UNIVERSITY OF PRIMORSKA
FACULTY OF MATHEMATICS, NATURAL SCIENCES AND INFORMATION TECHNOLOGIES
DEPARTMENT OF BIODIVERSITY

LAB PRACTICAL INSTRUCTIONS

SHARK MORPHOLOGY, ANATOMY, MORPHOMETRY, SAMPLING AND DISSECTION METHODS

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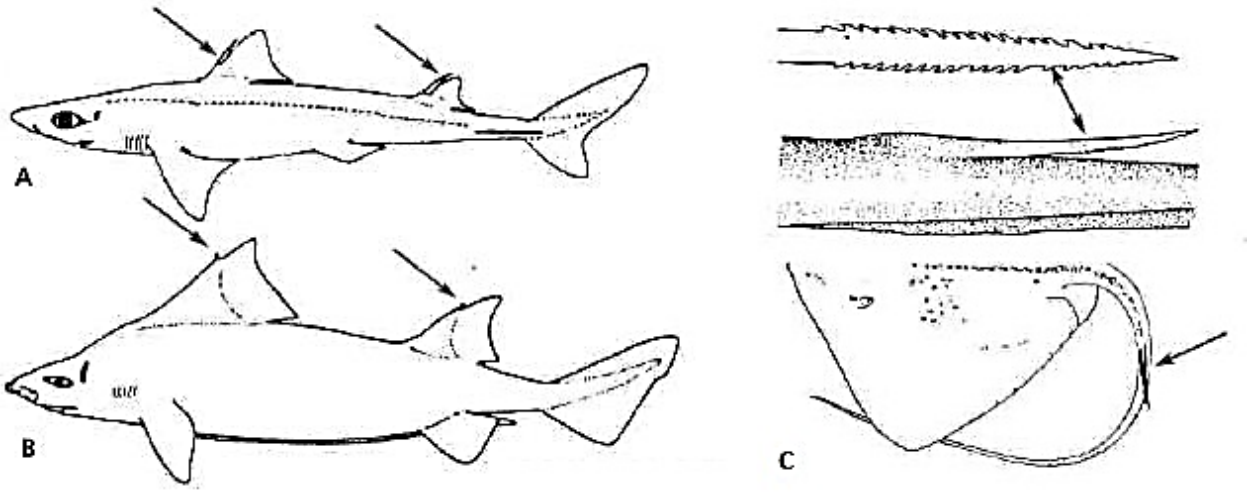
MORPHOLOGY AND MORPHOMETRIC CHARACHTERISTICS OF FISH

In order to determine family, genus or species of fish we most often use their morphological traits that can be easily recognized on the animal. But to be able to differentiate similar species we need to get acquainted with anatomy and morphology of fish body.

Most commonly used traits for determination are presence, shape and structure of fins; shape, size and position of scales; shape of lateral line (*linea lateralis*) and number of scales that form it; gill elements and number of gill slits. Other traits, that are often more difficult to determine, are bones of the head, position and number of sensory papillae and pores on the head, position and number of luminescent organs, number and shape of teeth etc.

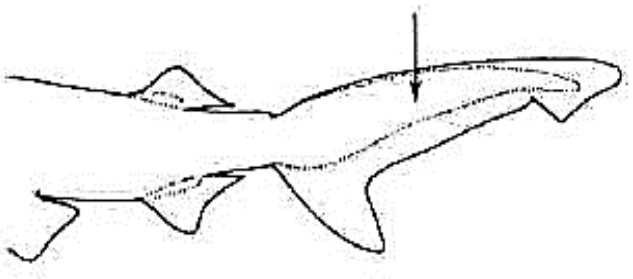
Fins are the most distinctive anatomical features of a fish. Fins are composed of bony spines or rays (*lepidotrichia*) protruding from the body. They are covered with skin and joined together or sometimes left separate. Depending on the position on the body fins are distinguished into **pectoral** (P), **ventral** (V), **dorsal** (D), **anal** (A) and **caudal** (C). Pectoral and ventral fins are paired, one fin on each side of the body. The number of dorsal fins can vary from 1 to 2, the number of anal from 1 to 2. Another type of fins are **adipose fin** found at salmon and trout (Salmonidae) and finlets, rayless non-retractable small fins, generally found behind last dorsal fin, found at mackerels (Scombridae). The number and type of fin can be written down as a fin formula.

Position and shape of the fins vary from species to species. Sometimes a fin can be reduced, transformed or even absent. Sharks belonging to Squalidae and Oxinotidae families have thorns attached to both dorsal fins (Picture 1A, 1B) and stingrays belonging to Rajiformes order have one or more thorns on the 1st dorsal fin (Picture 1C).

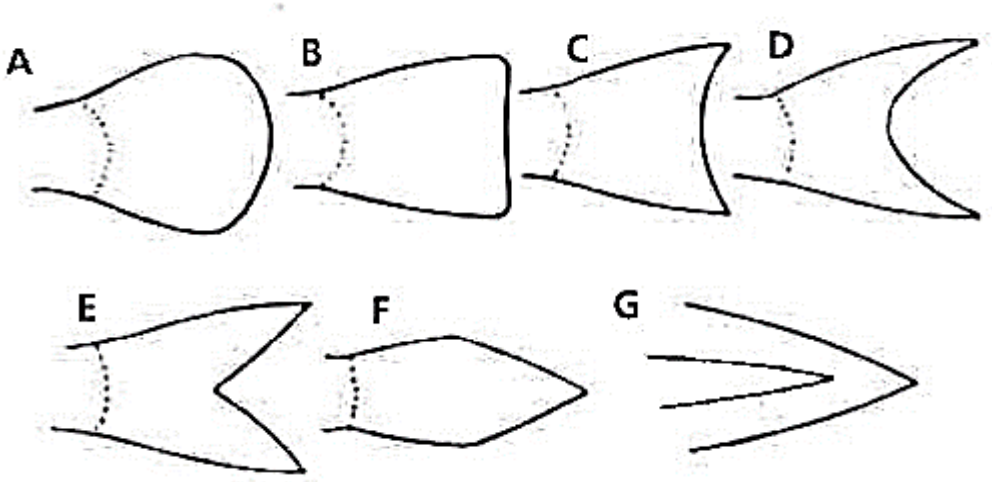


Picture 1: Thorns on dorsal fins characteristic for cartilaginous fish (Source: Jardas, 1996)

