United Nations Environment Programme
Mediterranean Action Plan
Regional Activity Centre For Specially Protected Areas

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RAC/SPA

CHONDRICHTHYAN FISHES OF LIBYA : PROPOSAL FOR A RESEARCH PROGRAMME

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FOREWORD

Cartilaginous fishes consist of sharks, rays and chimaeras. These fishes have traditionally been consumed in Libya, mainly sharks, the guitarfishes and some stingrays. Although no fishery data are available, most of the cartilaginous fishes are by-catches of fisheries targeted on swordfish, tunas, and demersal fishes. However, in the Gulf of Sirt, a seasonal artisanal fishery targets sharks with specific fixed shark net named « kellabia ». Also, it has been recently observed that some longliners tend to target sharks because of the economic value of their meat on the national market and of their fins on the international market.

Still, very little is known about the Libyan cartilaginous fishes, and no particular study has been so far dedicated to these fishes. Tortonese (1939) published a list of fishes from Tripoli area including 9 sharks and rays only. Some information is provided in the reports of several fishery surveys carried out to evaluate the benthic resources in the Libyan waters (Contrasimex, 1977; Sogreah, 1977; Zupanovic & El-Buni, 1982; Lamboeuf, 1995). Based on these reports, the number of shark and ray species occurring in the Libyan waters is variable and a systematic inventory is really needed, as 74 species are likely to occur in the Libyan waters, out of the 86 species known to date in the Mediterranean Sea (cf. list in appendix).

Because of the lack of information on these fishes, which apparently constitute an important resource within Libyan fisheries, the Marine Biology Research Centre of Tripoli (MBRC) and the Environment General Authority of Libya (EGA) were willing to jointly undertake a research programme on the cartilaginous fishes of Libya.

In this context, the Regional Activity Centre for Specially Protected Areas in Tunis (RAC-SPA) entrusted me to carry out an expertise in Libya from 24 June to 1st July 2005, in order to consider the conditions of the feasibility of such a study and to determine the content of an adapted research programme to be jointly carried out by MBRC and EGA. During this expertise trip, the visit of several landing places and fish markets and the extensive discussions with scientists of MBRC and EGA, allow to herein propose a research programme on cartilaginous fishes of Libya.

This programme proposal is considered as an implementation of the « Action Plan for the conservation of the cartilaginous fishes in the Mediterranean Sea » as defined by RAC/SPA in 2002.

RESEARCH OBJECTIVES

In order to obtain a scope on the biodiversity of the cartilaginous fishes in the Libyan waters, some data on their biology, and on their relative importance in the various fisheries, the research programme should include the three following parts:

1) A systematic inventory of the cartilaginous fishes of Libya

2) The biological study of some selected species

3) The collection of fishery data

1 – A SYSTEMATIC INVENTORY OF THE CARTILAGINOUS FISHES OF LIBYA

A systematic inventory should start by a review of the scientific and grey literature The list of the cartilaginous fishes recorded in Libyan waters is given in appendix. However, some records of this list are doubtful and should be checked.

The inventory should be completed by recording every species which will be observed during the research programme, at landing places, fish markets, on board of fishing vessels, etc.

Also, specimens preserved in existing collections (Museum, university study collection, etc) should be checked to complete the information.

The inventory should be documented: every species recorded should be referred to actual specimens. Thus it is highly recommended to constitute a reference collection as a support to the elaboration of the inventory. At least, a specimen of every species collected should be preserved (in formalin) and then deposited in the Museum collection of MBRC. Catalogue numbers should be given to every specimens deposited in the collection. A good quality label (made of « plastic paper ») with this catalogue number should be attached to the specimens and an external label should be stuck on the jar or on the barrel in which the specimen is kept.

The capture data and the main information on the specimens (TL, sex, weight, etc) should be recorded in a computerized file. Also, every specimen of the collection should be photographed before its preservation and the pictures should be added to the computerized catalogue of the collection. In the same way, any additional information available should be added as observation notes: for instance, some biometrical measurements or meristic characters, the references of tissue samples if some have been taken for genetic analysis, etc.

For the rays, the following photographs should be taken as a minimum: a general dorsal view of the specimen, a general ventral view of the specimen, and a close-up of the mouth-snout region. For the shark, the following photographs should be taken as a minimum: a lateral view of the specimen in a natural position, a dorsal view of the specimen, a ventral view of the snout and close-up pictures of the upper and lower teeth.

For the identification of the specimens, the main useful publications are the FAO species catalogues (sharks of the world), the Check List of the Fishes of the North-eastern Atlantic and of the Mediterranean Sea (CLOFNAM) and also the FAO regional guide on the cartilaginous fishes of the Mediterranean Sea which is in press (expected to be out in Autumn 2005). The complete references of these publications are given in appendix. Also specific, particular identification keys will be provided for some groups for which the identification of some species is delicate, such as the sharks of the genus *Carcharhinus* and the skates.

If needed, I will provide assistance in species identification: the difficult cases of identification could be submited to me by sending me photographs of the specimens as e-mail attached documents or by shipping me some samples for laboratory analysis.

This inventory should be an opportunity to collect the local names of the species.

2 – BIOLOGICAL STUDY OF SELECTED SPECIES

Biological studies are needed for fishery management and species conservation. Because of the relatively high biodiversity of cartilaginous fishes in Libyan waters, the biological studies have to focus on a limited number of species. The selection of these species depends on their importance in the fisheries or because of their interest for species conservation. Indeed, some species like the guitarfishes and the angelsharks are still relatively common in the Libyan waters, while they are very rare or even no longer occurring in the rest of the Mediterranean Sea. As the result, the following species have been selected in priority for their biology to be studied:

The longnose spurdog, *Squalus blainvillei* (Risso, 1826)
The smoothhound, *Mustelus mustelus* (Linnaeus, 1758)
The sandbar shark, *Carcharhinus plumbeus* (Nardo, 1827)
The blackchin guitarfish, *Rhinbatos cemiculus* E. Geoffroy St Hilaire, 1817
The common guitarfish, *Rhinobatos rhinobatos* (Linnaues, 1758)
The sawback angelshark, *Squatina aculeata* Cuvier, 1829
The smoothback angelshark, *Squatina oculata* Bonaparte, 1840
The common angelshark, *Squatina squatina*(Linnaus, 1758)

However, other species could be added later on with the development of the research programme. Also, it should be worth to add some skates (*Raja calavata, Raja miraetus*…) and stingrays (*Dasyatis pastinaca*) if logistic conditions allow regular sampling of these species.

