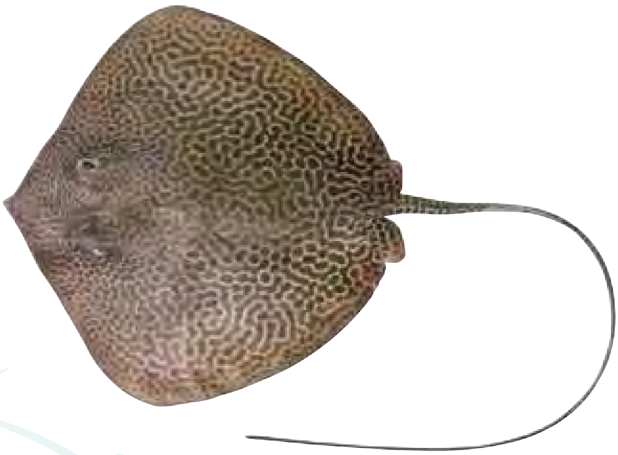
SHARKS AND RAYS *of* PAPUA NEW GUINEA



William T. White
Leontine Baje
Benthly Sabub
Sharon A. Appleyard
John J. Pogonoski
Ralph R. Mana

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Foreword

Papua New Guinea (PNG) is renowned for the diversity of its terrestrial fauna. Iconic species include the birds of paradise, tree kangaroos and the cryptic but photogenic cuscus. In contrast, the marine fauna of PNG is poorly described, despite the importance of marine resources for domestic consumption and international trade. This fine book starts to redress this imbalance, by pointing out the significance of sharks and rays in the traditional culture of PNG and going on to provide a comprehensive account of their biological diversity.

All coastal communities in PNG are involved in fishing for local food supply and wider commerce. Sharks are among the most important species exploited by large commercial operators, primarily for export—along with pelagic bony fishes (especially tunas) and prawns. Given the importance of these marine resources for livelihoods and commerce, the paucity of information on species composition, distribution and abundance is an impediment to sustainable management and one that needs to be addressed.

The Australian Centre for International Agricultural Research (ACIAR) is a statutory authority within the Australian Government, responsible for managing international research and development as part of the Australian aid program. ACIAR's thematic areas encompass crops, livestock, socioeconomics, natural resources, forestry and fisheries. PNG is ACIAR's largest country program, and fisheries work comprises a major part of the portfolio. Under the partnership model that characterises ACIAR's work, Australian fisheries scientists work closely with staff of the PNG National Fisheries Authority (NFA) in developing inland and marine aquaculture, as well as sports fisheries, in assessing commercial marine resources, and in building science and project-management capacity.

This magnificent book is the product of one such partnership. It embodies the knowledge generated by a project on the sustainable management of the shark resources of PNG, jointly implemented by scientific staff from the NFA and Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO). It is a comprehensive synthesis of the taxonomy and biology of all the sharks and rays present in PNG waters. Undoubtedly, it will be an invaluable guide for fisheries managers, and a high-quality resource for universities delivering marine biology courses in the Australia–Pacific region and beyond.

On behalf of ACIAR and the Australian aid program, I congratulate the authors, their institutes, and all involved in the preparation and production of the book. The breadth of information and quality of the publication testify to the rigour of the research and the professionalism of the partners: CSIRO and the NFA. This book is a significant contribution to knowledge of the fauna of PNG, and I hope that it is the forerunner of similar assessments of other PNG marine resources.

Dr Chris Barlow
Research Program Manager—Fisheries
Australian Centre for International Agricultural Research

Contents

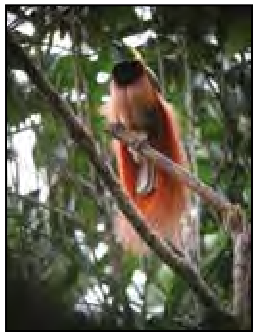
Introduction

Geography

Papua New Guinea (PNG) is situated in the south-eastern corner of the highly diverse Coral Triangle and is one of the most geologically, biologically and culturally diverse places in the world. It occupies the eastern half of the New Guinea mainland and its offshore islands, including Manus, New Britain, New Ireland and Bougainville. PNG has a very diverse geography (see map, page 6), extending from mountain ranges up to 4,500 m in height, which can experience snowfalls, to mangrove swamps and coral reefs along the coastline, to deepwater marine trenches of more than 8,000 m depth.

Ecology and culturally important fauna

The majority of mainland PNG is a northern extension of the Indo–Australian tectonic plate. Most of the larger offshore island chains lie on separate plates, and thus are closer to mainland PNG than ever before in their geological history. This complex geological nature of PNG has contributed to its highly diverse biota. PNG also contains some very iconic species, highly sought after by naturalists and enthusiasts since their first discovery. The most iconic species groups found in PNG would arguably be the birds-of-paradise (family Paradisaeidae), the males of which have fantastic plumage. They are culturally important, with some societies in PNG using the plumes in their dress and rituals. The Raggiana bird-of-paradise, *Paradisaea raggiana*, (right image) was made the national emblem of PNG and included on the national flag (left image) in 1971, and is also used on a number of the provincial flags.



Sharks and rays are also iconic species in PNG, particularly for certain cultural groups. In New Ireland, sharks are embedded in legend, which has led to the tradition of 'shark calling'. In the Sepik River, some villages have long believed that sawfish spirits 'will punish people who break fishing taboos by unleashing destructive rainstorms'. Some Iatmul clans in the Middle Sepik River use sawfish rostra as a totem, and decorated rostra form part of dance costumes. The image to the right shows an example of a decorated sawfish rostrum that has been incorporated into a dance

mask (deposited in the Ethnologisches Museum der Staatliche Museen zu Berlin). Sawfish heads are also sometimes seen carved on shields and masks. The East Sepik provincial flag (right image) includes a collage of images to represent the cultures of the province: a shark (to symbolise the coastal people), a crocodile (to symbolise the river people), a haus tambaran (to symbolise the hills and plains people), and kundu and garamut drums, spear and lime pot (to symbolise culture).

The legend of shark calling

Traditional PNG faith has a creator, Moroa, who created the world in a series of steps. Moroa created sharks, including one special shark Lembe, and divided the belly into two halves: the left side, which senses danger, and the right side, which would let a shark approach man fearlessly. Moroa told Lembe that man could catch the shark but, if man broke any taboos set out for him, Lembe must listen to his left side and stay away. But Lembe got tired of the lecture from Moroa and jumped into the sea. Moroa yelled and threw white sand at the shark, giving him his rough skin. Now that the shark skin was rough, man could easily snare him with a specially prepared noose that Moroa showed them how to make.

From this legend come the 'shark callers', who use a special rattle (right image) to attract sharks and then use a type of lasso (left image) to noose them and pull them into their canoes. This specialist 'fishing' and associated ancestor worship is considered prestigious because it was bestowed upon their ancestors from Moroa. Shark calling is still practised in three villages in New Ireland: Kontu, Tembin and Messe.

Scientific collection of sharks and rays in PNG

The first scientific collection of shark and ray material from PNG waters was during the French Voyage Autour du Monde (trip around the world) on-board *La Coquille* between 1822 and 1825 (renamed *L'Astrolabe* in 1826). The image on the right shows *L'Astrolabe* anchored at Nuka Hiva, French Polynesia, in 1846. The Voyage Autour du Monde included a visit to, and collection of material from, Port Praslin (Kambotorosch Harbour) in New Ireland in 1824. The first species

described from PNG, based on this material, were *Trygon halgani* Lesson, 1829 (= *Taeniura lessoni*) and *Scyllium ferrugineum* Lesson, 1831 (= *Nebrius ferrugineus*). Between 1874 and 1876, a German expedition to the south-west Pacific on-board the SMS *Gazelle* included collection of five species of sharks and rays from Bougainville and New Ireland.

The first detailed work of fishes, including sharks and rays in New Guinea, was not conducted until the mid-1900s by Ian S.R. Munro (Commonwealth Scientific and Industrial Research Organisation, CSIRO), which led to a New Guinea checklist (Munro 1958) and the book 'The fishes of New Guinea' (Munro 1967). The first dedicated research on the shark and ray fauna of PNG was conducted in the 1970s by Lionel W.C. Filewood, who worked for the Department of Agriculture, Stock and Fisheries at Kanudi in PNG. Filewood produced a detailed key to the sharks and rays of PNG, but it was never finalised or published and only exists in draft format. Many of the specimens he collected and images he obtained provided a strong basis for the current study.

Between 2010 and 2014, collaborative surveys led by the Muséum National d'Histoire Naturelle, Pro Natura International, Institut de Recherche pour le Développement and University of Papua New Guinea set out to take an inventory of the deepwater (100–1,500 m depth) benthic biodiversity in the Bismarck and Solomon seas area on-board the RV *Alis*. The fishes collected from these expeditions are deposited in the National Taiwan University Museum and Academia Sinica in Taiwan. These expeditions were crucial for improving our understanding of the deepwater shark and ray fauna of PNG, which was largely unknown before 2010. The shark and ray material from these surveys included at least six new species, including the Papuan guitarfish, *Rhinobatos manai*, shown to the right.

Fisheries in PNG

A variety of fisheries in PNG catch sharks and rays, either as a target or as bycatch. The only targeted commercial fishing for sharks was the target shark longline fishery, which ceased operation in July 2014. The closure of this fishery was related to the very high catches of silky shark, *Carcharhinus falciformis*, by this fishery (up to 95% of total catch), which had been listed in late 2013 as a no-take species by the Western & Central Pacific Fisheries Commission following an updated stock assessment showing significant declines in the region. Commercial fisheries that do not target sharks and rays, but in which they form part of the bycatch, include the tuna purse seine, tuna longline and Gulf of Papua prawn trawl fisheries.

Additionally, sharks and rays are caught, either by targeting or as bycatch, in many of the coastal (artisanal) fisheries. The catches from this sector are poorly documented and require urgent attention. In the Milne Bay Province, a number of fishing communities target sharks for their fins, and substantial quantities are landed at some locations. In other areas, sharks form a relatively minor bycatch, but they do supplement the incomes and nutritional requirements of those communities.

The National Fisheries Authority of PNG and this study

The National Fisheries Authority (NFA) of PNG is a non-commercial statutory authority that was established and operates under the *Fisheries Management Act 1998* and related regulations. The NFA vision is 'effectively managing our fisheries and marine resources for sustainable and equitable benefits'. The functions of the authority include 'manage the fisheries within PNG's fisheries waters in accordance with the Act and taking into account the international obligations of Papua New Guinea in relation to tuna and other highly migratory fish stocks'. The NFA recognised the paucity of data on the utilisation of sharks and rays in PNG and proposed this project to the Australian Centre for International Agricultural Research (ACIAR).

In 2014, ACIAR funded a 4-year project to assess the sustainable management of PNG's shark and ray resources, including investigating the biodiversity of chondrichthyans (sharks, rays and chimaeras). This project was a collaboration between the NFA, CSIRO, James Cook University and doMar Research in Australia. Between 2014 and 2016, an observer program was established to collect shark and ray catch data from the longline and prawn trawl (right image) fisheries. Between 2014 and 2017, coastal fisheries surveys were conducted throughout PNG. In addition, specimens of chondrichthyans deposited in biological collections around the world were examined, including the deepwater specimens collected during the RV *Alis* surveys of PNG between 2010 and 2014. Images were obtained from various sources to validate records of sharks and rays in PNG, particularly from divers and local dive operators. A reference collection of sharks and rays was also established that, as of September 2017, consists of more than 400 specimens that are catalogued at either the PNG National Fish Collection (previously Kanudi Fisheries Research Station) at the University of Papua New Guinea (Waigani, Port Moresby; left image) or the Australian National Fish Collection

(CSIRO) in Hobart, Tasmania. The biodiversity information collected led to the development of this field guide to the chondrichthyans of PNG.

Photographs and diagnostic characters are provided for 79 sharks, 51 rays and 2 chimaeras, along with notes on their biology, fishery, distribution and global conservation status. A key to each of the 39 families and 69 genera is also provided.

The project has provided a better understanding of the rich biodiversity of chondrichthyans in the New Guinea region. A total of five new species of shark and eight new species of ray were described based, in part or fully, on material collected. Eleven families not previously known from PNG were also recorded during this study, resulting from the examination of recently collected deepwater chondrichthyans. CSIRO has previously led the production of similar field guides to the chondrichthyan fauna of Indonesia, Borneo and the Persian Gulf by collaborating with regional agencies. This guide to the chondrichthyan fauna of PNG provides an interesting comparison with adjacent countries as well as highlighting the uniqueness of the fauna in PNG.

Image credits

1. Raggiana bird-of-paradise—markaharper1 [CC BY-SA 2.0], via Wikimedia Commons
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8. Papuan guitarfish—Jhen-Nien Chen, National Taiwan University Museum
9. Prawn trawl bycatch—Ronald Wala, National Fisheries Authority
10. National Fish Collection building—William White, CSIRO

Provinces with coastlines

1 Western
2 Gulf
3 Central
4 National Capital
5 Milne Bay
6 Oro
7 Morobe
8 Madang
9 East Sepik
10 Sandaun
11 Manus
12 West New Britain
13 East New Britain
14 New Ireland
15 Autonomous Region of Bougainville

Map of Papua New Guinea with the provinces separated by colour and the provincial capitals shown with a red circle. Numbers relate to the 15 provinces that have a marine coastline and that may be referred to throughout this guide. The major water bodies, including the main rivers, are also labelled.

How to use this book

This guide is designed to assist in the identification of the sharks, rays and chimaeras found in Papua New Guinea (PNG) waters.

A key is provided so that a reader can systematically identify a shark, ray or chimaera to its appropriate family and genus (when more than one genus is present) and be directed to the relevant pages. If the family is already known, users can go straight to the relevant chapter. When in doubt, we recommend using the families and genera key when trying to identify an animal. Note that the characters used in some cases relate to the species observed in PNG only. For example, the two genera *Chimaera* and *Hydrolagus* are traditionally separated based purely on presence or absence of an anal fin. However, this character can be variable, and the generic arrangement of the family needs to be reviewed. In this case, the characters used to separate the genera work for the two PNG species but would not be appropriate in the broader region.

Species profiles follow the family key, and these are organised in taxonomic sequence, commencing with the sixgill sharks (Hexanchidae) through to the chimaeras (Chimaeridae). Each order of sharks, rays or chimaeras is colour coded on the right-hand side of each page spread and, within each of these sections, families are organised in taxonomic order. Species within each of the families are organised in alphabetical order of their scientific names. Species accounts have been kept as simple as possible, but the use of some technical terms is unavoidable, and users should consult the illustrated glossary (p. 11) for a definition of these terms if uncertain of their meaning.

Species profiles

Aspects of the size, reproductive biology, diagnostic features, distribution, habitat and ecology, colour and utilisation of species, and comparison with similar species are provided for each species under appropriate subheadings. The current global International Union for Conservation of Nature (ICUN) Red List conservation status is also provided for each species.

Common and scientific names

The English common names generally follow those adopted by Ebert et al. (2013) for sharks; Last & Stevens (2009) for Australasian-region sharks, rays and chimaeras; and Last et al. (2016) for rays, with the exception of some recently described species for which common names were proposed by the relevant authorities. Local PNG common names were not included because of the large numbers of cultural groups and languages in PNG, resulting in many different names for some species. Such a comprehensive listing could not be achieved during this project.

The scientific name of each species consists of genus and species names, the name of the author(s) who named it, and the year in which it was named. Parentheses around the author(s) and date indicate that the author originally placed the species in a different genus. New species, or species of uncertain identity, are referred to by a generic name and 'sp.' Alternatively, 'cf ' is placed between the generic and species names if the species is similar to, but possibly different from, a named species.

Images and illustrations

Where possible, images of PNG specimens were used in the species treatments. When images were unavailable from PNG, a suitable image from an adjacent region was used. In these cases, priority was given to images of specimens from Australia or Indonesia. Exceptions to this protocol include images of the whale shark (*Rhincodon typus*) from the Okinawa Churaumi Aquarium in Japan, the bluntnose sixgill shark (*Hexanchus griseus*) from India, the smalleye stingray (*Megatrygon microps*) from Mozambique (based on an underwater image), and the sixgill stingray (*Hexatrygon bickelli*) from Taiwan. In each of these cases, we are confident that they refer to the same species based on molecular results to date.

Additional photographs were used, where possible, to highlight features indicative of a particular species that are not apparent on the primary image. When photographs were unavailable, line drawings were used. Line drawings used were illustrated by either Georgina Davis or Lindsay Marshall (www.stickfigurefish.com.au). The majority of photographs used in this book were taken from this study (National Fisheries Authority observers or project team) or from the Australian National Fish Collection image collection. For those images obtained outside of these sources, the photographer is credited in the 'Image details' section for each species.

Conservation status

The conservation status for each species, following the IUCN Red List of Threatened Species™ (www.iucnredlist.org), is provided as a symbol located below the primary image for each species, as of December 2017. The categories used are: NE—Not Evaluated, DD—Data Deficient, LC—Least Concern, NT—Near Threatened, VU—Vulnerable, EN—Endangered and CR—Critically Endangered. Species in one of the three latter categories (VU, EN and CR) are considered threatened. The colour of each of the symbols follows the standard colours for each category as defined by the IUCN. It should be noted that the Red List is a dynamic publication so we recommend consulting www.iucnredlist.org for updates on species of interest.

Size and basic biology

Measurements refer to the total length (TL) for all sharks and some rays (Pristidae, Rhinidae, Rhinobatidae, Glaucostegidae, skates, Torpedinidae, Narcinidae, Hexatrygonidae and Urolophidae), disc width (DW) for some rays (Dasyatidae, Gymnuridae, Aetobatidae, Myliobatidae, Rhinopteridae and Mobulidae) and precaudal length (PCL) for chimaeras. Total length is measured as a straight line from the tip of the snout to the tip of the extended upper caudal-fin lobe. Disc width is used in those ray groups where the tail can commonly be absent or damaged. In addition to the maximum size, the sizes at birth or hatching, and at sexual maturity, are given for each species when known. The number of pups per litter and the reproductive mode are also given when known. For oviparous species, a brief note on the egg cases (size and/or colour and shape) is provided where information was available.

Key features

These are the main features by which a species can be most easily identified in the field. They include body shape, teeth shapes, fin positions and dimensions, and colour patterns. The diagnostic characters for each species allow the separation of that species from other closely related species and genera. Although it is preferable to use simple features that can be readily used in the field, in some instances more technical features are included to ensure correct species identification.

Colour

A brief colour description of each species is provided. The colour descriptions typically describe the dorsal and ventral colouration, and any distinctive fin or other body markings.

Distribution

A brief sentence on the global geographical distribution is provided for each species, including known depth range. More detailed information on the distribution in PNG waters is given when known.

Habitat and biology

This section covers basic information such as habitat use (pelagic and oceanic, demersal on continental shelf, sexual segregation, etc.) and diet composition.

Utilisation

This section briefly details the interactions of each species with fisheries in PNG and, if known, what parts of the animals are used.

Remarks

This section includes any other relevant information that does not fit into the other categories, such as movement information, taxonomic notes, new records, and comparison with similar species outside PNG.

Similar species

This section provides basic information to separate the species in question from the most similar species occurring in PNG waters. This allows a reader to quickly compare similar local species without needing to turn between pages constantly.

Image details

This section provides the location, size and sex of the specimen(s) in the images provided for each species. Attributions are included when images were obtained outside the project or from CSIRO's image collection.

Fin identification guide

Many of the shark species encountered during this study were confirmed by examination of dried fins, mostly by DNA barcoding. As a result, it was considered highly relevant to include a guide to the commonly finned species of sharks based on the first dorsal fins. It should be noted that some closely related species are very difficult to separate based on only the first dorsal fin. Thus, this guide groups similar species together to avoid misidentification among species with similar-looking dorsal fins.

Indexes

Indexes of scientific names and common names are provided on pages 320 and 324, respectively.

Glossary

acute—sharp or pointed.

adelphophagy—method of matrotrophic embryonic nutrition in some viviparous species in which the embryo feeds on other embryos in the uterus.

adolescent—almost sexually mature.

adult—fully developed and sexually mature.

angular—forming a distinct angle.

anterior—relating to the front of an object.

apex—the tip, pointed end or extremity; usually in reference to a fin.

bar—an elongate vertical marking.

barbel—a tentacle-like sensory structure on the head.

base—part of a projection (often a fin) connected to the body.

benthic—living on the bottom of the ocean.

blotch—a patch that is different in colour to adjacent areas.

border—margin or edge.

brackish—waters with a salinity between fresh water and salt water, as in river estuaries.

bycatch—non-target catch components caught by artisanal and commercial fishers.

cartilage—a skeletal material consisting of a matrix of soft, white or translucent chondrin.

caudal fin—the tail fin.

caudal keel—a longitudinal fleshy ridge along the side of the caudal peduncle.

caudal peduncle—the narrow posterior part of the body connecting the caudal fin.

caudal sting—an enlarged, serrated bony structure on the tail of some rays (or sting).

cephalic lobe—a flat, roundish projection on the forehead of some rays.

cephalopod—a group of animals including cuttlefishes, nautili, squids and octopuses.

cetacean—a group of aquatic mammals that includes whales, dolphins and porpoises.

chimaera—a Holocephalan fish (e.g. chimaeras and ghost sharks).

circumglobal – distributed around the world within a certain latitudinal range.

circumtropical—distributed throughout the tropical regions of the world.

claspers—modified parts of pelvic fins in males that are used to transfer sperm to the female during mating.

cloaca—a common opening for digestive, urinary and reproductive tracts.

common name—the informal given name for an animal, which may vary across the geographic range for a species.

compressed—flattened laterally from side to side.

concave—curved inwards (opposite of convex).

continental shelf—the shelf-like part of the seabed adjacent to the coast to a depth of about 200 m.

continental slope—the typically steep, slope-like part of the seabed bordering the continental shelf to a depth of about 2,000 m.

convex—curving outwards (opposite of concave).

cosmopolitan—having a worldwide distribution.

cranium—part of the skull containing the brain.

crescentic—shaped like a new moon (roughly C-shaped).

crustaceans—a group of invertebrate animals including crabs, shrimps, prawns, lobsters and crayfish.

cusp—a projection on a tooth.

cusplet—a small cusp.

demersal—living on or near the seabed.

denticle—a tooth-like structure; scale of a shark or ray.

denticle band—a variably demarcated patch of denticles on the dorsal disc of many stingrays.

depressed—flattened ventrally (from top to bottom sides of the body).

depth—height of body or head from top to bottom; also distance from the sea surface to the bottom.

dermal—pertaining to the skin.

dermal lobes—outgrowths of skin.

disc—the combined head, trunk and enlarged pectoral fins of those cartilaginous fishes with depressed bodies (e.g. stingrays).

DNA—the main component of chromosomes (deoxyribonucleic acid), responsible for transfer of genetic information.

dorsal—relating to the upper part or surface of the back.

dorsal skin fold—a fold of skin along the dorsal mid-line of the tail in some rays.

dorsolateral—positioned or orientated between dorsal and lateral surfaces.

dorsoventral—referring to a specific direction, top to bottom.

dusky—darkish to greyish in colour.

egg case—a strong casing surrounding the fertilised eggs of some sharks, rays and chimaeras.

elasmobranch—a group of fishes comprising sharks and rays.

electric organ—an organ that produces an electrical discharge.

elevated—higher.

elongate—extended in length in relation to width.

embryo—unborn or unhatched offspring in the process of development.

embryonic—relating to the embryo.

endemic—native and restricted to an area.

epipelagic—the upper body of water that extends from the surface to about 200 m.

estuarine—an organism that lives or is found in estuaries.

eyelid—a moveable, muscular fold of skin capable of covering all or part of the exposed portion of the eyeball.

falcate—curved like a sickle.

family—a classification term used for grouping organisms, containing one or more closely related genera.

fauna—the communities of animals in an area.

filter feeding—a feeding strategy that uses special structures (e.g. gill rakers) to sieve food particles from the water.

free rear tip—the posterior tip of a fin closest to the fin insertion.

genetic—relating to genes and their characteristics.

genus—a classification term used for grouping organisms, containing one or more closely related species.

gestation—the time of development of young within the mother.

gillnet—a net used to tangle fishes.

gill opening—an opening (usually slit-like in sharks and rays) on the head that connects the gill chamber to the exterior.

granular—a rough or grainy surface.

habitat—the environment in which an organism lives.

hammer-shaped—shaped with paired lateral expansions, like the head of a mallet.

head—the specialised anterior part of an animal on which the mouth and major sensory organs are located; part other than body and tail.

histotrophy—a form of embryonic nutrition in which the developing embryos receive a lipid-rich histotroph, or uterine milk, usually delivered through extensions of the uterine wall called trophonemata.

hyomandibular pores—a line of enlarged pores on both sides of the mouth corners.

insertion—the posterior point of attachment of a fin to its base.

interdorsal—the area between the first and second dorsal fins.

interdorsal ridge—a ridge of skin between dorsal fins.

internarial space—the space between the nostrils.

internasal flap—a fleshy flap extending between the nostrils, sometimes partly covering the mouth.

interorbital space—the area on the top of the head between the eyes.

jaws—the part of the mouth supporting teeth.

juvenile—young fish, not yet sexually mature.

keel—a fleshy ridge.

labial furrow—a shallow groove that is sometimes present at the corners of the mouth.

lateral—referring to the sides.

lateral ridges—fleshy expansions on sides of body.

lip—the fleshy outer portion of the jaws.

lobe—a rounded outgrowth.

longitudinal—lengthwise (opposite of transverse).

longline—a fishing line with a number of baited hooks, usually suspended horizontally in the water column.

lunate—shaped like a crescent moon.

margin—edge or rim.

median—relating to the middle of an object.

mesopelagic—living in the open ocean at depths between 200 and 1,000 m.

molecular—relating to or consisting of molecules; molecular research focuses on the form and function of components of living cells, including DNA.

mouth—the opening through which food enters the alimentary canal.

mucus—a slimy solution of mucin or other viscous substances.

nape—the region of the head above and behind the eyes.

nictitating eyelid—a transparent, moveable membrane or inner eyelid that protects the eye.

nostril—the external opening of the nasal organs.

notch—an indentation or incision on an edge or surface.

obtuse—broadly rounded or having a blunt end.

oceanic—living in the open ocean.

ocellus (pl. ocelli)—an eye-like marking.

oophagy—a method of matrotrophic embryonic nutrition in viviparous species in which the embryo feeds on unfertilised eggs in the uterus.

oral—pertaining to the mouth.

orbit—a cavity in the skull that houses the eyeball.

origin (of a fin)—the most anterior point of a fin base.

oviparous—producing eggs that hatch after being deposited externally from the body of a pregnant female.

pectoral fin—paired fins just behind or below the gill opening.

pelagic—free-swimming in the seas, oceans or open water and not associated with the bottom.

pelvic fins—paired fins positioned on the ventral surface between the head and the cloaca.

pharynx—the passageway leading from the oral and nasal cavities in the head to the oesophagus.

placental—a method of matrotrophic embryonic nutrition in viviparous species in which nutrients are transferred across the mother's uterine epithelium, which is intimately connected with foetal tissue (placenta).

plain—uniformly coloured, without a contrasting colour pattern.

plankton—small microscopic organisms that drift or float in open water.

population—a biological unit that represents the individuals of a species living in a certain area.

pore—a small opening in the skin that has secretory or sensory functions.

posterior—relating to the hind or rear end of an object.

precaudal pit—a transverse or longitudinal notch on the caudal peduncle just anterior to the origin of the caudal fin in some sharks.

pups—newborns.

purse seine—a fishing net used to encircle surface-dwelling fish, usually landed into a boat rather than beached.

quadrangular—shaped with four distinct edges or margins.

raked—anterior margin of dorsal fin is on an angle, usually pointed posterodorsally.

reticulated—a network arrangement.

reticulations—markings in the general form of a net.

rhomboidal—diamond-shaped.

rostral cartilage—a gristly structure supporting the snout.

rostral teeth—tooth-like projections on the sides of the snout of sawfishes.

rostrum (adj. rostral)—a projecting snout.

rounded—margin evenly convex.

row—sequential arrangement of a structure (e.g. thorns or spots).

saddle—a blotch extending across the dorsal surface from one side to another.

salinity—the concentration of salt in water.

school—a close aggregation of fish swimming in association with each other.

scientific name—the formal binomial name of an organism, consisting of the genus and species names; only one valid scientific name exists per species.

seine—a fishing net designed to hang vertically in the water and the ends being drawn together to encircle fish.

serrate—saw-like.

sexual dimorphism—difference in physical form (shape) between the sexes.

skeleton—a structure whose main function is to strengthen and maintain the shape of an animal.

skin fold—an area where skin is bent over upon itself, forming a fleshy ridge.

snout—the part of the head in front of the eyes.

solitary—used in reference to a fish that occurs alone, not in schools or aggregations.

species—actually or potentially interbreeding populations that are reproductively isolated from other populations.

species complex—a group of closely related species that are very similar to one another and have often been confused and/or are thought to represent a single species.

spiracle—a respiratory opening behind the eye in sharks and rays.

spiracular fold—a fold of skin present on the hind margin of the spiracular opening in some ray species.

spot—a regularly shaped or rounded area of a colour different from adjacent areas.

stinging spine—see *caudal sting*.

stripe—a contrasting longitudinal pattern in the form of a line.

subequal—nearly equal.

substrate—the substance forming the bottom of the sea or ocean.

subterminal—positioned near but not at the end of an object.

symphysis (adj. symphysial)—relating to the medial junction of either the upper or lower jaw.

synonym (adj. synonymous)—each of two or more scientific names of the same rank used to denote the same taxon.

tail—the part of a fish between the cloaca and the origin of the caudal fin.

taxonomy—the science of classification of plants and animals.

tendril—a slender, curling barbel.

terminal—located at or forming the end of something.

thorn—large denticles on the surface of a ray or skate.

tip—the extremity of a part of a fish.

tooth rows—horizontal rows of teeth in the jaws.

total length—longest length of a fish, from snout tip to upper caudal tip or tail tip.

transverse—directed crosswise, across width (opposite of longitudinal).

trawl net—a fishing net that is dragged behind a boat.

truncate—terminating abruptly, as if cut off square.

trunk—the part of a fish between the head and the tail; between fifth gill slit and cloaca.

undulate—having a wavy or rippled appearance.

upright—anterior margin of dorsal fin is almost vertical, directed more or less at 90 degrees to its base.

uteri (sing. uterus)—female reproductive organs in which embryos develop before birth.

ventral—relating to the lower part or surface.

vertebrate—an animal having a vertebral column or backbone.

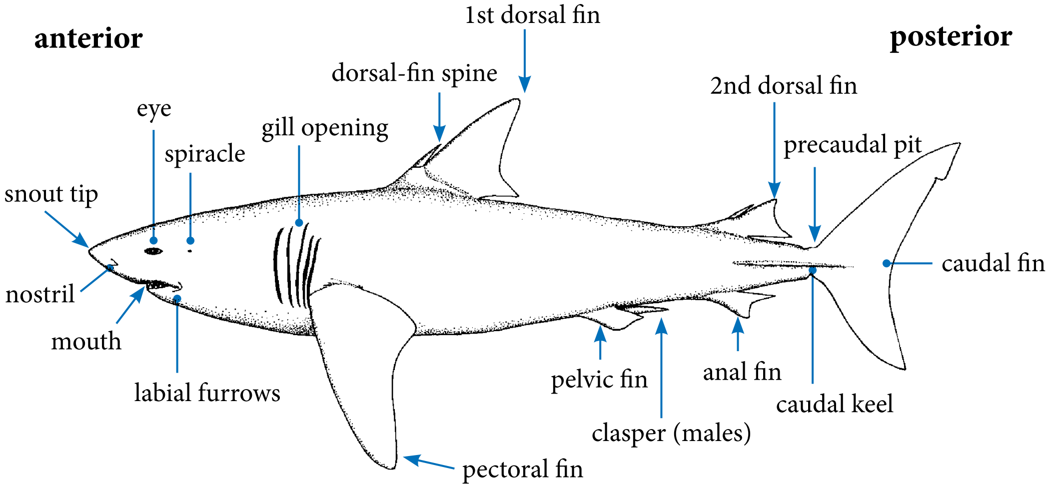
viviparous—producing live young from within the body of the parent female.

vs.—abbreviation of 'versus', used to compare or contrast characters between species.

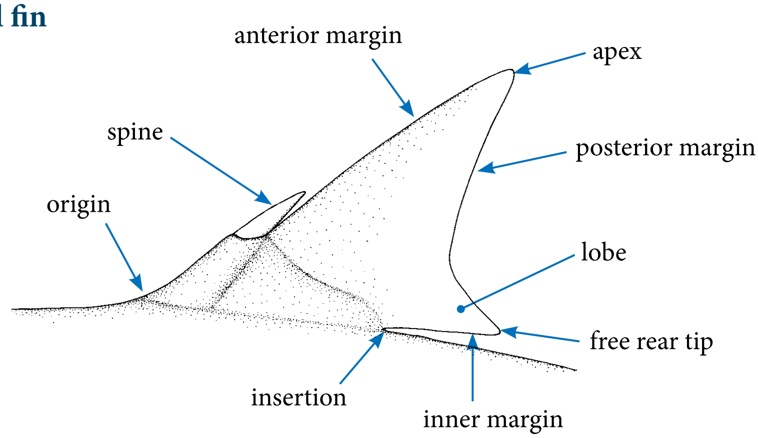
weakly—refers to a structure being poorly developed or represented.

widespread—distributed over a wide geographic range.