The caudal fin of sharks is asymmetric, the vertebral column is extend into upper lobe of the fin. This type of finis called heterocercal fin (Picture 2). Caudal fin of the bony fish is usually symmetric – homocercal, but can have different shapes: rounded (Picture 3A), straight (Picture 3B), slightly indented (Picture 3C), slightly or distinctly forked (Picture 3D and 3E), pointed (Picture 3F) and pointed with fused caudal, anal and dorsal fin (Picture 3G).



Picture 2: Heterocercal fin (Source: Jardas, 1996)



Picture 3: Caudal fin shapes of bony fish (Source: Jardas, 1996)

Another interesting example is a transformed inner part of ventral fin of sharks (Selachii) that functions as auxiliary copulatory organ – clasper (also *pterygopodium*).

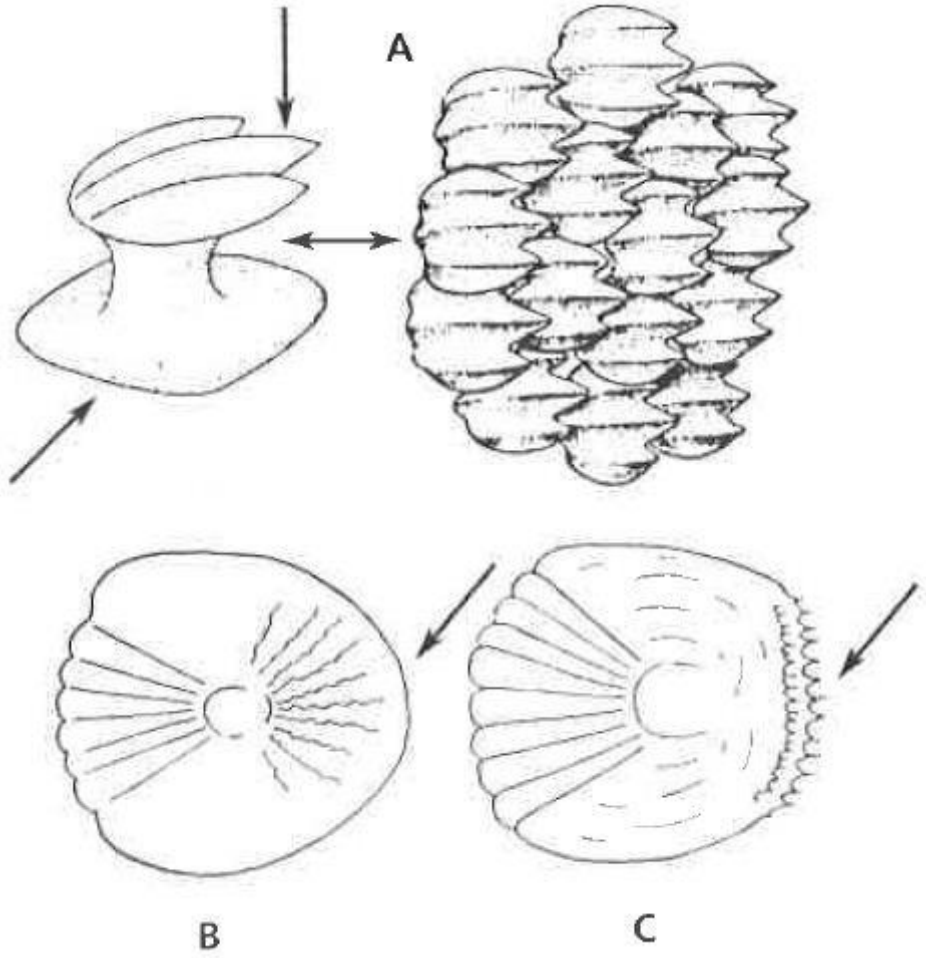
There are three basic types of fish scales are:

Placoid scales characteristic for cartilaginous fishes: sharks, skates and chimaeras. Placoid scale are formed of rectangular basal plate that is attached to dermis layer of the skin. Outwards extends a small vertebrate teeth (Picture 4A). The skin appears smooth from head to tail, but is rough in the opposite direction.

Cycloid scales are characteristic for higher order bony fish. They have a smooth texture and are uniform, with smooth outer edge (Picture 4B). The arrangement of cycloid scales resembles to that of the roof tiles.

Ctenoid scales are similar to cycloid, rough textured and with small teeth (ctenii) on the outer edges (Picture 4C).

Another type of scales are **ganoid** scales found for example in sturgeons (Acipenseridae). They are attached to special dermis pockets, are thicker and function also as defense mechanism.