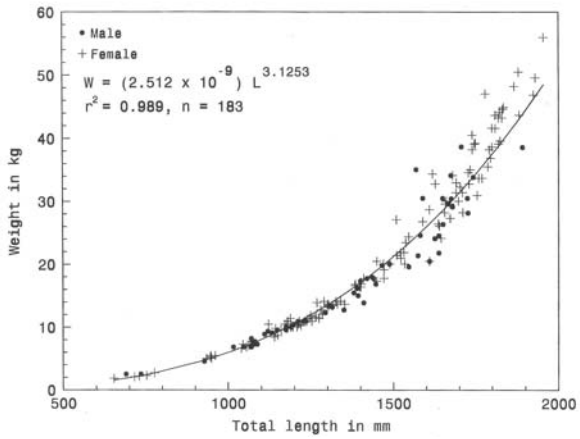
The biological studies concern mainly the investigation of the reproductive parameters and cycles, and of the alimentary diet, of the selected species. The ageing and growth could be considered later on if technical conditions are available to undertake such analysis.

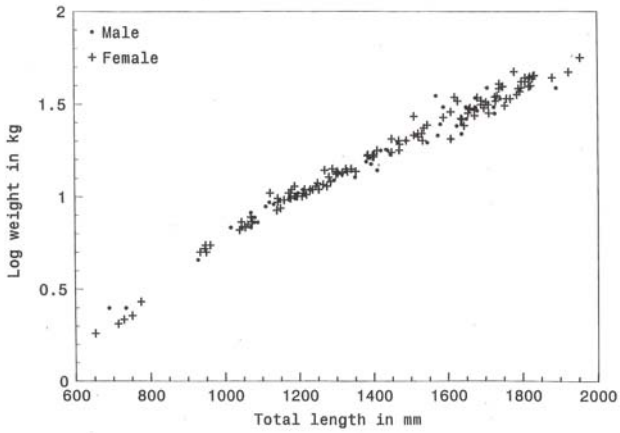
2 – 1 - LENGTH / WEIGHT RELATIONSHIP

The length / weight (as a matter of fact length / mass) relationship is a predictive model useful to estimate the production (catch weight) from the composition in length of the catches or the landings. The accuracy of the relationship depends on the size of the sample: the greater number of specimens is measured, the better. So it is recommended to sample more than the minimum statistical number of 30, in order to get a more significant relationship. The equation is of the following form:

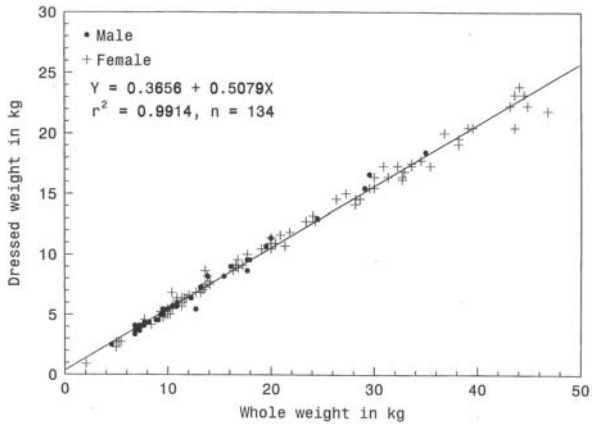
$$W = a\ TL^b$$

with W the weight, TL the total length, a being a constant depending on the species, and b the allometric parameter (usually close to 3). A linear regression is obtained in using log-transformed data.





The relationships should be established for the total weight as well as for the gutted weight, for males and females combined and separately. Or the regression between whole weights and dressed (gutted) weight could be used once it is established on a sample.



In some cases, the TL is not measurable on the carcasses because they are dressed with their tail more or less cut. In these cases, other relationships should be established on samples. For instance, the relationships between the TL and the fork length (FL) or the TL and the precaudal length (PCL). Once these regressions have been obtained, the length / weight relationships can be estimated. These regressions are of the following form:

$$TL = a + b\ FL$$
$$TL = a + b\ PCL$$

with a and b regression parameters (not the same as in the W/TL relationship)

2 – 2 - REPRODUCTION PARAMETERS AND INDICES

2 – 2 – 1 - Description of the reproductive tracts

The reproductive tracts of male and female cartilaginous fishes are rarely well documented. Those of the selected species should be described and illustrated (photos and drawings) to better understand their functional anatomy. Also, these knowledge are necessary

to measure or estimate the reproductive parameters and indices. Examples of reproductive tracts are given in appendix.

2 - 2 - 2 - Sex ratio

The sex ratio is the proportion of both sexes in a population of a given species. It can be assessed through samples taken on board of fishing vessel or at landing sites. The sex ratio of the samples will get close to that of the population if it is large enough. Usually, the sex ratio (SR) is expressed by the following regression:

SR = number of females / number of males

2 – 2 – 3 - Maturity

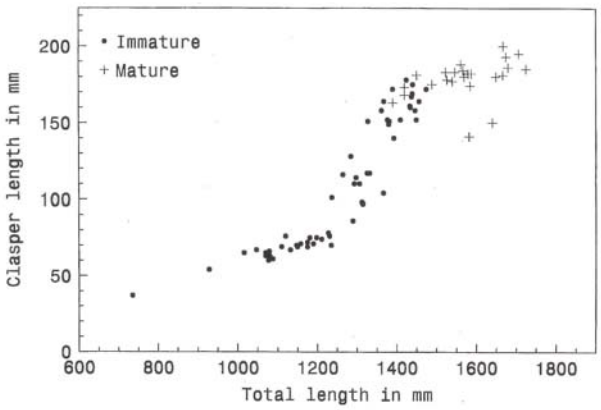
Males and females are mature when they can reproduce: they can mate together and produce viable offspring. This requires the presence of ripe oocytes in the ovaries of the females and ripe spermatozoa in the testes and sperm ducts of the males. Also, males can only mate if their claspers are fully developed.

The sexual maturity of male can be determined by regular observations of the claspers to follow their development. However, a shark can be adult with its claspers fully developed and functional but not active, because there is no sperm in its reproductive tracts. Thus, different stages of maturity can be defined for male and females elasmobranches. The following table gives the general maturity scale for elasmobranches; it is a model that should be adapted to the studied species in function of their particular mode of reproductive development: oviparous or viviparous.

2 – 2 –3 – 1 - Male maturity size

The length of the claspers is commonly used to estimate the size at maturity because there is a correlation between the development of the claspers and the stage of maturity (cf. the maturity scale given in appendix). Although there are several ways to measure the length of the claspers, it is recommended to take it as the direct measurement between the origin of the cloaca and the tip of the claspers.