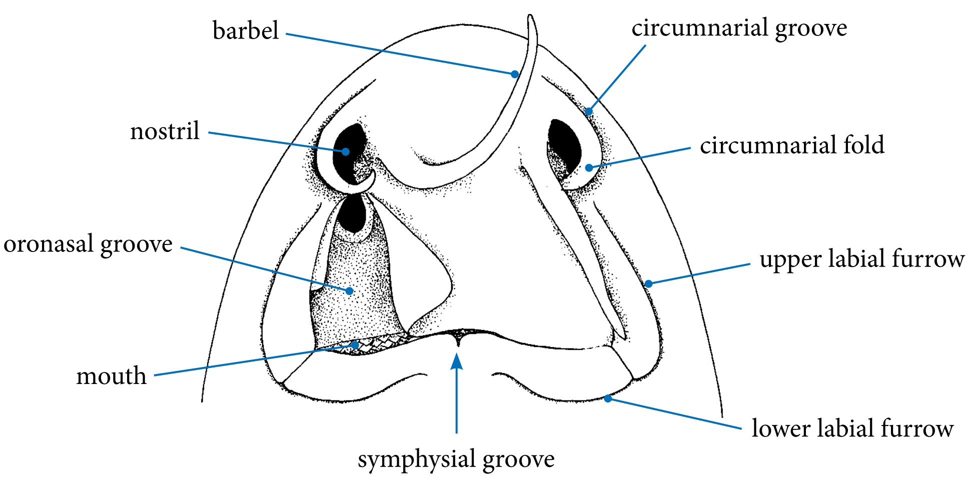
Structural features of sharks



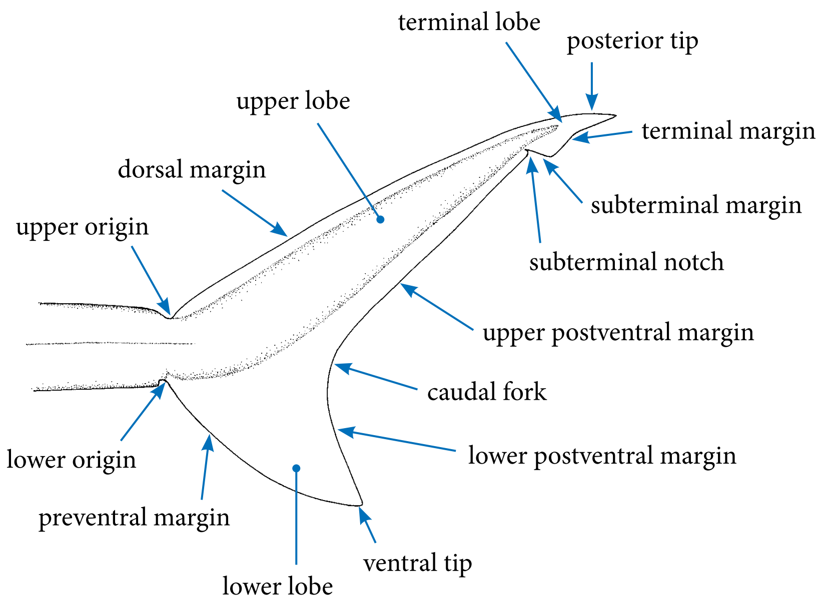
Shark dorsal fin



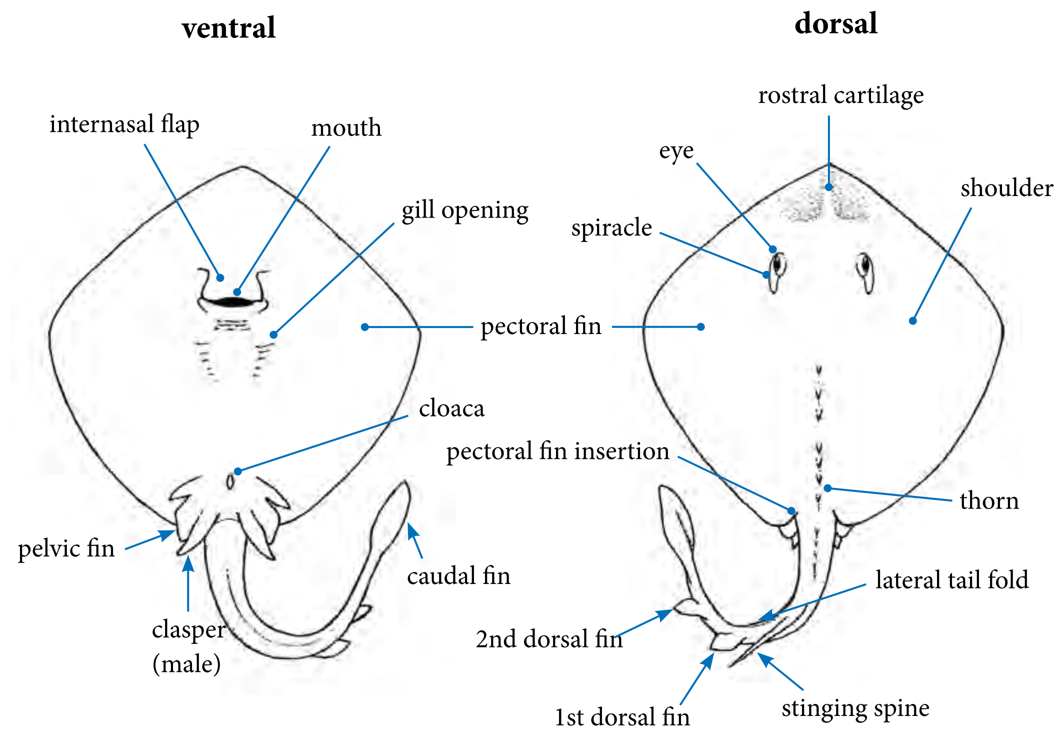
Shark undersurface of head



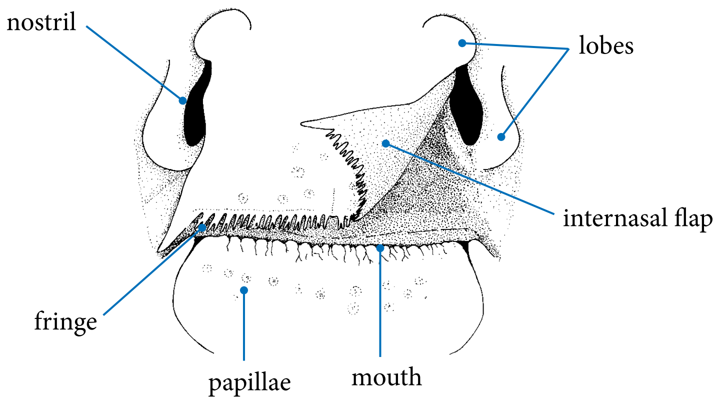
Shark caudal fin



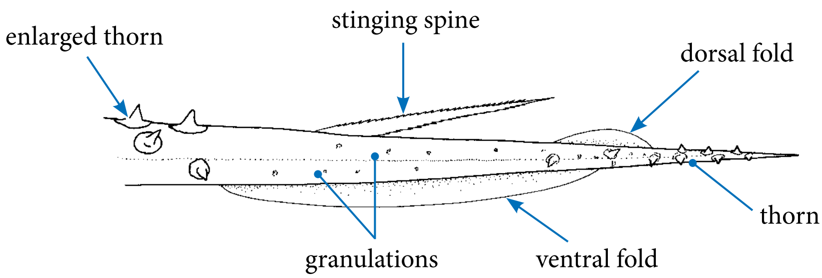
Structural features of rays



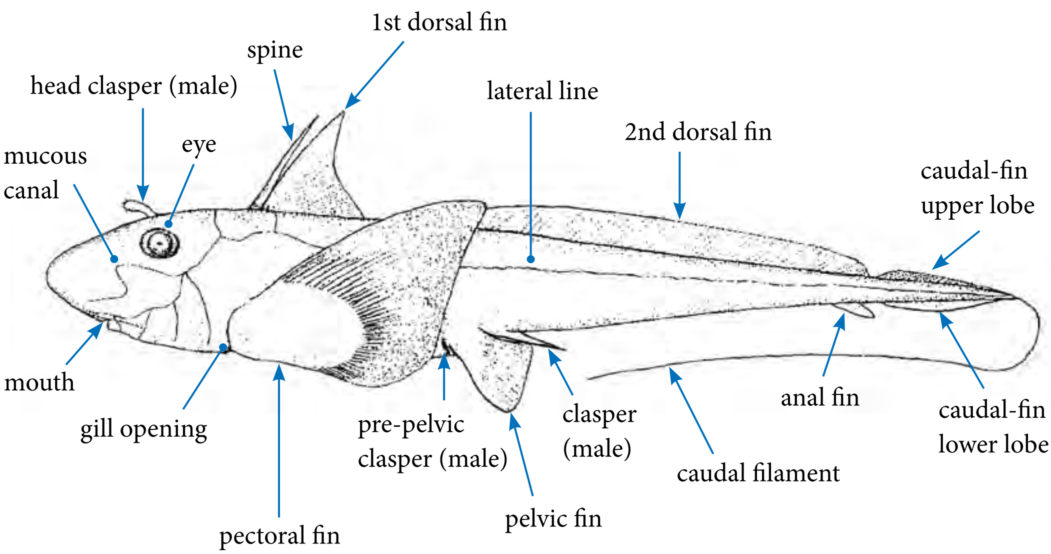
Ray nostrils and mouth (oronasal)



Ray tail (lateral)



Structural features of chimaeras



Key to families and genera

1. A single external gill opening on each side of head .... Chimaeridae (ghost sharks)

    Lateral line with tight undulations .... *Chimaera* (fig. 1; p. 294)

    Lateral line nearly straight to slightly undulating .... *Hydrolagus* (fig. 2; p. 296)

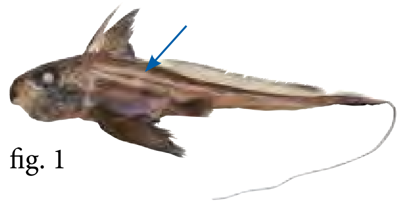


fig. 1

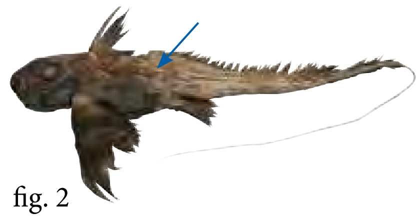


fig. 2

   5 or 6 pairs of gill openings 2

2. Snout saw-like, flattened and armed with lateral teeth .... Pristidae (sawfishes)

    Lower lobe of caudal fin relatively large, more than half length of upper lobe .... *Anoxypristis* (fig. 3; p. 192)

    Lower lobe of caudal fin small, less than half length of upper lobe .... *Pristis* (fig. 4; p. 194)

fig. 3

fig. 4

   Snout not saw-like, no rostral teeth 3

3. Gill openings on sides of head 4

   Gill openings on undersurface of head 24

4. A single dorsal fin; 6 or 7 gill openings on each side of head .... Hexanchidae (sixgill sharks) fig. 5; p. 34

   Two dorsal fins; 5 gill openings on each side of head 5

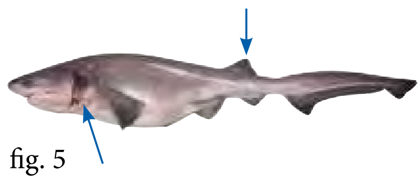


fig. 5

5. Anal fin absent 6

   Anal fin present, sometimes small 9

6. Caudal fin without a subterminal notch; teeth similar in shape in both jaws .... Squalidae (dogfishes) fig. 6; p. 36

   Caudal fin with a subterminal notch (usually obvious); teeth in upper jaw differing in shape to those in lower jaw 7

fig. 6

7. Ventral surface, sides and caudal fin with dark (luminescent) markings; upper teeth with lateral cusplets .... Etmopteridae (lanternsharks)

fig. 7; p. 52

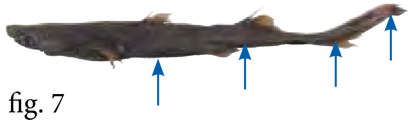


fig. 7

No dark luminescent markings on ventral surface, sides and caudal fin; upper teeth with a prominent cusp but no lateral cusplets 8

8. Dorsal-fin spines prominent; lower teeth short, broad and oblique; head not conical ... . Centrophoridae (gulper sharks)

Preoral snout very long, much longer than distance from mouth to pectoral-fin origin .... *Deania* (fig. 8; p. 50)

fig. 8

Preoral snout shorter than distance from mouth to pectoral-fin origin .... *Centrophorus* (fig. 9; p. 48)

fig. 9

Dorsal-fin spines absent; lower teeth with tall, triangular cusps; head conical .... Dalatiidae (kitefin sharks)

fig. 10; p. 58

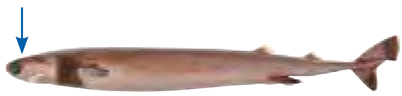


fig. 10

9. Head laterally expanded, hammer-shaped .... Sphyrnidae (hammerhead sharks)

Head very broad, narrow and wing-like; width of head about half of total length .... *Eusphyra* (fig. 11; p. 184)

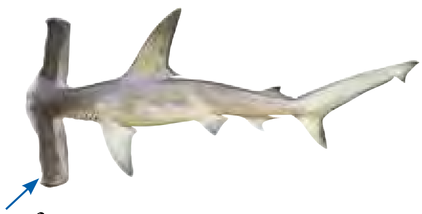


fig. 11

Head not as broad or wing-like; width of head less than 40% of total length .... *Sphyrna* (fig. 12; p. 186)

fig. 12

Head not hammer-shaped 10

10. Upper caudal-fin lobe very long; equal to or more than half total length; body not spotted or banded .... Alopiidae (thresher sharks)

fig. 13; p. 84

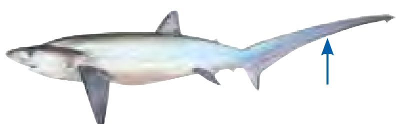


fig. 13

Upper caudal-fin lobe much less than half total length (caudal fin also long in *Stegostoma*, but body spotted and/or banded) 11

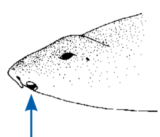


fig. 14

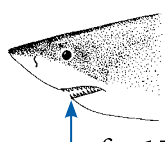


fig. 15

11. Whole mouth forward of front margin of eye (fig. 14) 12

Mouth partly beneath or behind front margin of eye (fig. 15) 16


fig. 16

12. Mouth very broad and at front of head (terminal); caudal fin with a well-developed lower lobe ....Rhincodontidae (whale sharks) fig. 16; p. 82

Mouth narrower and not at front of head (subterminal); caudal fin without an obvious lower lobe 7

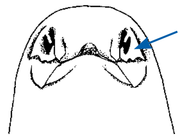


fig. 17

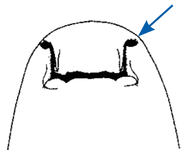


fig. 18

13. Outer margin of nostril with a fleshy lobe and groove (fig. 17) 14

Outer margin of nostril without a fleshy lobe or groove (fig. 18) 15

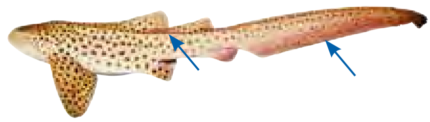


fig. 19


fig. 20

14. Caudal fin very long, almost equal to trunk length; strong ridges present on side of body .... Stegostomatidae (zebra sharks) fig. 19; p. 80

Caudal fin shorter, less than half trunk length; no ridges on sides of body ....Ginglymostomatidae (nurse sharks) fig. 20; p. 78

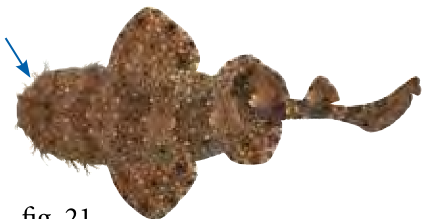


fig. 21

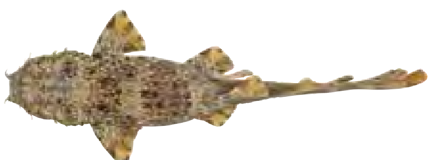


fig. 22

15. Body strongly depressed anteriorly; skin flaps along side of head behind nostrils ....Orectolobidae (wobbegongs)

Dermal lobes extensively branched, forming a dense fringe around front of head .... *Eucrossorhinus* (fig. 21; p. 60)

Dermal lobes mostly simple, not forming a dense fringe ....*Orectolobus* (fig. 22; p. 62)


fig. 23

Head and body cylindrical, not depressed; no skin flaps along side of head ....Hemiscylliidae (longtailed carpetsharks)

Nostrils subterminal on snout; no black ocellus behind fifth gill slit .... *Chiloscyllium* (fig. 23; p. 68)

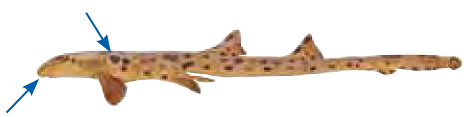


fig. 24

Nostrils almost terminal on snout; a large black or brown ocellus behind fifth gill slit ....*Hemiscyllium* (fig. 24; p. 72)

16. Caudal fin upper and lower lobes of almost equal length; a strong keel on either side of caudal peduncle ....Lamnidae (mackerel sharks) fig. 25; p. 88

Caudal fin upper lobe much longer than lower lobe; no, or only a low, keel on each side of caudal peduncle 17


fig. 25

17. Eyes very large, more than half greatest height of snout; gill openings extending onto dorsal surface of head ....Pseudocarchariidae (crocodile sharks) fig. 26; p. 94

Eyes smaller, less than half greatest height of snout; gill openings not extending onto dorsal surface of head 12

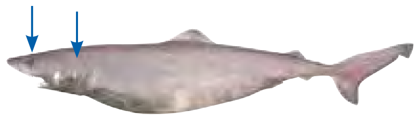


fig. 26

18. Eyelid fixed, not capable of closing over eye . ... Odontaspididae (sandtiger sharks) fig. 27; p. 92

Eyelid nictitating (capable of closing over eye) 19


fig. 27

19. First dorsal-fin origin well behind pelvic-fin origin.. 20

First dorsal-fin origin well in front of pelvic-fin origin 21

20. Supraorbital crests present on the cranium; a distinct colour pattern present .... Scyliorhinidae (catsharks)

Anterior nasal flaps greatly expanded, reaching mouth (fig. 28); dorsal fins similar in size............. *Atelomycterus* (fig. 30; p. 96)

Anterior nasal flaps much shorter, not reaching mouth (fig. 29); first dorsal fin much larger than second ....*Cephaloscyllium* (fig. 31; p. 100)

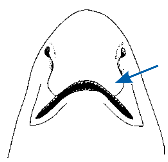


fig. 28

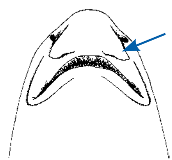


fig. 29

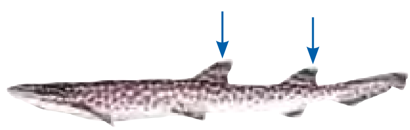


fig. 30

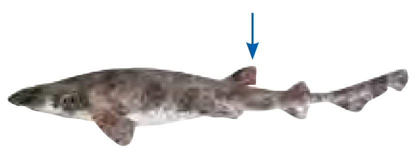


fig. 31

No supraorbital crests present; colour typically plain, sometimes with faint blotches or saddles .... Pentanchidae (deepwater catsharks)

a. Upper labial furrows very long, more than 3 times spiracle diameter, usually extending to front of eye (fig. 32)... *Apristurus* (fig. 34; p. 102)

Upper labial furrows much shorter, never extending to front of eye (fig. 33) .... b

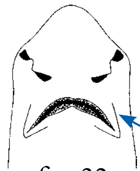


fig. 32

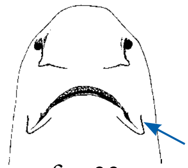


fig. 33

fig. 34

b. Body dark brownish to brownish grey, without saddle-like markings .... *Parmaturus* (fig. 35; p. 112)

Body greyish with distinct dark saddles present on sides and on caudal fin .... *Galeus* (fig. 36; p. 110)

fig. 35

fig. 36

21. Precaudal pits absent; leading edge of upper lobe of caudal fin smooth .... Triakidae (hound sharks)

a. First dorsal fin very long, its base about as long as caudal fin .... *Gogolia* (fig. 37; p. 116)

First dorsal fin much shorter .... b

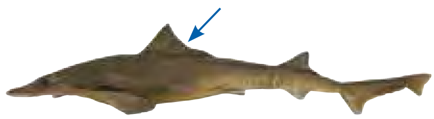


fig. 37

b. Origin of first dorsal fin over anterior half of pectoral inner margins; dorsal fins black-tipped .... *Iago* (fig. 38; p. 120)

Origin of first dorsal fin about over pectoral inner free rear tips; dorsal fins white-tipped .... *Hemitriakis* (fig. 39; p. 118)

fig. 38

fig. 39

Precaudal pits present; leading edge of upper lobe of caudal fin typically rippled............. 22

22. Caudal peduncle with lateral keels; upper labial furrows very long, reaching forward to front of eyes (fig. 40); body with a series of vertical dark bars on sides .... Galeocerdidae (tiger sharks)

fig. 41; p. 182

fig. 40

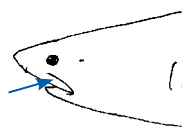


fig. 41

Caudal peduncle without lateral keels (weak keels present in *Prionace*); upper labial furrows rudimentary, or short to moderately long, but never reaching forward to front of eyes; body without vertical bars on sides .. 23

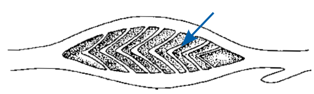


fig. 42

23. Small spiracles present; intestine with spiral valves (fig. 42) ....Hemigaleidae (weasel sharks)

Teeth noticeably protruding from mouth when closed; upper teeth narrow and slender; fins strongly falcate .... *Hemipristis* (fig. 43; p. 124)

Teeth not protruding from mouth when closed; upper teeth broad and short; fins only moderately falcate .... *Hemigaleus* (fig. 44; p. 122)

Spiracles absent; intestine with a scroll valve (fig. 45)........ Carcharhinidae (whaler sharks)

a. Second dorsal fin half or greater than half height of first dorsal fin .... b

Second dorsal fin less than half height of first dorsal fin .... d

b. First dorsal and upper caudal fin with distinct white tips; teeth with a single cusp and one or more large lateral cusplets (fig. 46) .... *Triaenodon* (fig. 47; p. 180)

First dorsal and upper caudal fin without white tips; teeth with a single cusp, no lateral cusplets.. c

c. Second dorsal fin almost same height as first dorsal fin; upper precaudal pit deep and crescent-shaped .... *Negaprion* (fig. 48; p. 170)

Second dorsal fin about half height of first dorsal fin; upper precaudal pit a shallow, longitudinal depression .... *Glyphis* (fig. 49; p. 164)

d. Second dorsal-fin origin well behind anal-fin origin (usually over anal-fin insertion, fig. 50); posterior margin of anal fin shallowly concave (fig. 50); ridges in front of anal fin very long (subequal to anal-fin base length) .... e

Second dorsal-fin origin usually about level with anal-fin origin (sometimes more posterior but always well anterior of anal-fin insertion, fig. 51); posterior margin of anal fin deeply concave or notched (fig. 51); ridges in front of anal fin short (about half anal-fin base or less) .... f


fig. 43


fig. 44

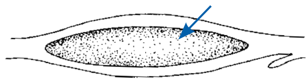


fig. 45

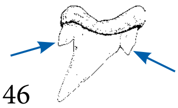


fig. 46

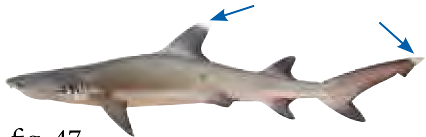


fig. 47

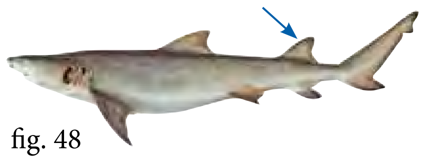


fig. 48

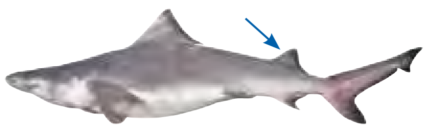


fig. 49

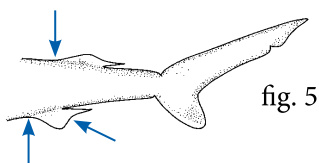


fig. 50

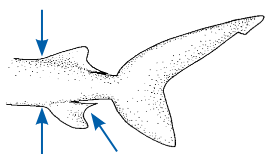


fig. 51

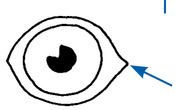


fig. 52

e. Notch present at posterior edge of eye (fig. 52); first dorsal-fin origin well behind adpressed pectoral-fin free rear tips............ .... *Loxodon* (fig. 53; p. 168)

Posterior edge of eye without a notch; first dorsal-fin origin over or only just behind adpressed pectoral-fin free rear tips............ .... *Rhizoprionodon* (fig. 54; p. 174)

f. First dorsal-fin base much closer to pelvic- than pectoral-fin bases; colour brilliant dark blue above; a low, weak keel present on each side of caudal peduncle........................ .... *Prionace* (fig. 55; p. 172)

First dorsal-fin base centred between pectoral- and pelvic-fin bases; colour light to dark greyish, greyish brown or brownish above; no keels on caudal peduncle .... *Carcharhinus* (fig. 56; p. 126)


fig. 53

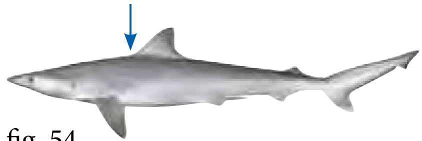


fig. 54

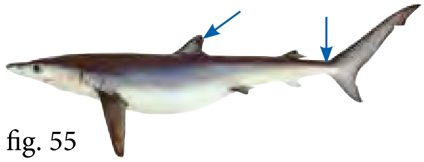


fig. 55

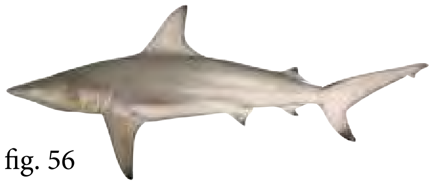


fig. 56

24. Pelvic fin divided into two lobes (fig. 57) . 25

Pelvic fin with a single lobe (fig. 58) 27

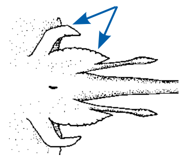


fig. 57

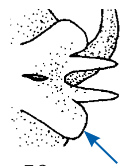


fig. 58

25. Dorsal surface entirely smooth; preorbital snout more than 8 times eye diameter; tail very short, thin and filamentous .... Anacanthobatidae (legskates) fig. 59; p. 220

Dorsal surface with thorns or fine denticles; preorbital snout much less than 8 times eye diameter; tail longer and slender, but not filamentous 26


fig. 59

26. Snout soft, with rostral cartilage thin and flexible ... Arhynchobatidae (softnose skates) fig. 60; p. 216

Snout firm, with a stiff rostral cartilage.......... ....Rajidae (hardnose skates) fig. 61; p. 218


fig. 60

27. Two prominent dorsal fins 28

No dorsal fins or a single dorsal fin 32

28. Body soft, flabby and smooth; electric organs present 29

Body firm to the touch and rough 30


fig. 61

29. Disc large relative to tail; first dorsal fin much larger than second .... Torpedinidae (torpedo rays) fig. 62; p. 214

Disc much smaller relative to tail; dorsal fins similar in size .... Narcinidae (numbfishes) fig. 63; p. 212

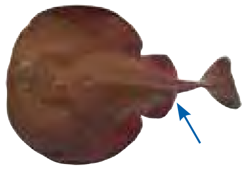


fig. 62

fig. 63

30. Caudal fin with a well-developed ventral lobe; pectoral and pelvic fins not touching.... .... Rhinidae (wedgefishes)

Head triangular; upper disc with small thorns .... *Rhynchobatus* (fig. 64; p. 202)

Head broadly rounded; upper disc with ridges lined with large thorns ....*Rhina* (fig. 65; p. 200)

Caudal fin without a well-defined lower lobe; pectoral and pelvic fins touching or overlapping 31

fig. 64

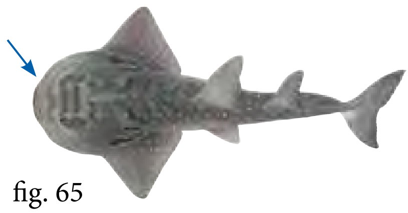


fig. 65

31. Nostrils long and narrow, anterior nasal opening rectangular, very large (fig. 66) .... Glaucostegidae (giant guitarfishes) fig. 68; p. 210

Nostrils not greatly elongate, anterior nasal aperture circular or oval, relatively smaller (fig. 67) .... Rhinobatidae (guitarfishes) fig. 69; p. 206

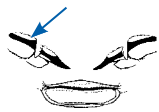


fig. 66

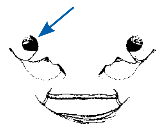


fig. 67

fig. 68

fig. 69

32. Anterior part of head extended beyond disc (fig. 70); eyes located laterally on side of head (fig. 70) 33

Anterior part of head not extended beyond disc (fig. 71); eyes located dorsally and well inward from disc margin (fig. 71) 36

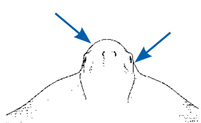


fig. 70

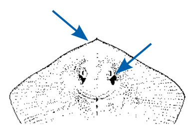


fig. 71

33. A pair of long, paddle-like flaps (cephalic lobes) extending forward from sides of head; teeth minute, in many rows .... Mobulidae (devilrays) fig. 72; p. 284

No cephalic lobes, instead with a single, fleshy rostral lobe or a pair of broadly rounded lobes; teeth much larger 34

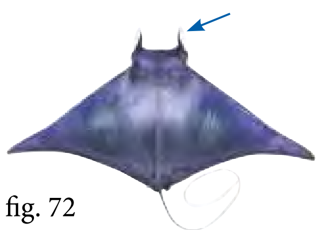


fig. 72

34. Margin of rostral lobe with a deep central notch forming two rounded lobes .... Rhinopteridae (cownose rays) fig. 73; p. 282

Margin of rostral lobe rounded, not bilobed 35

fig. 73

35. Margin of nasal curtain deeply notched (fig. 74); teeth in both jaws in a single row ... . Aetobatidae (pelagic eagle rays) fig. 76; p. 280

Margin of nasal curtain straight or slightly undulated to fringed (fig. 75); teeth in both jaws usually in 7 rows ....Myliobatidae (eagle rays) fig. 77; p. 276

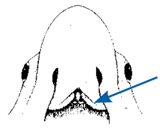


fig. 74

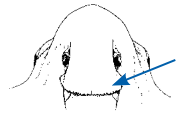


fig. 75

fig. 76

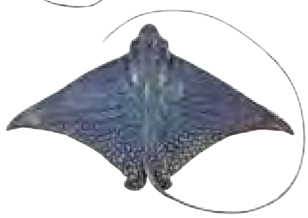


fig. 77

36. Six pairs of gill openings on ventral surface; spiracles widely separated from eyes .... Hexatrygonidae (sixgill stingrays) fig. 78; p. 222

Five pairs of gill openings on ventral surface; spiracles close to eyes.................................. 37

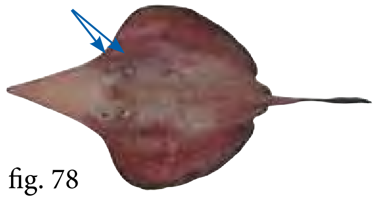


fig. 78

37. Disc very broad (more than 1.5 times wider than long); tail very short and filamentous ... . Gymnuridae (butterfly rays) fig. 79; p. 224

Disc width less than 1.5 times length; tail moderately long to very long with a thick base.. 38

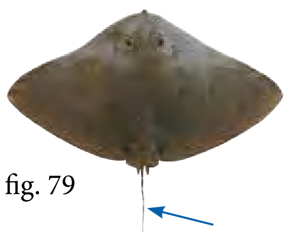


fig. 79

38. Caudal fin present .... Urolophidae (stingarees)

Dorsal surface of disc smooth; tail without thorns .... *Urolophus* (fig. 80; p. 274)

Dorsal surface of disc with some fine denticles; tail with small thorns along its midline .... *Spinilophus* (fig. 81; p. 272)

Caudal fin absent....... Dasyatidae (stingrays)

a. No skin folds on tail; base of tail narrow and typically rounded to slightly compressed in cross-section (fig. 82) .... b

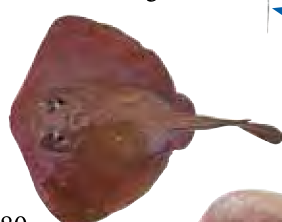


fig. 80

fig. 81

Skin folds present on undersurface of tail (also sometimes on dorsal surface behind sting); base of tail relatively broad, distinctly depressed (fig. 83) .... g

b. No stinging spine on tail; numerous long, sharp thorns over entire disc.... *Urogymnus* (in part, *U. asperrimus*; fig. 84; p. 266)

One or more stinging spines on tail (scar visible if missing); no long, sharp thorns present on disc (low thorns near midline of disc in some species) c

c. Strong dorsal colour pattern of spots, ocelli or reticulations... *Himantura* (fig. 85; p. 228)

Dorsal colour either plain or with small dark spots, not strongly patterned .... d

d. Disc subcircular to oval .... e

Disc rhombic ....f

e. Disc quite depressed; snout broadly triangular .... *Pateobatis* (in part, *P. hortlei*; fig. 86; p. 252)

Disc more robust and less depressed; snout obtuse .... *Urogymnus* (in part, 3 species; fig. 87; p. 264)

f. Tail with alternating black and white bands (less obvious in adults); dorsal surface with black or white spots .... *Maculabatis* (fig. 88; p. 232)

Tail plain, without banding; dorsal surface plain, without spots .... *Pateobatis* (in part, *P. fai* and *P. jenkinsii*; fig. 89; pp. 250, 254)

g. Ventral skin fold on tail tall and extending to tail tip ....h

Ventral skin fold on tail lower and terminating well before tail tip (when undamaged) i

h. Disc oval in shape; dorsal surface with numerous blue spots over a brownish background ....*Taeniura* (fig. 90; p. 258)

Disc subcircular in shape; dorsal surface with black and white mottling; no blue spots on body ... *Taeniurops* (fig. 91; p. 262)

i. Distance from cloaca to stinging spine

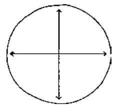


fig. 82

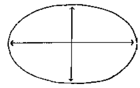


fig. 83


fig. 84

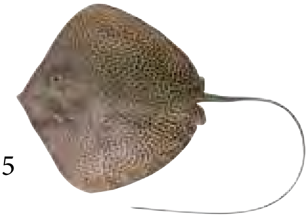


fig. 85


fig. 86


fig. 87


fig. 88

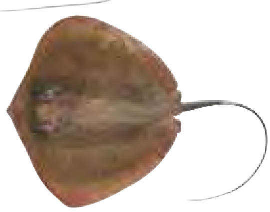


fig. 89


fig. 90

exceeding half of disc width; ventral skin fold on tail relatively tall (maximum height equal to or exceeding spiracle length) .... *Pastinachus* (fig. 92; p. 248)

Distance from cloaca to stinging spine less than half of disc width; ventral skin fold relatively low (maximum height much less than spiracle length) ....j

j. Disc shape cone-like, with a broadly rounded anterior profile; both dorsal and ventral surfaces entirely dark ....*Pteroplatytrygon* (fig. 93; p. 256)

Disc not cone-like (oval, subcircular or rhombic); ventral surface whitish .... k

k. Tail banded black and white behind sting; dark, transverse, mask-like band over eyes ....*Neotrygon* (fig. 94; p. 238)

Tail not banded beyond sting; without dark, transverse band through eyes l

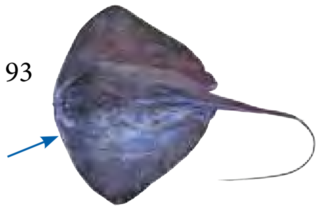
l. Disc very broadly angular; tail extremely broad at base, tapering rapidly at caudal sting .... *Megatrygon* (fig. 95; p. 236)

Disc rhombic, not broadly angular; tail moderately broad-based .... *Hemitrygon* (fig. 96; p. 226)

fig. 91

fig. 92

fig. 93



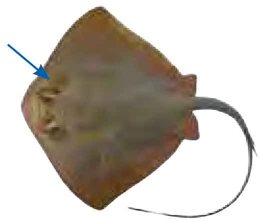


fig. 94

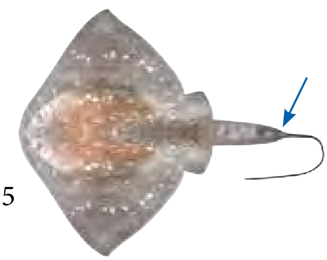


fig. 95

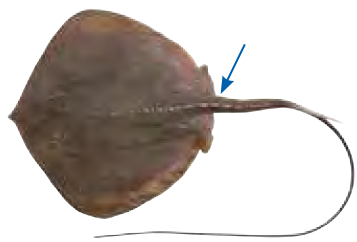
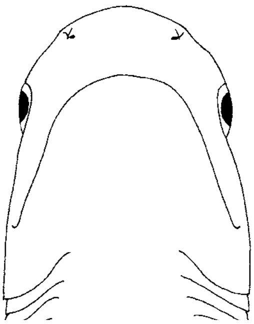


fig. 96

Species profiles

BLUNTNOSE SIXGILL SHARK

Hexanchus griseus (Bonnaterre, 1788)



Ventral head

NT

BIOLOGY

Maximum size: At least 482 cm TL, possibly to 550 cm TL

Maturity size: Females at 350–420 cm TL, males at 309–330 cm TL

Birth size: 61–74 cm TL

Litter size: 47–108 pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- 6 gill slits on each side of head
- A single dorsal fin located behind level of pelvic fins
- Eyes small, fluorescent green when fresh
- Snout broadly rounded (viewed from underneath)
- Anal fin present
- Caudal peduncle short
- Lower jaw with 6 rows of large, comb-like teeth

Colour: Dorsal surfaces blackish grey to chocolate brown, often with a pale stripe along the lateral line. Ventral surfaces greyish white. Fins with narrow white posterior margins. Eyes fluorescent green in life.