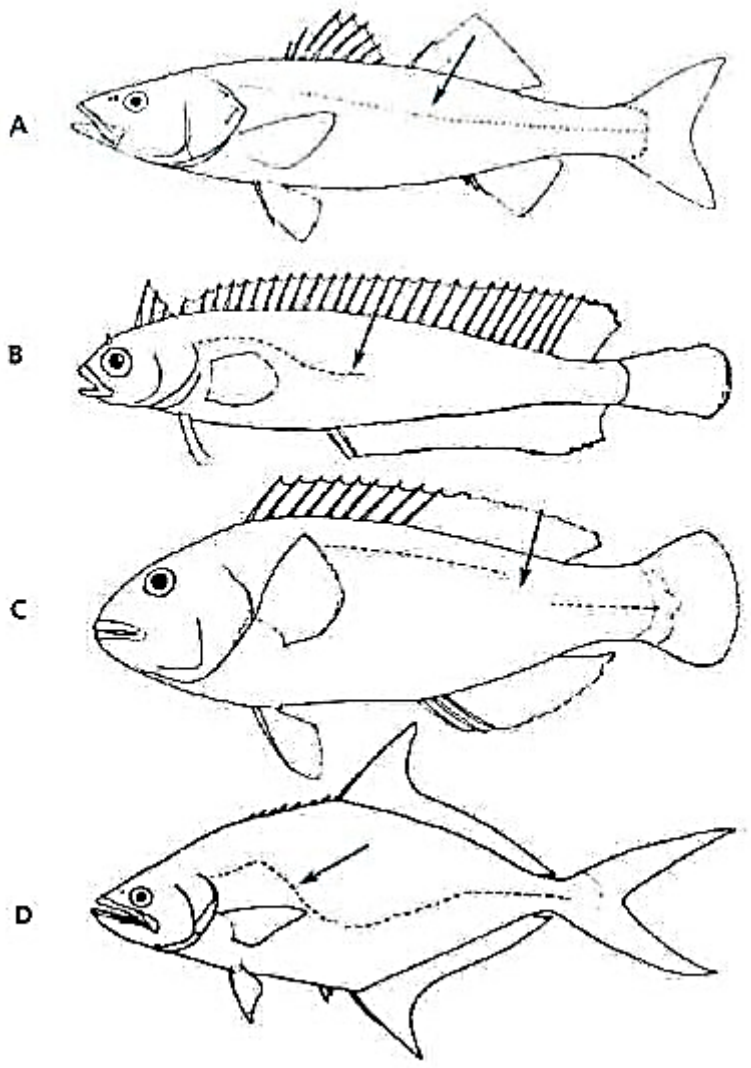


Picture 4: Basic scale types (Source: Jardas, 1996)

Along the fish body a distinct line can often be noticed. It is a special sensory organ of fish called a lateral line. The scales that form it are different from other scales as they contain a small pore that allows water to flow inside a dermal channel. This channel is filled with mucus and composed of ciliated sensory cells (**neuromast**) that detect changes in pressure and vibration of surrounding water. Lateral line has an important role in schooling behavior, predation and orientation.

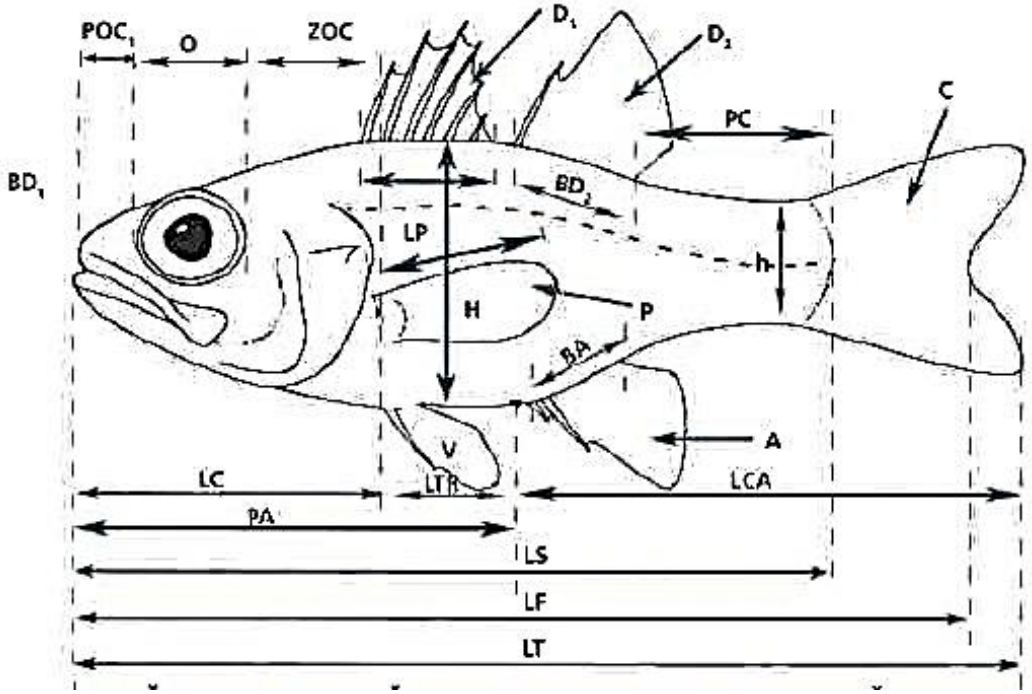
Lateral line can be continuous from head to tail (Picture 5A), can be continuous from head to the middle of the body (Picture 5B) or can be divided (Picture 5C). Species belonging to families Carangidae (i.e. *Lichia amia*) and Balistidae (i.e. *Balistes capriscus*) have a curved lateral line (Picture 5D).