To determine the size of maturity of males, the clasper length is plotted against the TL. Usually, the graph is S-shaped; the inflexion in the middle of the S-curve corresponds to the size at maturity, i.e. when the claspers extend over the rear tips of the pelvic fins.

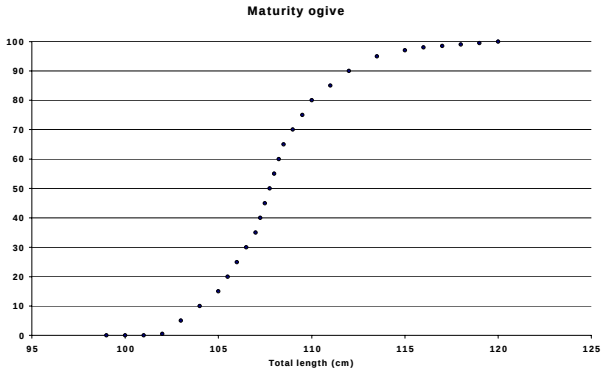


General maturity stages scale for cartilaginous fishes
(Should be adapted to the studied species, due to some variations between oviparous and viviparous modes of development)

Male	Female
Stage 1 – Juvenile (immature) Claspers undeveloped, not extending beyond the tip of the pelvic fin, they are flexible. Testis undeveloped, thread or leaf-like. Kidneys conspicuous not masked by the sperm ducts, which are thread-like. **Stage 2 – Adolescent (maturing)** Claspers reaching or extending somewhat beyond the tip of the pelvic fin, but they are still flexible. The clasper glan (tip of clasper) developing but still soft and flexible. Testis enlarged with developing spermatophoric follicles. Kidneys slightly obscured by the developing sperm ducts. **Stage 3 – Adult, mature but inactive** Claspers fully developed and rigid, they extend well beyond the tip of the pelvic fin. The clasper glan is fully formed and its cartilaginous internal components are rigid, often sharp or pointed. Testis swollen with developing spermatophoric spheres. Sperm ducts well developed, obscuring half of the kidneys. **Stage 4 – Adult, mature active** The clasper glans is still dilated; its soft components are reddened and swollen. Sperm flowing on pressure from cloaca and / or from clasper glans or groove. Testis swollen with developing spermatophoric spheres. Sperm ducts well-developed and obscuring most of the kidneys.	**Stage 1 – Juvenile (immature)** Ovaries small, leaf-like without differentiated oocytes. Nidamental glands undeveloped, present only as an opaque bulge of the oviduct. Oviducts narrow and thread-like. **Stage 2 – Adolescent (maturing)** Ovaries somewhat enlarged, its walls mainly transparent, with developing oocytes of various size. Nidamental glands small and developing, cream in colour with obvious white ends. Oviducts narrow and thread-like, sometime slightly widened posteriorly. **Stage 3 – Adult, developing** Ovaries with developing oocytes, some already large; its walls thickened. Nidamental glands fully developed, uniform white. **Stage 4 – Adult, mature active** Ovaries with large oocytes; large oocytes also present in the Fallopian tubes or already passing through to nidamental glands. Nidamental glands fully developed. Egg capsules if present, only partially extruded. Oviducts developed, walls thick and venous. **Stage 5 – Adult, laying** Ovaries with large oocytes. Nidamental glands fully developed, uniformly white. Fully formed eggs present in one or two oviducts. Oviducts developed. **Stage 6 – Adult, resting** Ovaries with oocytes of various sizes but without large ripe ones. Nidamental glands fully developed. No eggs in the Fallopian tubes or oviducts. Oviducts venous and stretched.

Notes:
eggs = fertilized oocytes
nidamental gland = egg shell gland
Fallopian tube = funnel-like tube between the ovaries and the nidamental glands receiving the ripe oocytes

If the samples are large enough, the « maturity ogive »' method can be used to determine the size at maturity of males. These ogives are obtained in plotting the percentages of mature males against length groups; the result is also a S-shaped curve; the maturity size is that corresponding to 50 %; meaning that 50 % of the males are mature at this particular size.

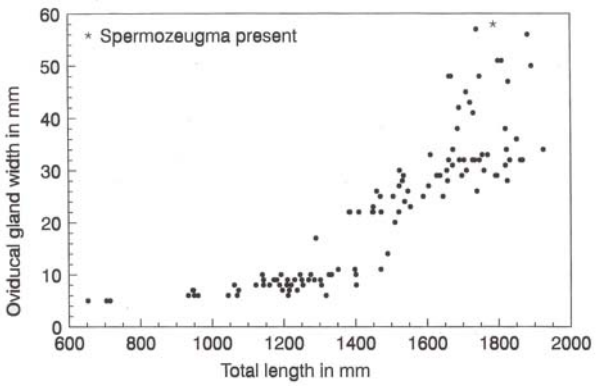


In some cases, sperm can be found in the reproductive tract before the claspers are fully developed. So, the maturity in male should be studied through the observation of both the clasper development and the presence of sperm in the reproductive tract.

2 – 2 – 3 – 2 - Female maturity size

Female maturity is determined by the observation of the reproductive tract: the development of the oocytes in the ovaries, of the nidamental gland and of the oviducts. This causes to examine a great number of females at different stages of maturity: juvenile, adolescent, adult, active, resting (cf. the maturity stage scale given above).

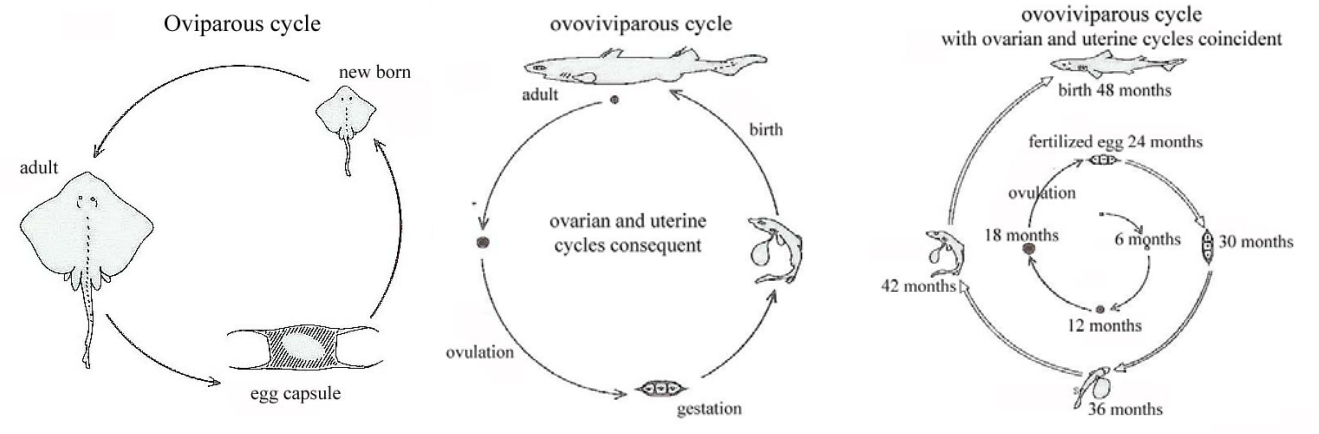
However, as for the males, some reproductive organs can be measured to determine the size at maturity: ex. the width of the oviduct, the size or the weight of the ovaries, the size or the weight of the nidamental gland. The width of the oviduct is commonly used and easier to measure than the other parameters, so it is herein recommended. Then the width of the oviduct is plotted against the TL, and as for the males, a S-shaped curve is obtained; its inflexion point giving the size at maturity.