Distribution: Circumglobal, from near the surface to at least 2,500 m. In PNG, two records from New Britain: observed by a recreational fisher in Kimbe Bay and previously collected from off Rabaul.

Habitat and biology: Juveniles and subadults sometimes enter shallow coastal bays; often associated with areas of upwelling and high productivity. Diet includes bony fishes, elasmobranchs, cephalopods and crustaceans, and adults also feed on billfishes, cetaceans and seals.

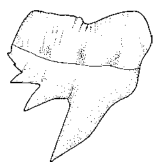
Utilisation: Rarely encountered by fisheries in PNG.

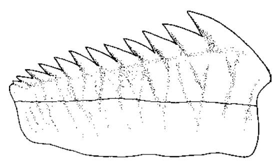
Remarks: A slow but strong swimmer. Adults are sensitive to light, so are typically found in deeper water; a recent telemetry study off Hawaii showed they undergo daily vertical migrations, with foraging likely occurring in the shallower waters at night.

Similar species: Distinct from other local shark species in possessing six pairs of gill slits (vs. five pairs in other shark species in region) and a single dorsal fin (vs. two dorsal fins).

Individual caught off Kimbe Bay. Although these are only partial images, they show a large shark with no anterior dorsal fin and a blunt head, confirming this species in PNG

Upper tooth





Lower tooth

Image details: Lateral: Cochin, India (juvenile female 87 cm TL, by K.K. Bineesh). Fishing: off Walindi in Kimbe Bay (supplied by Walindi Resort).

FATSPINE SPURDOG

Squalus crassispinus Last, Edmunds & Yearsley, 2007

Ventral head

DD

BIOLOGY

Maximum size: At least 67 cm TL

Maturity size: Males at ~45 cm TL

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- Caudal fin without a terminal lobe
- First dorsal fin slightly raked back
- Snout short, bluntly pointed in ventral view
- Caudal fin with a white posterior margin, without a dark bar near its fork
- Spines in front of dorsal fins very broad based
- Teeth similar in size and shape in both jaws

Colour: Dorsal surfaces pale greyish, with a bronze hue when fresh. Ventral surfaces white. Dorsal fin tips dusky to blackish. Caudal fin with a white posterior margin, not interrupted by a dark bar at fork.

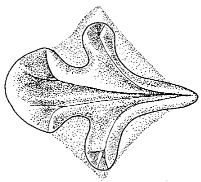
Distribution: Only known from off north-western Australia at depths of 187–262 m, and the Huon Gulf and Bismarck Sea in PNG at depths of 180–300 m.

Habitat and biology: Not known.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: The PNG records significantly extend the known range of this species from between North West Cape and Rowley Shoals in Western Australia to off the Bismarck and Solomon seas of PNG. The 67 cm TL PNG specimen is the largest known specimen for this species.

Similar species: Similar to the other *Squalus* species found in PNG but differs in having an entirely white posterior margin on the caudal fin that is not interrupted by a dark bar at fork (vs. a dark bar at fork). It also has distinctively robust dorsal spines compared with the other species.



Flank denticle

A moribund specimen caught in deepwater Nautilus traps and then placed on the substrate in shallower water for a photograph

Image details: Lateral: Huon Gulf, PNG (male 41.5 cm TL, by P. Neira). Ventral head: Bismarck Sea (female 67 cm TL). Underwater: PNG (by B. Halstead).

PAPUAN SPURDOG

Squalus cf. *edmundsi*

Ventral head

NE

BIOLOGY

Maximum size: Unknown; only known from a 24 cm TL female

Maturity size: Unknown

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- Caudal fin without a terminal lobe
- First dorsal fin tall and upright
- Snout elongate, narrowly triangular in ventral view
- Caudal fin with a dark bar on its lower lobe from ventral fin origin to the caudal fork; tips of upper and lower lobes white
- Spines in front of dorsal fins slender; second slightly longer
- Teeth similar in size and shape in both jaws

Colour: Dorsal surfaces probably greyish. Ventral surfaces whitish. Dorsal fin tips blackish. Caudal fin with a white posterior margin, interrupted by a broad black bar at fork extending about a third of the length of upper lobe.

Distribution: Only known from one specimen collected off New Ireland at a depth of 340–465 m.

Habitat and biology: Not known.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: Closely related to Edmund's spurdog, *S. edmundsi*, found in Western Australia and eastern Indonesia but differs slightly in structure of the CO1 gene. Additional material is required to determine whether it is a distinct species.

Similar species: Similar to *S. crassispinus* but differs in having a black bar at caudal fork that interrupts the white posterior margin (vs. white margin entire). It differs from *S. montalbani* in the dark caudal bar extending across base of ventral caudal lobe from origin to fork (vs. dark bar only present at posterior margin of caudal fin).

Flank denticle

Image details: Lateral and ventral head: New Ireland, PNG (female 24 cm TL).

PHILIPPINE SPURDOG

Squalus montalbani Whitley, 1931

Ventral head

VU

BIOLOGY

Maximum size: Females 106 cm TL, males 72 cm TL

Maturity size: Females at ~80 cm TL, males at 56–67 cm TL

Birth size: 20–24 cm TL

Litter size: 4–16 pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- Caudal fin without a terminal lobe
- First dorsal fin raked back
- Snout moderately elongate, somewhat pointed
- Caudal fin with a distinct dark bar above its fork extending onto upper lobe
- Spines in front of dorsal fins slender and relatively short
- Teeth similar in size and shape in both jaws

Colour: Dorsal surfaces greyish to greyish brown. Ventral surfaces whitish. Dorsal fin tips dusky. Caudal fin posterior margin dark centrally, tips of upper and lower lobes white.

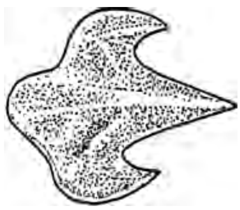
Distribution: Occurs off eastern and western Australia, eastern Indonesia and the Philippines at depths of 154–1,370 m. Single PNG specimen caught off Kavieng, New Ireland at 680 m depth.

Habitat and biology: Little known. Diet primarily consists of small fishes, cephalopods and crustaceans.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: New record for PNG, possibly widespread in the region. Underwent drastic declines in heavily trawled areas of eastern Australia between 1976 and 1997; likely highly susceptible to any significant level of fishing, as with many deepwater shark species.

Similar species: Similar to *S. crassispinus* but differs in having a mostly dark caudal fin posterior margin (vs. white margin entire). It differs from *S.* cf. *edmundsi* in the dark caudal markings restricted to the posterior margin (vs. dark bar extending across base of ventral caudal lobe from origin to fork).



Flank denticle

Image details: Lateral and ventral head: Kavieng, New Ireland, PNG (female 106 cm TL).

DWARF GULPER SHARK

Centrophorus atromarginatus Garman, 1913

Ventral head

DD

BIOLOGY

Maximum size: At least 94 cm TL

Maturity size: Females at ~75 cm TL, males at ~56 cm TL

Birth size: 30–36 cm TL

Litter size: 1–2 (usually 1) pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- Caudal fin with a prominent terminal lobe
- First dorsal fin short, with a moderately long free rear tip
- Second dorsal fin only slightly smaller than first
- Snout short, parabolic in ventral view
- Pectoral-fin free rear tips elongate
- Dorsal spines moderately long and slender
- Denticles block-like, flat and sessile

Colour: Dorsal surfaces greyish to greyish brown. Ventral surfaces slightly paler. Most fins with dusky tips (distinctly black in juveniles).

Distribution: Occurs in the north-west Indian and western Pacific oceans, from the Gulf of Aden to PNG and north to Japan, at depths of 100–540 m. In PNG, recorded from the Huon Gulf and off Madang.

Habitat and biology: Little known. Diet consists of small bony fishes and shrimps.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: Caught regularly in the Huon Gulf. Low productivity of this species makes it highly susceptible to any targeted fishing pressure.

Similar species: Similar to *C. moluccensis* but differs in having a taller second dorsal fin (vs. relatively low). It differs from *C. longipinnis* in having a much shorter first dorsal fin (vs. very long-based first dorsal fin).

Flank denticles

Freshly excised embryo removed from a pregnant female post-capture

Image details: Lateral and ventral head: Huon Gulf, PNG (female 71 cm TL, by P. Neira). Embyro: Huon Gulf, PNG (late-term embryo, by P. Neira). Denticles: Indonesia (adult).

GULPER SHARK

Centrophorus granulosus (Bloch & Schneider, 1801)

Ventral head

Juvenile

NE

BIOLOGY

Maximum size: Females 173 cm TL, males 124 cm TL

Maturity size: Females at 150 cm TL, males at 105 cm TL

Birth size: 35–47 cm TL

Litter size: 4–11 pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- Caudal fin with a prominent terminal lobe
- First dorsal fin moderately long, with a very long free rear tip
- Second dorsal fin about same height as first
- Snout relatively short
- Pectoral-fin free rear tips only slightly produced (not elongate)
- Dorsal spines short and robust
- Denticles of juveniles tricuspid and raised on pedicels; those of larger individuals not raised and unicuspid

Colour: Dorsal surfaces dark brown. Ventral surfaces slightly paler. Fins without markings.

Distribution: Widespread in the Atlantic and Indo–west Pacific oceans, but not recorded from the eastern Pacific, at depths of 98–1,700 m. In PNG, known from two specimens caught in the Huon Gulf and off Madang at depths of 550–675 m.

Habitat and biology: Little known. Diet consists of bony fishes, small sharks, squid and lobsters.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: Only known from two specimens but likely more widespread in PNG at depths below 500 m.

Similar species: Similar to *C. longipinnis* but differs in being much larger and in having a much shorter first dorsal-fin base (vs. very long dorsal-fin base).

Large female landed in the Huon Gulf during surveys of the deepwater fish fauna

Flank denticles—juvenile

Flank denticles—adult

Image details: Lateral and ventral head: New South Wales, Australia (female 152 cm TL). Juvenile: Western Australia (female 49 cm TL). Denticles: Juvenile—male embryo 35 cm TL, adult—male 126 cm TL. Fresh specimen: Huon Gulf, PNG (female 170 cm TL, by P. Neira).

LONGFIN GULPER SHARK

Centrophorus longipinnis White, Ebert & Naylor, 2017

Ventral head

Late-term embryo

NE

BIOLOGY

Maximum size: At least 90.5 cm TL

Maturity size: Males at 68 cm TL

Birth size: 35–41 cm TL

Litter size: Only 1 pup (based on two observed litters)

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- Caudal fin with a prominent terminal lobe
- First dorsal fin extremely long
- Second dorsal fin almost at tall as first
- Snout moderately long
- Pectoral-fin free rear tips elongate
- Dorsal spines moderately long and broad-based
- Denticles block-like, flat and sessile

Colour: Dorsal surfaces brown, often with a reddish hue. Ventral surfaces paler. Fins without markings in adults; dorsal and caudal fins mostly blackish with narrow white posterior margins in small juveniles.

Distribution: Occurs in eastern Indonesia, PNG, the Philippines and Taiwan. In PNG, known from several specimens caught in the Huon Gulf at depths of 330–460 m.

Habitat and biology: Nothing known.

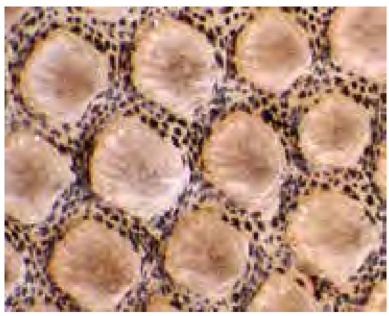
Utilisation: Not encountered by current fisheries in PNG.

Remarks: First recorded from PNG in May 2017 and only described as a new species in late 2017.

Similar species: Similar to *C. granulosus* but differs in being smaller and in having a very long first dorsal-fin base (vs. a proportionally shorter dorsal-fin base). It differs from *C. moluccensis* in having a much taller second dorsal fin (vs. very low second dorsal fin), and from both that species and *C. atromarginatus* in having a much longer first dorsal fin.

Two female specimens landed in the Huon Gulf during surveys of the deepwater fish fauna

Flank denticles—juvenile



Flank denticles—adult

Image details: Lateral and ventral head: Huon Gulf, PNG (female 89 cm TL, by P. Neira). Embryo: Huon Gulf, PNG (late-term embryo 34.6 cm TL, by P. Neira). Denticles: Taiwan (juvenile—female 41 cm TL; adult—female 86 cm TL). Fresh specimens: Huon Gulf, PNG (females ~70 cm TL, by P. Neira).

ENDEAVOUR DOGFISH

Centrophorus moluccensis Bleeker, 1860

Ventral head

DD

BIOLOGY

Maximum size: 100 cm TL

Maturity size: Females at 85 cm TL, males at 70 cm TL

Birth size: ~33 cm TL

Litter size: 1–2 (usually 2) pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- Caudal fin with a prominent terminal lobe
- Second dorsal fin much lower than first
- First dorsal fin relatively short
- Pectoral-fin free rear tips very elongate
- Second dorsal-fin origin posterior to pelvic-fin free tips
- Snout short and broadly rounded
- Denticles flat and sessile, not elevated on pedicels

Colour: Dorsal surfaces greyish to brownish. Ventral surfaces paler. Dorsal fins with dusky to blackish tips (more pronounced in embryos) and white posterior margins. Caudal fin with whitish posterior margin, upper lobe with a black blotch in juveniles.

Distribution: Occurs in the Indian and west Pacific oceans, from southern Africa to Australia and north to Japan at depths of 125–820 m. In PNG, only known from off northern New Ireland at depths of 409–680 m.

Habitat and biology: Feeds mainly on bony fish and cephalopods, but also crustaceans and elasmobranchs.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: Underwent drastic declines in heavily trawled areas of eastern Australia between 1976 and 1997; highly susceptible to any significant level of fishing, as with many deepwater shark species.

Similar species: Similar to other *Centrophorus* species in PNG but differs in having a relatively low second dorsal fin much less than half first dorsal fin height (vs. second dorsal fin larger, at least half of height of first dorsal fin).

Mid-term embryo removed from a pregnant female, highlighting the large yolk sac from which the embryo receives its nutrition for the whole gestation period

Image details: Lateral and ventral head: Kavieng, New Ireland, PNG (female 96 cm TL). Embryo: Lombok, Indonesia (~18 cm TL).

LONGSNOUT DOGFISH

Deania quadrispinosa (McCulloch, 1915)

Ventral head

NT

BIOLOGY

Maximum size: At least 119 cm TL

Maturity size: Females at 85–110 cm TL, males at 80–87 cm TL

Birth size: 23–25 cm TL

Litter size: 8–18 pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- Caudal fin with a prominent terminal lobe
- Snout very long and spatulate
- Dorsal fins similar in size
- Pectoral-fin free rear tips not produced
- Second dorsal-fin origin about opposite to pelvic-fin insertions
- Second dorsal-fin spine much longer than first
- Skin delicate, easily damaged (e.g. in trawls)

Colour: Dorsal surfaces brownish, greyish or black. Ventral surfaces slightly paler. Fins sometimes with narrow white edges; juveniles with dark blotches on dorsal and caudal fins.

Distribution: Occurs from southern Africa to New Zealand and north to Taiwan at depths of 150–1,360 m. In PNG, only known from a single specimen collected in the Huon Gulf at 480–680 m depth.

Habitat and biology: Feeds mainly on bony fishes.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: Underwent drastic declines in heavily trawled areas of eastern Australia between 1976 and 1997; highly susceptible to any significant level of fishing, as with many deepwater shark species.

Similar species: Similar to *Centrophorus* species but differs in having a very elongate and depressed snout. Possibly confused with deepwater catsharks, which have similarly long snouts and dark colouration, but readily separated by its absence of an anal fin and a strong spine in front of each dorsal fin.

Juvenile specimen freshly landed during deepwater trawl surveys in the Huon Gulf, presenting the first record of this species in PNG waters

Image details: Lateral and ventral head: Victoria, Australia (female 110 cm TL). Fresh image: Huon Gulf, PNG (female 31 cm TL, by J.-N. Chen).

BLACKMOUTH LANTERNSHARK

Etmopterus evansi Last, Burgess & Séret, 2002

Ventral head

LC

BIOLOGY

Maximum size: At least 34 cm TL

Maturity size: Males at 26 cm TL

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Probably viviparous (yolk-sac dependent)

KEY FEATURES

- Caudal fin with a distinct terminal lobe
- Second dorsal fin about twice the size of first dorsal fin
- Body slender and cylindrical
- Pelvic flank marking with anterior branch about equal to or shorter than posterior branch
- First dorsal spine short; second spine very long and curved
- Denticles on sides not arranged in regular lines

Colour: Dorsal surfaces light brownish. Ventral surfaces much darker. A dark blotch in front of lower caudal origin, and on central and upper caudal fin. Several lines of black dashes along sides, most obvious above pelvic flank markings.

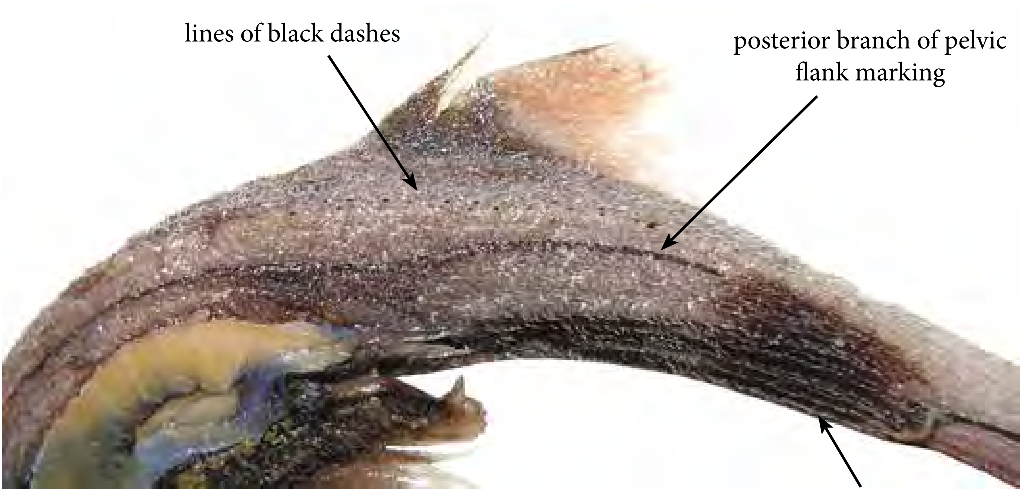
Distribution: Previously only known from north-western Australia (Dampier Archipelago to Ashmore Reef) and Tanimbar Islands in Indonesia at depths of 430–555 m. In PNG, known from four specimens collected off Madang and west of Manus Island at depths of 520–689 m.

Habitat and biology: Not known.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: First record of this species in the western Pacific. The presence of dark dashes along the sides of this species is not well documented and is considered to be one of the key differences between this species and *E. dislineatus* from the Coral Sea.

Similar species: Similar to *E. samadiae* but differs in having the denticles on the sides not arranged in regular lines (vs. mostly arranged in regular lines). Also similar to *E. fusus* but differs in having a pelvic flank marking with a narrow and long anterior and posterior branch (vs. shorter and broader anterior and posterior branches).



Mid-lateral region, highlighting the pelvic flank markings and other distinctive colour markings

Image details: Lateral: Madang, PNG (female 18 cm TL). Ventral head: west of Manus Island, PNG (adult male 34 cm TL). Pelvic region: Madang, PNG (juvenile male 17 cm TL).

PYGMY LANTERNSHARK

Etmopterus fusus Last, Burgess & Séret, 2002

Ventral head

LC

BIOLOGY

Maximum size: At least 30 cm TL

Maturity size: Males at 25–26 cm TL

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Probably viviparous (yolk-sac dependent)

KEY FEATURES

- Caudal fin with a distinct terminal lobe
- Second dorsal fin about twice the size of first dorsal fin
- Body slender and cylindrical
- Pelvic flank marking with a short anterior branch and a slightly longer posterior branch with a broadly truncated tip
- First dorsal spine short; second spine very long and curved
- First dorsal-fin origin well forward of pectoral-fin free tips

Colour: Dorsal surfaces dark greyish or blackish. Ventral surfaces darker. Fins paler, often with dark margins; caudal-fin upper lobe dark-edged.

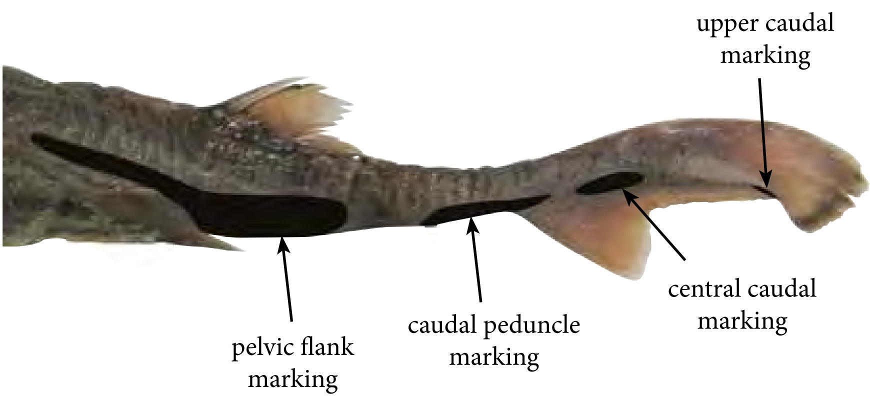
Distribution: Previously only known from off Broome in Western Australia at depths of 430–550 m; possibly also off Java in Indonesia at depths of 120–200 m. In PNG, known only from a single specimen collected off Madang Province at a depth of 500–510 m.

Habitat and biology: Not known.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: First record of this species in the western Pacific. Additional specimens are required to confirm this species is conspecific with the Western Australian specimens.

Similar species: Similar to *E. evansi* and *E. samadiae* but differs in having shorter and broader anterior and posterior branches on the pelvic flank marking (vs. anterior and posterior branches long and very narrow).



Posterior lateral region, highlighting the pelvic flank, caudal peduncle and caudal luminescent markings (highlighted with black)

Image details: All images: Madang Province, PNG (female 26 cm TL).

PAPUAN LANTERNSHARK

Etmopterus samadiae White, Ebert, Mana & Corrigan, 2017

Ventral head

NE

BIOLOGY

Maximum size: At least 28 cm TL

Maturity size: Females at 28 cm TL, males at 23 cm TL

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Probably viviparous (yolk-sac dependent)

KEY FEATURES

- Caudal fin with a distinct terminal lobe
- Second dorsal fin about twice the size of first dorsal fin
- Body slender and cylindrical
- Pelvic flank marking with long, thin anterior branch slightly shorter than posterior branch
- First dorsal spine short; second spine very long and curved
- Denticles on sides arranged in regular lines

Colour: Dorsal surfaces greyish to silvery black, with a pale stripe along dorsal midline. Ventral surfaces blackish. A dark blotch in front of lower caudal origin and on central and upper caudal fin. Short black dashes variably present on body. Fins dark-based but rest paler.

Distribution: Only recently discovered in PNG, and not known from elsewhere, based on specimens from East Sepik, Madang and Morobe provinces (Bismarck and Solomon seas) at depths of 340–785 m.

Habitat and biology: Not known.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: Closest to *Etmopterus brachyurus* from the north-west Pacific but differs in some morphological characters and on a molecular level. *Etmopterus brachyurus* specimens from Australia need to be compared with this species and true *E. brachyurus*.

Similar species: Similar to *E. evansi* but differs in having denticles arranged in regular lines on body (vs. not arranged in regular lines). Also similar to *E. fusus* but differs in having long and very narrow anterior and posterior branches of the pelvic flank marking (vs. much shorter and broader anterior and posterior branches).

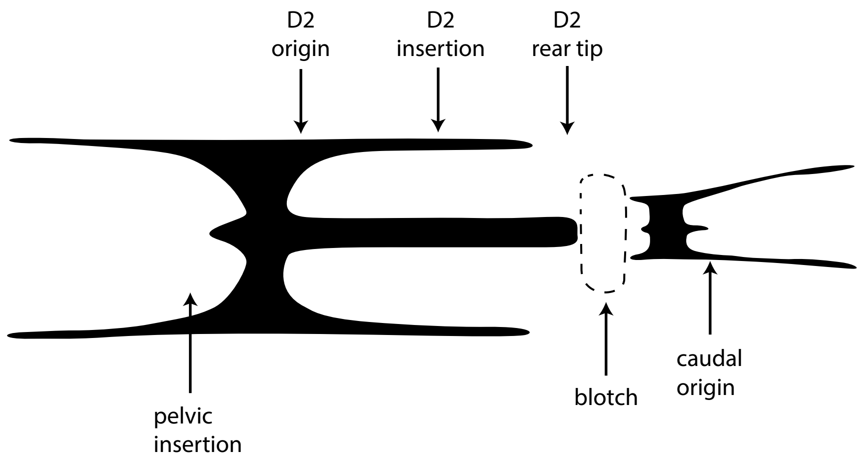


Illustration of pelvic flank and lower caudal/caudal peduncle luminescent markings (viewed from underneath)

Image details: Lateral and ventral head: Madang Province, PNG (adult male 26.5 cm TL).

COOKIECUTTER SHARK

Isistius brasiliensis (Quoy & Gaimard, 1824)

Ventral head

LC

BIOLOGY

Maximum size: Females 50 cm TL, males at least 40.5 cm TL

Maturity size: Females at 38–44 cm TL, males at 31–37 cm TL

Birth size: 14–15 cm TL

Litter size: 6–9 pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- Dorsal fins close together, very small and without spines
- Body slender, cigar-shaped
- First dorsal fin well posterior, its base over anterior pelvic-fin base
- Distinct dark collar around gill region
- Snout conical
- Caudal fin with similar-sized upper and lower lobes
- Lower teeth greatly enlarged and triangular

Colour: Dorsal surfaces dark brown, with a prominent dark-brown collar around gill region, darkest ventrally. Ventral surfaces paler. Fin tips translucent; caudal fin lobes dark.

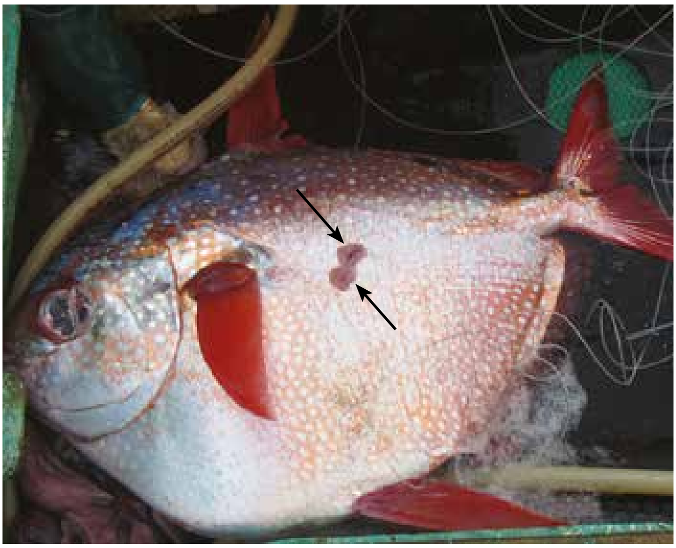
Distribution: Widespread and oceanic in all temperate and tropical seas. In PNG, known from two specimens collected from the far northern waters and from their distinctive bite marks on fish caught in the pelagic fisheries.

Habitat and biology: An ectoparasite on large fish and marine mammals; bite marks from this species are commonly seen on large bony fish and cetaceans, particularly when caught in or by fishing gear. Lips are suctorial, and it has a modified pharynx, allowing it to suction onto larger prey; it then spins, and its large lower teeth bore out a plug of flesh, leaving a crater-like wound. Diet also contains some whole prey such as squid.

Utilisation: Rarely encountered by fisheries in PNG, although bite marks regularly seen.

Remarks: Able to maintain neutral buoyancy as a result of its large, oily liver. Strongly luminescent, which it possibly uses to attract its prey.

Similar species: None; very distinctive elongate shark with small, posteriorly placed dorsal fins and no anal fin.



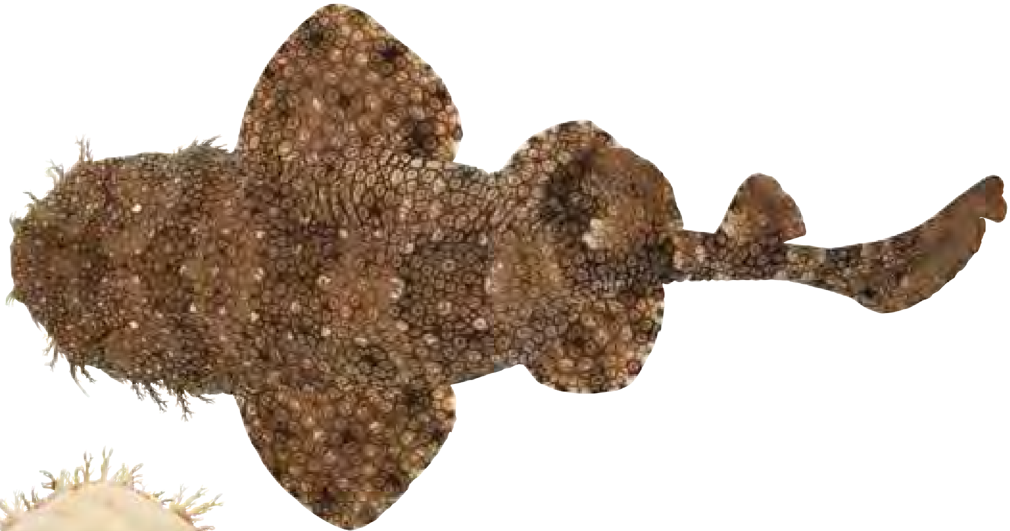
Opah, *Lampris guttatus*, with two bite marks from *Isistius brasiliensis* on sides (indicated by arrows)

Lower teeth

Image details: Lateral and ventral head: New South Wales, Australia (adult male 40.5 cm TL). Fish: Bismarck Sea, PNG. Open mouth: Keelung, Taiwan (42 cm TL).

TASSELLED WOBBEGONG

Eucrossorhinus dasypogon (Bleeker, 1867)



Ventral head

BIOLOGY

Maximum size: At least 125 cm TL, possibly to 150 cm TL

Maturity size: Males at 112 cm TL

Birth size: ~20 cm TL

Litter size: Unknown

Reproductive mode: Presumably viviparous (yolk-sac dependent)

KEY FEATURES

- Body very wide and moderately flattened
- Dense tassel of dermal lobes around head margin
- Nasal barbels branched, with multiple lobes
- Anal fin present, located just anterior to caudal fin
- Dorsal fins short-based and tall; first slightly larger than second
- Striking mosaic pattern of fine reticulations and blotches

Colour: Dorsal surfaces and fins strongly patterned with fine reticulations and blotches, forming a complex mosaic. Ventral surfaces mostly pale, similar to dorsal pattern on tail and outer half of paired fins.

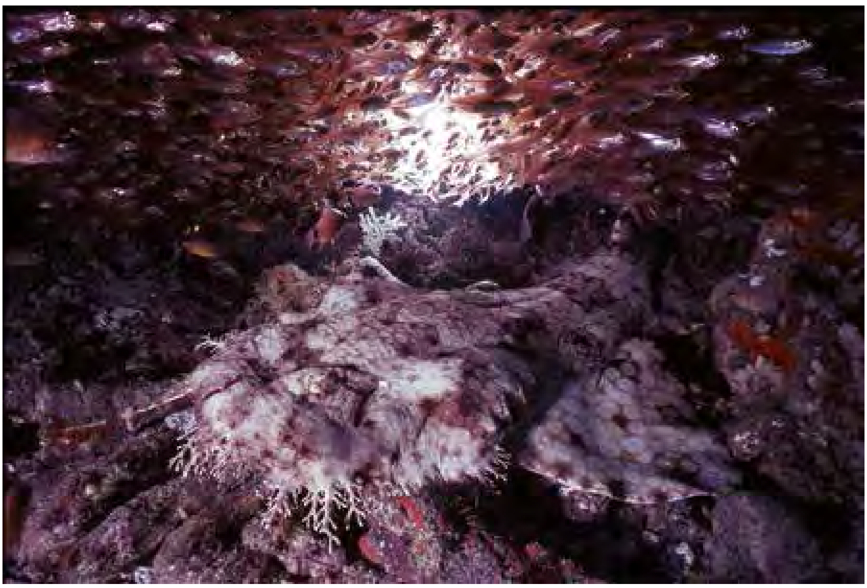
Distribution: Known only from northern Australia and New Guinea in depths to at least 50 m. In PNG, possibly widespread; verified from Central, Milne Bay, Morobe and New Britain provinces; not recorded from New Ireland.

Habitat and biology: Found on coral heads and reef walls on coral reefs, where its colour pattern provides superb camouflage. Feeds on bony fishes and invertebrates; probably an ambush predator.

Utilisation: Probably caught occasionally by line fishers and spearfishers in PNG, but not verified. Some anecdotal information that it was targeted by some coastal fishers in Central Province previously, but not confirmed in this study.

Remarks: Possibly a solitary species. Individuals often found at the same dive sites over many years, suggesting a small home range. Nocturnal hunter, spending the day resting in caves or on ledges.

Similar species: Superficially similar to other species of wobbegong found in PNG but clearly separable based on the dense tassel of dermal lobes around the head (vs. dermal lobes less numerous and not dense), and a much broader body and paired fins.



Individual resting in a cave, highlighting the densely fringed head and excellent camouflage this species has on reef habitat

Image details: Dorsal and ventral head: Queensland, Australia (female 67 cm TL). Underwater: PNG (by B. Halstead).