Picture 5: Shapes of lateral line of bony fish (Source: Jardas, 1996)

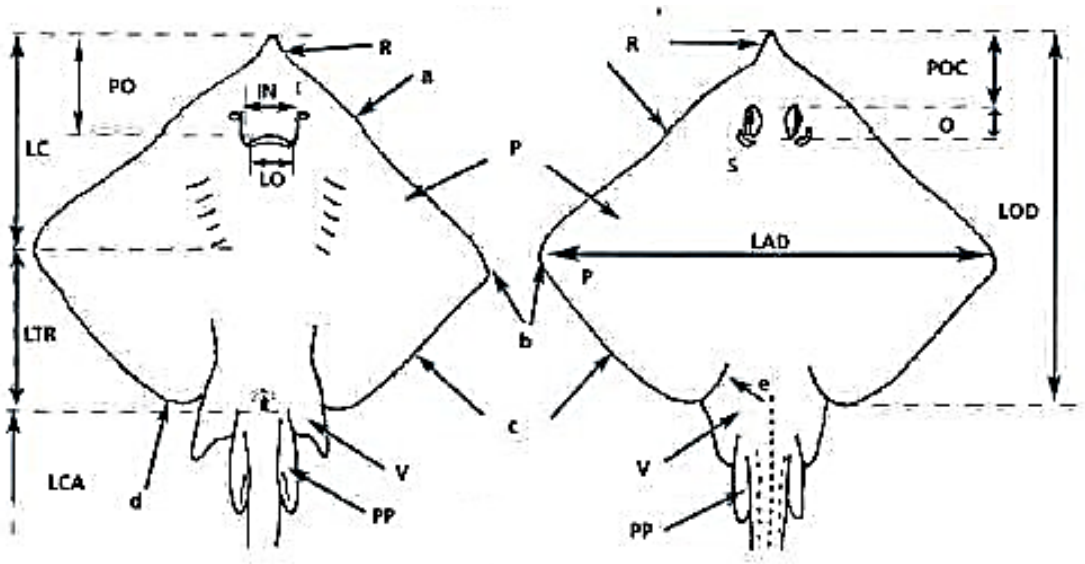


Additional to morphological traits we use also morphometric characteristics: i.e. animal weight and different measures of length or their ratios to determine the species or to assess the trends in population. Morphometric characteristics and morphological traits are shown on Picture 6, Picture 7 and Picture 8 with acronyms explained in Table 1.

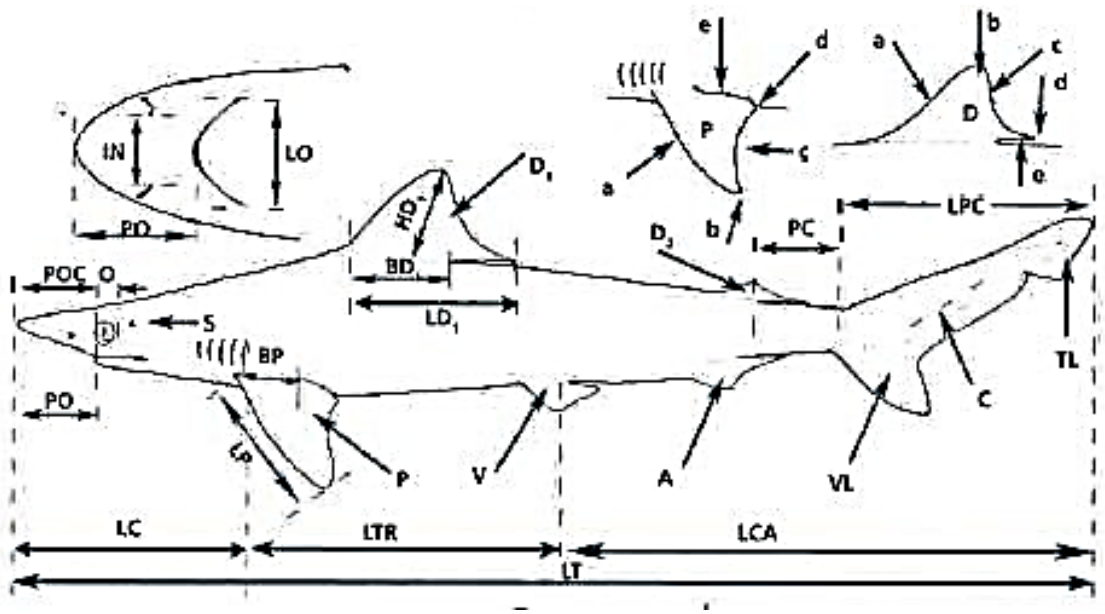
Picture 6: Morphology and some morphometric characteristics of bony fish (Source: Jardas, 1996)



Picture 7: Morphology and some morphometric characteristics of cartilaginous fish – infraclass Batoidea



(Source: Jardas, 1996)



Picture 8: Morphology and some morphometric characteristics of cartilaginous fish – infraclass Selachii (Source: Jardas, 1996)

Table 1: Acronyms and definitions of morphological traits and morphometric characteristics of fish

Acronym	Definition	Acronym	Definition
A	anal fin	LTR	body length
BA	anal fin base length	O	eye diameter
BD1/BD2	caudal fin base length	P	pectoral fin
BP	pectoral fin base length	PA	length from mouth to anus
C	caudal fin	Pa(Da)	posterior edge of pectoral(dorsal) fin
D/D1/D2	dorsal fin	Pb(Db)	top of the pectoral (dorsal) fin
DL	dorsal lobe of the caudal fin	Pc(Dc)	anterior edge of the pectoral (dorsal) fin
H	maximum body height	Pd(Dd)	anterior unattached edge of the pectoral
h	minimum body height		(dorsal) fin
IN	nasal width	Pe(De)	interior edge of the pectoral (dorsal) fin
LAD	disc width	PC	tail base length
LC	head length	PO	snout space (length)
LCA	tail length	POC	preorbital space
LF	fork length	PP	pterygopodium (male reproductive organ)
LO	mouth width	R	rostrum (snout)
LOD	disc length	S	spiracle
LP	pectoral fin length	TL	top lobe of the caudal fin
LPC	caudal fin length	V	ventral fin
LS	standard length	VL	ventral lobe of the caudal fin
LT	total length	ZOC	space between the eye and 1st dorsal fin

INSTRUCTIONS FOR SHARK DISSECTION

Examine the external shark morphology:

Find:

1. lateral line – along the body side, lightly coloured horizontal striped, composed of multiple pores: these lead to receptors, sensitive to water vibrations

2. spiraculum – behind/above eyes. Spiraculum is an opening through which the water enters the mouth and then exists through the gills (breathing).