Also, if the samples are large enough to calculate proportion of mature females in the different size groups, a maturity ogive can be draw in plotting these percentages against the length groups; the size at maturity is determine by the 50% of the mature females.

2 – 2 – 4 – Reproductive cycle

The elasmobranches reproductive cycles are often complex as shown in the following figure:



Three main types of reproductive cycles are observed in elasmobranches: continuous reproduction, annual and biannual cycles. The data and observations collected should allow to determine the reproductive cycles of the studied species: is the reproduction continuous or with annual or biannual cycle?

The presence of scars in the skin of the females can provide information on the mating period, as males bit the females during mating.

2 – 2 – 4 – 1 -Male reproductive cycle

The timing of the reproductive cycle of male elasmobranches is generally determined by using various gonad size indices, through histological examination of the testes, or by noting the presence and amount of sperm products in the reproductive tract throughout the year.

The gonadosomatic index (GSI) provides information on the variation in size of the testes, hence the period of production of sperm. The GSI is expressed as a percentage of the total body weight:

GSI = (weight of the testes / total weight of the body) x 100

In observing the variations of the GSI throughout the year, it is possible to determine the mating period, assuming that the GSI is high during that period.
However, these observations should be correlated with other data such as the presence of sperm in the reproductive tract and the presence of mating scares in the skin of the females.

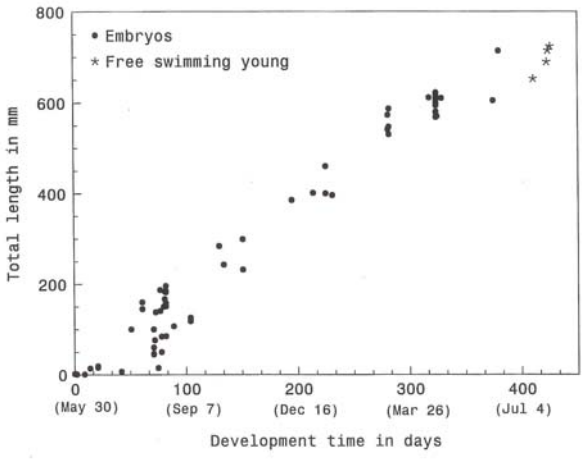
Also, histological studies of the testes could complete the macroscopic observations. For that purpose the testes should be preserved in 10% formalin or Bouin solution. Then it is processed according to the usual histological techniques (staining, slicing into thin lamellae and observation through high resolution microscopes). This could be carried out only if facilities for histological techniques are available.

2 – 2 – 4 – 2 - Female reproductive cycle

The ovulation period is determined in measuring throughout the year the diameter (with callipers) of the developing oocytes in the ovaries: during the ovulation period the ovaries exhibit several large ripe oocytes. A mean maximum oocytes diameter (MOD) is calculated and plotted against time (months).

2 – 2 – 4 – 2 – 1 - Gestation period

For viviparous species, the length of gestation period is usually determined by following through the year the size of eggs and embryos found within the uterus. Also, this could be achieved in observing throughout the year the length and weight of the eggs and embryos in the uterus.



2 – 2 – 4 – 2 – 2 - Parturition

The time between the capture of females with the largest uterine embryos and of females with the smallest uterine eggs can give some indication of when parturition is occurring.

2 – 2 – 4 – 2 – 3 - Resting period

The reproductive cycle may include a resting period, which can last several months. The observation throughout the year of the proportion of gravid females provides indication of whether or not the female undergoes a resting phase between pregnancies. If all or nearly all the mature females are pregnant, this may indicate that there is no resting phase. Information can also be obtained by comparing the development of oocytes and of embryos in the uterus in each individual. A resting cycle is usually apparent by determining if the ovulation and gestation cycles are concurrent or if they are sequential.

2 – 2 – 4 – 3 - Size at birth

The comparison between the largest embryos found in the uterus and the smallest free-living individuals, particularly those with the umbilical scar still present, provide information on the size at birth.

2 – 2 – 5 - Fecundity

The uterine fecundity of elasmobranches species is mainly determined by simply counting the number of eggs and embryos within the uterus of viviparous species. However, it should be noted that often embryos abort during the stress of the capture, so this should be taken into consideration in the counting. The ovarian fecundity is estimated by counting the number of developing ova in the ovary. In some species uterine and ovarian fecundity have been found to be very similar.

Determining fecundity for oviparous species is more difficult. It can be estimated by counting the number of developing eggs in the ovary, but many oviparous species have a very extended breeding season with eggs continuing to develop throughout the year, and this approach may lead to an underestimation of eggs produced. One method of estimating fecundity for oviparous species is to determine the ovulation rate and the duration of the egg laying period and to use these values to calculate the number of eggs lay by the female during the period.

In many species of elasmobranches there is a positive relationship between fecundity and the size of the female. Presumably, as a female becomes larger this increases in total length and girth results in a larger space in the body cavity to accommodate pups. This relationship should be investigated for the selected species.

2 – 3 - ALIMENTARY DIET

The analysis of the stomach contents allows investigating the alimentary diet. This information is needed to understand the ecological function of the predacious fishes like sharks and rays, in the marine ecosystem, hence its implication in the fisheries and conservation.

The research programme should aim to study the alimentary diet of the selected species of cartilaginous fishes through the method of the stomach content analysis.

The stomach should be collected on specimens recently caught and their contents preserved deep-frozen or in formalin. In the laboratory, the food items should be sorted and identified to the lowest taxonomic level possible. Numbers and weights of every prey category should be measured.

The qualitative analysis will consist to establish a list of the prey species and to comment it.