ORNATE WOBBEGONG

Orectolobus ornatus (De Vis, 1883)

Ventral head

LC

BIOLOGY

Maximum size: 110 cm TL

Maturity size: Both sexes at ~80 cm TL

Birth size: 20 cm TL

Litter size: 2–16 (average 9) pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- Body wide and moderately flattened
- 5–6 dermal lobes on each side of head in front of eyes
- Nasal barbels simple, with two small basal branches
- Anal fin present, located just anterior to caudal fin
- Dorsal fins moderately tall, similar in size
- Colour pattern strongly ornamented with margins of corrugated saddles highlighted with black borders

Colour: Dorsal surfaces with a very ornate and variegated pattern of speckles and blotch-shaped saddles; a distinct white spot behind each spiracle. Ventral surfaces pale yellowish green.

Distribution: Known from off eastern Australia, from Sydney to at least Port Douglas, mainly coastal but also to depths of at least 100 m. In PNG, confirmed from off Port Moresby in Central Province; possibly restricted to the southern coast of mainland PNG.

Habitat and biology: Found in bays, on weed-covered rock and coral reefs in shallow water, including offshore islands. Feeds on bony fishes, sharks, rays, cephalopods and crustaceans.

Utilisation: Unknown; possibly caught by spearfishers where it occurs.

Remarks: Nocturnal, resting in aggregations or singly in caves, in trenches and under ledges by day, and actively foraging at night. Prefers clearer water than some other wobbegong species. Declines in population numbers of New South Wales (Australia) resulted in a spearfishing ban for all wobbegongs in state waters.

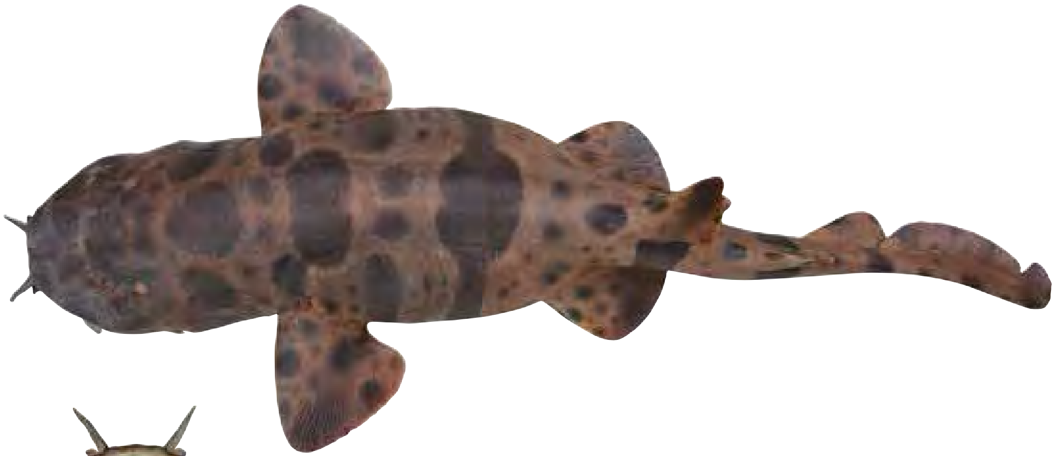
Similar species: Similar to *Orectolobus* sp. 1 from off Madang but differs in having a more ornate colour pattern (vs. less dense pattern of reticulations and ocelli) and a narrower body.

Freshly caught adult male specimen from either the 1960s or 1970s

Image details: Dorsal and ventral head: Queensland, Australia (adult male 82 cm TL). Fresh: PNG (by L.W.C. Filewood).

NORTHERN WOBBEGONG

Orectolobus wardi Whitley, 1939



Ventral head

LC

BIOLOGY

Maximum size: At least 63 cm TL

Maturity size: Males at 45 cm TL

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- Body wide and moderately flattened
- 2 dermal lobes on each side of head in front of eyes
- Nasal barbels simple, not branched
- Anal fin present, located just anterior to caudal fin
- Dorsal fins moderately tall, similar in size
- Colour pattern brownish with 3 large brown blotches on back before first dorsal fin

Colour: Body brown with three large dark-brown blotches on back before first dorsal fin; dark saddle under each dorsal fin; other medium to large blotches interspersed between larger markings, including on fins. A pale V-shaped marking between eyes and a pale semicircular ring above each nostril. Slightly paler ventrally.

Distribution: Known from off northern Australia (from Coral Bay to Cape York), eastern Indonesia (Aru Islands) and PNG, in mostly very shallow coastal waters (but recorded to 42 m depth in Western Australia). In PNG, known only from Bobo (Bristow) Island in Western Province; possibly restricted to Western Province of PNG.

Habitat and biology: Found mostly on shallow reefs, usually in less than a few metres of water. Feeds on bony fishes and invertebrates.

Utilisation: Unknown; possibly caught by spearfishers where it occurs.

Remarks: Specimens required to confirm PNG populations are the same as northern Australia and eastern Indonesia. Western Australian and eastern Indonesian specimens separate at a genetic level; probably a species complex.

Similar species: Similar to other wobbegong species in PNG but much smaller and with only two dermal lobes on each side of head in front of eyes (vs. >five dermal lobes), and dermal lobes broad and unbranched (vs. narrow and branched). The colour is far less densely patterned than in the other wobbegong species.

Front view of head with the pale V-shaped marking between eyes and the faint pale semicircular rings above each nostril

Image details: All images: Aru Islands, Indonesia (adult male ~50 cm TL, by M. Erdmann).

PAPUAN WOBBEGONG

Orectolobus sp. 1

NE

BIOLOGY

Maximum size: At least 80 cm TL

Maturity size: Unknown; only male known adult at 80 cm TL

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Presumably viviparous (yolk-sac dependent)

KEY FEATURES

- Body wide and moderately flattened
- 6–8 dermal lobes on each side of head in front of eyes
- Nasal barbels simple, with two small basal branches
- Anal fin present, located just anterior to caudal fin
- Dorsal fins moderately tall, first distinctly larger than second
- Colour strongly patterned with broad, darker saddles and lighter-coloured blotches

Colour: Body strongly patterned; a series of dark-brown saddles, and numerous dark rings and reticulations; a white spot behind each spiracle. Ventral surfaces mostly whitish; brown rings and blotches extending onto margin of head and outer paired fins; dark saddles also extending onto tail.

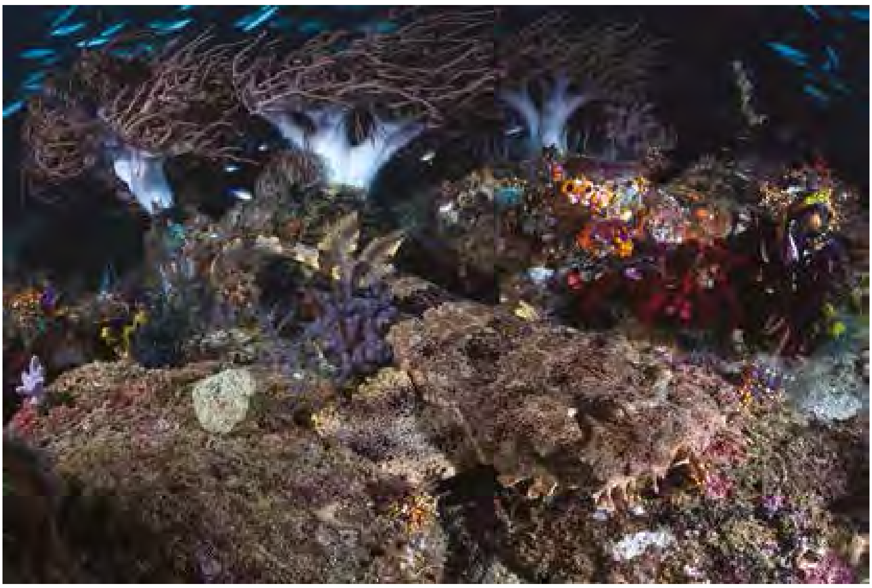
Distribution: Known from a single adult male specimen collected off Madang in 2012.

Habitat and biology: Unknown.

Utilisation: Unknown; possibly caught by spearfishers where it occurs.

Remarks: Similar in colour to the Indonesian wobbegong, *O. leptolineatus*, but preliminary molecular results suggest it is possibly a distinct species. Additional specimens required to confirm its identity. Specimens observed off West Papua (see image below) need to be compared with the Indonesian and Papuan wobbegongs.

Similar species: Similar to *O. ornatus* but less densely patterned, and with a broader head and body. Differs from *Eucrossorhinus dasypogon* in having far less dermal lobes around the margin of the head (vs. dense fringe of dermal lobes).



Individual of a specimen of *Orectolobus leptolineatus* from West Papua resting on the reef, highlighting the dermal lobes on the head and the excellent camouflage this species has on reef habitat

Image details: Dorsal image: Madang PNG (adult male ~80 cm TL, by B. Séret). Underwater: *Orectolobus* cf. *leptolineatus* from West Papua (by M. Erdmann).

WHITESPOTTED BAMBOOSHARK

Chiloscyllium plagiosum (Bennett, 1830)

Ventral head

NT

BIOLOGY

Maximum size: 95 cm TL

Maturity size: Females at ~65 cm TL, males at 50–60 cm TL

Hatching size: 9–12 cm TL

Egg cases: Dark brown, subrectangular

Reproductive mode: Oviparous

KEY FEATURES

- Body and tail slender
- Dorsal fins relatively small and well separated
- Anal-fin base much shorter than base of lower caudal-fin lobe
- Prominent predorsal and interdorsal ridges
- Nostrils located behind snout tip (subterminal)
- Weak lateral skin ridges present on trunk
- Body pale greyish brown with numerous white and dark spots, dark bands and saddles

Colour: Body pale greyish brown with a serious of brown saddles on body and tail; numerous white and dark spots.

Distribution: Found in the Indo–west Pacific, from southern India to Indonesia and PNG, and north to southern Japan, in mostly coastal waters. In PNG, verified from images taken in the late 1960s and 1970s; probably restricted to Madang, East Sepik and Sandaun provinces.

Habitat and biology: Nocturnal, resting in reef crevices during the day and actively foraging at night. Diet consists mainly of benthic invertebrates, but also bony fishes.

Utilisation: Unknown; possibly caught by coastal fishers (e.g. spearfishers) in the northern waters of PNG.

Remarks: In Taiwan, males and females were found to mature at 4.4 and 4.5 years, respectively, and attain 7 years of age.

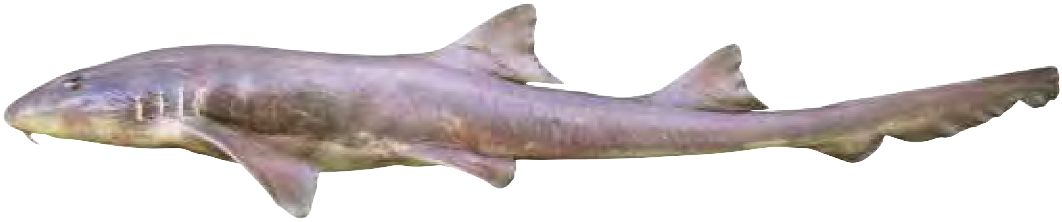
Similar species: Similar to *C. punctatum* but differs in having a strong colour pattern in adults (vs. plain brown, possibly with faint brown saddles) and dorsal fins with straight posterior margins (vs. concave).

Egg cases freshly removed from pregnant female with yolk visible inside the egg case and the tendrils off one side of each egg capsule; tendrils used for attachment of the egg capsule to the substratum

Image details: Lateral: Java, Indonesia (adult male ~60 cm TL, by Fahmi). Ventral head: Da-xi, Taiwan (female 67.5 cm TL). Egg cases: Da-xi, Taiwan.

BROWNBANDED BAMBOOSHARK

Chiloscyllium punctatum Müller & Henle, 1838



Ventral head

Juvenile

NT

BIOLOGY

Maximum size: 132 cm TL

Maturity size: Females at ~84 cm TL, males at 65–66 cm TL

Hatching size: 13–18 cm TL

Egg cases: Dark brown, subrectangular; 11 cm long by 5 cm wide

Reproductive mode: Oviparous

KEY FEATURES

- Body and tail slender
- Dorsal fins large and well separated
- Anal-fin base much shorter than base of lower caudal-fin lobe
- No predorsal, interdorsal or lateral trunk ridges
- Nostrils located behind snout tip (subterminal)
- Subadults and adults uniform greyish or brownish (sometimes with faint brown bands)
- Juveniles (<30 cm TL) with ~10 dark-brown bands

Colour: Adults uniformly brownish to greyish, sometimes with very faint saddles evident; margins of gill slits and ventral surfaces pale. Juveniles pale with about 10 dark bands; sometimes with a variable number of small dark spots between bands.

Distribution: Found in the Indo–west Pacific, from eastern India to northern Australia and PNG, and north to southern Japan, in depths to at least 85 m. In PNG, common inshore, particularly in the Gulf of Papua; not recorded from New Britain, New Ireland or Bougainville.

Habitat and biology: Commonly found in tide pools on reefs, in mangroves, and on inshore sandy and muddy areas. Diet consists of crustaceans, cephalopods, worms and small fishes. In captivity in Australia, mating occurs July to September and eggs are deposited by females in July to February; two females deposited an average of 115 eggs each over two seasons, 40 of which were viable. Egg cases hatch about 90 days after deposition.

Utilisation: Common in the bycatch of the Gulf of Papua prawn trawl fishery; also caught by coastal fishers in some areas.

Remarks: Females can apparently store sperm for at least 45 months. In the Phuket aquarium in Thailand, both sexes matured after one year.

Similar species: Similar to *C. plagiosum* but differs in being uniformly coloured in adults (vs. strongly patterned) and dorsal fins with concave posterior margins (vs. straight posterior margins).

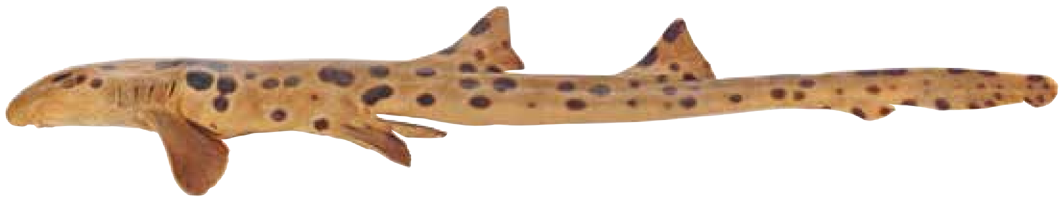
Adult specimen observed over a shallow reef flat

Egg case

Image details: Lateral: Gulf of Papua, PNG (adult female 84 cm TL). Ventral head: south of Kerema, PNG (juvenile male 39 cm TL). Juvenile: Gulf of Papua, PNG (male 21 cm TL). Egg case: Gulf of Papua, PNG. Underwater: PNG (by B. Halstead).

PAPUAN EPAULETTE SHARK

Hemiscyllium hallstromi Whitley, 1967



Ventral head

VU

BIOLOGY

Maximum size: 77 cm TL

Maturity size: Males at 47–64 cm TL

Hatching size: By 19 cm TL

Egg cases: Unknown

Reproductive mode: Oviparous

KEY FEATURES

- A large white-ringed black spot (ocellus) above pectoral fin on each side, surrounded by 3–6 large black spots
- Numerous dark-brown spots on body (about twice eye size)
- Snout uniform yellowish brown, without dark spots
- Nostrils nearly at front of snout (terminal)
- Cheek usually with a pair of large dark-brown spots
- No, or only a few, spots on pectoral and pelvic fins

Colour: Body with relatively large dark spots, widely spaced; a white-ringed, dark spot behind gill slits surrounded above and behind by dark spots. Snout without dark spots. Paired fins either without spots or with few spots present.

Distribution: Found only in southern PNG and from Murray Island in Torres Strait, Australia, in very shallow depths. In PNG, restricted to the southern coastline to southern Milne Bay Province.

Habitat and biology: Found over shallow reefs and seagrass beds. Diet not known but presumably dominated by benthic invertebrates.

Utilisation: Unknown; sought after by the aquarium trade but extent of collecting for this purpose in PNG is unknown.

Remarks: Originally described in 1967 based on three live specimens in the Taronga Zoo Park Aquarium in Sydney collected from the Port Moresby area. The Gulf of Papua presents a geographic barrier to this species, and research is needed to closely compare the Torres Strait and Central Province populations.

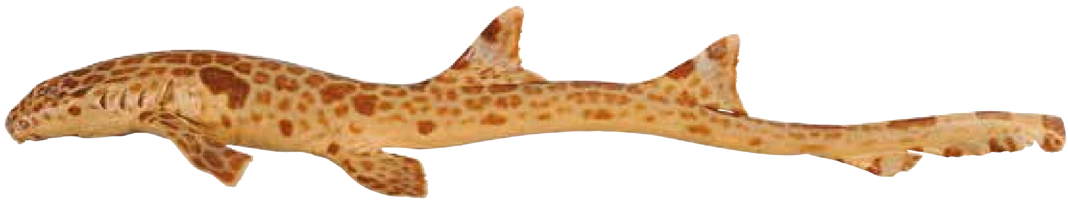
Similar species: Similar to *H. michaeli* and *H. strahani* but differs in having a colour pattern of dark-brown spots (vs. colour pattern of leopard-like spots or dark with numerous white spots, respectively).

Adult specimen observed at night on rocky habitat adjacent to seagrass in Bootless Bay near Port Moresby

Image details: Lateral and ventral head: Port Moresby area, PNG (adult male 73 cm TL). Underwater: Loloata Island, PNG (by G. Allen).

LEOPARD EPAULETTE SHARK

Hemiscyllium michaeli Allen & Dudgeon, 2010



Ventral head

BIOLOGY

Maximum size: At least 82 cm TL

Maturity size: Females at 82 cm TL, males at ~78 cm TL

Hatching size: Unknown; smallest juvenile ~20 cm TL

Egg cases: Unknown

Reproductive mode: Oviparous

KEY FEATURES

- A large white-ringed black spot (ocellus) above pectoral fin on each side (absent in neonates)
- Head, body and fins covered with polygonal, leopard-like spots
- Snout covered in numerous dark-brown spots
- Nostrils nearly at front of snout (terminal)
- A series of 9–10 faint bars often apparent on sides and tail, becoming more prominent on caudal fin (distinct in neonates)

Colour: Head, body and fins covered with dark-brown, polygonal, leopard-like spots; a large white-ringed black spot above pectoral fin on each side. Juveniles pale with a series of dark-brown saddles. Ventral surfaces pale.

Distribution: Found only in southeastern PNG in Milne Bay and Oro provinces at depths of 2–20 m.

Habitat and biology: Found on shallow inshore reefs. Diet not known but presumably dominated by benthic invertebrates.

Utilisation: Unknown; sought after by the aquarium trade but extent of collecting for this purpose in PNG is unknown.

Remarks: Was previously considered to be the same as the Indonesian speckled catshark, *H. freycineti*, from West Papua but recently separated as a distinct species endemic to south-eastern PNG.

Similar species: Similar to *H. hallstromi* and *H. strahani* but differs in having a colour pattern of leopard-like spots (vs. colour pattern of dark-brown spots or dark with numerous white spots, respectively).

Adult specimen on reef habitat (top) and juvenile on sandy substrate (bottom)

Image details: Lateral and ventral head: Samarai Island, PNG (female 72 cm TL). Underwater: Milne Bay, PNG (top—adult male, by B. Halstead; bottom—juvenile, by G. Allen).

HOODED CARPETSHARK

Hemiscyllium strahani Whitley, 1967

Ventral head

VU

BIOLOGY

Maximum size: 80 cm TL

Maturity size: Females at ~73 cm TL, males at ~60 cm TL

Hatching size: Unknown

Egg cases: Unknown

Reproductive mode: Oviparous

KEY FEATURES

- Head and body reddish brown with many white spots and dash-like markings
- Mouth, chin and tip of snout dark brown to blackish
- A variable-sized black spot above pectoral fin on each side, partially rimmed with white
- Nostrils nearly at front of snout (terminal)
- 7–8 darker brown saddles across back and dorsal caudal fin

Colour: Head and body reddish brown with a series of darker saddles; covered with many white spots, some elongate, forming dash-like markings. Mouth, chin and ventral snout tip with a mostly dark-brown to blackish mask-like marking. Margins of paired fins dark with white spots.

Distribution: Found only in northern New Guinea, from Jayapura in West Papua to Madang in PNG, at depths of 3–18 m.

Habitat and biology: Found on shallow coral reefs and nearshore seagrass beds. Diet not known but presumably dominated by benthic invertebrates.

Utilisation: Unknown; possibly sought after by the aquarium trade but extent of collecting for this purpose in PNG is unknown.

Remarks: Specimens from Madang and Jayapura differ in aspects of the colouration of the head and are also different at a molecular level; further investigation is required to determine whether the West Papua and PNG populations represent separate species.

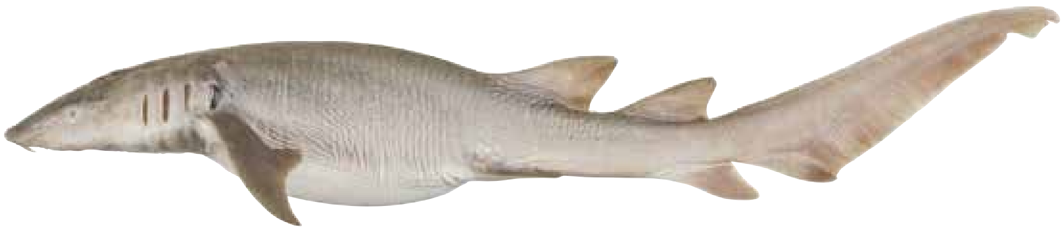
Similar species: Similar to *H. hallstromi* and *H. michaeli* but differs in having a colour pattern of numerous white spots and dashes (vs. colour pattern of dark-brown spots or dark leopard-like spots, respectively).

Adult specimen observed at night on rocky habitat in Madang Bay

Image details: Lateral and ventral head: PNG (female 73.5 cm TL). Underwater: Madang Bay, PNG (by P. Laboute).

TAWNY SHARK

Nebrius ferrugineus (Lesson, 1831)



Ventral head

VU

BIOLOGY

Maximum size: 320 cm TL

Maturity size: Females at ~230 cm TL, males at ~225 cm TL

Birth size: 40–60 cm TL

Litter size: Up to 32 (usually ~26) pups

Reproductive mode: Viviparous; oophagy reported in Japanese populations with litters of only 1–4 pups

KEY FEATURES

- Caudal fin asymmetrical, its length about one-third of TL
- Nostrils close to front of snout, with short barbels
- Spiracle much smaller than eye
- Dorsal fins with angular tips; first slightly larger than second
- Body uniformly sandy to greyish brown
- Teeth in both jaws small, compressed and multicuspid

Colour: Uniformly brown to greyish brown. Ventral surfaces paler.

Distribution: Found in the Indo–west and central Pacific, from south-eastern Africa to Tahiti and north to southern Japan, at depths to at least 70 m.

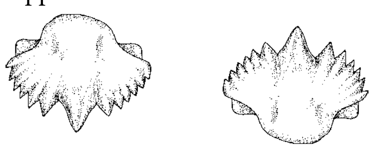
Habitat and biology: Typically found resting in groups in caves and rocky crevices by day and foraging over sandy areas near reefs by night. Feeds on cephalopods (mainly octopuses), sea urchins, corals, crustaceans, reef fishes and sometimes sea snakes.

Utilisation: Caught occasionally by prawn trawlers in the Gulf of Papua and also coastal fisheries in coral reef habitats. Although large, the fins are of minimal value, and some fin buyers do not purchase fins from this species because of the low quality.

Remarks: Feeds by using its muscular pharynx as a suction pump to extract prey out of immediate reach in rocky crevices and caves. Has a limited home range, often returning to the same daytime resting place. Known to spin and spit water when caught on line.

Similar species: A distinct species with a relatively long caudal fin and posteriorly placed dorsal fins, unlikely to be confused with any other species in PNG.

Upper tooth



Lower tooth

Specimen observed resting in a cave, highlighting the uniform colouration

Image details: Lateral and ventral head: Western Australia (juvenile male 73 cm TL). Underwater: PNG (by B. Halstead).

ZEBRA SHARK

Stegostoma fasciatum (Hermann, 1783)

Juvenile 60 cm TL

Juvenile 39 cm TL

EN

Ventral head

BIOLOGY

Maximum size: 235 cm TL

Maturity size: Females at 169–171 cm TL, males at 147–183 cm TL

Hatching size: 20–36 cm TL

Egg cases: Dark brown to purplish black, 17 cm × 8 cm × 5 cm

Reproductive mode: Oviparous; parthenogenesis also reported

KEY FEATURES

- Caudal fin very long and blade-like
- Prominent ridges on dorsal surface and sides
- Spiracle similar in size to eye
- Body yellowish brown with numerous dark-brown spots in large individuals
- Body dark brown with vertical white bars and spots in juveniles less than 50 cm TL
- Teeth in both jaws small and tricuspid

Colour: Adults yellowish to dark brown with many large dark-brown spots. Juveniles (<50 cm TL) dark with many white bars (zebra-like pattern); begins to transition to adult colour pattern >50 cm TL.

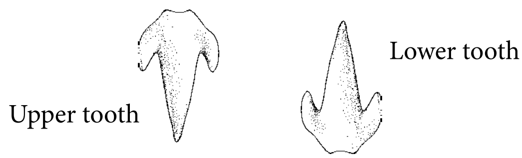
Distribution: Found in the Indo–west Pacific, from southern Africa to New Caledonia and north to southern Japan.

Habitat and biology: Typically found resting on and near coral reefs by day, and foraging by night; forms seasonal aggregations at some sites. Feeds mainly on gastropods and bivalves, but also crustaceans and fishes.

Utilisation: Caught by prawn trawlers in the Gulf of Papua and also coastal fisheries in coral reef habitats. Fins are of minimal value, and some fin buyers do not purchase fins from this species because of the low quality.

Remarks: It has been suggested that the zebra-like pattern of small juveniles mimics poisonous sea snakes to avoid predation; newly hatched juveniles are often seen on the surface in shallow water swimming in a snake-like motion.

Similar species: A distinct species with a very long caudal fin and distinct colour pattern.



Adult specimen observed on sandy substrate next to coral reef in Bootless Bay near Port Moresby

Image details: Lateral: Australia (adult female >200 cm TL). Ventral head: south of Kerema, PNG (juvenile male 72 cm TL). Juveniles: Gulf of Papua, PNG (39 and 60 cm TL). Underwater: Bootless Bay, PNG (by T. Wu, www.tonywublog.com/).

WHALE SHARK

Rhincodon typus Smith, 1828

Ventral head

EN

BIOLOGY

Maximum size: At least 1,500 cm TL, possibly 1,700–2,100 cm TL

Maturity size: Females at ~800 cm TL, males at ~600 cm TL

Birth size: 55–64 cm TL

Litter size: One pregnant female contained 300 pups

Reproductive mode: Viviparous, retaining egg cases until hatching

KEY FEATURES

- Adults huge, attaining more than 15 m in length
- Head very broad and flattened
- Mouth very wide, located almost at front of head (terminal)
- Caudal peduncle depressed, with strong, fleshy keels on sides
- Prominent ridges on dorsal surface and sides
- Caudal fin semi-lunate
- Colour pattern of pale spots and stripes on a dark background

Colour: Dorsal surfaces greyish, bluish to brownish, with a pattern of cream-coloured spots between pale vertical and faint horizontal stripes, giving a checkerboard appearance. Ventral surfaces white.

Distribution: Found in all tropical and warm temperate seas, generally in the vicinity of cold-water upwellings. In PNG, observed by dive operators in some areas and interacts with the purse seine fishery in the north.

Habitat and biology: Epipelagic in both coastal and oceanic waters. A filter feeder, feeding on a variety of planktonic and nektonic prey, such as fish eggs, crustaceans and small schooling fishes.

Utilisation: Occasionally caught in purse seine sets but released alive; no information available on survivability of post-release individuals.

Remarks: Satellite tracking data have shown that they are highly migratory and can make regular dives to depths of 1,000 m. Aggregations of hundreds of individuals form at certain locations with seasonal productivity spikes (e.g. coral spawning in Ningaloo Reef, Western Australia). Important for ecotourism in a number of countries. Protected in most countries where it occurs.

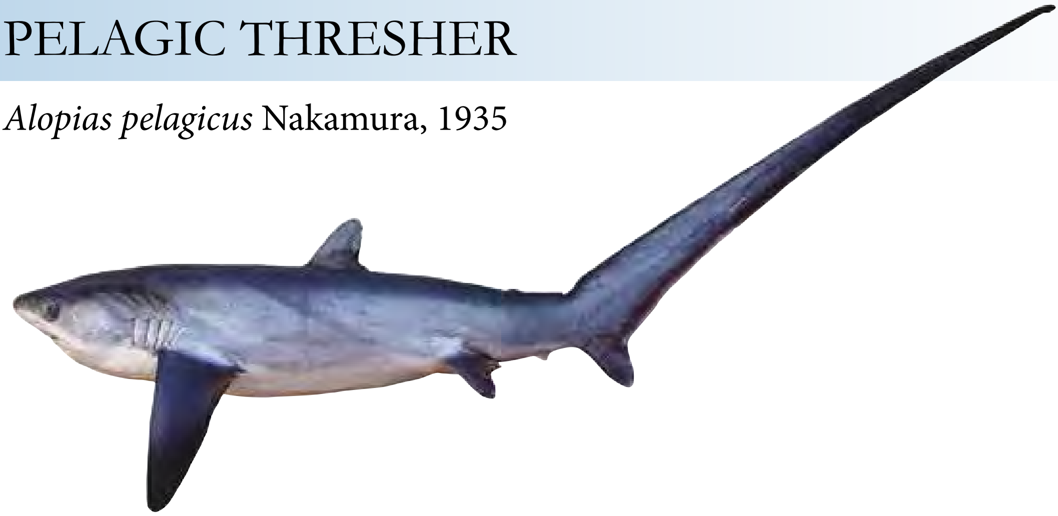
Similar species: A very large and distinct species, unlikely to be confused with other species.

Specimen observed adjacent to shallow reef with snorkeller in background

Image details: Lateral: Okinawa Churaumi Aquarium, Japan (adult male). Underwater: PNG (by B. Halstead).

PELAGIC THRESHER

Alopias pelagicus Nakamura, 1935



Ventral head

VU

BIOLOGY

Maximum size: 390 cm TL

Maturity size: Females at 256–290 cm TL, males at 260–270 cm TL

Birth size: 130–160 cm TL

Litter size: 2 pups, one per uterus

Reproductive mode: Viviparous, with oophagy

KEY FEATURES

- Upper caudal lobe nearly as long as rest of shark
- Profile of head strongly arched between eyes
- No deep grooves on nape
- Eyes moderately large, almost central on side of head
- First dorsal-fin origin closer to pectoral-fin rear tip than pelvic-fin base
- White part of belly not extending over pectoral-fin base

Colour: Dorsal surfaces greyish to bluish grey, often with a metallic hue. Ventral surfaces white.

Distribution: Tropical and subtropical waters of the Indo-Pacific, from the surface to at least 152 m depth. Widespread in PNG, particularly in the Bismarck and Solomon seas.

Habitat and biology: Pelagic and mostly oceanic species that occasionally enters shallower waters near outer reef edges or seamounts. Feeds on squids and small pelagic fishes, using its long whip-like tail to strike and stun its schooling prey. No reproductive seasonality.

Utilisation: Caught by pelagic longline fisheries and possibly as bycatch in the purse seine fisheries. Fins and meat are used when retained.

Remarks: Records of *A. vulpinus* from PNG probably all relate to this species; *A. vulpinus* differs in having the ventral white colouration extending above the pectoral-fin bases (vs. white area not extending above pectoral-fin bases in *A. pelagicus*). Males mature at 7–8 years and females at 8–9 years.

Similar species: Similar to *A. superciliosus* but differs in lacking a deep groove on the nape (vs. a deep groove present on the nape) and eyes laterally positioned (vs. pointing dorsolaterally).

Pregnant female with two mid-term embryos removed; note elongate eggs that embryos feed on during gestation (oophagy)

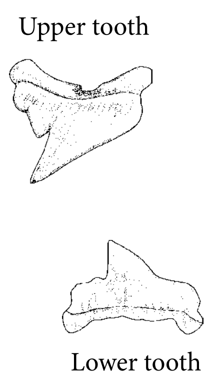
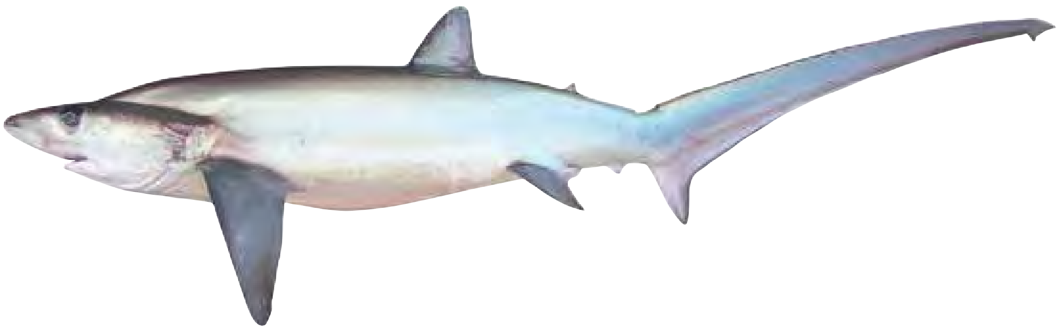


Image details: Lateral and ventral head: Bali, Indonesia (juvenile male 167 cm TL). Female with embryos: Bismarck Sea, PNG (female 256 cm TL).

BIGEYE THRESHER

Alopias superciliosus Lowe, 1841



Ventral head

VU

BIOLOGY

Maximum size: At least 480 cm TL

Maturity size: Females at 330–350 cm TL, males at 270–290 cm TL

Birth size: 100–140 cm TL

Litter size: 2–4 pups

Reproductive mode: Viviparous, with oophagy

KEY FEATURES

- Upper caudal lobe nearly as long as rest of shark
- Profile of head nearly straight between eyes
- A deep groove on each side of nape
- Eyes very large, directed upwards, the top almost level with dorsal surface of head
- First dorsal fin closer to pelvic-fin base than pectoral-fin rear tip
- White part of belly not extending over pectoral-fin base

Colour: Dorsal surfaces purple to violet greyish, often with a metallic sheen. Ventral surfaces white.

Distribution: Circumglobal in all tropical and warm temperate seas, from the surface to at least 700 m depth. Widespread in PNG, particularly in the Bismarck and Solomon seas.

Habitat and biology: A pelagic and mostly oceanic species, which can occasionally enter shallow waters near outer reef edges and seamounts; during the day found mostly in deeper waters (300–500 m, 6–12 °C) and at night in shallower waters (0–100 m, 20–26 °C). Feeds mainly on cephalopods and small to medium pelagic fishes, using its long upper caudal lobe to stun its schooling prey. No reproductive seasonality.

Utilisation: Caught by pelagic longline fisheries and possibly as bycatch in the purse seine fisheries. Fins and meat are used when retained.

Remarks: More common in deeper waters than *A. pelagicus*, thus more susceptible to deeper set longlines, such as those targeting albacore tuna. Males mature at 9–10 years and females at 12–13 years.

Similar species: Similar to *A. pelagicus* but differs in having a deep groove on the nape (vs. no groove present on the nape) and eyes directed upwards (vs. lateral, not directed upwards).