3. claspers – copulatory organs on the inner side of the pelvic fins

4. cloaca – on the ventral side between pelvic fins. It represents a drain for excrements of digestive, urinary and genital tracts.

5. Take a look at the placoid scales (use a magnifying scope or a microscope).

External measurements

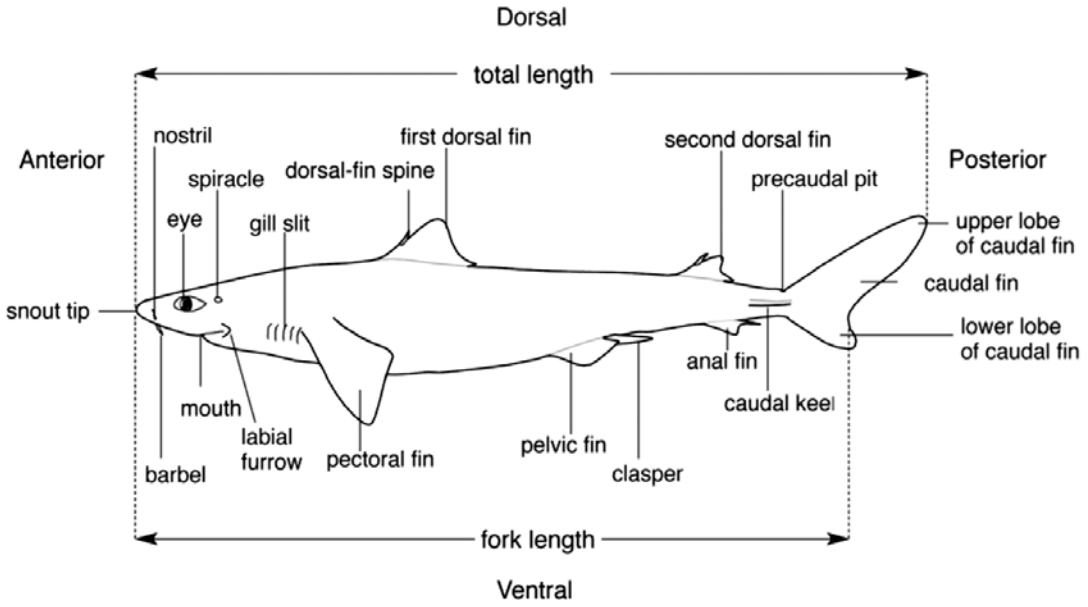
Use a ruler or a meter and measure the length. Use centimeters as the unit!

Total Length – from the tip of the jaw to the most distal part of the tail (follow body curvature!).

Fork Length – from the tip of the jaw to the centre of the tail fork (follow body curvature!).

Clasper Length – from the top of cloaca to the tip of the clasper, along the inner length.

Use a scale and weigh the shark.



Fill out the form:

Species:

Date:

Time:

Type of capture or acquisition:

Vessel:

Location(coordinates):

N

E

Body legth (cm):

Total

Fork

Sex: M / F

Clasper length (cm):

Caught for food (Y / N):

Weight (kg):

Total

(Eviscerated)

Personal data

Name:

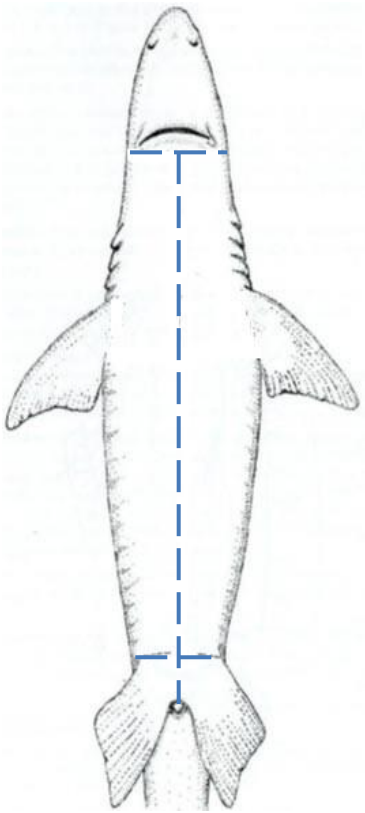
Surname:

Telephone number:

Dissection

When using scissors or scalpel, do not make deep cuts, as you may damage the underlying tissue.

Make a central-ventral cut from the cloaca to just below the jaw. The cut should be shallow. Make two additional cuts like shown in the picture.



Turn the body wall inside-out.

Visceral organs are attached to the dorsal side via a double peritoneum membrane, called mesentery.

Digestive tract and associated structures

1. Esophagus – A connection between mouth and stomach. Sharks have a short and wide esophagus.

2. Stomach – J-shaped, composed of two parts, separated by a bend. The stomach ends with a piloric sphincter – a muscle opening, which opens and closes the passage into intestine.