The quantitative analysis should include the estimate of the following parameters usually used in diet studies:

2-3-1- The Vacuum index (VI)

It is the percentage of empty stomachs in the samples analyzed.

2-3-2- Percentage of prey item in number (%N)

It is the ratio expressed in percentage between the number of individuals of a prey item i (n_i) and the total number of preys (N_t) :

$$\%N = 100 \times (n_i / N_t)$$

2-3-3- Percentage of prey item in weight (%W)

It is the ratio expressed in percentage between the weight of individuals of a prey item i (w_i) and the total weight of preys (W_t) :

$$\%W = 100 \times (w_i / W_t)$$

2-3-4- Frequency of occurrence of prey item (%O)

It is the ratio between the number of observations of a prey item i (n_i) and the total number of full stomachs analyzed (N_t) :

$$\%O = n_i / N_t$$

2-3-5 The percent index of relative importance (IRI)

This index has been proposed as a standardized measure in dietary analysis. It is calculated with the following equation:

$$IRI = \%O_i (\%W_i + \%N_i)$$

where i is one of the prey item, %O its frequency occurrence, %W and %N its proportions of the stomach contents by weight and by number respectively.

3 - FISHERY DATA

Management of fisheries needs fishery data. Without these data, it is impossible to estimate the state of exploitation of the resources. These data includes the catch estimates for both target species and any bycatch species involved in the fishery, either kept or discarded. The collection of these data should be continuous in order to establish a database, which allows analysis of the evolution of the fisheries, and to determine its current status. Catch estimates can be obtained in a variety of ways including fishery observers, logbooks, dockside and shoreside monitoring. I is therefore imperative that efforts are made to collect fishery data for catch estimates.

3 – 1 - Description of the fisheries

The different fisheries should be described. The gears used usually characterize a fishery: various kinds of nets, pelagic or bottom longlines, trawls, traps, etc. In the same way, the number of vessels involved in every fishery should be counted and their main characteristics recorded.

3 – 2 – Catch estimates

The basic data consist of weights of the catches by species and by fishery. They can be collected at landing sites or on fish markets. Also, it is very useful to complete these data by at-sea monitoring, which provides the most robust catch data. This is achieved by regular embarkment of fishery biologists on board of selected fishing vessels. These observers should record the number of individuals by species, their size, and their weight. They also should note the final fate of the sharks: saved for the market, used as bait, discarded alive, discarded dead, discarded after removing fins.

The carcasses are often dressed (gutted, or gutted and finned, etc.) so conversion factors should be calculate on samples to estimate the total production in « wet weight ».

To make the record of fishery data easier, codes should be used for the species. Also, adapted fishery data sheets should be designed (a model is given in appendix).

3 – 3 - Catch by unit effort

The catch per unit effort (CPUE) is a very important parameter for fishery management: it allow to evaluate the state of the fishery, its trends and shifts, hence that of the resources. The unit effort is expressed by unit time, by gear, or by any factor characterizing the fishing activity.

For example, the CPUE for longline fisheries the number or the weight of fish caught by 100 hooks. For trawl fisheries, it could be the number or weight of fish by hour of fishes or their weight caught by hour, referring to the time during which the gear was in use, effectively working in the water. In the same way, it could be the number or weight of fish caught by unit of soaking time for the gillnet fisheries. When little data are available, like in artisanal fisheries, the CPUE could be simply expressed as the catch per day.

These data on fishing effort should be collected through direct observations and by interviews of the fishermen. When available, logbooks should provide effort data.

3 – 4 - Fishing areas

The record of accurate fishing areas is necessary to distinguish the potential geographical variability in catch rates and the seasonality of the fishing activity. Its geographical coordinates should better describe the location: the latitude and longitude of every set.

In the same time, the depth of the fishing station should be recorded.

These data should be obtained by interviews of fishermen, and analysis of logbooks when available. They will be used to draw maps of geographical distribution of the species and of the fishing grounds through the time, and of their bathymetric distributions.

3 – 5 – Sex and sizes composition of the catches

In order to assess the composition of the populations and its evolution during time, sex and size (mainly TL) should be regularly recorded on samples on landing places and at-sea when possible.

LANDING SITES AND STRATEGY OF SAMPLING

Pending on the creation of a national fishery service to collect fishery data, it will be necessary to start collecting specific fishery data on cartilaginous fishes. These data should be as accurate as possible, i.e. cracked by species, and representing the total catches in the Libyan waters. But, because of the numerous landings places along the 1770 km long coast of Libya, the research programme should focus on a limited number of landing sites and associated fish markets. The following places have been selected for their important landings of cartilaginous fishes, from west to east:

Farwah
Zuwarah
Tripoli fish market of Bab al Bahar
El Khoms
Misratah
The Gulf of Sirt

The following strategy of sampling should be adopted as a start. It could be adapted in function of the means available, the season and the observations made during the first field trips

- The sites of Farwah and Zuwarah should be visited the same day, monthly.
- The Bab al Bahar fish market of Tripoli should be visited every day, since it is the most important market, receiving catches from many landing places, and easiest place to sample.
- The sites of El Khoms and Misratah should be visited the same day, monthly.
- The about 10 sites along the Gulf of Sirt would need about 7 days to be visited. A monthly sampling should be an objective, but a particular effort should be made during the shark-fishing season, from March to June. During this season, it should be very useful to have some permanent observers in selected sites. For that purpose, the help of university students could be obtained.

THE « SHARK TEAM »

Scientists of MBRC and EGA are already working jointly on various studies, and some of them have initiated preliminary investigations on a potential research programme on cartilaginous fishes of Libya. They constitute the nucleus of the « shark team » which includes the following persons:

Abdhallah ben Abdhallah (University of Tripoli)
Abdulmaula Hamza (EGA)
Esam Aburass (EGA)
Khaled El Dofanni (EGA)
Hisham Ghmati (MBRC)
Akram Alturky (MBRC)
Abdul Baset Abuissa (MBRC)
Salem W. Zgozi (MBRC)
Ali Mujahed (MBRC)

For the research programme on cartilaginous fishes, some of them would work full-time, and other part-time only. Also, some would act as representatives of their respective administration.

For the cohesion of the team, I would recommend to nominate a team leader.

Although this programme is a collective task, every scientist involved in it should be responsible for a part of it. The dispatching of the responsibilities is function of their personal affinities and skills, and should be jointly defined by the directions of MBRC and EGA.

TIMETABLE

It is hope that the research programme starts as soon as possible. It seems that the material conditions have already been planed by MBRC and EGA so that the programme could start when the scientific content is approved by both organisms.