Dorsal image, highlighting the upward directed eyes and the deep groove on the nape

Upper tooth

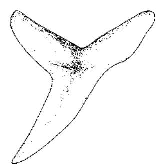


Image details: Lateral: Bismarck Sea, PNG (female 282 cm TL). Ventral head: Central Java, Indonesia (female 153 cm TL). Dorsal: Bismarck Sea, PNG (female 329 cm TL).

SHORTFIN MAKO

Isurus oxyrinchus Rafinesque, 1810

Ventral head

VU

BIOLOGY

Maximum size: ~400 cm TL

Maturity size: Females at ~270 cm TL, males at ~195 cm TL

Birth size: 60–70 cm TL

Litter size: 4–25 (mostly 10–18, average 12) pups

Reproductive mode: Viviparous, with oophagy

KEY FEATURES

- Strong lateral keel on caudal peduncle
- Snout sharply pointed, its undersurface white
- Pectoral fin short, much shorter in length than head
- Eye relatively small (compared with *I. paucus*)
- Anal-fin origin about level with midbase of second dorsal fin
- Anterior teeth with smooth-edged cusps, curved in at bases but with tips reversed and curving outwards

Colour: Dorsal surfaces indigo blue (becoming grey after death), grading to lighter blue on the sides to white ventrally; undersurface of snout white.

Distribution: Circumglobal in tropical and temperate seas, rarely in water less than 16 °C) from the surface to at least 650 m depth. In PNG, found throughout, particularly in the Bismarck and Solomon seas.

Habitat and biology: A pelagic and mostly oceanic species, occasionally found around islands and close to land. Feeds mainly on cephalopods, turtles, porpoises, seabirds, smaller sharks and bony fishes (e.g. mackerels, tunas and bonitos). Gestation possibly 15–18 months with a 3-year reproductive cycle.

Utilisation: Caught by pelagic longline fisheries and possibly as bycatch in the purse seine fisheries. Fins and meat are used when retained.

Remarks: Possibly the fastest of all sharks; able to maintain its body temperature higher than surrounding sea water via a heat-exchanging circulatory system. Potentially dangerous, occasionally attacking boats. Males mature at about 8 years and females at about 18 years.

Similar species: Similar to *I. paucus* but differs in having a more pointed snout that is white ventrally (vs. less pointed snout that is dusky ventrally) and pectoral fins far shorter than length of head (vs. pectoral fins about as long as head).

Freshly landed individual, highlighting the blue colouration, the relatively short pectoral fins and the sharply pointed snout

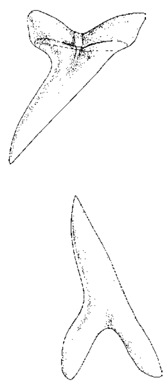


Image details: Lateral: Lombok, Indonesia (female ~223 cm TL). Ventral head: Bismarck Sea, PNG (adult male 210 cm TL). Freshly caught: Bismarck Sea, PNG (adult male 204 cm TL).

LONGFIN MAKO

Isurus paucus Guitart, 1966

Ventral head

VU

BIOLOGY

Maximum size: ~430 cm TL

Maturity size: Females at ~245 cm TL, males at 190–228 cm TL

Birth size: 92–97 cm TL

Litter size: 2–8 pups

Reproductive mode: Viviparous, with oophagy and adelphophagy

KEY FEATURES

- Strong lateral keel on caudal peduncle
- Snout broadly pointed, its undersurface dusky to dark
- Pectoral fins long, about equal in length to head
- Eyes relatively large (compared with *I. oxyrinchus*)
- Anal-fin origin about level with second dorsal-fin insertion
- Anterior teeth with smooth-edged cusps, relatively straight, tips not curved outwards

Colour: Dorsal surfaces bluish to bluish grey, becoming dark grey after death. Ventral surfaces dusky to whitish.

Distribution: Probably circumglobal in all tropical waters, but records are sporadic and patchy; found in deeper water.

Habitat and biology: A pelagic and oceanic species. Probably feeds mainly on pelagic fishes and cephalopods; one individual had dolphin remains in its stomach. Its large eye suggests it may feed in deeper water.

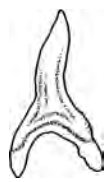
Utilisation: Caught rarely by pelagic longline fisheries. Fins and meat are used when retained.

Remarks: Much rarer than *I. oxyrinchus.* Able to maintain its body temperature slightly higher than surrounding sea water via a heat-exchanging circulatory system.

Similar species: Similar to *I. oxyrinchus* but differs in having a less pointed snout that is dusky ventrally (vs. more pointed snout that is white ventrally) and pectoral fins about as long as head (vs. pectoral fins far shorter than length of head). Landings of this species in the target longline fishery were mostly attributable to *Prionace glauca,* which is similar in having a pointed snout, dark-blue colouration and long pectoral fins, but clearly differs in having an asymmetrical caudal fin, with a much longer upper lobe and shorter lower lobe (vs. caudal fin lunate, with upper and lower lobes of similar length, in *I. paucus*).

Freshly landed specimen, highlighting the bluish colouration, long pectoral fins and strong keels on the caudal peduncle

Upper tooth

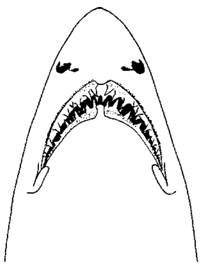


Lower tooth

Image details: Lateral and ventral head: Lombok, Indonesia (female ~240 cm TL). Fresh: Bismarck Sea, PNG (female 164 cm TL).

SANDTIGER SHARK

Carcharias taurus Rafinesque, 1810



Ventral head

BIOLOGY

Maximum size: 320 cm TL, possibly to 430 cm TL

Maturity size: Females at 220–230 cm TL, males at 190–200 cm TL

Birth size: 85–105 cm TL

Litter size: 2 pups

Reproductive mode: Viviparous, with oophagy and adelphophagy

KEY FEATURES

- Dorsal and anal fins similar in size
- Eyes very small, without nictitating eyelid
- First dorsal-fin base closer to pelvic-fin base than pectoral-fin base
- Snout flattened and conical
- Mouth long, extending well behind eyes
- Upper and lower anterior teeth long and slender, with a small cusplet on each side of main cusp

Colour: Dorsal surfaces brownish to bronzy, sometimes with variable number of reddish to brownish spots on the posterior half of body and caudal fin. Ventral surfaces paler.

Distribution: Found in tropical and temperate waters of the Atlantic, Indian and western Pacific oceans, from the surf zones to at least 190 m depth. In PNG, known only from a single underwater observation in Milne Bay (see below).

Habitat and biology: A mostly coastal species that occurs near the bottom in a range of habitats, including shallow bays and reefs. Can be solitary or occur in aggregations of up to 80 individuals. Feeds on bony fishes, crustaceans, squids, and other sharks and rays. Viviparous, with intrauterine cannibalism, where the most developed embryo feeds on its siblings; only one embryo survives in each uterus at the end of the 9–12-month pregnancy.

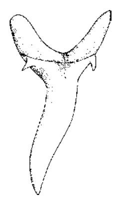
Utilisation: Unknown in PNG. Many global populations have been reported to have been seriously depleted.

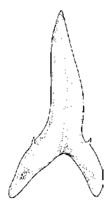
Remarks: Aggregation sites are important for diving ecotourism in some areas (e.g. eastern Australia). Highly sought after in public aquaria because of its large size, docile nature and long life span (more than 30 years in aquaria). The pattern of spots on the sides has been successfully used to identify individual sharks.

Similar species: A distinct species with two similar-sized dorsal fins, a flattened and conical snout and slender, elongate teeth.

Adult specimen observed in Milne Bay with diver beneath

Upper tooth





Lower tooth

Image details: Lateral: eastern Australia (live adult male). Underwater: Milne Bay, PNG (by B. Halstead).

CROCODILE SHARK

Pseudocarcharias kamoharai (Matsubara, 1936)

Ventral head

Late-term embryo

NT

BIOLOGY

Maximum size: 122 cm TL

Maturity size: Females at 87–98 cm TL, males at ~74–81 cm TL

Birth size: 36–45 cm TL

Litter size: 2–4 (usually 4) pups

Reproductive mode: Viviparous, with oophagy and possibly with adelphophagy

KEY FEATURES

- Eyes very large
- Mouth very long, extending well behind eyes
- Gill slits long, extending onto dorsal surface of head
- Caudal fin large, not symmetrical
- Weak keels, and upper and lower precaudal pits present on caudal peduncle
- Teeth long, thin and dagger-shaped

Colour: Dorsal surfaces dark brown to dark greyish; a variable-sized white blotch sometimes present behind mouth corners on sides on head (most obvious in embryos and juveniles). Ventral surfaces paler.

Distribution: Found in all tropical and subtropical waters, from the surface to at least 590 m depth. In PNG, recorded from the Bismarck, Solomon and Coral seas.

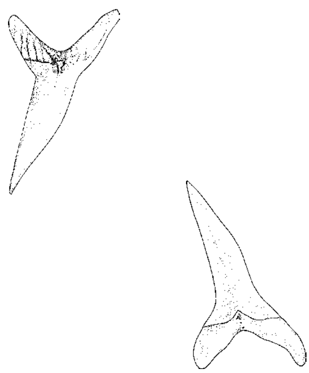
Habitat and biology: Oceanic, epipelagic and mesopelagic. Diet poorly known, but its grasping dentition suggests a diet of mesopelagic fishes, cephalopods and crustaceans. No seasonality in reproductive cycle; possibly requires a long resting phase between pregnancies to generate the energy required for the next pregnancy.

Utilisation: Caught by pelagic longline fisheries, but typically discarded because of its small size.

Remarks: Undergoes vertical migrations from deeper waters during the day to near the surface at night. Liver contains high quantities of low-density squalene oil, presumably used to achieve near-neutral buoyancy.

Similar species: A distinct lamniform species, unlikely to be confused with other species in PNG. At first glance, could be mistaken for one of the squaliform sharks but differs in having long, slender teeth (vs. low, broader teeth) and a small anal fin (vs. no anal fin).

Upper tooth



Lower tooth

Image details: Lateral: Lombok, Indonesia (female 106 cm TL). Ventral head: Bali, Indonesia (female 102 cm TL).

CORAL CATSHARK

Atelomycterus marmoratus (Bennett, 1830)

Ventral head

NT

BIOLOGY

Maximum size: 70 cm TL

Maturity size: Females at 49–57 cm TL, males at 47–62 cm TL

Hatching size: 10–13 cm TL

Egg cases: Dark brown, elongate, with short tendrils; 6–8 cm × 2–3 cm

Reproductive mode: Oviparous; lays pairs of egg cases

KEY FEATURES

- Dorsal fins large and relatively tall, about equal in size
- Snout short and narrowly rounded
- Very large nasal flaps reaching mouth
- Body slender and almost cylindrical (not flattened)
- Labial furrows very long; uppers and lowers about equal
- No crests of enlarged denticles on upper or lower caudal fin
- Darkish brown with numerous black spots and smaller white spots

Colour: Dorsal surfaces with numerous large dark-brown spots (some merging to form elongate blotches) and large white spots; a white stripe on head from below eye and through the gill slits; dorsal fins with white tips. Ventral surfaces paler.

Distribution: Found in the Indo–west Pacific, from Pakistan to New Guinea and northwards to southern China. In PNG, recorded only from the northern mainland coastline.

Habitat and biology: Nocturnal; found in crevices and holes on coral reefs during the day and emerging at night to hunt. Diet consists mainly of molluscs, crustaceans and small bony fishes. Lays egg cases in pairs.

Utilisation: Unknown.

Remarks: Although wide ranging, recently found to be a species complex with two new species described off Indonesia: the Bali catshark, *A. baliensis*, and the spotted-belly catshark, *A. erdmanni*, which differ in colour pattern. Specimens off PNG are needed to confirm that they are *A. marmoratus*. A common aquarium species in some areas, living up to 20 years in captivity.

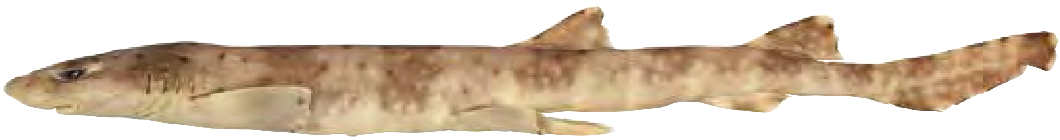
Similar species: Similar to *A. marnkalha* found in the northern Torres Strait but differs from that species in having poorly defined, indistinct saddles (vs. distinct, well-defined saddles) and body with numerous large spots (vs. smaller and less numerous spots on body).

Egg case

Image details: Lateral and ventral head: Bali, Indonesia (female 54 cm TL). Egg case: Lombok, Indonesia.

EASTERN BANDED CATSHARK

Atelomycterus marnkalha Jacobsen & Bennett, 2007



Ventral head

DD

BIOLOGY

Maximum size: 49 cm TL

Maturity size: Females and males at ~35 cm TL

Hatching size: Unknown

Egg cases: Unknown

Reproductive mode: Oviparous

KEY FEATURES

- Dorsal fins small and relatively low, about equal in size
- Snout short and rounded
- Very large nasal flaps reaching mouth
- Body slender and almost cylindrical (not flattened)
- Labial furrows very long; uppers and lowers about equal
- No crests of enlarged denticles on upper or lower caudal fin
- Pale brownish with darker saddles, with numerous small white and brown spots

Colour: Dorsal surfaces pale greyish with a series of dark-brown saddles and variably developed dark bars. Vertical rows of small white spots on body and fins; some dark spots also present. Ventral surfaces pale.

Distribution: Found only in northern Australia and PNG, at depths of 10–74 m (mostly less than 50 m). In PNG, only known from the south-western-most reaches in the northern Torres Strait.

Habitat and biology: Found over sandy to course rubble bottoms. Diet consists mainly of crustaceans, cephalopods and small bony fishes. No pregnant females recorded.

Utilisation: Unknown.

Remarks: Not observed in the catches of the prawn trawl fishery in the Gulf of Papua; thus appears to be restricted to the northern Torres Strait area of PNG.

Similar species: Similar to *A. marmoratus* found in northern mainland PNG but differs in having distinct, well-defined saddles (vs. poorly defined, indistinct saddles) and body with smaller and less numerous spots (vs. numerous large spots).

Image details: Lateral and ventral head: Queensland, Australia (adult male 39 cm TL).

STEVEN’S SWELLSHARK

Cephaloscyllium stevensi Clark & Randall, 2011

Ventral head

Juvenile

NE

BIOLOGY

Maximum size: At least 66 cm TL

Maturity size: Females at 59 cm TL, males at 52 cm TL

Hatching size: Unknown, smallest juvenile 20.6 cm TL

Egg cases: Unknown

Reproductive mode: Oviparous

KEY FEATURES

- First dorsal fin much larger than second
- Snout strongly flattened, short and very broad
- Body robust and flattened
- No labial furrows at mouth corners
- No crests of enlarged denticles on upper or lower caudal fin
- Body with dark-brown saddles and blotches, and numerous small white spots

Colour: Dorsal surface brown with a series of dark-brown saddle blotches and a dense mottling of small white spots and dark-brown blotches; white spots appear to be larger on males than females. Terminal lobe of caudal fin with a dark V-shaped marking. Ventral surfaces brownish with irregular blotches. Juveniles (~20 cm TL) medium brown with dark transverse markings appearing as narrow bars and hollow saddles.

Distribution: Known only from New Britain, New Ireland and Madang provinces in PNG, at depths of 240–616 m.

Habitat and biology: Poorly known.

Utilisation: Not caught by current fishing practices in PNG.

Remarks: As with other swellsharks, it has a highly inflatable cardiac stomach that it can inflate by swallowing water as a form of defence against predation. Forms part of a complex of variegated swellshark species that differ in colour pattern and at a molecular level. This species is very similar to *C. signourum* from the Coral Sea and was tentatively considered to be conspecific, but molecular data provide further evidence that it is a distinct species.

Similar species: Distinct from other catsharks in PNG by having a more robust and depressed head and anterior body.

Moribund specimen placed on shallow reef for photograph after being caught in deep water in a Nautilus trap

Image details: Lateral and ventral head: East New Britain, PNG (female 60 cm TL). Juvenile: off Madang Province, PNG (female 20.6 cm TL). Underwater: Milne Bay, PNG (captured specimen, by B. Halstead).

BROADMOUTH CATSHARK

Apristurus macrostomus Chu, Meng & Li, 1985

Ventral head

DD

BIOLOGY

Maximum size: At least 48 cm TL

Maturity size: Males at ~38 cm TL

Hatching size: Unknown

Egg cases: Unknown

Reproductive mode: Presumably oviparous

KEY FEATURES

- Snout moderately long (preoral length about 9–10% of TL)
- Anal fin long and low
- Second dorsal fin larger than first
- Labial furrows long; upper furrows longer than lowers
- No enlarged denticles on upper or lower caudal fin
- Brown to greyish brown in colour

Colour: Body uniformly dark brown. Fins darker brownish, most with whitish or translucent posterior margins. Dorsal and pectoral fins with narrow black anterior margins.

Distribution: Found in the north-west Pacific, in the South China Sea and off Taiwan, and off PNG at depths of 600–913 m. In PNG, known from seven specimens collected off Morobe, Manus and Madang provinces.

Habitat and biology: Poorly known.

Utilisation: Not caught by current fishing practices in PNG.

Remarks: First recorded in PNG based on specimens collected in 2010–14; previously known only from the north-west Pacific. Although previously considered to be rare, recent surveys off northern Taiwan found it was quite common. Difficulties in identifying members of this genus and the depths it occurs in are the reasons for the lack of information available.

Similar species: Similar to *A. yangi* but differs in having a much shorter snout (vs. snout very long); also similar to *A. nakayai* but differs in lacking a white iris (vs. iris distinctly white when fresh) and being smaller (males mature at 38 vs. 56 cm TL, respectively) and with a much less robust body (vs. body robust). It differs from *Apristurus* sp. 1 in having a narrower snout (vs. snout broad).

Fresh specimen just landed by deepwater trawl off Madang, highlighting the uniform brownish colouration and moderately long snout

Image details: Lateral and ventral head: Madang, PNG (adult male 38 cm TL). Fresh specimen: Madang, PNG (female 26 cm TL, by J.-N. Chen).

MILK-EYE CATSHARK

Apristurus nakayai Iglésias, 2013

Ventral head

NE

BIOLOGY

Maximum size: 68 cm TL

Maturity size: Males at ~56 cm TL

Hatching size: Unknown

Egg cases: Unknown

Reproductive mode: Presumably oviparous

KEY FEATURES

- Snout moderately long (preoral length about 8% of TL)
- Anal fin very long and low
- Second dorsal fin much larger than first
- Labial furrows long; upper furrows longer than lowers
- Iris of eye distinctly white when fresh
- No enlarged denticles on upper or lower caudal fin
- Blackish brown in colour

Colour: Body uniformly blackish brown. Dorsal fin posterior margins pale. Iris of eye shiny white when fresh.

Distribution: Known only from three adult males, one collected off New Caledonia at a depth of 953–1,022 m, and two off PNG. The PNG specimens were collected from off New Ireland and Lae at depths of 672–1,150 m.

Habitat and biology: Unknown.

Utilisation: Not caught by current fishing practices in PNG.

Remarks: The PNG specimens were the first record of this species outside New Caledonia and only the second and third specimens known of this species. Additional specimens from PNG are required to determine whether it is restricted to the outer island chains, or more widely distributed in PNG.

Similar species: Similar to the other *Apristurus* species in PNG but differs in being larger and more robust, and having a white iris when fresh. It also differs from *A. yangi* in having a much shorter snout (vs. snout very long) and from *Apristurus* sp. 1 in having a narrower snout (vs. snout broad).

Lateral head of fresh specimen, highlighting the distinctive white iris

Image details: Lateral and ventral head: New Ireland, PNG (adult male 56 cm TL). Lateral head: off Lae, PNG (freshly landed adult male, by Academia Sinica).

YANG'S LONGNOSE CATSHARK

Apristurus yangi White, Mana & Naylor, 2017

Ventral head

NE

BIOLOGY

Maximum size: At least 44 cm TL

Maturity size: Females at 44 cm TL

Hatching size: Unknown

Egg cases: Brown, narrow, smooth; 5.9 cm × 1.4 cm

Reproductive mode: Oviparous; one female contained a single egg case

KEY FEATURES

- Snout very long (preoral length about 13% of TL) and narrow
- Anal fin very long and low
- Second dorsal fin much larger than first
- Labial furrows long; upper furrows longer than lower
- Egg capsule narrow with a relatively smooth surface
- No enlarged denticles on upper or lower caudal fin
- Pale brown in colour

Colour: Body uniformly pale brownish; slightly darker dorsally. Margin of snout and anterior edge of fins blackish. Inside of mouth dark brown to blackish.

Distribution: Only known from two specimens collected from Vitiaz Strait and off New Ireland in PNG at depths of 630–786 m.

Habitat and biology: Largely unknown. A pregnant female contained a single elongate egg case.

Utilisation: Not caught by current fishing practices in PNG.

Remarks: First discovered during deepwater trawl surveys in PNG in 2010 and 2014. Part of a species complex of long-snout *Apristurus* that includes *A. garricki* from off New Zealand, *A. australis* from off Australia, and *A. herklotsi* from the north-west Pacific.

Similar species: Differs from the other three *Apristurus* species found in PNG in having a much longer snout and far more slender body.

Egg case

Freshly landed juvenile from a deepwater trawl off New Ireland, highlighting the long snout and pale colouration

Image details: Lateral, ventral head and egg case: Vitiaz Strait, PNG (pregnant female 44 cm TL). Fresh specimen: New Ireland, PNG (freshly landed female 20.5 cm TL).

PAPUAN SHORTNOSE CATSHARK

Apristurus sp. 1

Ventral head

NE

BIOLOGY

Maximum size: Unknown (based on a 25 cm TL juvenile)

Maturity size: Unknown

Hatching size: Unknown

Egg cases: Unknown

Reproductive mode: Presumably oviparous

KEY FEATURES

- Snout moderately long (preoral length about 9% of TL)
- Head relatively broad (interorbital width ~9% of TL)
- Second dorsal fin much larger than first
- Labial furrows long; upper furrows longer than lower furrows
- No enlarged denticles on upper or lower caudal fin
- Brownish black in colour

Colour: Body uniformly brownish; fins paler posteriorly.

Distribution: Only known from a single juvenile male specimen collected from Astrolabe Bay in PNG at a depth of 851–865 m.

Habitat and biology: Unknown.

Utilisation: Not caught by current fishing practices in PNG.

Remarks: Juveniles of this genus of catsharks are notoriously difficult to distinguish; additional specimens, including adults, are required to determine whether this species is undescribed or conspecific with another regional species.

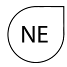
Similar species: Differs from the other three *Apristurus* species found in PNG in having a much broader snout.

Image details: Lateral and ventral head: Madang, PNG (juvenile male 25 cm TL).

CORRIGAN'S CATSHARK

Galeus corriganae White, Mana & Naylor, 2016

Ventral head



BIOLOGY

Maximum size: At least 37 cm TL (based on adolescent males)

Maturity size: Unknown; males not mature at 37 cm TL

Birth size: Unknown

Litter size/egg cases: Unknown

Reproductive mode: Unknown; viviparous or oviparous

KEY FEATURES

- Head moderately long and broad
- Dorsal fins low; first slightly larger than second
- Labial furrows at corners of mouth moderately long
- Crest of enlarged denticles on upper caudal peduncle and fin
- No crest of enlarged denticles on lower caudal peduncle or fin
- Body grey with dark saddles under dorsal fins and on caudal fin
- Pectoral fins with a distinct black anterior margin

Colour: Dorsal surfaces greyish with four distinct darker dorsal saddles located below dorsal fins and on tail; dorsal fins dark basally from extension of dark saddles onto fins. Pectoral fins with very distinctive black anterior margins. Roof of mouth and tongue dark grey to blackish. Ventral surfaces paler.

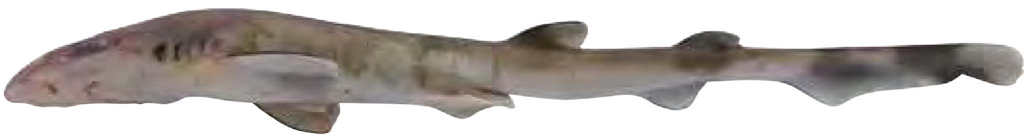
Distribution: Only known from off Madang Province and off south-western West New Britain Province in PNG, at depths of 500–742 m.

Habitat and biology: Unknown. Adult specimens not recorded.

Utilisation: Not caught by current fishing practices in PNG.

Remarks: First discovered during deepwater trawl surveys in PNG between 2010 and 2014. Part of a species complex of deepwater catsharks that includes *G. priapus* from New Caledonia and *G. gracilis* from the Coral Sea.

Similar species: Differs from the other deepwater catsharks in PNG in having a paler colouration with distinct dark saddles on the sides and tail (vs. uniform body colouration).



Lateral view of freshly landed specimen, highlighting the distinctive dark saddles under dorsal fins and on caudal fin

Ventral anterior view of freshly landed specimen, highlighting the distinct black anterior margins on the pectoral fins

Image details: All images: Madang Province, PNG (adolescent male 31 cm TL).

VELVET CATSHARK

Parmaturus lanatus Séret & Last, 2007

Ventral head

DD

BIOLOGY

Maximum size: Unknown, largest specimen juvenile at 36 cm TL

Maturity size: Unknown

Hatching size: Unknown

Egg cases: Unknown

Reproductive mode: Probably oviparous (needs confirmation)

KEY FEATURES

- Head depressed, its height about half its width
- Low crests on upper and lower caudal-fin lobes without enlarged denticles
- Dorsal fins similar in size
- No white margins on fins
- Head slightly longer than distance between pectoral and pelvic fins
- Labial furrows rudimentary

Colour: Body dark brown to greyish; darker ventrally. Gills and fins darker.

Distribution: Only known from off Tanimbar Island off eastern Indonesia (Arafura Sea) and off Madang Province in PNG, at depths of 840–985 m.

Habitat and biology: Unknown. Adult specimens not yet recorded.

Utilisation: Not caught by current fishing practices in PNG.

Remarks: First recorded in PNG during deepwater trawl surveys off Madang Province in 2012. Additional specimens required, particularly adults, to allow a better description of this poorly known species.

Similar species: Differs from *Parmaturus* sp. 1 in having dorsal fins similar in size (vs. second dorsal fin much larger than first) and lacking white posterior margins on most fins (vs. fins mostly white-edged).

Image details: Lateral and ventral head: Madang Province, PNG (female 21 cm TL).

WHITEFIN CATSHARK

Parmaturus sp. 1

Ventral head

NE

BIOLOGY

Maximum size: Only known from a juvenile male of 25 cm TL

Maturity size: Unknown

Hatching size: Unknown

Egg cases: Unknown

Reproductive mode: Probably oviparous (needs confirmation)

KEY FEATURES

- Head depressed, its height about three-quarters width
- Crests of enlarged denticles on upper and lower caudal-fin lobes
- Second dorsal fin much larger than first
- Dorsal, anal and caudal fins with a distinct white posterior margin
- Head longer than distance between pectoral and pelvic fins
- Labial furrows short but well defined

Colour: Dorsal surfaces uniformly pale brown. A darkish saddle-like marking extending over gills and slightly onto the dorsal and well onto the ventral surfaces. A thin black stripe extending along midline of ventral trunk. Ventral surfaces paler brown.

Distribution: Only known from a single specimen collected west of Manus Island in PNG, at a depth of 980–985 m.

Habitat and biology: Unknown. Adult specimens not yet recorded.

Utilisation: Not caught by current fishing practices in PNG.

Remarks: First recorded in PNG during deepwater trawl surveys off PNG in 2010. Additional specimens required, particularly adults, to allow detailed comparisons with similar species.

Similar species: Differs from *P. lanatus* in having the second dorsal fin much larger than first (vs. dorsal fins similar in size) and having white posterior margins on most fins (vs. fins not white-edged).

Anterior ventral view, highlighting the dark saddle-like marking extending beneath the gill slits and the thin blackish stripe on the ventral midline

Image details: All images: Madang Province, PNG (juvenile male 25 cm TL).

SAILBACK HOUNDSHARK

Gogolia filewoodi Compagno, 1973

Ventral head

DD

BIOLOGY

Maximum size: At least 74 cm TL

Maturity size: Single known female mature at 74 cm TL

Birth size: ~22 cm TL

Litter size: Pregnant female holotype contained 2 pups

Reproductive mode: Viviparous, without yolk-sac placenta

KEY FEATURES

- First dorsal fin long, its base about as long as caudal fin and more than twice first dorsal-fin height
- Precaudal pits absent
- Snout long; preoral length more than 1.6 times mouth width
- Labial furrows long; uppers twice as long as lowers
- First dorsal-fin origin about opposite pectoral-fin insertions
- Dorsal fin tips plain or dusky

Colour: Upper surfaces dark grey to greyish brown. Dorsal fins with dusky posterior margins. Pectoral fin posterior margins pale. Ventral surfaces paler.

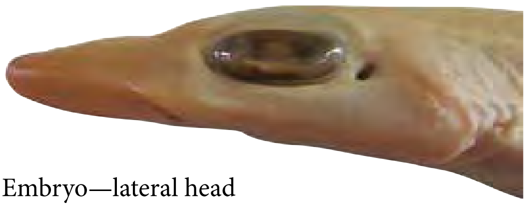
Distribution: Only known from a single pregnant female, containing two late-term pups, caught in Astrolabe Bay, Madang Province, in PNG at a depth of 73 m.

Habitat and biology: Unknown.

Utilisation: Unknown.

Remarks: Only known specimen caught by handline in Astrolabe Bay off the mouth of the Gogol River near Madang in July 1970.

Similar species: Differs from other triakid species recorded in PNG in having a very long first dorsal fin.



Embryo—lateral head

Embryo—ventral head

Image details: Lateral and ventral head: Madang Province, PNG (pregnant female 72 cm TL). Embryo lateral head and ventral head: Madang Province, PNG (late-term embryo 22.4 cm TL).

PAPUAN HOUNDSHARK

Hemitriakis sp. 1

NE

BIOLOGY

Maximum size: Unknown; at least 80 cm TL

Maturity size: Unknown

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Probably viviparous, without yolk-sac placenta

KEY FEATURES

- First dorsal fin relatively short, its base much shorter than caudal fin
- Precaudal pits absent
- Snout moderately long; preoral length less than 1.5 times mouth width
- Lower lobe of caudal fin well developed
- First dorsal-fin origin over posterior part of pectoral-fin free tips
- Dorsal fin with broad white tips

Colour: Upper surfaces pale greyish brown. Dorsal fins with broad white tips extending as a narrow white edge on the upper posterior margin.

Distribution: Only known from a single adult male (not retained) caught off northern New Ireland in PNG (depth unknown).

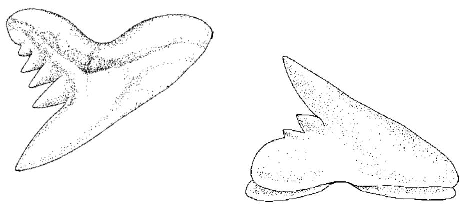
Habitat and biology: Unknown.

Utilisation: Unknown; possible bycatch of the deepwater snapper handline fishery.

Remarks: Only known specimen caught, but not retained, in 2016 while handlining for deepwater snapper off northern New Ireland. Specimens required to ascertain whether this represents a new species. A similar, possibly undescribed species was recorded recently off the Solomon Islands and may be conspecific with this species.

Similar species: Differs from the other triakid species recorded in PNG in having distinct white-tipped dorsal fins.

Upper tooth



Lower tooth

Teeth of *H. falcata* to highlight typical dentition in this genus

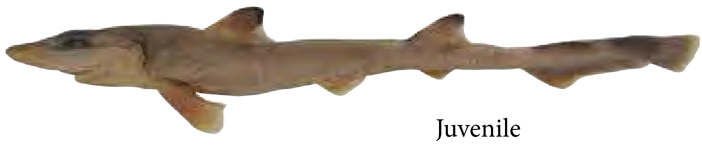
Ventral head of *H. indroyonoi* to highlight typical head morphology in this genus

Image details: Fresh specimen: New Ireland, PNG (adult male, by Malakai). Ventral head (*H. indroyonoi*): Bali, Indonesia (adult male 96 cm TL).

LONGNOSE HOUNDSHARK

Iago garricki Fourmanoir & Rivaton, 1979

Ventral head



Juvenile

LC

BIOLOGY

Maximum size: 75 cm TL

Maturity size: Females at 62–65 cm TL, males at 45–55 cm TL

Birth size: ~22 cm TL

Litter size: 4–5 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- First dorsal fin relatively short, its base much shorter than caudal fin
- Precaudal pits absent
- Snout relatively long; preoral length less than 1.5 times mouth width
- Lower lobe of caudal fin poorly developed
- First dorsal-fin origin over anterior half of pectoral-fin free tips
- Dorsal fin with broad black tips

Colour: Dorsal surfaces greyish brown. Dorsal fins with distinct black tips (becoming less obvious in adults; very distinct in juveniles) and paler free rear tips. Tip of caudal fin white. Ventral surfaces paler.

Distribution: Found in the western central Pacific, including the Philippines, Indonesia, northern Australia, Vanuatu and PNG at depths of 250–475 m. In PNG, known from a single specimen collected off Kavieng, New Ireland, at a depth of 333–420 m.

Habitat and biology: Poorly known. Diet, based on a few specimens examined, consists of cephalopods.

Utilisation: Not caught by current fishing practices in PNG.

Remarks: Previously considered to have a restricted distribution in the south-west Pacific, but now confirmed northwards to the Philippines.

Similar species: Differs from *Hemitriakis* sp. 1 in having distinct black-tipped dorsal fins (vs. dorsal fins white-tipped) and from *Gogolia filewoodi* in having a short first dorsal fin (vs. first dorsal fin very long).

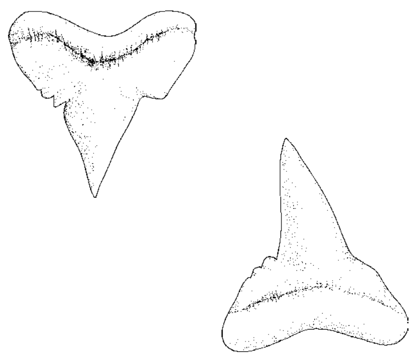
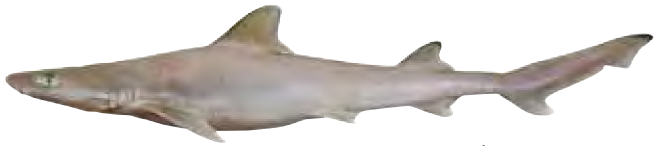


Image details: Lateral: West Java, Indonesia (female ~56 cm TL). Ventral head: Bali, Indonesia (female 65 cm TL). Juvenile: New Ireland, PNG (female 22 cm TL).

AUSTRALIAN WEASEL SHARK

Hemigaleus australiensis White, Last & Compagno, 2005

Ventral head



Juvenile

LC

BIOLOGY

Maximum size: 110 cm TL

Maturity size: Females at 65 cm TL, males at 60 cm TL

Birth size: 21–30 cm TL

Litter size: 1–19 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Spiracle present, small
- Gill slits small, less than twice eye length
- Mouth very short and broadly arched
- Dorsal, anal, pelvic, pectoral and lower caudal fins falcate
- Teeth concealed when mouth closed
- Anterior lower teeth with short, erect cusps (roots strongly arched)

Colour: Dorsal surfaces pale bronze to greyish. Second dorsal and upper caudal fin tips dark (less evident in adults). First dorsal fin posterior margin usually pale. Ventral surfaces pale.