3. Spiral Valve – Identifiable by an extensive net of arteries and veins on the surface.

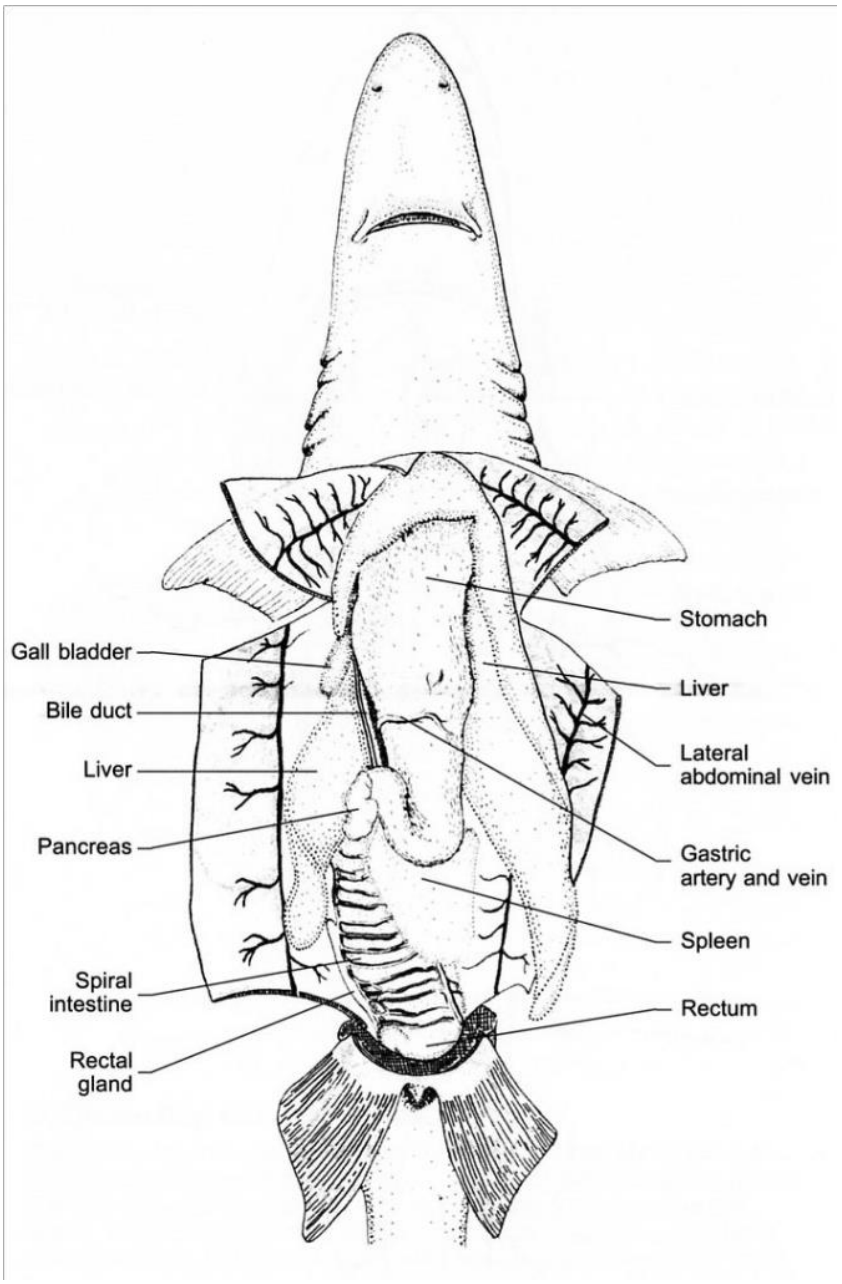
4. Rectum – The short part of the digestive tracts, between the intestine and cloaca. Hard excrements are collected in the rectum.

5. Liver – Liver is composed of three lobes, two larger ones and one smaller one. The gallbladder is found in the smaller lobe. Gallbladder stores bile, produced by the liver.

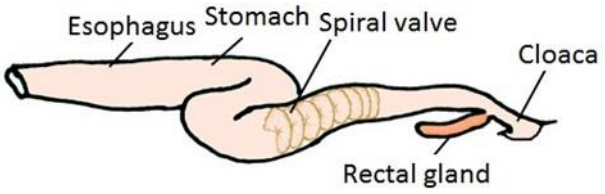
6. Pancreas – found along the duodenum and the lower part of the stomach. The products of pancreas enter the duodenum through the pancreatic duct.

7. Spleen – dark organ of triangular shape, found caudally to the stomach and proximally (in front of) to the spiral intestine. Despite being part of the lymphatic system, it is closely connected to digestive organs of all vertebrates. It acts predominantly as a blood filter, and partially as a blood-forming organ, but also takes part in immune responses.

8. Rectal gland – thin, finger-like structure, leading to the colon. It excretes salt (NaCl) in concentrations higher than those in the shark's body fluids or the sea water (osmoregulatory organ).



Remove the liver by cutting off its cranial part (closer to the head). Cut through the esophagus where it enters the body cavity above the stomach. Cut out the colon at its caudal part (closer to the tail). Cut through the membranes connecting the stomach, intenstine, pancreas and spleen to the body wall.



Once the digestive tracts has been isolated, make a cut along its length. The stomach should contain remains of partially digested prey. Collect these remains and wash them with running water (in the sink), using the sieve or a fine mesh. Store and label your samples.

Once you cut out and remove the digestive tracts, you should be able to see the reproductive organs, kidney and various ducts connected to these organs.

Kidney – Sharks have two dark coloured kidneys, lying on either side of the central body line, along the entire body cavity.

