Histology and anatomy of clinically healthy Atlantic lumpfish, *Cyclopterus lumpus* L.)

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Lumpfish, *Cyclopterus lumpus*, has become an important species in the Norwegian aquaculture industry as it is used as a biological control measure for controlling salmon lice infections. From 2012 to 2017 the numbers of cultivated lumpfish increased from 431 000 to 30 286 000[1], meaning that in numbers farmed, lumpfish is now the second most important fish in Norway. The lumpfish is itself exposed to a number of infections, both parasitic, bacterial and virological[2], and the knowledge of these infections and their importance is deficient. In order to assess the importance of infections on the host and in different types of tissues, a detailed knowledge of the normal histology is crucial for tissue changes to be detected and compared with the normal state. As part of a project on parasitic infections in lumpfish, we carried out a study to describe the normal anatomy and histology of lumpfish, sizes ranging from <5 grams to 132 grams.

Here we present the normal anatomy and histology of two diagnostically relevant tissues; the heart and kidney. Images and descriptions of all tissues included in the study will be available in a public database at the end of 2020.

Methods: Groups of farmed lumpfish, sized <5g-132g, were used in this project. For the fry (<5g) the entire fish were fixated in formalin (>48h). For the juveniles (>5g) the target organs (skin, gills, heart, liver, kidney, spleen and pancreas) were dissected and fixated in formalin (>48h). Before further processing, these biopsies were systematically dissected into smaller pieces (figure 1) with an aim to include all parts of the organ in transversional and sagittal sections. The biopsies were embedded in paraffine wax, sectioned (5μm) and stained with hematoxylin and eosin (HE). Some selected specimens were also stained with AB-PAS, Van Gieson and May-Grünwald-Giemsa stains.

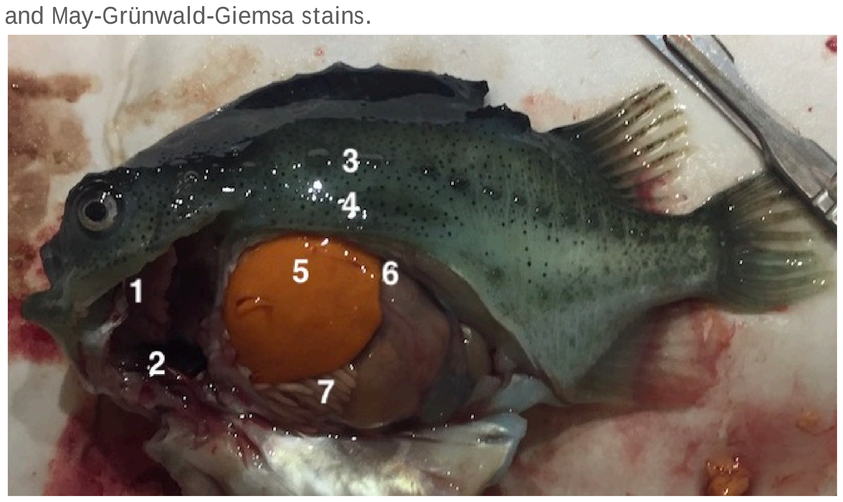


Figure 1: Organs included in the study:

1: gills
2: heart
3: skin and skeletal muscle
4: kidney
5: liver
6: spleen
7: pyloric caeca with pancreas and adipose tissue

The lumpfish heart

The endothelium of the atrium in lumpfish differs distinctly from that in salmon. While salmon atrial endothelial cells are relatively flat and uniform, the atrial endothelium of the lumpfish varies substantially. Amongst the lumpfish individuals investigated the shape and size of the atrial endothelial cells varied from small and cubic or rounded, to large and cylindrical.