Distribution: Found in northern Australia and PNG, mostly inshore but also to depths of 170 m. In PNG, possibly restricted to the southern coastline from Western Province to Orangerie Bay (Central and Milne Bay Province); records from off West New Britain need confirmation.

Habitat and biology: Common on trawl grounds, such as seagrass and sand–mud bottoms. A specialist feeder, with diet consisting almost exclusively of cephalopods, especially octopus; some crustaceans also eaten. Produces two litters each year after about a 6-month gestation period.

Utilisation: Common component of the bycatch of the Gulf of Papua prawn trawl fishery.

Remarks: Once thought to be conspecific with the more widespread *H. microstoma* but found to represent a separate species with a restricted distribution.

Similar species: Differs from *Hemipristis elongata* in having teeth concealed when mouth closed (vs. teeth protruding from mouth when closed) and gills relatively small (vs. gill slits very large).

Landings of *H. australiensis* in the bycatch of the Gulf of Papua prawn trawl fishery

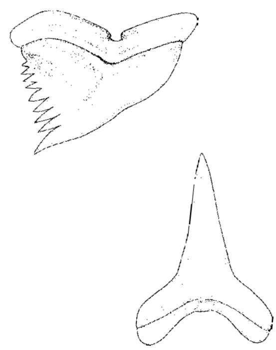


Image details: Lateral and ventral head: Gulf of Papua, PNG (adult male 74 cm TL). Juvenile: south of Kerema, PNG (female 31 cm TL). Fresh specimens: Gulf of Papua, PNG.

SNAGGLETOOTH SHARK

Hemipristis elongata (Klunzinger, 1871)

Ventral head

Juvenile

VU

BIOLOGY

Maximum size: At least 230 cm TL

Maturity size: Females at ~120 cm TL, males at 110–136 cm TL

Birth size: 45–53 cm TL

Litter size: 2–11 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Spiracle present, small
- Gill slits large, more than twice eye length
- Snout relatively long, broadly rounded
- Fins strongly falcate
- Teeth protruding prominently from mouth when closed
- Anterior lower teeth with long, strongly hooked cusps

Colour: Dorsal surfaces greyish brown. Upper caudal fin with a dark blotch (less evident in adults). Second dorsal fin broadly white-tipped underlined by a black area in juveniles, becoming black-tipped in larger specimens (almost plain in adults). Ventral surfaces pale.

Distribution: Widespread in the Indo–west Pacific, from southern Africa to PNG and northwards to China, to depths of at least 132 m. In PNG, verified from Western Province and Milne Bay Province, but probably widespread.

Habitat and biology: Appears to be naturally rare compared with other inshore sharks. Feeds on cephalopods, bony fishes, and sharks and rays. Gestation period is 7–8 months, possibly breeding in alternate years.

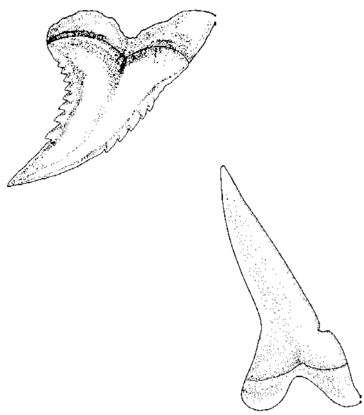
Utilisation: Occasionally caught in trawl and coastal fisheries where it occurs. Dried fins sold to local buyers and subsequently exported.

Remarks: In India, the flesh is considered of the highest quality to eat. Stock declines have been reported in some locations. Attains at least 15 years of age.

Similar species: Differs from *Hemigaleus australiensis* in having teeth protruding from mouth when closed (vs. teeth concealed when mouth closed) and gills very large (vs. relatively small).

Dried jaws in the Kanudi Fisheries Research Station collection, highlighting the large relative size of the teeth in this species

Upper tooth



Lower tooth

Image details: Lateral: Bali, Indonesia (adult male 172 cm TL). Ventral head: Jakarta, Indonesia (male 114 cm TL). Juvenile: Java, Indonesia (male 65 cm TL). Dried jaws: Yule Island, PNG.

SILVERTIP SHARK

Carcharhinus albimarginatus (Rüppell, 1837)

Ventral head

VU

BIOLOGY

Maximum size: ~300 cm TL

Maturity size: Females at 160–199 cm TL, males at 160–180 cm TL

Birth size: 63–81 cm TL

Litter size: 1–11 (usually 5–6) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- First dorsal, pectoral, pelvic and caudal fins with distinct white tips
- Interdorsal ridge present
- Apex of first dorsal fin pointed or narrowly rounded
- Snout rather long and parabolic
- Upper teeth triangular, cusps oblique, edges distinctly notched and serrated
- Lower teeth serrated but more slender and erect than uppers

Colour: Dorsal surfaces bronze, becoming brownish or greyish after death. First dorsal, pectoral, pelvic and caudal fins with distinct white tips. Second dorsal, anal and upper pelvic fins sometimes dusky. Ventral surfaces almost white.

Distribution: Widespread in the tropical Indo-Pacific, from south-eastern Africa to Central America, to depths of at least 800 m.

Habitat and biology: An inshore and offshore pelagic shark, rather than oceanic, occurring throughout the water column. Diet includes a variety of pelagic and demersal fishes. Gives birth every second year after a 12-month gestation period.

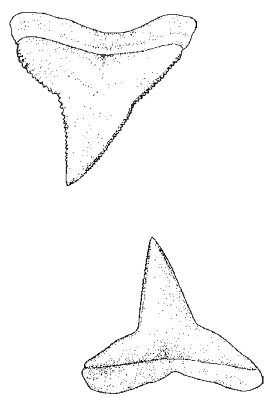
Utilisation: Caught by shark longline fishery (when operational) and by coastal fishers in a number of provinces. Meat sometimes used for human consumption, and dried fins sold to local buyers and subsequently exported.

Remarks: Known to be aggressive when provoked; thus potentially dangerous to humans. Found to make relatively localised movements, with most sharks recaptured less than 2 km from tagging site. Important for dive tourism in some areas, including PNG (e.g. Kavieng, Kimbe Bay), but localised depletions have been reported in some areas. Maximum age of PNG populations reported as 18 years for both sexes, with males mature at 10.5 years and females at 14.8 years.

Similar species: Similar in size and morphology to *C. amblyrhynchos*, which can also sometimes have a white-tipped first dorsal fin, but differs in lacking the broad black caudal fin posterior margin, which is diagnostic for that species.

Individual cruising, with a rainbow runner, *Elagatis bipinnulata*, beneath

Upper tooth

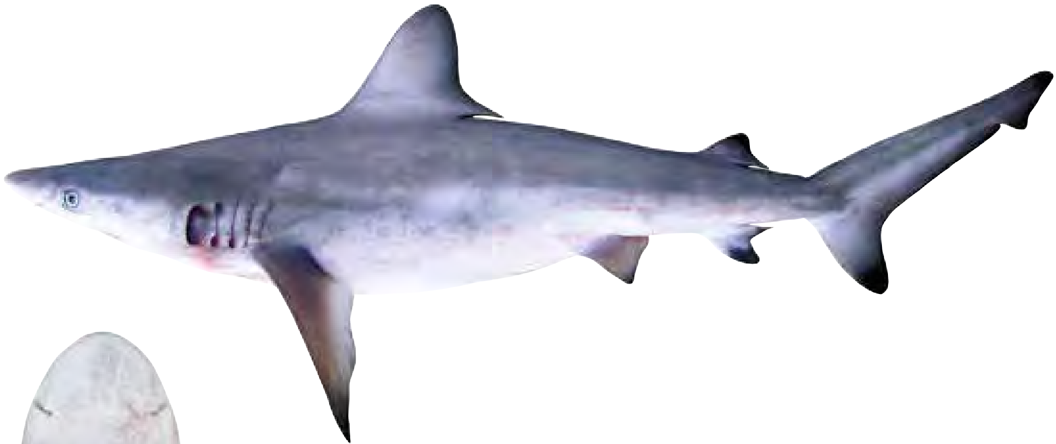


Lower tooth

Image details: Lateral: Bismarck Sea, PNG (female 180 cm TL). Ventral head: Australia (juvenile female 79 cm TL). Underwater: Kimbe Bay (by P. Lange and Walindi Resort).

BIGNOSE SHARK

Carcharhinus altimus (Springer, 1950)



Ventral head

DD

BIOLOGY

Maximum size: At least 285 cm TL

Maturity size: Females at 225 cm TL, males at 190–216 cm TL

Birth size: 60–75 cm TL

Litter size: 3–15 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- First dorsal fin relatively tall, its height less than half predorsal length
- First dorsal-fin origin over pectoral-fin insertions
- Interdorsal ridge present
- Snout moderately long and rounded
- Upper teeth triangular, erect to slightly oblique, long and pointed, edges serrated
- Lower teeth erect, narrow and serrated

Colour: Dorsal surfaces bronze to grey; greyish after death. Fin tips often dusky. Ventral surfaces almost white.

Distribution: Patchy but circumglobal in tropical and warm temperate seas in depths of mostly 80–430 m (juveniles as shallow as 25 m). In PNG, confirmed from off Milne Bay Province and off New Ireland.

Habitat and biology: A mainly bottom-dwelling species. Diet includes a variety of demersal bony fishes, sharks, rays and cephalopods. Two pregnant females with embryos of ~60 cm TL were caught in June 2014 off Milne Bay Province, suggesting timing of birth is probably in June or July.

Utilisation: Caught by shark longline fishery (when operational) and by coastal fishers in some areas (e.g. Milne Bay Province). Meat sometimes used for human consumption, and dried fins sold to local buyers and subsequently exported.

Remarks: Differs in habitat from other members of this genus in preferring deepwater areas, although undergoing vertical migrations to near the surface at night.

Similar species: Similar to *C. plumbeus* in its tall, anteriorly positioned first dorsal fin and presence of a ridge between the dorsal fins, but differs in having a shorter, although tall, first dorsal fin (vs. very tall) and moderately long snout (vs. snout moderately short).

Fresh specimen landed by one of the target shark longline boats

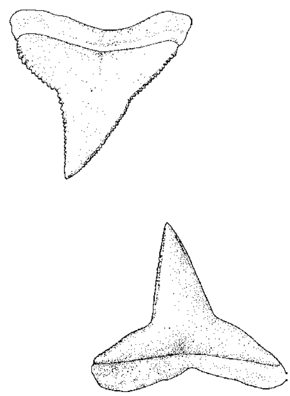
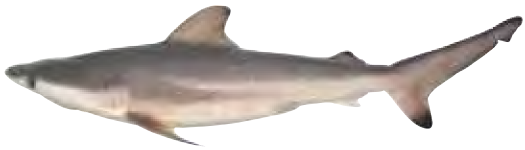


Image details: Lateral and ventral head: Lombok, Indonesia (juvenile male 106 cm TL). Fresh specimen: Milne Bay Province, PNG (pregnant female 250 cm TL).

GRACEFUL SHARK

Carcharhinus amblyrhynchoides (Whitley, 1934)



Late-term embryo

NT

Ventral head

BIOLOGY

Maximum size: 178 cm TL

Maturity size: Both sexes at 110–115 cm TL

Birth size: 50–60 cm TL

Litter size: 2–8 (average 3) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Second dorsal-fin origin over anal-fin origin
- Interdorsal ridge absent
- Snout short and pointed; internarial space 1–1.2 times preoral snout length
- Upper labial furrows very short
- Fins mostly with black tips (anal fin sometimes plain)
- Upper and lower teeth with narrow, erect cusps

Colour: Dorsal surfaces bronze, becoming grey after death; a pale stripe along side of body. All fins, except anal fin, with conspicuous black tips. Ventral surfaces almost white.

Distribution: Found in the tropical Indo–west Pacific, the Gulf of Aden to PNG and northwards to the Philippines, to depths of at least 50 m. In PNG, confirmed from Western, Gulf and East Sepik provinces, but probably more widespread, at least in the mainland region.

Habitat and biology: An inshore species. Diet consists mainly of bony fishes, but also cephalopods and crustaceans. Gestation lasts for 9–10 months.

Utilisation: Caught by coastal fishers in some provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

Remarks: Belongs to the 'black-tip' (*C. limbatus*) species complex, which can be difficult to distinguish. Commonly caught with bull sharks at the mouth of the Sepik River.

Similar species: Similar to *C. limbatus* and *C. tilstoni* but differs in having a more robust body (vs. body more slender) and a short snout (vs. snout moderately long).

Fresh specimen from the bycatch of the Gulf of Papua prawn trawl fishery

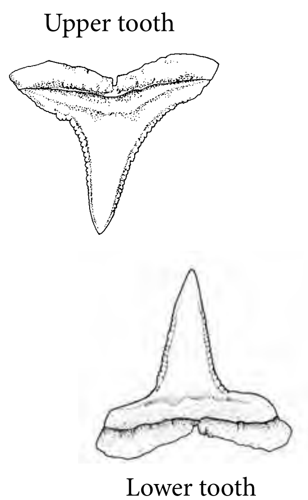
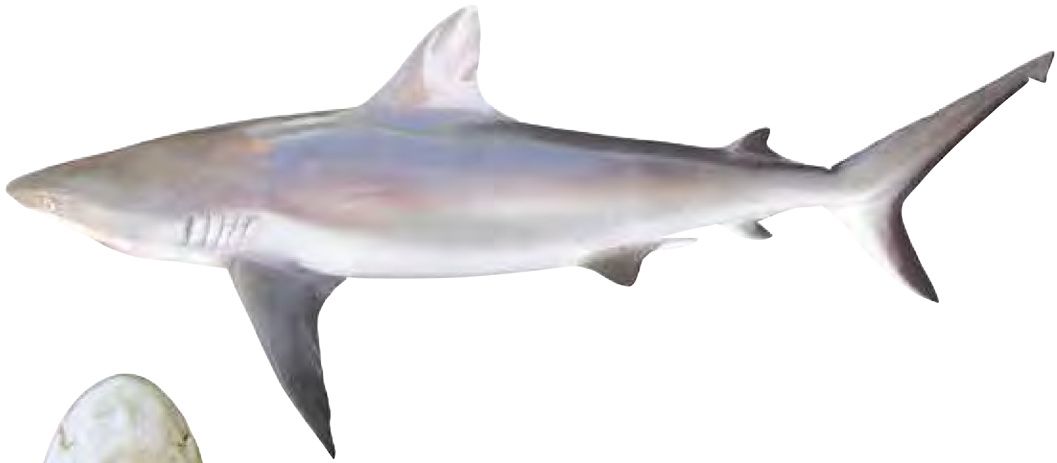


Image details: Lateral and ventral head: Java, Indonesia (female 54.5 cm TL). Embryo: Jakarta, Indonesia (male 40 cm TL). Fresh specimen: Gulf of Papua, PNG (female 87 cm TL).

GREY REEF SHARK

Carcharhinus amblyrhynchos (Bleeker, 1856)



Ventral head

NT

BIOLOGY

Maximum size: 255 cm TL, but rarely above 180 cm TL

Maturity size: Both sexes at 130–140 cm TL

Birth size: 45–64 cm TL

Litter size: 1–6 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Entire posterior edge of caudal fin with wide black border
- Interdorsal ridge weak or absent
- First dorsal fin relatively tall, its origin over pectoral-fin inner margins
- Snout broadly rounded
- Upper teeth long, narrowly triangular, with notch on one edge
- Lower teeth narrow, upright, edges weakly serrated

Colour: Dorsal surfaces bronze to greyish, becoming grey after death; a faint white stripe on sides. Caudal fin with a broad black posterior margin; first dorsal fin plain, sometimes with a white tip; other fins with dusky tips. Ventral surfaces almost white.

Distribution: Widespread in the tropical Indo–west and central Pacific, from south-eastern Africa to the central Pacific islands, to depths of about 280 m.

Habitat and biology: One of the most common sharks found on coral reefs; found mostly near deep drop-offs and reef passes. Diet consists mainly of small fishes, but also cephalopods and crustaceans. Gestation lasts 12–14 months.

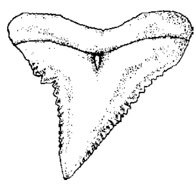
Utilisation: Caught in large numbers by the shark longline fishery (when operational) and by coastal fishers in a number of provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

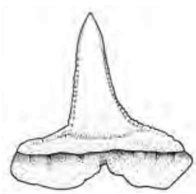
Remarks: Can be very aggressive in presence of bait; has a threat display if provoked, which precedes an attack or flight by the shark. Maximum age of PNG populations reported as 15 years for both sexes, with males mature at about 6 years and females at about 9 years. Recent stock assessment analysis for this species in PNG suggests it is unlikely that this species can be fished sustainably when caught at high rates. Localised depletions have occurred at a number of locations.

Similar species: Can be confused with *C. albimarginatus* when first dorsal fin is white-tipped, but differs in having a broad black posterior margin on the caudal fin (vs. caudal fin not black-edged) and other fins not white-tipped (vs. pelvic, pectoral and caudal fins white-tipped).

Cruising specimen, highlighting the distinctive black edge on the caudal fin, with remora on ventral and dorsal surfaces

Upper tooth



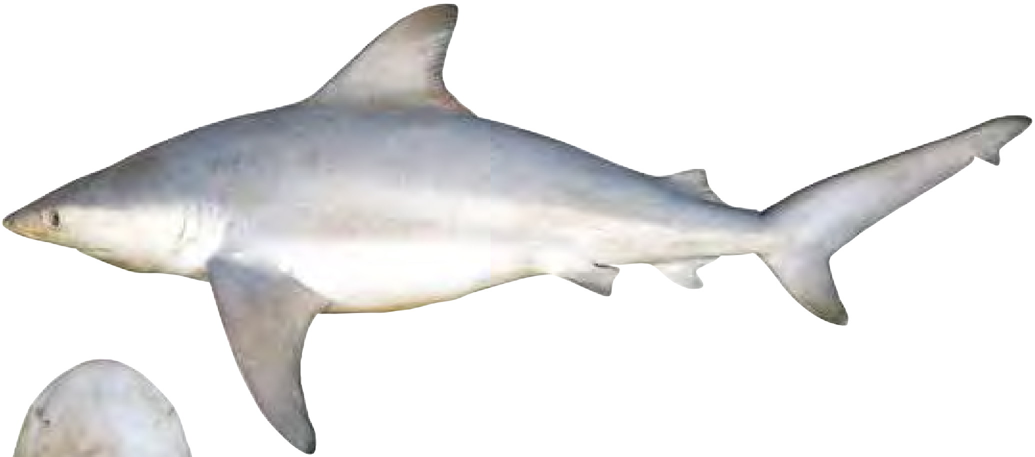


Lower tooth

Image details: Lateral: Bismarck Sea, PNG (adult male 132 cm TL). Ventral head: Gulf of Papua, PNG (juvenile male 71 cm TL). Underwater: Kimbe Bay, PNG (by N. Sumanatemeya and Walindi Dive).

PIGEYE SHARK

Carcharhinus amboinensis (Müller & Henle, 1839)



Ventral head

DD

BIOLOGY

Maximum size: 280 cm TL

Maturity size: Females at 198–223 cm TL, males at 195–210 cm TL

Birth size: 60–72 cm TL

Litter size: 6–13 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- First dorsal-fin height more than three times height of second
- Notch on posterior margin of anal fin relatively acute (<90^{o})
- Interdorsal ridge absent
- Snout very short and broadly rounded; preoral length less than internarial space
- Upper and lower teeth broadly triangular, with erect to slightly oblique cusps with serrated edges
- Usually 11 rows of teeth on each side of lower jaw

Colour: Dorsal surfaces grey; a faint white stripe on sides. Fin tips dusky in juveniles, plain in adults. Ventral surfaces almost white.

Distribution: Widespread in the eastern Atlantic and Indo–west Pacific, from south-eastern Africa to PNG, from the surface to depths of about 100 m.

Habitat and biology: A mostly inshore species. Diet consists of small bony fishes, sharks, rays, crustaceans, cephalopods and other molluscs. Gestation lasts about 12 months, with birth occurring in November or December in northern Australia.

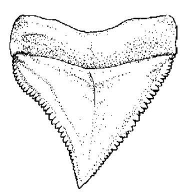
Utilisation: Caught by prawn trawlers in the Gulf of Papua and by coastal fishers in some provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

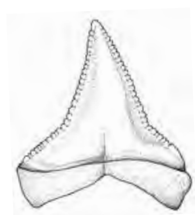
Remarks: Juveniles have relatively localised movements, while larger individuals move greater distances. A potentially dangerous species but with no proven attacks. Some suggestion that it is rare when *C. leucas* is common, possibly due to competitive exclusion.

Similar species: Very similar and easily confused with *C. leucas*, but differs in having a larger first dorsal fin relative to the second dorsal fin, and anal fin with an acute posterior margin forming an angle of less than 90° (vs. less acute, angle more than 90°).

Fresh specimen from the bycatch of the Gulf of Papua prawn trawl fishery

Upper tooth





Lower tooth

Image details: Lateral and ventral head: Freshwater Bay, PNG (female 91 cm TL). Fresh specimen: Gulf of Papua, PNG (female 95 cm TL).

SPINNER SHARK

Carcharhinus brevipinna (Müller & Henle, 1839)

Ventral head

NT

BIOLOGY

Maximum size: 300 cm TL

Maturity size: Both sexes at 190–200 cm TL

Birth size: 60–81 cm TL

Litter size: 3–15 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Dorsal and caudal fins with black tips in adults (plain in juveniles)
- Interdorsal ridge absent
- Snout long and pointed; internarial space 1–1.2 times preoral snout length
- First dorsal fin low, its height >2.2 times in distance between dorsal fins
- Upper labial furrows relatively long and distinct
- Upper and lower teeth similar, nearly symmetrical, with very narrow, erect cusps

Colour: Dorsal surfaces bronze to greyish, fading to grey after death. Fins plain at birth, with distinct black tips becoming more distinct with increasing size. Ventral surfaces almost white.

Distribution: Widespread in the Atlantic Ocean and Indo–west Pacific, from south-eastern Africa to New Caledonia and northwards to Japan, from the surface to depths of at least 75 m.

Habitat and biology: A very active schooling shark; highly migratory in some parts of its range (e.g. Gulf of Mexico). Diet consists mostly of pelagic bony fishes, and also rays and cephalopods. Gestation lasts about 10–12 months, with females having a 2-year reproductive cycle.

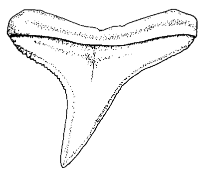
Utilisation: Juveniles caught by prawn trawlers in the Gulf of Papua; also caught by coastal fishers in some provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

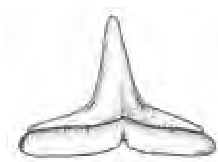
Remarks: Common name comes from its ability to frequently spin out of the water during a feeding run through a school of small fish. Both sexes found to mature at 8–10 years of age.

Similar species: Similar to *C. limbatus* and *C. tilstoni* but differs in having a longer snout with prominent labial furrows (vs. labial furrows very short) and a low first dorsal fin (vs. first dorsal fin relatively tall). Juveniles could be mistaken for *C. macloti*, which has a similar long snout but differs from this species in having second dorsal-fin origin level with anal-fin origin (vs. second dorsal-fin origin level with midbase of anal fin).

Fresh specimen from the target shark longline catch, highlighting the more distinct black tips on fins in larger individuals

Upper tooth





Lower tooth

Image details: Lateral and ventral head: Gulf of Papua, PNG (female 87 cm TL). Fresh specimen: Bismarck Sea, PNG (female 158 cm TL).

NERVOUS SHARK

Carcharhinus cautus (Whitley, 1945)

Ventral head

DD

BIOLOGY

Maximum size: 150 cm TL

Maturity size: Females at ~85 cm TL, males at ~80 cm TL

Birth size: 35–40 cm TL

Litter size: 1–6 (average 4) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Posterior margin of caudal fin with a distinct, narrow black edge
- Interdorsal ridge absent
- First dorsal fin with a narrow black anterior margin, but without a black blotch at its tip
- Snout short and blunt; internarial space 1.1–1.2 times preoral snout length
- Upper teeth narrowly triangular and deeply notched with coarse serrations at their base

Colour: Dorsal surfaces bronze to greyish, sometimes with a greenish yellow hue; a white stripe on the sides. Lower caudal and pectoral fins with black tips; a dark anterior edge on dorsal, upper caudal and pectoral fins. Ventral surfaces almost white.

Distribution: Found only in northern Australia, PNG and Solomon Islands. In PNG, only confirmed from Western and Central provinces.

Habitat and biology: A shallow inshore shark. Diet consists mainly of bony fishes, but also crustaceans and cephalopods; terrestrial snakes also sometimes recorded. Gestation lasts 8–9 months, with birth in October or November in northern Australia; females have a 2-year reproductive cycle.

Utilisation: Probably caught occasionally by coastal fishers in some provinces.

Remarks: Common name comes from its extremely timid and skittish nature. Attains a maximum age of 16 years, with males mature at 4 years and females at 5 years. Adults found to segregate by sex in shallow waters, with pregnant females in shallower waters, including mangrove estuaries, and males in deeper waters.

Similar species: Most similar to *C. melanopterus* but differs in having no distinct black tip on first dorsal fin (vs. a very distinct, broad black tip on first dorsal fin).

Fresh adult (top) and neonate (bottom), highlighting the yellowy-green tinge to the body colour and the black fin edges

Upper tooth

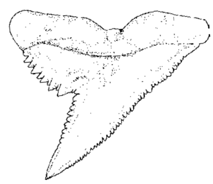


Image details: Lateral and ventral head: Queensland, Australia (53.5 cm TL). Fresh specimen: Shark Bay, Western Australia (adult female ~96 cm TL; neonate ~48 cm TL).

AUSTRALIAN BLACKSPOT SHARK

Carcharhinus coatesi (Whitley, 1939)

Ventral head

NE

BIOLOGY

Maximum size: 88 cm TL

Maturity size: Both sexes at about 70 cm TL

Birth size: 30–40 cm TL

Litter size: 1–3 (usually 2) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Second dorsal fin with conspicuous dusky to black tip, but all other fins plain
- First dorsal fin moderately tall, strongly falcate
- Interdorsal ridge usually present
- Snout moderately long, narrowly parabolic
- Upper teeth with strongly oblique cusps, flanked on one side by strong, smooth-edged cusplets
- Lower teeth narrow, upright, often with smooth-edged cusplets

Colour: Dorsal surfaces pale brown, sometimes greyish after death. Second dorsal fin with a distinct black tip; other fins plain. Ventral surfaces almost white.

Distribution: Found only in northern Australia and New Guinea to depths of at least 123 m. In PNG, confirmed from Western, Gulf, Central, Milne Bay and East Sepik provinces; very common in the Gulf of Papua.

Habitat and biology: A mostly coastal shark. Diet consists mainly of bony fishes, but also crustaceans and cephalopods. Breeding occurs throughout the year; thus no reproductive seasonality; gestation period unknown.

Utilisation: Common in the bycatch of the Gulf of Papua prawn trawl fishery and possibly caught by coastal fisheries in some provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

Remarks: Part of a species complex of 'blackspot' sharks (*Carcharhinus sealei-dussumieri* complex), and only recently recognised as being a valid species. The introduction of bycatch reduction devices in the northern Australia prawn trawl fishery has reduced the number of larger individuals of this species being caught. Currently no bycatch reduction devices in the Gulf of Papua fishery, but being investigated. Attains at least 6.5 years of age.

Similar species: Differs from other *Carcharhinus* species in having a distinctly black-tipped second dorsal fin, but all other fins plain (vs. more than just second dorsal fin black-tipped, or fins plain or dusky).

Fresh specimens from the bycatch of the Gulf of Papua prawn trawl fishery

Upper tooth

Lower tooth

Image details: Lateral and ventral head: Gulf of Papua (female 74 cm TL). Fresh specimens: Gulf of Papua, PNG. Teeth: Australia (female 76 cm TL).

SILKY SHARK

Carcharhinus falciformis (Bibron, 1839)

Ventral head

VU

BIOLOGY

Maximum size: ~330 cm TL

Maturity size: Females at 190–210 cm TL, males at 180–210 cm TL

Birth size: 56–87 cm TL

Litter size: 1–16 (average 8–10) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- First dorsal fin relatively low; origin well behind pectoral-fin rear tips
- Interdorsal ridge present
- Second dorsal fin low, its inner margin very long (1.6–3.0 times its height)
- Snout moderately long and narrowly rounded
- Upper teeth narrow, with one edge prominently notched
- Lower teeth narrow and upright

Colour: Dorsal surfaces dark brown to dark grey. First dorsal fin plain; other fins plain or with dusky tips. Ventral surfaces almost white.

Distribution: Widespread in all tropical seas and sometimes makes seasonal incursions into warm temperate areas; from the surface to depths of at least 500 m.

Habitat and biology: Oceanic and epipelagic; mostly found in water less than 200 m deep near continental shelf edges, and over deepwater reefs and seamounts; also found in the open sea. Known to segregate by size, with juveniles in offshore nursery areas close to land. Diet consists mainly of pelagic bony fishes, but also cephalopods and pelagic crabs. No obvious reproductive seasonality; breeding possibly every 2 years.

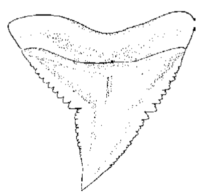
Utilisation: The most abundant shark caught in the shark longline fishery (when operational) and purse seine fishery; also caught in the tuna longline fishery and by coastal fisheries in many provinces, particularly Milne Bay Province. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

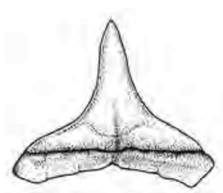
Remarks: An active, fast-swimming species that can sometimes be aggressive. Maximum age of PNG populations reported as 28 years, with males mature at 11.6 years and females at 14 years; slower growing than in other regions and thus less likely to be able to withstand high fishing pressure. Serious declines have been reported in some regions.

Similar species: Similar to, and can be confused with, *C. obscurus* but differs in having a more posteriorly positioned first dorsal fin with its origin well behind pectoral-fin rear tips (vs. first dorsal-fin origin about level with pectoral-fin rear tips) and snout more narrowly rounded to somewhat pointed (vs. snout more broadly rounded).

Cruising specimen, highlighting the plain, unmarked fins

Upper tooth





Lower tooth

Image details: Lateral: Bismarck Sea, PNG (male 130 cm TL). Ventral head: Bismarck Sea, PNG (adult male 210 cm TL). Underwater: PNG (by B. Halstead).

CREEK WHALER

Carcharhinus fitzroyensis (Whitley, 1943)

Ventral head

LC

BIOLOGY

Maximum size: 135 cm TL

Maturity size: Females at 90 cm TL, males at 80 cm TL

Birth size: ~50 cm TL

Litter size: 1–7 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Pectoral fins broad and triangular, not falcate
- First dorsal fin large, its origin over or slightly forward of pectoral-fin insertions
- Snout long and parabolic
- Interdorsal ridge absent
- Fins not black-tipped
- Upper anterior teeth with slightly oblique, serrated cusps and strong cusplets

Colour: Dorsal surfaces bronze, fading to greyish brown after death. Fins without obvious markings. Ventral surfaces almost white.

Distribution: Found only in northern Australia and southern PNG, to depths of 40 m. In PNG, confirmed from Western and Gulf provinces; probably restricted to the southern coastline.

Habitat and biology: A strictly coastal shark, found in the surf zone to the edge of the coastal shelf. Diet consists mainly of bony fishes, but also some crustaceans. In Australia, females give birth each year between February and May.

Utilisation: Caught by prawn trawlers in the Gulf of Papua, and also by coastal fisheries in Western and Gulf provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

Remarks: First confirmed from PNG during this study. Juveniles use bays as nursery grounds. Males and females attain at least 9 and 12.5 years of age, respectively.

Similar species: A distinctive species differing from other *Carcharhinus* species in having broadly triangular, non-falcate pectoral fins (vs. pectoral fins falcate).

Fresh specimen from the bycatch of the Gulf of Papua prawn trawl fishery, highlighting the broad, non-falcate pectoral fins and bronze colour when freshly landed

Upper tooth

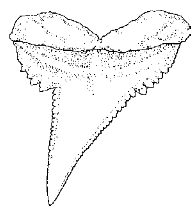
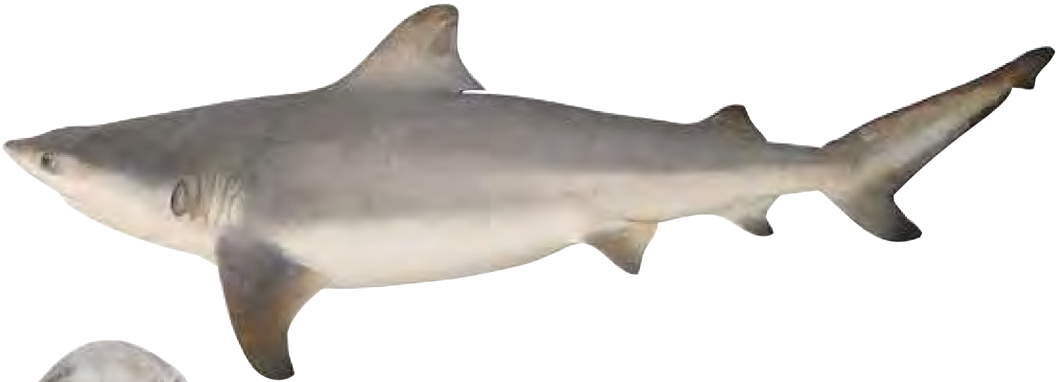


Image details: Lateral and ventral head: Gulf of Papua, PNG (juvenile male 76 cm TL). Fresh specimen: Gulf of Papua, PNG (female 89 cm TL).

BULL SHARK

Carcharhinus leucas (Valenciennes, 1839)



Ventral head

NT

BIOLOGY

Maximum size: ~340 cm TL

Maturity size: Females at ~230 cm TL, males at ~220 cm TL

Birth size: 56–81 cm TL

Litter size: 1–13 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- First dorsal-fin height up to 3 times height of second
- Notch on posterior margin of anal fin obtuse (forming a right angle or more)
- Interdorsal ridge absent
- Snout very short and broadly rounded; preoral length less than internarial space
- Upper teeth triangular; edges with broad, heavy, serrated cusps
- Lower teeth narrowly triangular and upright, usually in 12 rows on each side

Colour: Dorsal surfaces grey; a faint white stripe on each side. Juveniles with dusky to black fin tips and upper caudal fin with a narrow dark posterior margin. Fins mostly plain in adults. Ventral surfaces almost white.

Distribution: Cosmopolitan in tropical and warm temperate seas, estuaries, rivers and lakes, to depths of at least 150 m. In PNG, widespread, including well upstream in freshwater rivers and lakes.

Habitat and biology: Capable of tolerating a wide range of salinities from marine to freshwater rivers and lakes to hypersaline lakes. Recorded nearly 4,000 km from the sea in the Amazon system; often found in turbid waters. Diet includes a wide variety of prey, including fish, turtles, birds, dolphins, terrestrial mammals, crocodiles, crustaceans, molluscs and echinoderms; prefers bony fish, sharks and rays. Gestation period of 10–11 months; females give birth in estuaries and river mouths, and young remain in river systems for up to 5 years.