The programme should last 2 years so that the biological cycles of the studied species could be investigated correctly. An extension of a few months could be necessary as some species might have a bi-annual reproductive cycle.

Priority should be given to the definition of the sampling strategy, which should be detailed and scheduled in function of the human and material resources available.

Regular report should be provided to MBRC, EGA, and RAC-SPA : a technical report every 6 months and the draft scientific report 6 months after the end of the programme.

Simulation:

If the programme is launched in October, first year, technical reports should be provided in April second year, October second year, April third year and October third year (end of the programme). The draft of the scientific report should be provided in April fourth year.

Manuscripts for publication in scientific journals should be prepared to be submitted by the end of fourth year.

Appendix 1 :

Chondrichtyan fishes in the Mediteranena Seawith occurrences in Libyan water

	Tortonese 1939	**FNAM 1973**	**SOGREAH 1977**	**Zupanovic & El Buni 1982**	**FAO 1987**	**Lamboeuf 1995**	**MEDIFAUNE 2001**	FISHBASE **2005**
SHARKS								
Order HEXANCHIFORMES								
Family HEXANCHIDAE								
Heptranchias perlo						:	:	:
Hexanchus griseus					:		:	:
Hexanchus nakamurai		?						
Order SQUALIFORMES								
Family ECHINORHINIDAE								
Echinorhinus brucus		:			:		:	:
Family SQUALIDAE								
Squalus acanthias		:	:	:	:	:	:	:
Squalus blainvillei		:			:		:	:
Squalus cfr megalops								
Family ETMOPTERIDAE								
Etmopterus spinax					:		:	:
Family CENTROPHORIDAE								
Centrophorus granulosus		:		:	:		:	:
Centrophorus sp. (non uyato)		:		:	:		:	:
Family SOMNIOSIDAE								
Centroscymnus coelolepis		:					:	:
Somniosus rostratus		:						:
Family OXYNOTIDAE								
Oxynotus centrina	:	:	:	:	:	:	:	:
Family DALATIIDAE								
Dalatias licha		:			:		:	:
Order SQUATINIFORMES								
Family SQUATINIDAE								
Squatina aculeata				:	:		:	:
Squatina oculata					:	:	:	:
Squatina squatina		:	:	:			:	:
Family ODONTASPIDIDAE								
Carcharias taurus					:		:	:
Odontaspis ferox					:		:	:
Family ALOPIIDAE								
Alopias superciliosus								:
Alopias vulpinus					:		:	:
Family CETORHINIDAE								
Cetorhinus maximus		:					:	:
Family LAMNIDAE								

Carcharodon carcharias		:			:		:	:
Isurus oxyrinchus		:			:		:	:
Isurus paucus (Probably)								
Lamna nasus		:					:	:
Order CARCHARHINIFORMES								
Family SCYLIORHINIDAE								
Scyliorhinus canicula		:	:	:	:	:	:	:
Scyliorhinus stellaris		:		:	:		:	:
Galeus atlanticus								
Galeus melastomus		:		:	:		:	:
Family TRIAKIDAE								
Galeorhinus galeus		:	:	:	:		:	:
Mustelus asterias		:		:	:	:	:	:
Mustelus mustelus	:	:		:	:	:	:	:
Mustelus punctulatus		:	:		:		:	:
Family CARCHARHINIDAE						:		
Carcharhinus altimus							:	
Carcharhinus brachyurus					?		:	
Carcharhinus brevipinna		:		:	:		:	:
Carcharhinus falciformis		?					:	
Carcharhinus limbatus	:	:		:	:		:	:
Carcharhinus melanopterus		:			:		:	:
Carcharhinus obscurus								
Carcharhinus plumbeus		:		:	:		:	:
Rhizoprionodon acutus							:	
Prionace glauca		:		:	:		:	:
Galeocerdo cuvieri (Probably)								
Family SPHYRNIDAE								
Sphyrna lewini								
Sphyrna mokarran				:			:	:
Sphyrna tudes								
Sphyrna zygaena		:		:	:		:	:
RAYS								
Order RAJIFORMES								
Family PRISTIDAE								
Pristis pectinata								
Pristis pristis								
Suborder RHINOBATOIDEI								
Family RHINOBATIDAE								
Rhinobatos cemiculus	:	:		:	:		:	:
Rhinobatos rhinobatos		:	:	:	:		:	:
Suborder TORPEDINOIDEI								
Family TORPEDINIDAE								
Torpedo marmorata	:	:	:	:	:	:	:	:
Torpedo nobiliana		:		:	:		:	:
Torpedo torpedo	:	:	:	:	:	:	:	:
Suborder RAJOIDEI								
Family RAJIDAE								
Dipturus batis				:				

Dipturus oxyrinchus		:	:	:	:	:	:	:
Leucoraja circularis							:	
Leucoraja fullonica				:				
Leucoraja melitensis			:	:			:	
Leucoraja naevus			:	:				
Leucoraja rondeleti (cf fullonica)								
Raja africana								
Raja asterias		:	:	:	:		:	:
Raja brachyura								
Raja clavata		:	:	:			:	:
Raja miraletus	:	:	:	:	:		:	:
Raja montagui			:	:	?		:	
Raja polystigma				:	:		:	
Raja radula		:	:	:	:	:	:	:
Raja undulata					:		:	
Rostroraja alba	:		:	:	:		:	
Suborder MYLIOBATOIDEI								
Family DASYATIDAE						:		
Dasyatis centroura		:		:	:		:	:
Dasyatis marmorata							:	
Dasyatis pastinaca	:	:	:	:	:		:	:
Dasyatis « tortonesei »		:				:	:	:
Pteroplatytrygon violacea		:			:		:	
Himantura uarnak								
Taeniura grabata		:			:		:	:
Family GYMNURIDAE								
Gymnura altavela		:	:	:	:	:	:	:
Family MYLIOBATIDAE								
Myliobatis aquila		:	:	:	:	:	:	:
Pteromylaeus bovinus		:		:	:		:	:
Family RHINOPTERIDAE								
Rhinoptera marginata		:			:		:	:
Falmily MOBULIDAE								
Mobula mobular		:			:		:	:
CHIMAERAS								
Order CHIMAERIFORMES								
Family CHIMAERIDAE								
Chimaera monstrosa								
Number of sharks	3	27	6	17	33	9	39	36
Number of rays	6	20	15	22	21	8	27	19
Number of chimaeras	0	0	0	0	0	0	0	0
Number of Chondrichthyes	9	47	21	39	54	17	66	55

Number of sharks recorded in Libya	**42** versus 49 in the Mediterranean Sea
Number of rays recorded in Libya	**32** versus 36 in the Mediterranean Sea
Number of chimaeras recorded in Libya	**0**.versus 1 in the Mediterranean Sea
Number of Chondrichthyes in Libya	**74** versus 86 in the Mediterranean Sea

Appendix 2 :

SELECTED BOOKS & PUBLICATIONS

BOOKS

Note: The following books content many papers on various aspects of the anatomy, biodiversity, life history, biology and ecology of chondrichthyan fishes, including reproduction and feeding habits which are not listed in the sections (below) related to these topics. Extensive bibliographies are given for every chapter. These books are highly recommended.

