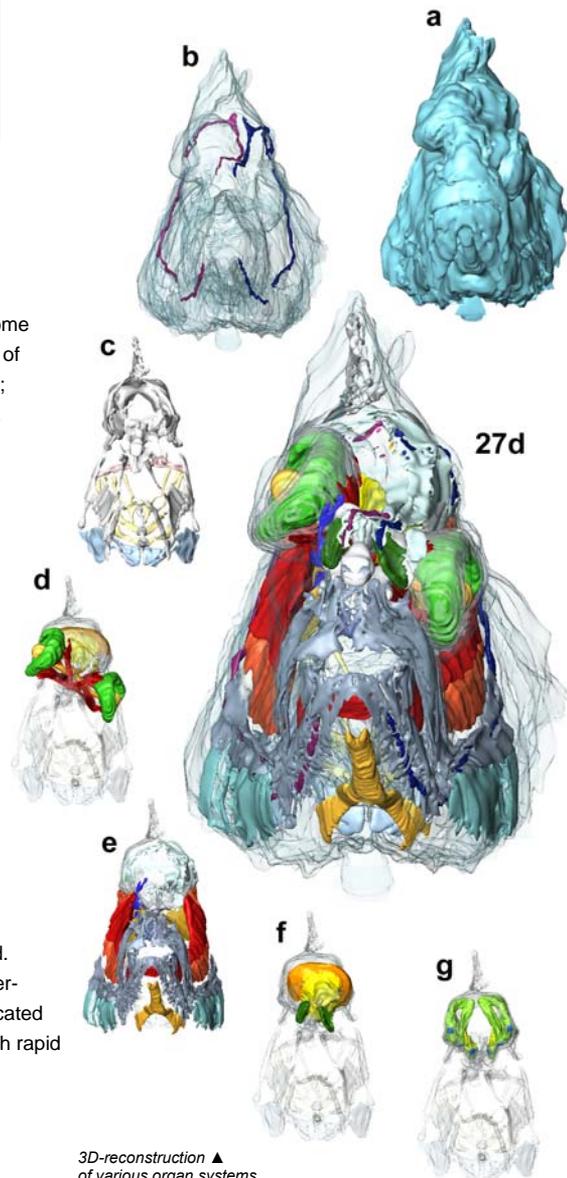
This is the first synoptic demonstration of all organ systems indicated above in a developing flatfish head. Obviously the (re)organization of the flatfish head is performed in a parsimonious way, being a little more complicated in slowly metamorphosing species (e.g. turbot), compared with rapid metamorphosers like the sole.



▲ Chondrocranium of the 18d and 27d old turbot with the respective orientation of the eyes and supporting structures. The right taenia marginalis is resorbed (→) to provide an unhindered way of the migrating eye. The right lateral os ethmoidale (blue) is placed ventro-nasally of the eye.

## Methods

To visualize the complex developmental events within the flatfish head during metamorphosis we reconstructed digital 3D-models from semithin section series through the heads of three larval stages of *P. maxima* (4d, 18d, 27d post hatching, the latter two shown here). Together with the histological images the 3D-data permit a detailed morphological and morphometrical description of the interdependent formation of all organ systems involved.



▲ 3D-reconstruction of various organ systems of the 27d old turbot larva (frontal view).

a) Outer surface, b) Lateral line system, c) Chondrocranium, d) Eyes, e) Osteocranium and jaw muscles, f) Brain and olfactory system, g) Labyrinth organ.