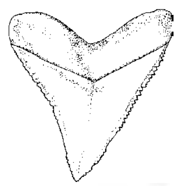
Utilisation: Caught by prawn trawlers in the Gulf of Papua, in coastal fisheries in a number of provinces, and rarely by the target longline fishery (when operational). Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

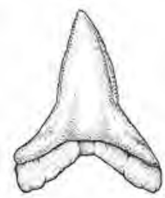
Remarks: A very dangerous shark with an extremely aggressive nature, especially in murky waters where it is often found; in clear water, appears less aggressive to humans. Destruction of nearshore habitats that are critical as nursery grounds for this species poses a threat in a number of areas. Popular for dive ecotourism in some areas with good visibility (e.g. Fiji).

Similar species: Easily confused with *C. amboinensis* but differs in having a lower first dorsal fin relative to the second dorsal fin, and anal fin with a less acute posterior margin forming an angle of more than 90° (vs. more acute, angle less than 90°).

Cruising specimen with two remora attached

Upper tooth



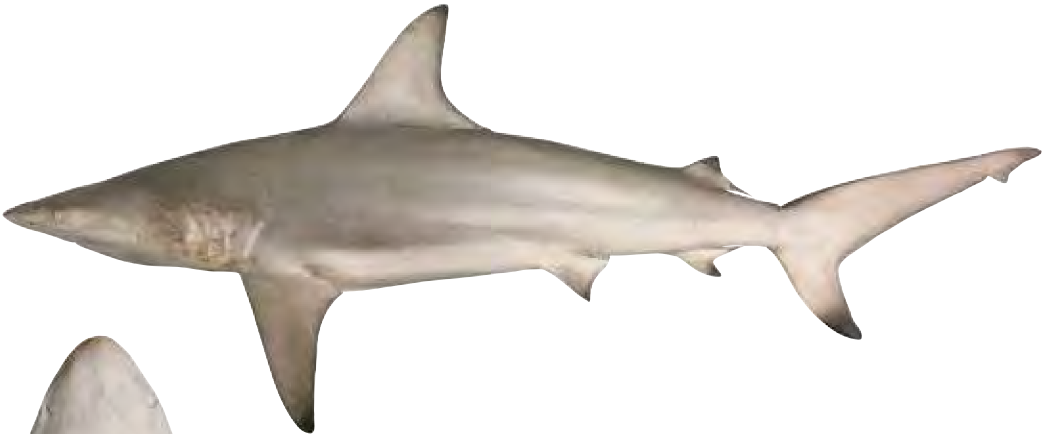


Lower tooth

Image details: Lateral and ventral head: Central Java, Indonesia (juvenile male 79 cm TL). Underwater: PNG (by B. Halstead).

COMMON BLACKTIP SHARK

Carcharhinus limbatus (Valenciennes, 1839)



Ventral head

NT

BIOLOGY

Maximum size: 250 cm TL

Maturity size: Females at 165–180 cm TL, males at 180–190 cm TL

Birth size: 55–72 cm TL

Litter size: 1–10 (usually 4–7) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Dorsal and caudal fins with black tips (less evident in adults)
- Interdorsal ridge absent
- Snout moderately long and pointed; internarial space 1.2–1.4 times preoral snout length
- First dorsal fin relatively high, its height 2.2 times or less in distance between dorsal fins
- Upper labial furrows short, barely noticeable
- Ventral surface of pelvic fins with distinct black tips

Colour: Dorsal surfaces bronze, fading to grey after death; a faint white stripe on each side. Juveniles with black-tipped fins (anal and pelvic fins sometimes plain); fins sometimes plain or dusky in large individuals. Ventral surfaces almost white.

Distribution: Cosmopolitan in tropical and warm temperate seas, usually in less than 30 m depth.

Habitat and biology: Pelagic over continental and coastal shelves, mostly close inshore but sometimes well offshore. Diet consists of bony fish, sharks, rays, cephalopods and crustaceans. Gestation of 10–12 months, with females breeding every second year; females move inshore to give birth in nursery grounds.

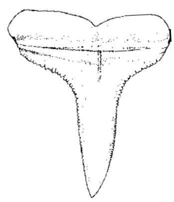
Utilisation: Caught by prawn trawlers in the Gulf of Papua (juveniles), in coastal fisheries in a number of provinces, and by the target longline fishery (when operational). Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

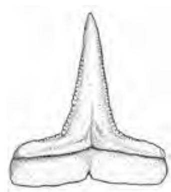
Remarks: Occasionally leaps out of the water while feeding on small fish. Sometimes forms large aggregations; often segregates by age and sex. Attains a maximum age of at least 12 years, with males mature at 5–6 years and females at 6–7 years.

Similar species: Almost identical to *C. tilstoni* but differs in having more vertebrae (precaudal centra >92 vs. <91) and ventral pelvic fins with distinct black tips (vs. ventral pelvic fins plain or with dusky tips). Also similar to *C. amblyrhynchoides* but differs in being more slender (vs. body more robust) and having a longer snout. Possibly confused with *C. brevipinna* but differs in having a shorter snout with very short labial furrows (vs. labial furrows long and prominent) and a relatively tall first dorsal fin (vs. first dorsal fin low).

Cruising specimen, highlighting the distinctive black-tipped fins

Upper tooth





Lower tooth

Image details: Lateral and ventral head: Daru, PNG (juvenile male 126 cm TL). Underwater: Kavieng, PNG (by D. Borcherds).

OCEANIC WHITETIP SHARK

Carcharhinus longimanus (Poey, 1861)

Ventral head

VU

BIOLOGY

Maximum size: 350 cm TL, usually less than 300 cm TL

Maturity size: Females at 175–200 cm TL, males at 168–198 cm TL

Birth size: 55–77 cm TL

Litter size: 1–15 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- First dorsal and pectoral fins enlarged, with very broadly rounded tips
- Fin tips mottled white in adults (some black tips in juveniles)
- Interdorsal ridge present
- Snout short and broadly rounded
- Upper teeth strongly serrated, with broad, erect, triangular cusps (more oblique posteriorly)
- Lower teeth narrow and upright (not figured)

Colour: Dorsal surfaces bronze to greyish. Newborns and small juveniles with black tips to most fins; in specimens over 130 cm TL, black tips fade, and first dorsal, pectoral, pelvic and caudal fins develop mottled white tips. Ventral surfaces paler.

Distribution: Cosmopolitan in tropical and warm temperate seas, from the surface to at least 150 m depth.

Habitat and biology: Oceanic and pelagic, mostly well offshore but also sometimes close inshore when continental shelf is narrow. Diet consists mainly of pelagic bony fishes and cephalopods, but also stingrays, sea birds, turtles, marine gastropods, crustaceans and marine mammal carrion. Gestation period about 12 months, but with no apparent reproductive seasonality; females probably breed every second year.

Utilisation: Caught by the target longline (when operational), tuna longline and purse seine fisheries. Dried fins sold to local buyers and subsequently exported.

Remarks: Prefers water temperatures above 20 °C. The mottled white fins may mimic schools of baitfish, which attract tuna and mackerels. A very dangerous shark, which is responsible for many open-ocean attacks after air or sea disasters. Major population declines have been reported in some areas. Both sexes mature at about 5–7 years of age.

Similar species: A distinct species clearly separable from other *Carcharhinus* species by the broadly rounded fin tips and the white-mottled first dorsal-, caudal- and pectoral-fin tips (most distinct in adults).

Fresh specimen from the target shark longline catch, highlighting the broadly rounded fin tips

Upper tooth

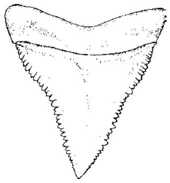


Image details: Lateral: Bismarck Sea, PNG (155 cm TL). Ventral head: Central Java, Indonesia (juvenile male 87 cm TL). Fresh specimen: Bismarck Sea, PNG (female 170 cm TL).

HARDNOSE SHARK

Carcharhinus macloti (Müller & Henle, 1839)

Ventral head

Juvenile

NT

BIOLOGY

Maximum size: 110 cm TL

Maturity size: Females at 70–89 cm TL, males at 69–74 cm TL

Birth size: 31–40 cm TL

Litter size: 1–2 (usually 2) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Second dorsal-fin origin opposite midbase of anal fin
- First dorsal-fin inner margin extremely long, about two-thirds of fin base
- Interdorsal ridge absent
- Snout long and pointed, hard (rostral cartilage hypercalcified)
- Upper teeth with narrow, oblique or nearly erect central cusp; surrounded by strong cusplets
- Lower teeth tall, narrow, upright and smooth edged

Colour: Dorsal surfaces bronze, fading to greyish brown after death; a faint pale stripe on each side. Fins lacking distinct markings; posterior margins of some fins sometimes pale-edged. Ventral surfaces almost white.

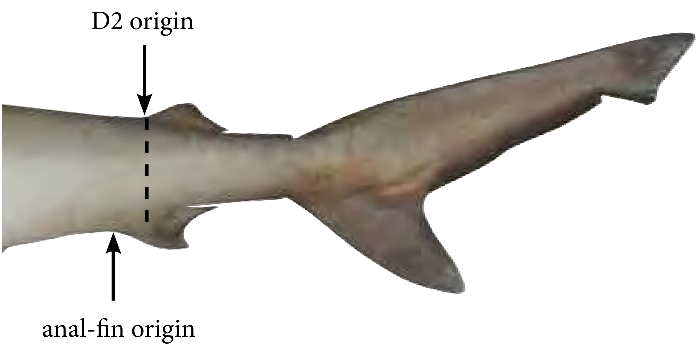
Distribution: Found in the tropical Indo–west Pacific, from east Africa to PNG and northwards to South Korea, to depths of 170 m. In PNG, confirmed from Gulf, Central and East Sepik provinces.

Habitat and biology: A mostly inshore species that can form large, sexually segregated aggregations. Diet consists mainly of bony fishes, but also cephalopods and crustaceans. In Australia, gives birth in July after a gestation period of about 12 months; females breed every 2 years.

Utilisation: Caught by prawn trawlers in the Gulf of Papua and by coastal fisheries in some provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

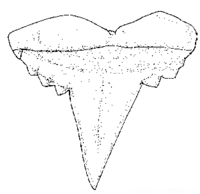
Remarks: The only *Carcharhinus* species to have a hypercalcified rostrum, which can be felt by pinching the snout, most evident in larger individuals. Attains at least 12 years of age.

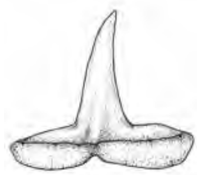
Similar species: A distinct species clearly separable from other *Carcharhinus* species by having the second dorsal-fin origin level with anal-fin midbase (vs. level with anal-fin origin). Also often misidentified as one of the *Rhizoprionodon* species, but differs from this genus in having second dorsal and anal fins similar sized (vs. anal fin much larger than second dorsal fin), and posterior margin of anal fin deeply notched (vs. anal-fin posterior margin almost straight).



Posterior lateral view, highlighting the position of the second dorsal fin relative to the anal fin

Upper tooth





Lower tooth

Image details: Lateral: Gulf of Papua, PNG (female 81 cm TL). Ventral head: Gulf of Papua, PNG (female 38 cm TL). Juvenile: Gulf of Papua, PNG (juvenile male 41 cm TL).

BLACKTIP REEF SHARK

Carcharhinus melanopterus (Quoy & Gaimard, 1824)

Ventral head

NT

BIOLOGY

Maximum size: 180 cm TL, usually less than 150 cm TL

Maturity size: Females at 96–130 cm TL, males at 91–105 cm TL

Birth size: 33–52 cm TL

Litter size: 2–4 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- First dorsal and lower caudal fins with broad black tips
- Posterior margin of caudal fin with a distinct, narrow black edge
- Interdorsal ridge absent
- Snout short and bluntly rounded; internarial space 0.8–1.1 times preoral snout length
- Upper teeth narrowly triangular, erect to oblique with coarse serrations at their base

Colour: Dorsal surfaces yellowish brown to grey; a distinct pale stripe on each side. First dorsal and ventral caudal fins distinctly black; other fins usually with smaller black tips (second dorsal often plain). Ventral surfaces white.

Distribution: Found in the tropical Indo–west and central Pacific, from south-eastern Africa to the central Pacific islands. Widespread in PNG on shallow coral reefs.

Habitat and biology: Found in very shallow water (usually only a few metres deep) on coral reefs and reef flats, and near reef drop-offs, as well as in mangrove habitats during high tides; occasionally found in brackish waters. Diet consists mainly of bony fishes, but also crustaceans, cephalopods, other molluscs and terrestrial snakes. In northern Australia, females give birth in each November after an 8–9-month gestation; gestation longer in other areas (e.g. 16 months in Red Sea population).

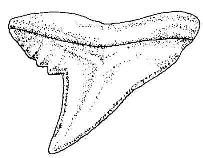
Utilisation: Common catch of coastal fishers operating in shallow reef habitats; common incidental catch when fishing for reef fish. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

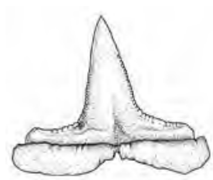
Remarks: A strong swimmer found both alone and in small groups; they have a relatively small home range. Important for dive ecotourism in many areas. Not considered dangerous but has been known to be aggressive to spearfishers. Maximum age of north-eastern Australian populations reported for males and females as 10 and 15 years, respectively, with males mature at 4.2 years and females at 8.5 years.

Similar species: Most similar to *C. cautus* but differs in having a distinct black tip on first dorsal fin (vs. first dorsal fin without a distinct black tip).

Specimen cruising over reef flats, highlighting the pale stripe on side

Upper tooth





Lower tooth

Image details: Lateral: Daru, PNG (male 82 cm TL). Ventral head: Lombok, Indonesia (female 63 cm TL). Underwater: PNG (by B. Halstead).

DUSKY SHARK

Carcharhinus obscurus (Lesueur, 1818)

Ventral head

VU

BIOLOGY

Maximum size: 365 cm TL

Maturity size: Females at 295–310 cm TL, males at 265–280 cm TL

Birth size: 69–100 cm TL

Litter size: 3–14 (usually 5–12) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- First dorsal-fin origin opposite pectoral-fin free rear tip
- Second dorsal-fin inner margin long, its length 1.6–2.1 times its height
- Interdorsal ridge present
- Snout short and rounded
- Upper teeth low, broadly triangular, erect to moderately oblique, edges serrated
- Lower teeth narrow, upright, edges weakly serrated (not figured)

Colour: Dorsal surfaces bronzy grey to dark grey; a faint pale stripe on each side. Fin tips mostly dusky in juveniles, plain in adults. Ventral surfaces paler.

Distribution: Cosmopolitan, but patchy, in tropical and warm temperate seas, from the surf zone to depths of at least 400 m.

Habitat and biology: Found throughout the water column on coastal and continental shelves, but also seen well offshore following ships; newborn juveniles found in inshore nursery areas away from the rest of the population. Diet consists mainly of bony fishes, sharks and rays, but also cetaceans, crustaceans and cephalopods. In Western Australia, females give birth during summer and autumn after a 16-month gestation; females breed every second or third year.

Utilisation: Occasionally caught by the target longline fishery (when operational), and probably also the tuna longline fishery and possibly the purse seine fishery.

Remarks: A highly migratory species, moving into warm temperate and subtropical waters in summer months, and then moving into tropical waters when water begins to cool. Maximum age of the Western Australian population reported as 32 years, with males mature at 20–23 years and females at 17–22 years. Very similar to *C. galapagensis*, which is mostly restricted to oceanic islands; this species not verified from PNG but likely to be present in the outer island chains.

Similar species: Similar to, and commonly confused with, *C. falciformis* but differs in having a first dorsal-fin origin in line with pectoral-fin rear tips (vs. first dorsal-fin origin well behind pectoral-fin rear tips) and a more broadly rounded snout (vs. snout narrowly rounded).

Fresh specimen from the target shark longline catch, highlighting the large size of individuals of this species observed in PNG waters

Upper tooth

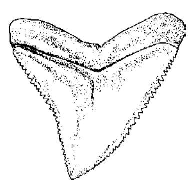


Image details: Lateral and ventral head: Queensland, Australia (juvenile male 126 cm TL). Fresh specimen: Bismarck Sea, PNG (female 305 cm TL).

SANDBAR SHARK

Carcharhinus plumbeus (Nardo, 1827)

Ventral head

VU

BIOLOGY

Maximum size: 240 cm TL, possibly to 300 cm TL

Maturity size: Females at 145–185 cm TL, males at 130–180 cm TL

Birth size: 52–75 cm TL

Litter size: 1–14 (usually 5–12) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- First dorsal fin very tall, its height about half predorsal length
- First dorsal-fin origin over pectoral-fin insertions
- Interdorsal ridge present
- Snout short and broadly rounded
- Upper teeth broadly triangular, erect to slightly oblique
- Lower teeth narrow, upright, edges serrated

Colour: Dorsal surfaces pale bronze to greyish brown; a faint pale stripe on each side. Dorsal and upper caudal fin sometimes with dusky edges; pectoral, pelvic, caudal and anal fins of juveniles often with pale tips and posterior margins, less evident in adults. Ventral surfaces pale.

Distribution: Cosmopolitan, but patchy, in tropical and warm temperate seas, from the intertidal to depths of at least 280 m, mostly 20–55 m.

Habitat and biology: Common in bays and near river mouths, but also offshore on oceanic banks and near drop-offs. Diet consists mainly of bony fishes, but also crustaceans and cephalopods. In Australia, females give birth between February and April after a 12-month gestation; females breed every second year.

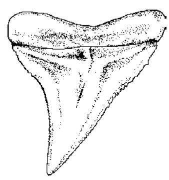
Utilisation: Occasionally caught by the target longline fishery (when operational) and by coastal fisheries in some provinces.

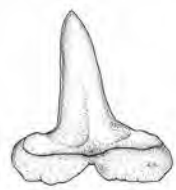
Remarks: Migratory in some areas, moving towards warmer waters during colder months; juveniles segregated from adults, and sexes tend to also segregate from each other. Maximum age of the Western Australian population reported as 25 years, with males mature at 13.8 years and females at 16.2 years.

Similar species: Most similar to *C. altimus* but differs in having a very tall first dorsal fin (vs. lower first dorsal fin) and relatively short snout (vs. snout moderately long).

Fresh specimen from the target shark longline catch, highlighting the very tall first dorsal fin that larger individuals develop

Upper tooth





Lower tooth

Image details: Lateral: Bali, Indonesia (female 107 cm TL). Ventral head: Lombok, Indonesia (juvenile male 87.5 cm TL). Fresh specimen: Bismarck Sea, PNG (adult male, 172 cm TL).

SPOT-TAIL SHARK

Carcharhinus sorrah (Valenciennes, 1839)

Ventral head

NT

BIOLOGY

Maximum size: 160 cm TL

Maturity size: Both sexes at 90–95 cm TL

Birth size: 45–60 cm TL

Litter size: 1–8 (average 3) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Second dorsal, pectoral and lower caudal fins strikingly black-tipped
- Second dorsal fin very low with an extremely long inner margin (exceeding twice fin height)
- Interdorsal ridge present
- Snout moderately long and pointed
- Upper teeth with oblique cusp, with strong cusplets on one side
- Lower teeth narrow, oblique, without cusplets

Colour: Dorsal surfaces bronze, fading to brownish grey to grey after death; a pale stripe on each side. Pectoral, second dorsal and lower caudal fins with distinct black tips; first dorsal and upper caudal fins with dusky margins. Ventral surfaces almost white.

Distribution: Found in the tropical Indo–west Pacific, from south-eastern Africa to Solomon Islands and northwards to southern Japan, from the intertidal to depths of at least 140 m. In PNG, confirmed from Western, Gulf, Central and Milne Bay provinces.

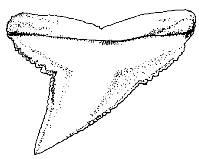
Habitat and biology: Found mostly in shallow water over muddy bottoms, but also near coral reefs; usually in midwater or near the surface. Diet consists mainly of bony fishes, but also crustaceans and cephalopods (mostly octopuses). In Australia, females give birth in January after a 10-month gestation; females breed every year.

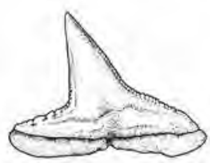
Utilisation: Caught by coastal fisheries in some provinces and occasionally in the bycatch of the Gulf of Papua prawn trawl fishery. Although recorded in the catches of the target longline fishery, these appear to be all (or mostly) misidentifications.

Remarks: Newborns found in shallower water, segregated from adults. Maximum age of northern Australian populations reported for males and females as 7 and 5 years, respectively, with both sexes mature at 2–3 years. Population genetic studies have shown that Indonesian and northern Australian populations are not shared.

Similar species: Commonly confused with the black-tipped species (*C. amblyrhynchoides*, *C. brevipinna*, *C. limbatus* and *C. tilstoni*) but differs in having an interdorsal ridge (vs. no interdorsal ridge) and in having the first dorsal and pelvic fins not distinctly black-tipped (vs. usually distinctly black-tipped, at least in juveniles).

Upper tooth





Lower tooth

Image details: Lateral: Borneo, Malaysia (female 64 cm TL). Ventral head: Borneo, Malaysia (female 68 cm TL).

AUSTRALIAN BLACKTIP SHARK

Carcharhinus tilstoni (Whitley, 1950)

Ventral head

LC

BIOLOGY

Maximum size: 200 cm TL

Maturity size: Females at 105–115 cm TL, males at 105–110 cm TL

Birth size: 55–60 cm TL

Litter size: 1–6 (average 3)

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Dorsal and caudal fins with black tips (less evident in adults)
- Interdorsal ridge absent
- Snout moderately long and pointed; internarial space 1.2–1.4 times preoral snout length
- First dorsal fin relatively high, its height <2.2 times in distance between dorsal fins
- Upper labial furrows short, barely noticeable
- Ventral surface of pelvic fins without distinct black tips

Colour: Dorsal surfaces bronze, fading to grey after death; a faint white stripe on each side. All fins (except sometimes anal and pelvic fins) black-tipped. Ventral surfaces almost white.

Distribution: Found only in northern Australia and mainland PNG, from close inshore to depths of about 150 m. In PNG, confirmed from Western, Gulf, Milne Bay and East Sepik provinces.

Habitat and biology: Pelagic over continental and coastal shelves, mostly close inshore but sometimes more offshore. Diet consists mainly of bony fishes, but also cephalopods. Gives birth in January after a 10-month gestation; females breed every year.

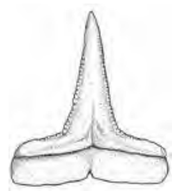
Utilisation: Caught by prawn trawlers in the Gulf of Papua (juveniles) and in coastal fisheries in the southern mainland provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

Remarks: Often forms large aggregations. Maximum age of northern Australian populations reported for males and females as 8 and 12 years, respectively, with both sexes mature at 3–4 years.

Similar species: Almost identical to *C. limbatus* but differs in having less vertebrae (precaudal centra <91 vs. >92) and ventral pelvic fins without distinct black tips (vs. ventral pelvic fins with distinct black tips). Also similar to *C. amblyrhynchoides* but differs in being more slender (vs. body more robust) and having a longer snout. Possibly confused with *C. brevipinna* but differs in having a shorter snout with very short labial furrows (vs. labial furrows long and prominent) and a relatively tall first dorsal fin (vs. first dorsal fin low).

Fresh specimen from the bycatch of the Gulf of Papua prawn trawl fishery

Upper tooth



Lower tooth

Image details: Lateral and ventral head: Gulf of Papua, PNG (juvenile male 69 cm TL). Fresh specimen: Gulf of Papua, PNG (adult male 139 cm TL).

NORTHERN RIVER SHARK

Glyphis garricki Compagno, White & Last, 2008

Ventral head

BIOLOGY

Maximum size: 251 cm TL

Maturity size: Females at ~177 cm TL, males at ~140 cm TL

Birth size: 50–60 cm TL

Litter size: At least 9 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Second dorsal fin tall, slightly more than half height of first
- Precaudal pits shallow and longitudinal
- Ventral tips of pectoral fins without a distinct black blotch
- Boundary between light and dark areas (waterline) on head passing more than an eye diameter below eye
- Snout elongate, depressed and broadly rounded
- Upper teeth broadly triangular, erect and serrated
- Lower teeth erect and slender (tips of front teeth spear-shaped in largest individuals)

Colour: Dorsal surfaces greyish; light and dark areas on head form a distinct boundary (waterline), passing more than an eye diameter below eye. Ventral surfaces white.

Distribution: Found only in northern Australia and southern PNG. In PNG, confirmed from coastal areas of Western and Gulf provinces, and likely restricted to these areas.

Habitat and biology: Found in turbid freshwater rivers, brackish estuaries and adjacent coastal marine waters. Diet consists mainly of bony fishes, sharks and rays. In northern Australia, probably gives birth around October.

Utilisation: Caught by coastal fishers in Western and Gulf provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

Remarks: Found in freshwater to coastal marine waters, although not in upper reaches of rivers; prefers brackish waters in the tidal reaches of rivers. First recorded from PNG in the 1960s, but not recorded again until 2014 during field surveys to Daru and Katatai in Western Province during this study.

Similar species: Similar to *G. glyphis* but differs in having the waterline passing well below level of eye (vs. passing just below eye) and second dorsal fin about half height of first (vs. second dorsal fin about three-quarters height of first).

Dorsal view, highlighting the broad pectoral fins and broadly rounded snout

Upper tooth

Lower tooth

Image details: Lateral and dorsal: Daru, PNG (113 cm TL). Ventral head: Western Australia (juvenile male 99 cm TL).

SPEARTOOTH SHARK

Glyphis glyphis (Müller & Henle, 1839)

Ventral head

EN

BIOLOGY

Maximum size: ~260 cm TL

Maturity size: Females at ~250 cm TL, males at ~228 cm TL

Birth size: 50–65 cm TL

Litter size: 6–7 pups (based on anecdotal records)

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Second dorsal fin tall, about three-quarters height of first
- Precaudal pits shallow and longitudinal
- Ventral tips of pectoral fins with a distinct black blotch
- Boundary between light and dark areas (waterline) on head passing just below eye
- Snout short and broadly wedge-shaped
- Upper teeth broadly triangular, erect to semi-oblique and serrated
- Lower teeth erect and slender (tips of front teeth spear-shaped in adults)

Colour: Dorsal surfaces greyish; light and dark areas on head form a distinct boundary (waterline), passing just below eye. Ventral surfaces almost white.

Distribution: Found only in northern Australia and southern PNG. In PNG, confirmed from coastal areas of Western and Gulf provinces, and likely restricted to these areas.

Habitat and biology: Found in turbid freshwater rivers, brackish estuaries and adjacent coastal marine waters. Diet consists of bony fishes and crustaceans. In northern Australia, newborn individuals commonly seen in some rivers from October to December. In PNG, a pregnant female caught in October contained near-term embryos; thus birth likely occurs in October.

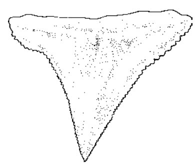
Utilisation: Caught by coastal fishers in Western and Gulf provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

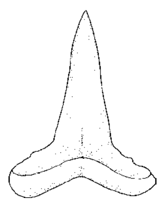
Remarks: Juveniles and subadults found in freshwater rivers through to brackish estuaries. First recorded from PNG in the 1960s, but not recorded again until 2014 during field surveys to Daru and Katatai in Western Province during this study. These recent PNG specimens represented the first adult males and females recorded for this species, and provided confirmation that it occurs in coastal marine waters.

Similar species: Similar to *G. garricki* but differs in having the waterline passing just below level of eye (vs. passing well below eye) and second dorsal fin about three-quarters height of first (vs. second dorsal fin about half height of first).

Fresh specimen caught in coastal gillnet fishery in Daru, highlighting the tall second dorsal fin

Upper tooth





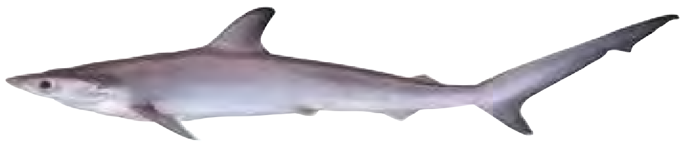
Lower tooth

Image details: Lateral and ventral head: Northern Territory, Australia (juvenile male 77 cm TL). Fresh specimen: Daru, PNG (adult male ~230 cm TL).

SLIT-EYE SHARK

Loxodon macrorhinus Müller & Henle, 1839

Ventral head



Newborn

LC

BIOLOGY

Maximum size: 99 cm TL

Maturity size: Females at 66–79 cm TL, males at 62–82 cm TL

Birth size: 40–55 cm TL

Litter size: 2–4 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Eyes large, with distinct notch on their posterior edge
- Second dorsal-fin origin over anal-fin insertion
- First dorsal-fin upright, base short (its length 2–3 times in distance between pectoral and pelvic fins)
- Preanal ridges very long, equal to length of anal-fin base
- Snout very long and parabolic
- Upper and lower teeth with smooth-edged, narrowly triangular and oblique cusps

Colour: Dorsal surfaces bronze to greyish. Pectoral, pelvic and lower caudal fins with pale tips. Ventral surfaces almost white.

Distribution: Found in the tropical and subtropical Indo–west Pacific, from south-eastern Africa to PNG and northwards to southern Japan, at depths of 7–100 m. In PNG, only confirmed from off New Ireland and East New Britain, but probably more widespread.

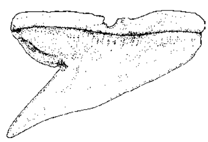
Habitat and biology: Found over coastal and continental shelves in clear water; six individuals caught off New Ireland and East New Britain by shark longlines were taken offshore over deep water; a specimen was also recorded in the bycatch of the deepwater snapper fishery off Kavieng, New Ireland. Diet consists of small bony fishes (particularly anchovies), crustaceans and cephalopods. In north-eastern Australia, females give birth each December or January after a 9–12-month gestation.

Utilisation: Caught occasionally by longline fisheries; probably caught by coastal fisheries in some provinces. Meat likely used for human consumption, and dried fins, although small, probably sold.

Remarks: Prefers very clear water, at least in coastal areas (e.g. adjacent to reefs). Interestingly, all records from PNG to date were taken from deeper, more offshore waters. Maximum age of a north-eastern Australian population reported for males and females as 7 and 9 years, respectively, with males mature at 1.9 years and females at 1.4 years. Size at birth varies regionally (e.g. 54–55 cm TL in Indonesia vs. 40–43 cm TL in northern Australia).

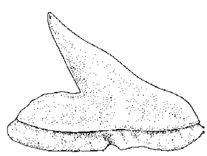
Similar species: Similar to *Rhizoprionodon* species but differs in having a more posteriorly positioned first dorsal fin and eyes with a small but distinct posterior notch (vs. no notch on eyes).

Upper tooth



notch

Eye



Lower tooth

Image details: Lateral and ventral head: Lombok, Indonesia (female 60.5 cm TL). Juvenile and eye: Deira, United Arab Emirates (~45 cm TL).

SICKLEFIN LEMON SHARK

Negaprion acutidens (Rüppell, 1837)

Ventral head

Mid-term embryo

VU

BIOLOGY

Maximum size: 310 cm TL

Maturity size: Both sexes at ~220 cm TL

Birth size: 50–70 cm TL

Litter size: 1–14 (average 9) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Second dorsal fin relatively large, similar height to first
- Upper precaudal pit deep and crescentic
- Interdorsal ridge absent
- Snout short and very broadly rounded
- Anal fin large, about same height as second dorsal fin
- Fins without any distinct markings (sometimes black-edged)
- Upper and lower teeth upright with narrow, smooth-edged cusps

Colour: Dorsal surfaces uniform pale yellow to light brown or greyish. Fins without distinct markings, but may be black-edged. Ventral surfaces whitish.

Distribution: Found in the tropical Indo–west and central Pacific, from the intertidal zone to depths of at least 90 m. In PNG, confirmed from Western and Milne Bay provinces, but probably widespread.

Habitat and biology: A relatively slow-swimming species mostly found in bays, estuaries, mangrove stands, shallow sand and reef flats, and lagoons. Diet consists mainly of bony fishes and rays, but also crustaceans and cephalopods. Gestation lasts 10–11 months, with females breeding every second year.

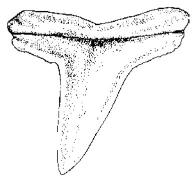
Utilisation: Caught occasionally by coastal fisheries in some provinces. Meat likely used for human consumption, and dried fins sold to local buyers and subsequently exported.

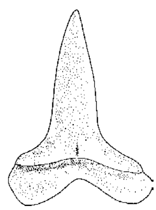
Remarks: Prefers turbid, still water. Usually shy and rarely approaches people; juveniles can be inquisitive. Movement studies have shown that juveniles have very restricted movements. Adults more active at night; juveniles often found in the intertidal zone during the day.

Similar species: A distinctive species, but general body colour of live sharks similar to that of *Carcharhinus cautus* and *C. melanopterus*; differs in having both dorsal fins similar in height (vs. second dorsal fin much smaller than first).

First (left) and second (right) dorsal fins (dried), highlighting their different shapes despite similar height

Upper tooth



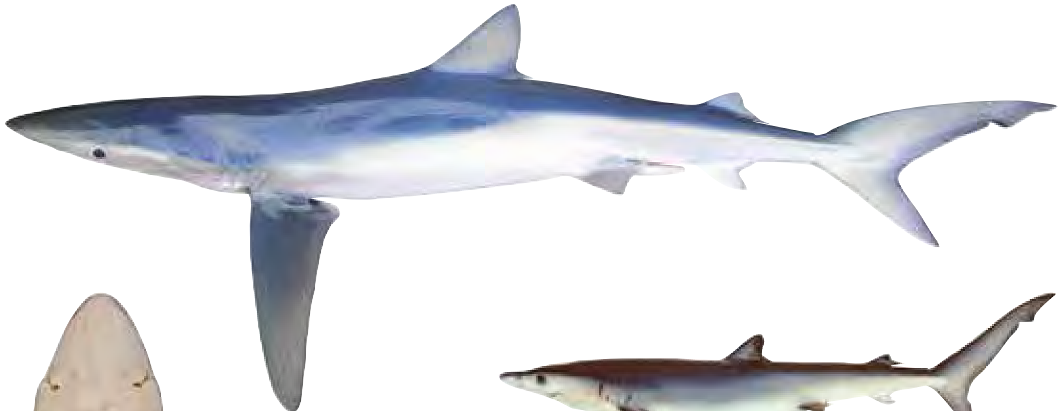


Lower tooth

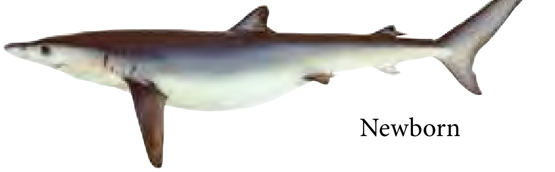
Image details: Lateral and ventral head: Queensland, Australia (female 84 cm TL). Embryo: Lombok, Indonesia (~31 cm TL). Dorsal fins: PNG.