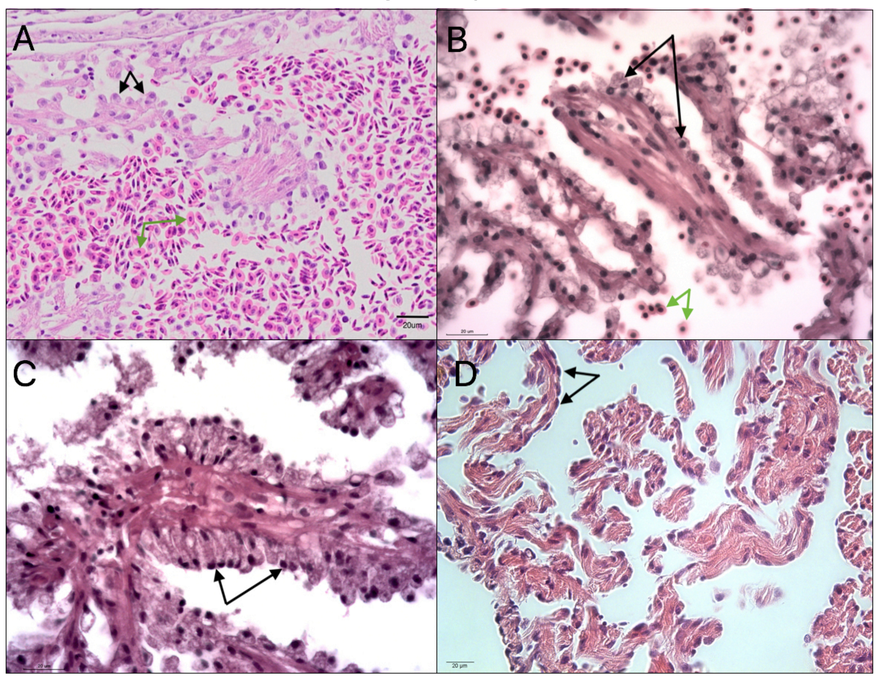


Figure 3: Heart endothelial cells from different sizes of lumpfish (A,B,C) and Atlantic salmon (D). 40x, HE. Black arrows: endothelial cells, Green arrows: red blood cells.

A: Atrium from lumpfish fry (<5g), showing rounded endothelial cells with a round/oval cell nucleus.

B: Atrium from lumpfish 95g, from sea, with rounded vacuolized endothelial cells and a central circular cell nucleus.

C: Atrium from lumpfish 75g, showing columnar endothelial cells with an apically placed circular cell nucleus.

D: Atrium from Atlantic salmon showing a single layer squamous endothelium.

The study is part of the project "Infections with the microsporidia *Nucleospora cyclopteri* in lumpsucker, *Cyclopterus lumpus*" funded by The Norwegian Seafood Research Fund (FHF) (project number 901320).