CARRIER J.C., MUSICK J.A. & M.R. HEITHAUS (eds), 2004 – Biology of sharks and their relatives. CRC Presse, 596 p.

HAMLETT W.C. (ed.), 1999 - Sharks, Skates, and Rays: The Biology of Elasmobranch Fishes. John Hopkins Press, Baltimore, MD, 515 p.

PRATT H.L. Jr, GRUBER S.H. & T. TANIUCHI, 1990 – Elasmobranchs as Living Resources : Advances in the Biology, Ecology, Systematics and the Status of the Fisheries. *NOAA Technical Report NMFS*, 90 : 518 p.

SYSTEMATICS (IDENTIFICATION)

COMPAGNO L.J.V., 1984 - Sharks of the World. An Annotated and Illustrated Catalogue of Shark Species Known to Date. Part 1 - Hexanchiformes to Lamniformes. *FAO Fisheries Synopsis*, 125, Vol. 4, Pt. 1 : 1-249.

COMPAGNO L.J.V., 1984 - Sharks of the World. An Annotated and Illustrated Catalogue of Shark Species Known to Date. Part 2 - Carcharhiniformes. *FAO Fisheries Synopsis* 125, Vol. 4, Pt. 2 : 251-655.

COMPAGNO L.J.V., 2001 - Sharks of the World. An Annotated and Illustrated Catalogue of Shark Species Known to Date. Volume 2 – Bullhead, mackerel and carpet sharks (Heterodontiformes, Lamniformes and Orectolobiformes). *FAO Species catalogue for Fishery Purposes*, n° 1, vol. 2 : 1-269.

SERENA F., *in press* (2005) – Field identification guide to the sharks and rays of the Mediterranean and Black Sea. FAO Species Identification Guide for Fishery Purposes. Rome, FAO. 95 p.

WHITEHEAD P.J.P., BAUCHOT M.-L., HUREAU J.-C., NIELSEN J. & E. TORTONESE, 1984 – Fishes of the <North-eastern Atlatic and the Mediterranean. Volume 1 : 510 p.. UNESCO, Paris.

REPRODUCTION

CASTRO J.I., 1996 – Biology of the blacktip shark, *Carcharhinus limbatus,* off the southeatern United States. *Bull. Mar. Sci*., 59 : 508-522.

PRATT H.L., 1988 – Elasmobranch gonad structure – a descriptin and survey. *Copeia,* 1988 : 719-729.

PRATT H.L. & J.C. CARRIER, 2001 – A review of elasmobranch reproductive behaavior with a case study on the nurse shark, *Ginglymostoma cirratum. Environ. Biol. Fish.*, 60 : 157-188.

WOURMS J.P., 1977 – Reproduction and development in chondrichthyan fishes. *Am. Zool*., 17 : 379-410.

WOURMS J.P. & L.S. DEMSKI (eds), 1990 – The reproduction and development of sharks, rays and ratfihes : some papers from the Symposium on the reproduction and development of cartilaginous Fishes, held at the 6th AES meeting. Charleston South Carolina, June 1990. *Environ. Biol. Fish.*, 38 : 7-294.

FEEDING HABITS

BOWEN S., 1996 – Quantitative description of the diet. Pp. 513-532 *in* : Fisheries Techniques (Murphy B.R. & D.W. Willis, eds). American Fisheries Society, Bethseda, MD.

CORTES E., 1997 – A critical review of methods of studying fish feding based on analysis of stomach contents : application to elasmobranch fihses. *Can. J. Fish. Aquaat. Sci*., 54(3) : 726-738.

CORTES E., MANIRE C.A. & R.E. HUETER, 1996 – Diet, feeding habits and diel feeding chronology of the bonnehaed shark, *Sphyrna tiburo,* in southwest Florida. *Bull. Mar. Sci*., 58 : 353-367.

EBERT D.A., COWLEY P.D. & L.J.V. COMPAGNO, 1996 – Aprliminary investigation of the feeding ecology of catsharks (Scyliorhinidae) off the west coast of southern Africa. *S. Afr. J. Mar. Sci.*, 17 : 233-240.

ELLIS J.R., PAWSON M.G. & S.E. SHACKLEY, 1996 – The comparative feeding ecology of six specie of shark and four species of ray (Elamsobranchii) in the north-east Atlantic. J. Mar. Biol. Assoc. U.K., 76 : 89-106.

GELSLEICHTER J., MUSICK J. & S. NICHOLS, 1999 – Food habits of the smooth dogfish, *Mustelus canis*, dusky shark, *Carcharhinus obscurus*, Atlantic sharpnose, *Rhizoprionodon terranovae*, and the sand tiger, *Carcharias taurus*, from the northwest Atlantic Ocean. *Environ. Biol. Fish*., 54 : 205-217.

SMALE M.J. & L.J.V. COMPAGNO, 1997 – Life history and diet of two southern African smoothhound sharks, *Mustelus mustelus* and *Mustelus palumbes* (Triakidae). *S. Afr. J. Ma. Sci.*, 18 : 229-248.

STILLWELL C.E. & N.E. KOHLER, 1993 – Food habits of the sandbar shark *Carcharhinus plumbeus* off the US norheast coast, with estiates of daily ration. *Fish. Bull*., 91 : 138-150.

CONSERVATION

CAMHI M., FOWLER S., MUSICK J., BRAUTIGAM A. & S. FORDHAM, 1998 - Sharks and their relatives : Ecology and Conservation. IUCN Occassional paper n° 20, IUCN Cambridge UK and Gland Switzerland.