Male reproductive system

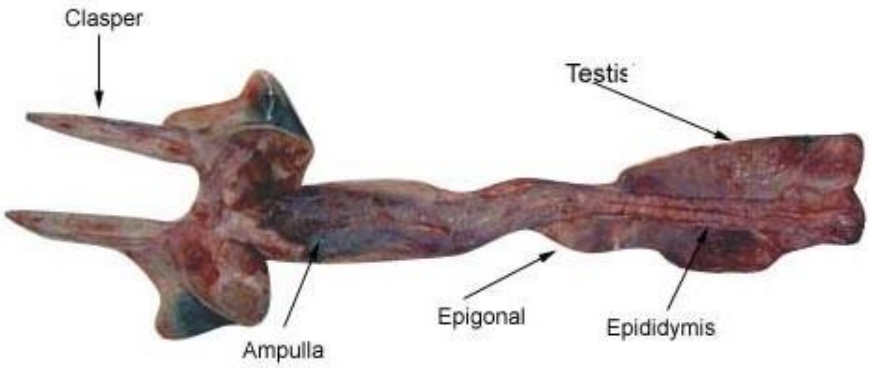
Testes – Oval and places dorsally to the liver. Testes produce male gametes.

Epididymis – Structure linked to the testis, in which sperm is collected.

Semen duct (Vas deferens) – Very curved duct, transferring sperm to the seminal vesicle.

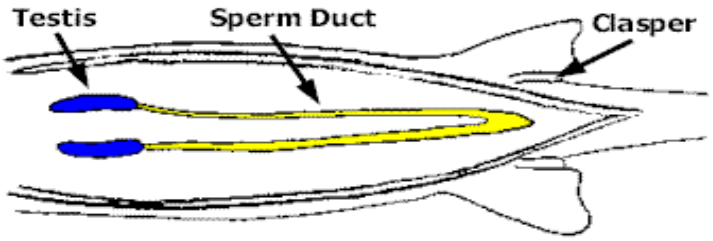
Epigonal Organ – In some species the testes are placed in the epigonal organ, which is part of the imune system.

Seminal Vesicle – Enlarged part of the vas deferens, to store sperm.

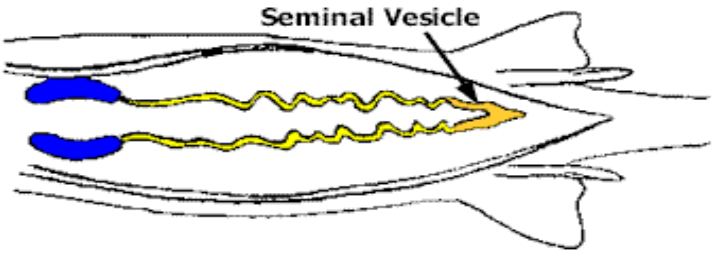


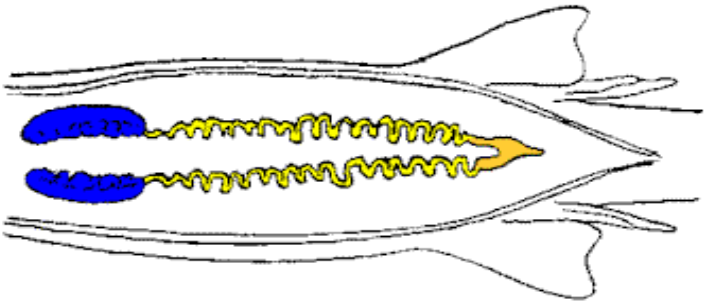
Take a look at the gonads and determined the sexual maturity stage. Circle the stage of your specimen.

Juvenile



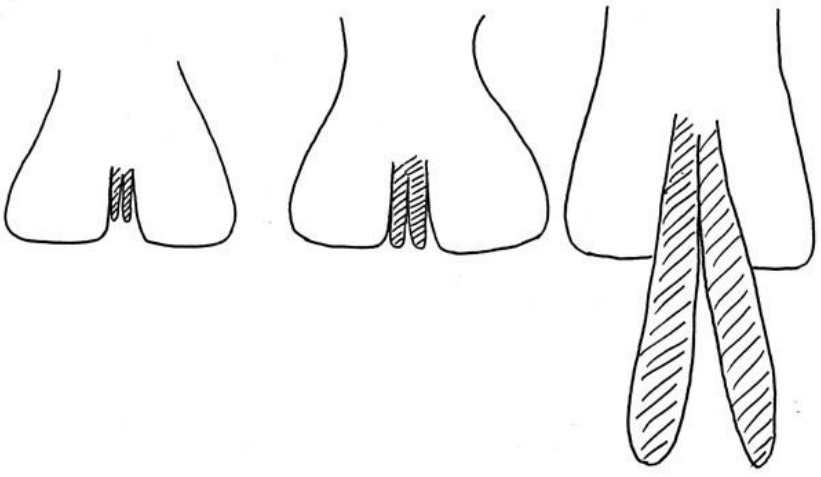
Entering sexual maturity





Sexually mature

Look at the claspers and determine the sexual maturity stage:



Immature Maturing Mature

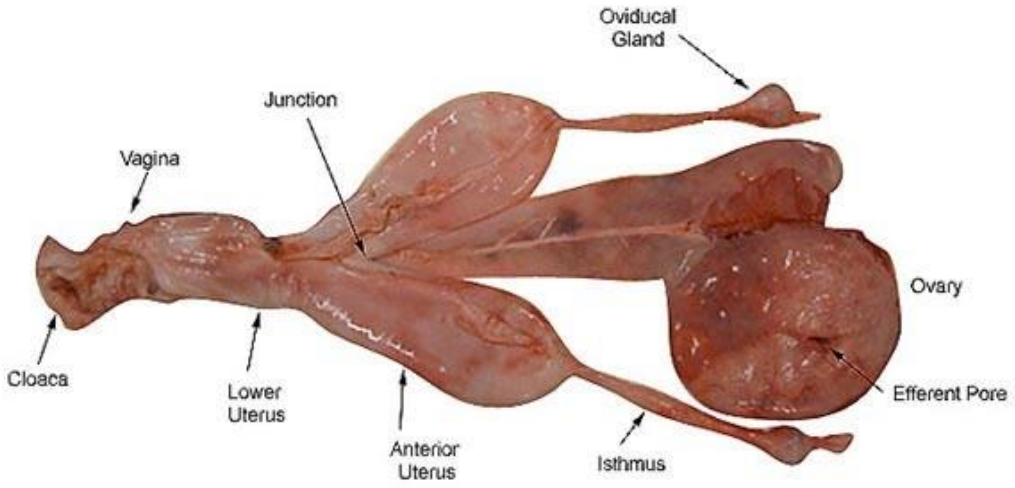
Female reproductive system

Ovaries – Two organs of cream colour, lying dorsally to the liver and on each side of the central body line. Depending on the sexual maturity, it may be possible to see the egg cells in the ovaries. The egg cells move to the body cavity and then into the oviducts, once they are ready to be fertilised.

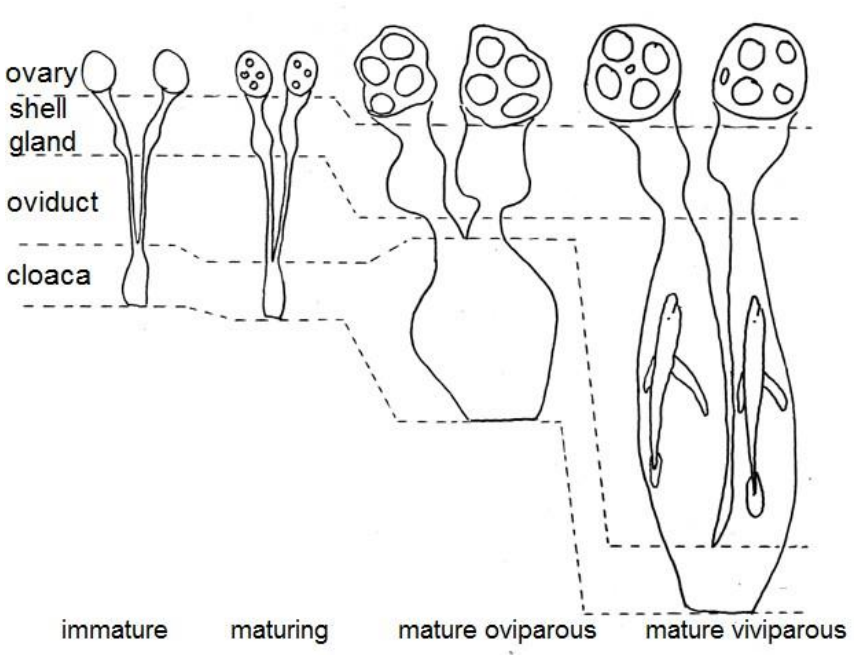
Oviducts – Elongated ducts, lying dorsally and laterally along the body cavity. These structures are well defined in sexually mature animals. Both oviducts have a joint opening into the body cavity, called the ostium.

Shell Gland – Found in the cranial part of the oviducts. This gland excretes a thin shell around a group of egg cells, and also represents a reservoir for storing sperm. The sperm cells fertilise the eggs when these travel through the gland.

Uterus – An enlarged caudal part of the oviduct.



Look at the gonads and determine the sexual maturity stage. Circle the stage of your specimen.



Take samples of the following tissues for ecological and toxicological studies:

Age:
(spine / vertebrae)

Stomach contents:

Gonads:

Toxicology:

Gills:

Liver:

Kidney:

Muscle:

Spleen:

Brain:

Now that the dissection is finished, it is time to clean the lab and the equipment!

1. Put all shark parts into the rubbish bag.

2. Wash and dry and tools and the table.

ANALYSING STOMACH CONTENTS IN FISH

Stomach contents analysis can provide an insight into the feeding patterns of fish, and a quantitative assessment of their feeding habits. Detailed descriptions of diet are also important for the understanding of trophic interactions and ecological aspects such as behaviour, body condition, habitat use, energetic input, and intra- and inter-specific interactions.

Always measure the total length to 1mm precision and body weight to 0.1 g precision. Record the sex and age class of your animals. Feeding behaviour often differs depending on sex, developmental stage or time of year, so it is important to include samples from both sexes, all age classes and all seasons.

Stomach contents sampling during the dissection is relatively easy. Be careful to collect all particles. Store the prey remains in 5% neutralised formalin for further analyses. Before you start identifying the prey, leave the samples in water for 5 minutes and then start the examination. Most prey remains can be sorted into main categories by naked eye. If you are unsure, use a magnifying scope, microscope and taxonomic keys. Prey remains are often small particles. Hard parts such as otoliths, scales or vertebrae have identifiable, species-specific characteristics, which enable you to identify them.

Sort the prey remains into the following categories:

- Gastropoda and Bivalvia (snails and mussels)
- Cephalopoda (cephalopods)
- Polychaeta (polychaetes)
- Malacostraca (crustaceans)
- Actynopterigii (bony fish)
- Algae (algae)
- Unidentified organic material
- Anthropogenic remains
- Parasites

Methods of stomach contents analysis can broadly be divided into two groups: qualitative and quantitative. In qualitative analyses, we aim to identify all organisms in the digestive tract as accurately as possible, which requires a lot of experience. The main aspects of quantitative methods are determination of frequency, the number of remains and the gravimetric method. Parasites, anthropogenic remains and unidentifiable prey remains are not included in the diet analysis.

LITERATURE

Jardas, I. 1996. **Jadranska ihtiofauna**. Čakovec, Tisak Zrinski.
Kryštufek, B. in Janžekovič, F. 1999. **Ključ za določanje vretenčarjev Slovenije.** Ljubljana, DZS.