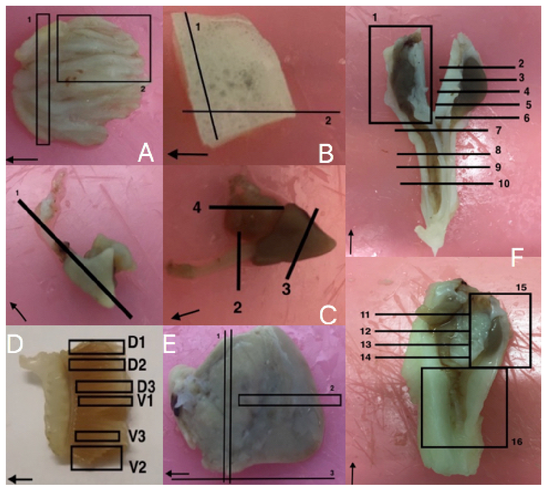


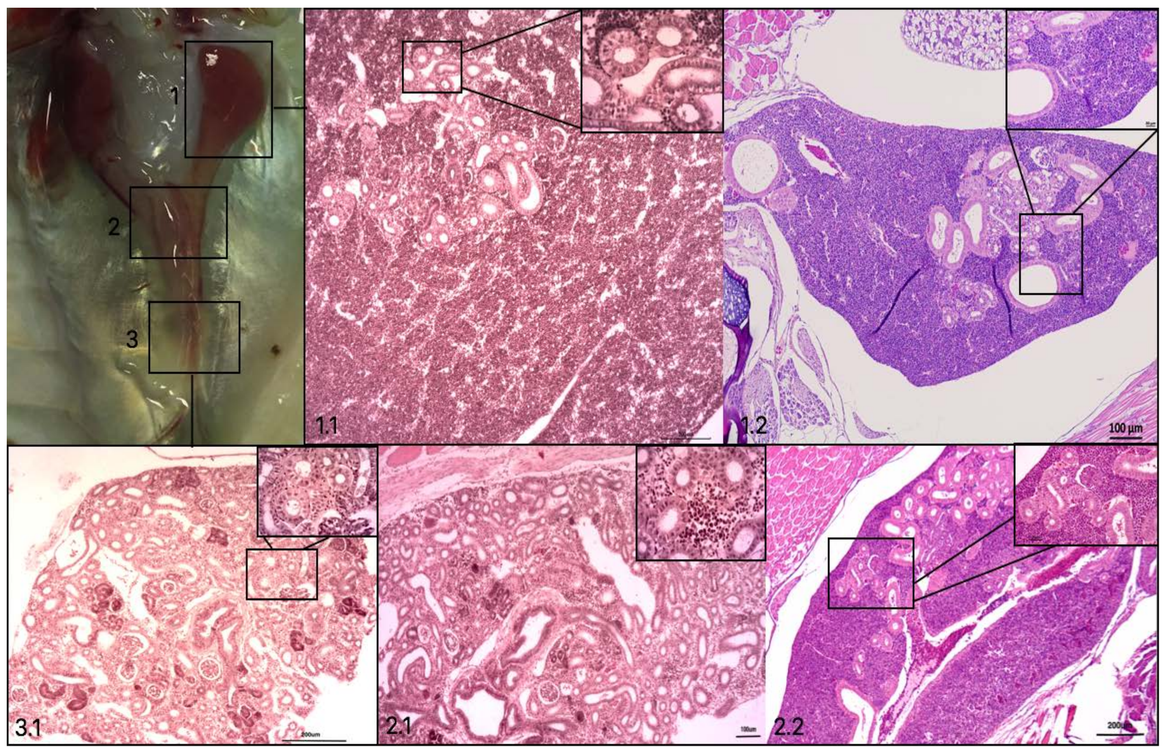
Figure 2. The systematic dissection of the organs showing where sections were taken;

A: pyloric caeca with pancreas and adipose tissue
B: skin and skeletal muscle
C: heart
D: gills
E: liver
F: kidney.

The spleen was processed as whole-organ sections.

The lumpfish kidney

The kidney consists of excretory, hematopoietic and endocrine tissue. The kidney of the lumpfish is macroscopically different from the salmon kidney. While the salmon kidney is more I-shaped in its length the kidney of lumpfish splits in a clear V-shape cranially (upper left figure 4). Compared to what is seen in salmon, the hematopoietic tissue in lumpfish is more concentrated in the anterior part, clearly distinct from mid- and posterior kidney, which mainly consist of excretory tissue.



Figur 4 – Kidney in lumpfish. 1; head kidney, where 1.1 is a sagittal section of a 125 g lumpfish, scale bar 200 µm, 1.2 sagittal section of fry (<5g). 2; mid-kidney, where 2.1 is a cross section from a 132g lumpfish, scale bar 100 µm, 2.2 sagittal section from fry (<5g). 3.1; cross section of posterior kidney from a 132g lumpfish.

REFERENCES

[1] Fiskeridirektoratet, 2019
[2] Karlsbakk E., Alarcon M., Hansen H. & Nylund A. (2014). Sykdom og parasitter i vill og oppdrettet rognkjeks [Diseases and parasites of lumpsucker (*Cyclopterus lumpus*)]. Fisken og Havet, Særnr. 1, 37-39

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