Appendix 3 :

Data sheet for biological observations on sharks and rays

Name(s) of the observer(s) : Date :

Locality (landing site, fish market) :

Locality of capture : Name of the vessel :

Gear : Depth range :

Species :

N°	Sex	TL or DW in mm	Total Weight in g	Gonads Weight in g	Liver Weight in g	Clasper length or uterus width in mm	Number of ripe ovocytes L / R	Number of eggs / embryos L / R	Sex of embryos	TL of embryos	Stomach Preserved or Empty	Specimen or sample preserved
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
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25												
26												
27												
28												
29												
30												

Remarks :

Appendix 4 :

Data sheet for fishery data on sharks and rays

Name(s) of the observer(s) : Date :

Locality (landing site, fish market) :

Locality of capture : Name of the vessel :

Gear : Depth range :

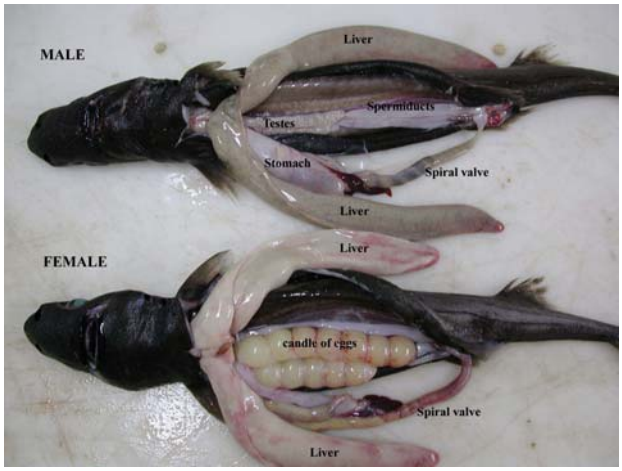
Species :

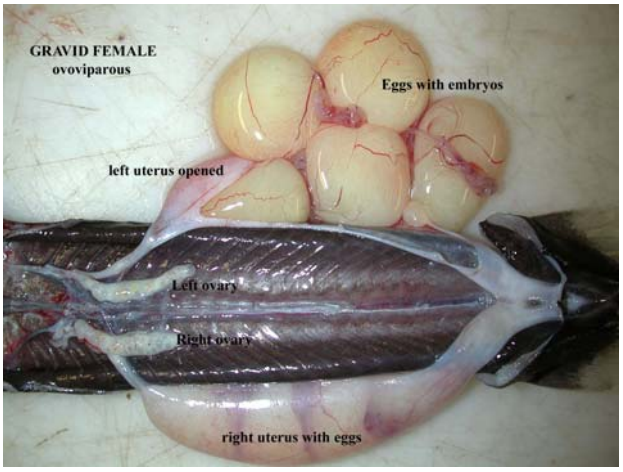
Species	Number of specimens	Measured or estimated weight	Specimen or sample preserved

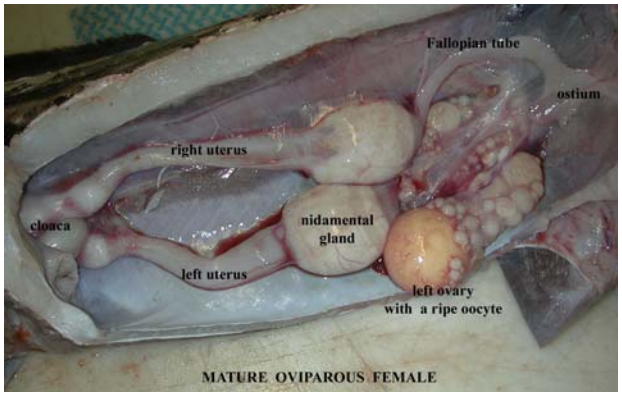
Remarks :

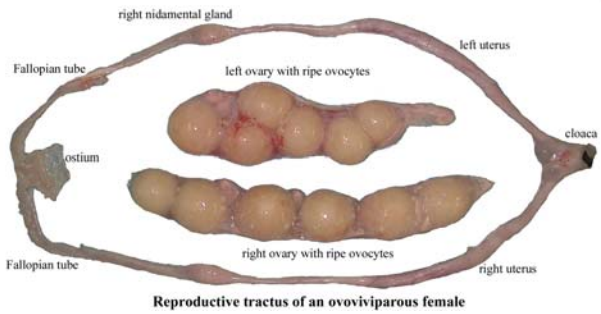
Appendix 5:

Examples of reproductive tracts in cartilaginous fishes



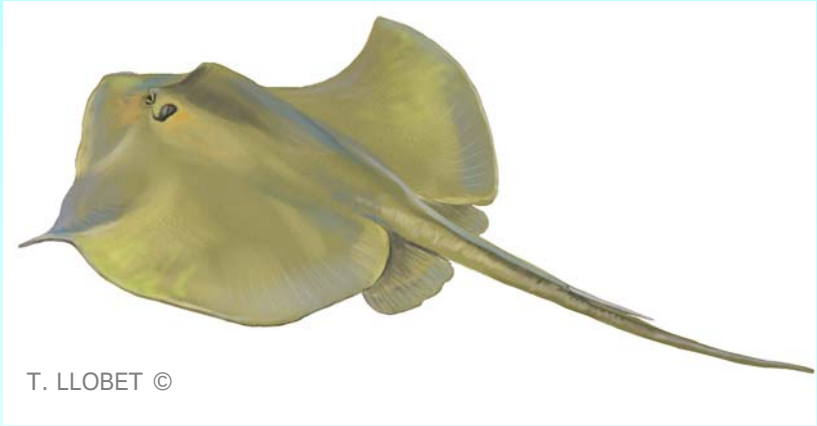




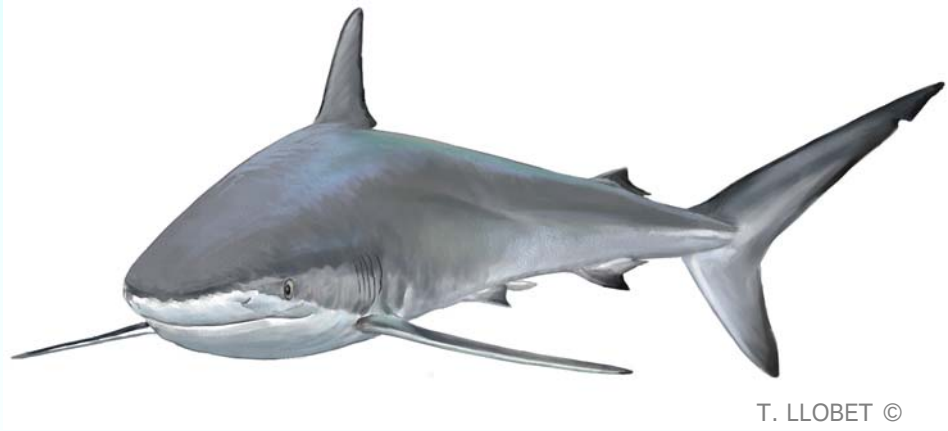


Reproductive tractus of an ovoviviparous female

T. LLOBET ©



T. LLOBET ©



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