BLUE SHARK

Prionace glauca (Linnaeus, 1758)



Ventral head



Newborn

NT

BIOLOGY

Maximum size: 383 cm TL

Maturity size: Females at 207–220 cm TL, males at 182–220 cm TL

Birth size: 35–50 cm TL

Litter size: 4–135 (usually 15–30) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- First dorsal-fin base closer to pelvic fin than pectoral-fin base
- Pectoral fin very long and scythe-like
- Caudal peduncle with weak lateral keels
- Upper surfaces indigo blue; white below
- Snout very long and narrowly rounded
- Upper teeth narrowly triangular, oblique and finely serrated (somewhat hooked in adults)
- Lower teeth slender, erect and finely serrated

Colour: Dorsal surfaces indigo blue, often fading to dull grey after death. Fins without distinct markings, except for dusky ventral pectoral-fin tips. Ventral surfaces white.

Distribution: Cosmopolitan in all tropical and temperate seas, from the surface to at least 1,000 m depth.

Habitat and biology: Oceanic and pelagic, usually well offshore but also occurs inshore where the continental shelf is narrow; prefers water temperatures of 12–20 °C. Diet consists mainly of pelagic bony fishes and cephalopods, but also small sharks and seabirds. Gestation lasts 9–12 months, with females breeding every 1 or 2 years.

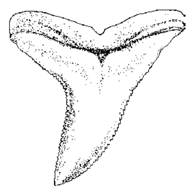
Utilisation: Caught by the target shark longline (when operational) and tuna longline fishery, probably also in the purse seine fishery. Meat typically discarded because of poor quality, but fins retained, dried and exported.

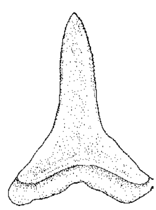
Remarks: Migrate seasonally to warmer waters in some areas; capable of undertaking trans-Atlantic migrations and from Northern to Southern Hemisphere; reported to frequently dive from the surface to more than 600 m depth. Size classes and sexes segregate. Potentially dangerous because of its persistence, but not very aggressive. One of the most heavily fished sharks globally.

Similar species: A distinctive species. Rarely misidentified as *Isurus paucus* based on the similar pointed snout, dark-blue colouration and long pectoral fins, but differs in having an asymmetrical caudal fin, with a much longer upper lobe and shorter lower lobe (vs. caudal fin lunate, with upper and lower lobes of similar length).


Example of a large litter of pups from a pregnant female shark

Upper tooth





Lower tooth

Image details: Lateral: Bismarck Sea, PNG (adult male 255 cm TL). Ventral head and newborn: Tasmania, Australia (juvenile male 58 cm TL). Litter from pregnant female: Bismarck Sea, PNG.

MILK SHARK

Rhizoprionodon acutus (Rüppell, 1837)

Ventral head

Newborn

LC

BIOLOGY

Maximum size: 100 cm TL

Maturity size: Females at 70–81 cm TL, males at 68–72 cm TL

Birth size: 31–39 cm TL

Litter size: 1–8 (usually 2–5) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Second dorsal-fin origin opposite anal-fin insertion
- Anal fin larger than second dorsal fin, its posterior margin shallowly concave
- Preanal ridges very long, about equal to length of anal-fin base
- Snout long and narrowly rounded
- Upper labial furrows long and prominent, 1.4–2% of TL
- Upper and lower teeth narrowly triangular and oblique (smooth-edged to finely serrate)

Colour: Dorsal surfaces bronze to greyish, fading to grey after death. Pectoral, pelvic, anal and lower caudal-fin tips and pectoral-fin posterior margins pale; upper lobe of caudal edged with black and with a dusky tip. Ventral surfaces white.

Distribution: Found in the eastern Atlantic and Indo–west Pacific, from close inshore to depths of at least 200 m. In PNG, widespread, although not confirmed from New Ireland or Bougainville.

Habitat and biology: Found throughout the water column, usually near the bottom, on coastal and continental shelves. Diet consists mainly of bony fishes, but also crustaceans and cephalopods. Gestation lasts about 12 months, but with no reproductive seasonality; females probably give birth each year.

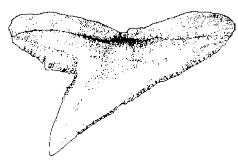
Utilisation: Caught as bycatch in the Gulf of Papua prawn trawl fishery and also by coastal fishers in a number of provinces, particularly Western and Gulf provinces. Meat used for human consumption, and dried fins of at least larger sharks sold to local buyers and subsequently exported.

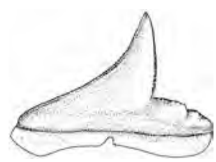
Remarks: Populations appear to have increased in some areas where there have been declines in large inshore sharks (e.g. South Africa). Regional differences in some DNA sequences suggest this may represent a complex of species. Maximum age of north-eastern Australian populations reported for males and females as 4.5 and 8.1 years, respectively, with males mature at 1.1 years and females at 1.8 years.

Similar species: Similar to *R. oligolinx* and *R. taylori* but differs in having long and prominent upper labial furrows (vs. upper labial furrows very short).

Two fresh specimens from the bycatch of the Gulf of Papua prawn trawl fishery

Upper tooth





Lower tooth

Image details: Lateral and ventral head: Gulf of Papua, PNG (adult male 77 cm TL). Juvenile: Gulf of Papua, PNG (male 36 cm TL). Fresh specimens: Gulf of Papua, PNG.

GREY SHARPNOSE SHARK

Rhizoprionodon oligolinx Springer, 1964

Ventral head

LC

BIOLOGY

Maximum size: 70 cm TL

Maturity size: Females at 32–41 cm TL, males at 29–38 cm TL

Birth size: 21–26 cm TL

Litter size: 3–5 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Second dorsal-fin origin opposite anal-fin insertion
- Anal fin larger than second dorsal fin, its posterior margin shallowly concave
- Preanal ridges very long, about equal to length of anal-fin base
- Snout long and narrowly rounded
- Upper labial furrows very short, less than 1% of TL
- 15–22 enlarged pores in total from each side near mouth corners
- Teeth with narrowly triangular, smooth-edged, oblique cusps

Colour: Dorsal surfaces bronze to greyish, fading to grey after death. Pectoral-fin posterior margins pale; upper lobe of caudal edged with black. Ventral surfaces white.

Distribution: Found in the Indo–west Pacific, from the Persian Gulf to northern Australia and northwards to southern Japan. In PNG, only known from one dried jaw without locality data.

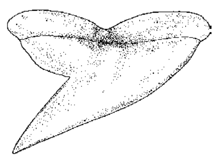
Habitat and biology: Found inshore and offshore on coastal and continental shelves. Diet consists of bony fishes, crustaceans and cephalopods. Reproductive biology mostly unknown, although females give birth in January and February off Mumbai in India.

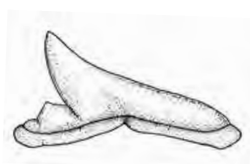
Utilisation: Unknown; likely to be caught by coastal fisheries and as bycatch in the prawn trawl fishery if populations confirmed in PNG.

Remarks: This species is included based only on a set of dried jaws re-identified as this species; known from northern Australia based on a single record from the Gulf of Carpentaria. More specimens needed to confirm presence in PNG; possibly only rarely found in PNG. There were no locality data for the dried jaw specimen, but it was presumed to be from PNG waters given the localised nature of the PNG fish collection.

Similar species: Similar to *R. acutus* but differs in having very short upper labial furrows (vs. upper labial furrows very long and prominent). Also similar to *R. taylori* but differs in having a total of 15–22 enlarged pores near mouth corners (vs. 7–16 enlarged pores in total near mouth corners).

Upper tooth



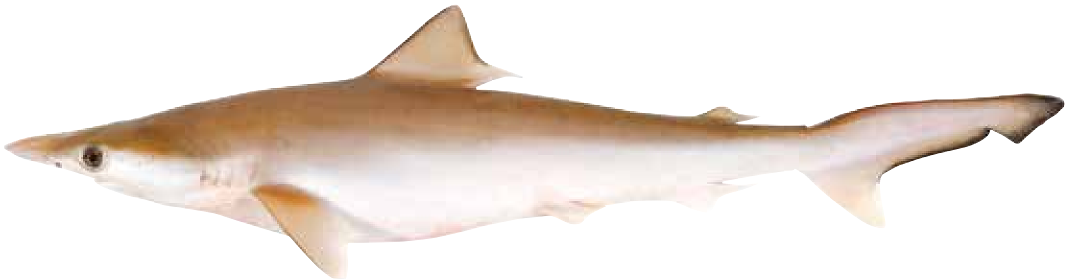


Lower tooth

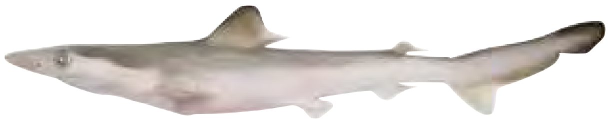
Image details: Lateral and ventral head: Java, Indonesia (female 46 cm TL).

AUSTRALIAN SHARPNOSE SHARK

Rhizoprionodon taylori (Ogilby, 1915)



Ventral head



Late-term embryo

LC

BIOLOGY

Maximum size: 68 cm TL

Maturity size: Females at 42–55 cm TL, males at 40–42 cm TL

Birth size: 22–26 cm TL

Litter size: 1–10 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Second dorsal-fin origin opposite anal-fin insertion
- Anal fin larger than second dorsal fin, its posterior margin shallowly concave
- Preanal ridges very long, about equal to length of anal-fin base
- Snout long and narrowly rounded
- Upper labial furrows short, less than 1.3% of TL
- 7–16 enlarged pores in total from each side near mouth corners
- Teeth with narrowly triangular, smooth-edged, oblique cusps

Colour: Dorsal surfaces bronze to greyish, fading to grey after death. Dorsal-fin anterior margins dark; upper lobe of caudal fin edged with black and tip black; pectoral and lower caudal-fin tips pale. Ventral surfaces white.

Distribution: Found only in northern Australia, southern West Papua and PNG, from close inshore to depths of at least 110 m. In PNG, confirmed from Western, Gulf , Central and East Sepik provinces.

Habitat and biology: Found over coastal and continental shelves, usually near the bottom. Diet consists of bony fishes, crustaceans and cephalopods. In northern Australia, gestation lasts about 12 months, with females giving birth each January; females suppress development of eggs for a number of months before embryonic development begins (embryonic diapause).

Utilisation: Caught in very high numbers by the Gulf of Papua prawn trawl fishery, and large individuals possibly caught by coastal fishers in some provinces (e.g. Western and Gulf provinces). Meat used for human consumption, and dried fins of at least larger sharks possibly sold to local buyers and subsequently exported.

Remarks: One of the most biologically productive species of sharks. Maximum age of PNG populations reported for males and females as 3.6 and 4.6 years, respectively, with males mature at about 0.5 years and females at about 1 year.

Similar species: Similar to *R. oligolinx* but differs in having a total of 7–16 enlarged pores near mouth corners (vs. 15–22 enlarged pores in total near mouth corners). Also similar to *R. acutus* but differs in having short upper labial furrows (vs. upper labial furrows very long and prominent).

Example of a large catch of this species from a single trawl set in the Gulf of Papua prawn fishery

Upper tooth

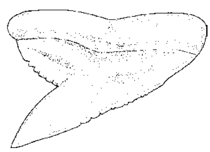


Image details: Lateral and ventral head: Gulf of Papua, PNG (female 37 cm TL). Embryo: Merauke, West Papua (female ~20 cm TL). Fresh: Gulf of Papua, PNG.

WHITETIP REEF SHARK

Triaenodon obesus (Rüppell, 1837)

Ventral head

NT

BIOLOGY

Maximum size: 170 cm TL

Maturity size: Females at 105–122 cm TL, males at 104–116 cm TL

Birth size: 52–60 cm TL

Litter size: 1–5 (usually 2–3) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Second dorsal fin relatively large, about half size of first
- First dorsal and upper caudal fins with distinctive white tips
- Snout very short, blunt and broadly rounded
- Nasal flaps extended slightly
- First dorsal-fin origin well behind pectoral-fin free tips
- Upper and lower teeth smooth-edged, with long, narrow central cusp, flanked either side by a strong cusplet

Colour: Dorsal surfaces greyish brown, often with a few scattered dark-brown spots. First dorsal and upper caudal-fin tips (also sometimes second dorsal- and lower caudal-fin tips) white; fins may be dark-edged. Ventral surfaces white.

Distribution: Widespread in the Indo-Pacific from south-eastern Africa to Central America, to depths of 300 m, but usually 8–40 m.

Habitat and biology: A reef-associated shark often found resting on the bottom, in caves or under ledges during the day, and actively foraging over the reef at night. Diet consists of bony fishes, crustaceans and octopuses. Gestation lasts 10–12 months, with females breeding every second year.

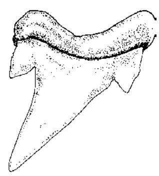
Utilisation: Common catch of coastal fisheries in coral reef areas. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

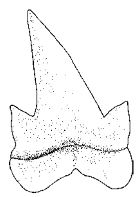
Remarks: Has a relatively narrow home range, returning to the same resting places by day. A curious species that is rarely aggressive to divers; popular for dive ecotourism. Maximum age of Australian populations reported for males and females as 14 and 19 years, respectively, with males mature at about 7 years and females at about 8 years.

Similar species: A distinctive species, unlikely to be confused with other members of the family because of the combination of its large second dorsal and anal fins, and white-tipped first dorsal and upper caudal fins.

Small group of individuals on coral reef habitat in Kimbe Bay

Upper tooth



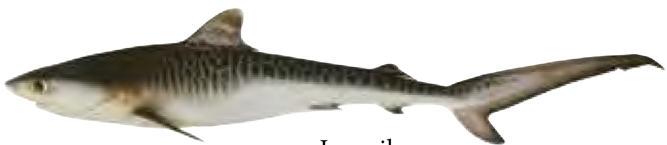


Lower tooth

Image details: Lateral and ventral head: New Ireland, PNG (62 cm TL). Underwater: Kimbe Bay, PNG (by W. Tan & Walindi Dive).

TIGER SHARK

Galeocerdo cuvier (Péron & Lesueur, 1822)



Juvenile

Ventral head

NT

BIOLOGY

Maximum size: ~600 cm TL (one record of 740 cm TL)

Maturity size: Females at 250–350 cm TL, males at 226–290 cm TL

Birth size: 50–80 cm TL

Litter size: 10–82 (average 33) pups

Reproductive mode: Viviparous, without yolk-sac placenta

KEY FEATURES

- Spiracle present, small and slit-like
- Caudal peduncle with a low, rounded, lateral keel
- Snout broad, very short and bluntly rounded
- Upper labial furrows very long, subequal to preoral length
- Sides usually with dark vertical bars (absent in large adults)
- Teeth in both jaws coarsely serrated, one edge deeply notched, the other strongly convex, with basal cusplets

Colour: Dorsal surfaces grey with dark vertical reticulations in newborns, forming vertical bars in sharks up to 300 cm TL, faint or absent in large adults. Fins without markings. Ventral surfaces white.

Distribution: Cosmopolitan in all tropical seas and making seasonal migrations in warm temperate areas, from surface to depths of at least 150 m.

Habitat and biology: Found close inshore to well offshore, from turbid estuaries to clear reefs; most active at night. One of a few shark species categorised as a true scavenger; diet consists of bony fishes, sharks, rays, crustaceans, cephalopods, reptiles (turtles, sea snakes, marine iguanas), birds, marine mammals, carrion and a variety of indigestible objects. Gestation lasts 12–16 months, with females breeding at least every second year.

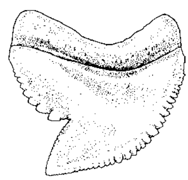
Utilisation: Caught in longline fisheries and in coastal fisheries in a number of provinces; unlikely to be landed unless targeting sharks because of large size. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

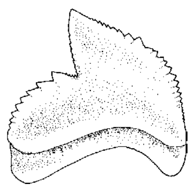
Remarks: One of the most dangerous sharks because of its large size, indiscriminate diet and occurrence in shallow water. Often undergoes irregular, unpredictable movements, although sometimes makes seasonal migrations. Maximum age of eastern Australian populations reported for males and females as 28 and 33 years, respectively, with both sexes mature at 10–13 years. Previously placed in the family Carcharhinidae but differs in having a spiracle (vs. spiracle absent), extremely long upper labial furrows (vs. upper labial furrows much shorter), and embryonic development lacking a placental connection (vs. with placental connection).

Similar species: A distinctive species, unlikely to be confused with other species in PNG.

A large tiger shark landed by the target shark longline fishery, highlighting the very long upper labial furrows

Upper tooth



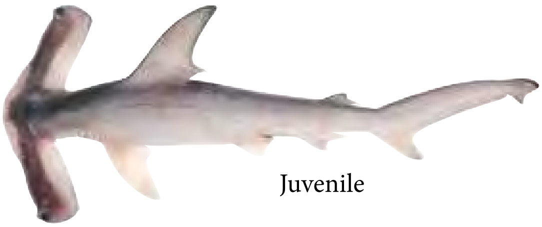


Lower tooth

Image details: Lateral: Bali, Indonesia (female 193 cm TL). Ventral head and juvenile: Australia (72 cm TL). Fresh specimen: Bismarck Sea, PNG (adult male 362 cm TL).

WINGHEAD SHARK

Eusphyra blochii (Cuvier, 1816)



Juvenile

EN

BIOLOGY

Maximum size: 186 cm TL

Maturity size: Females at 111–120 cm TL, males at 103–108 cm TL

Birth size: 37–47 cm TL

Litter size: 6–25 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Head extremely broad and wing-shaped, its width about half of TL
- Anterior midline of head with a shallow indentation
- First dorsal fin very tall and strongly falcate
- Upper precaudal pit longitudinal (not crescentic)
- Second dorsal-fin origin over posterior third of anal-fin base
- Upper and lower teeth small, oblique and smooth-edged

Colour: Dorsal surfaces grey to greyish brown. Head of newborns distinctly bicoloured, dark grey centrally with posterior third and central anterior region pale; becomes less evident in larger individuals. Fins without distinct markings; caudal-fin posterior margin dusky. Ventral surfaces almost white.

Distribution: Found in the Indo–west Pacific from the Persian Gulf to PNG and northwards to Taiwan; not evenly distributed throughout its range, with the majority of sharks focused around major river outflows. In PNG, not confirmed from the outer island chains.

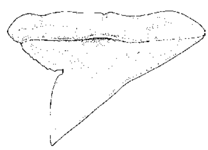
Habitat and biology: Found in mostly shallow waters of the coastal and continental shelves. Diet consists mainly of small bony fishes, but also crustaceans and some cephalopods. In Australia, birth occurs in February and March after a 10–11-month gestation; a pregnant female caught in the Gulf of Papua in September contained six near-term embryos, suggesting a different reproductive pattern, but more data are required.

Utilisation: Caught in large numbers in the Gulf of Papua prawn trawl fishery and also caught by coastal fisheries in a number of provinces, particularly Western and Gulf provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

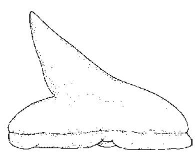
Remarks: Attains at least 21 years of age. Populations have undergone serious declines in some areas; their apparent preference for coastal waters near major river outflows makes them particularly vulnerable in some areas.

Similar species: A distinctive species, similar to the *Sphyrna* species but differs in having a much wider head, 40–50% of TL (vs. head width less than a third of TL).

Upper tooth



Ventral head



Lower tooth

Image details: Lateral: Gulf of Papua, PNG (female 78 cm TL). Ventral head: Katatai, PNG (female 94 cm TL). Juvenile: Gulf of Papua, PNG (female 41 cm TL).

SCALLOPED HAMMERHEAD

Sphyrna lewini (Griffith & Smith, 1834)

Ventral head

Juvenile

EN

BIOLOGY

Maximum size: 350 cm TL

Maturity size: Females at 200–220 cm TL, males at 155–165 cm TL

Birth size: 42–55 cm TL

Litter size: 13–41 (average 25) pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Head broad, but its width less than one-third of TL
- Anterior margin of head curved, shallowly indented at midline
- First dorsal fin relatively tall, broad and moderately falcate
- Second dorsal fin short with long rear tip and weakly concave posterior margin
- Upper precaudal pit crescentic
- Upper teeth narrowly triangular, upright to relatively oblique
- Lower teeth slightly more slender and erect

Colour: Dorsal surfaces olive, bronze or brownish grey. Fins mostly plain; ventral pelvic-fin tips dusky; pectoral, second dorsal and lower caudal-fin tips black-tipped in juveniles, plain or dusky in larger individuals. Ventral surfaces pale.

Distribution: Cosmopolitan in tropical and warm temperate seas, from the surface to at least 275 m depth.

Habitat and biology: Found over coastal and continental shelves to well offshore; juveniles mainly in shallow inshore areas, subadults in deeper water and adults aggregating more offshore around seamounts; adult females more offshore than males. Diet consists mainly of bony fishes and cephalopods, but also sharks and rays. In Australia, birth occurs between October and January after a 9–10-month gestation; in PNG, pregnant females caught in June contained either near-term embryos or recently fertilised eggs, suggesting possibly a different cycle.

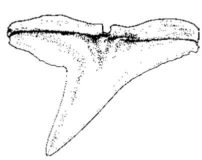
Utilisation: Juveniles caught in the Gulf of Papua prawn trawl fishery; juveniles, subadults and adults caught in the target shark longline fishery (when operational), occasionally in the tuna longline fishery, and in coastal fisheries. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

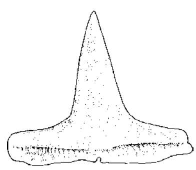
Remarks: Aggregates during the day and disperses into deeper water at night to feed. Important for dive ecotourism in some areas. Populations have undergone serious declines in some areas. Maximum age of eastern Indonesian populations reported for males and females as 19 and 35 years, respectively, with males mature at about 9 years and females at about 13 years.

Similar species: Similar to *S. zygaena* but differs in having the anterior margin of head indented centrally (vs. no medial indentation on anterior head). Also similar to *S. mokarran* but differs in having the anterior margin of head curved (vs. nearly straight) and second dorsal fin short (vs. very tall).

Cruising specimen along a reef edge

Upper tooth



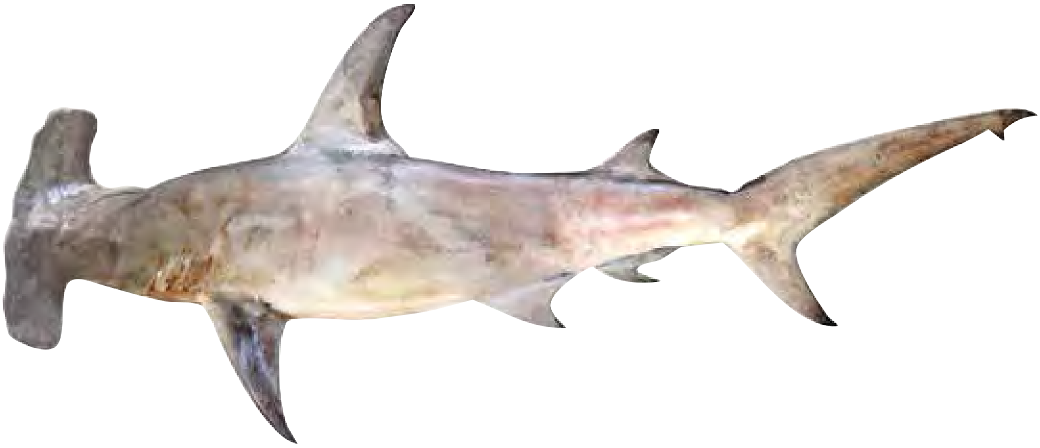


Lower tooth

Image details: Lateral: Bismarck Sea, PNG (female 150 cm TL). Ventral head: Bismarck Sea, PNG (female 235 cm TL). Juvenile: Gulf of Papua, PNG (male 60 cm TL). Underwater: PNG (by B. Halstead).

GREAT HAMMERHEAD

Sphyrna mokarran (Rüppell, 1837)



Ventral head

EN

BIOLOGY

Maximum size: 600 cm TL, rarely above 450 cm TL

Maturity size: Females at 210–300 cm TL, males at 225–269 cm TL

Birth size: 50–70 cm TL

Litter size: 6–42 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Head broad, but its width less than one-third of TL
- Anterior margin of head nearly straight, shallowly indented at midline
- First dorsal fin very tall, strongly falcate in adults
- Second dorsal fin tall with short rear tip and strongly concave posterior margin
- Upper precaudal pit crescentic
- Upper teeth triangular and oblique, lower teeth slightly more erect

Colour: Dorsal surfaces bronze or brownish grey. No distinct fin markings in adults; juveniles with a dark second dorsal-fin tip. Ventral surfaces pale.

Distribution: Circumglobal in tropical and warm temperate seas, at depths of 0–80 m.

Habitat and biology: Found mostly in shallow waters, but also well offshore. Diet consists mainly of bony fishes and rays, but also crustaceans and cephalopods. In Australia, birth occurs in December or January after an 11-month gestation.

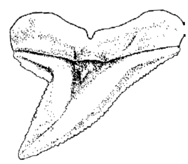
Utilisation: Caught occasionally in the Gulf of Papua prawn trawl fishery and in coastal fisheries in some provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

Remarks: Can be aggressive, mainly to spearfishers. Mostly nomadic and migrates seasonally. Maximum age of eastern Australian populations reported for males and females as 32 and 39 years, respectively, with both sexes mature at about 8 years.

Similar species: Similar to *S. zygaena* but differs in having the anterior margin of head indented centrally (vs. no medial indentation on anterior head). Also similar to *S. lewini* but differs in having the anterior margin of head nearly straight (vs. curved) and second dorsal fin very tall (vs. short).

Cruising specimen, highlighting the tall and falcate first dorsal fin

Upper tooth



Lower tooth

Image details: Lateral and ventral head: Lombok, Indonesia (male 216 cm TL). Underwater: PNG (by B. Halstead).

SMOOTH HAMMERHEAD

Sphyrna zygaena (Linnaeus, 1758)

Newborn

Ventral head

VU

BIOLOGY

Maximum size: ~350 cm TL

Maturity size: Females at ~265 cm TL, males at 250 cm TL

Birth size: 50–61 cm TL

Litter size: 20–50 pups

Reproductive mode: Viviparous, with yolk-sac placenta

KEY FEATURES

- Head broad, but its width less than one-third of TL
- Anterior margin of head well arched, not indented at midline
- First dorsal fin tall, moderately falcate in adults
- Second dorsal fin short with long rear tip and weakly concave posterior margin
- Upper precaudal pit crescentic
- Upper teeth triangular and oblique; lower teeth similar but smaller (lower teeth not figured)

Colour: Dorsal surfaces olive to dark greyish brown. No distinct fin markings, except dusky-tipped ventral pectoral fin. Ventral surfaces white.

Distribution: Circumglobal in temperate seas, also tropical waters in some regions, from the surface to at least 60 m depth. In PNG, only confirmed from Milne Bay Province.

Habitat and biology: Found close inshore on coastal shelves to well offshore. Diet consists mainly of cephalopods, but also bony fishes. In Australia, birth occurs between January and March after a 10–11-month gestation.

Utilisation: Caught occasionally in coastal fisheries in Milne Bay Province. Meat probably used for human consumption, and dried fins sold to local buyers and subsequently exported.

Remarks: Juveniles can form huge migrating schools. Maximum age of the tropical eastern Atlantic population reported as 21 years. Mostly considered a temperate species but also present in catches of tropical fisheries in the region (e.g. Indonesia and PNG).

Similar species: Similar to *S. lewini* but differs in having no medial indentation on anterior head (vs. anterior margin of head indented centrally). Also similar to *S. mokarran* but differs in having the anterior margin of head curved (vs. nearly straight) and second dorsal fin short (vs. very tall).

Dried first dorsal fin taken in the Milne Bay Province coastal shark fishery

Upper tooth

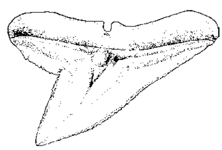
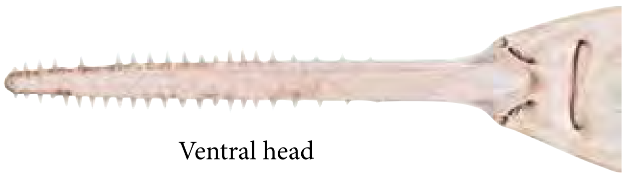


Image details: Lateral and ventral head: Central Java, Indonesia (juvenile male 165 cm TL). Juvenile: Western Australia (female 54 cm TL). Dorsal fin: Milne Bay Province, PNG (estimated 152 cm TL).

NARROW SAWFISH

Anoxypristis cuspidata (Latham, 1794)



Ventral head

EN

BIOLOGY

Maximum size: At least 350 cm TL, possibly to 470 cm TL

Maturity size: Females at 225 cm TL, males at ~200 cm TL

Birth size: Unclear, between 43 and 70 cm TL

Litter size: ~12 pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- First dorsal-fin origin well posterior to pelvic-fin origins
- Ventral lobe of caudal fin well developed
- Rostral saw very long and narrow, with teeth slightly closer together near tip than at middle of saw
- Rostral teeth absent from base of saw
- Denticles lacking from most of body; skin smooth

Colour: Dorsal surfaces yellowish brown, fading to grey after death. No distinct fin markings. Rostral teeth white. Ventral surfaces white.

Distribution: Found in the Indo–west Pacific, from the Red Sea to PNG and northwards to southern Japan, in shallow coastal waters to depths of at least 40 m. In PNG, confirmed from Western, Gulf, Central, Madang, Manus and East Sepik provinces.

Habitat and biology: A coastal species, also venturing into estuaries. Diet consists of bony fishes and crustaceans. Little known about its reproductive biology.

Utilisation: Caught as bycatch in the Gulf of Papua prawn trawl fishery and by coastal fisheries (hook and gillnet) in a number of provinces, including Western, Gulf, Milne Bay and East Sepik provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported; rostra sometimes sold as curios.

Remarks: Likely to be a more active swimmer than other sawfishes, based on the strong lower caudal lobe they possess. Reported to be mature at 2–3 years of age. More productive than the other sawfish species, but population declines and range contraction have still been recorded for this species.

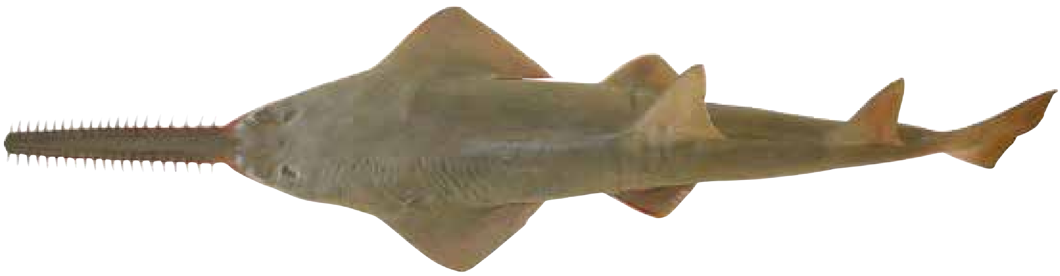
Similar species: Differs from all other sawfishes in having a long lower lobe on the caudal fin (vs. lower lobe short) and a toothless portion at the base of the rostral saw.

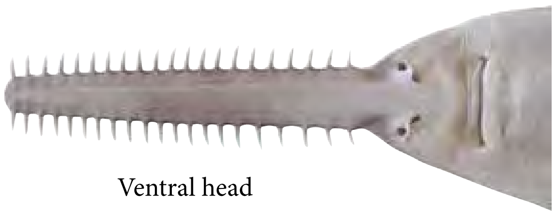
Fresh specimen from the bycatch of the Gulf of Papua prawn trawl fishery

Image details: Dorsal: Gulf of Papua, PNG (female 133 cm TL). Ventral head: Queensland, Australia (female 133 cm TL). Fresh: Gulf of Papua, PNG (adolescent male 188 cm TL).

DWARF SAWFISH

Pristis clavata Garman, 1906





Ventral head

EN

BIOLOGY

Maximum size: At least 310 cm TL

Maturity size: Males at ~260 cm TL, females probably slightly larger

Birth size: 65 cm TL

Litter size: Unknown

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- First dorsal-fin origin slightly behind pelvic-fin origins
- Ventral lobe of caudal fin short, but conspicuous
- Rostral saw short and broad, with teeth near tip and at middle of saw a similar distance apart
- Rostral teeth present near base of saw
- Pair of rostral teeth at snout tip similar to other tooth pairs, not curved
- Body covered entirely in rough denticles

Colour: Dorsal surfaces yellowish brown (sometimes slightly greenish brown). No distinct fin markings. Rostral teeth white. Ventral surfaces white.

Distribution: Found (at least historically) in the Indo–west Pacific, from Réunion (not confirmed) to PNG. In PNG, confirmed only from Western and Gulf provinces.

Habitat and biology: A coastal inshore species, found on tidal flats, mangrove swamps and bays, estuaries and brackish parts of tidal rivers; juveniles use estuarine areas, rather than upper freshwater reaches, for at least their first 3 years of life. Diet consists of bony fishes and crustaceans. Little known about its reproductive biology; in northern Australia, pupping is thought to occur from November to March.

Utilisation: Caught in coastal fisheries in Western and Gulf provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported; rostra likely sold as curios.

Remarks: Previously considered to be possibly extinct in PNG, but recent surveys showed they are still present in catches in Western and Gulf provinces. In north-eastern Australia, estimated to attain a maximum age of 34 years, with males mature at 8 years. Has undergone severe global population declines.

Similar species: Most similar to *P. pristis* but differs in having first dorsal-fin origin about level with pelvic-fin origins (vs. first dorsal-fin origin well in front of pelvic fins) and pair of rostral teeth at snout tip not curved outwards (vs. slightly curved outwards).

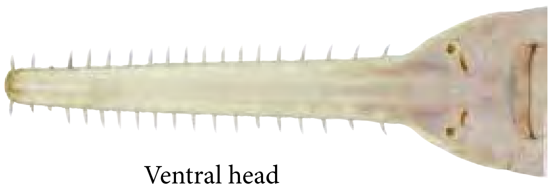
Dried caudal fin from coastal fishery catches in Western Province

Front half of a dried rostrum, showing outermost rostral teeth similar to penultimate pair, not curved outwards

Image details: Dorsal and ventral head: Western Australia (female 91 cm TL). Caudal fin: Gulf Province, PNG (estimated 303 cm TL). Rostrum: Daru, PNG (estimated 89 cm TL).

LARGETOOTH SAWFISH

Pristis pristis (Linnaeus, 1758)



Ventral head

CR

BIOLOGY

Maximum size: At least 656 cm TL, but possibly more than 700 cm TL

Maturity size: ~280–300 cm TL

Birth size: 72–90 cm TL

Litter size: 1–13 pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- First dorsal-fin origin well forward of pelvic-fin origins
- Ventral lobe of caudal fin short, but conspicuous
- Rostral saw short and broad, with teeth near tip and at middle of saw a similar distance apart
- Rostral teeth present near base of saw
- Pair of rostral teeth at snout slightly but distinctly curving anterolaterally
- Body covered entirely in rough denticles

Colour: Dorsal surfaces yellowish brown, fading to greyish after death. No distinct fin markings. Rostral teeth white. Ventral surfaces white.

Distribution: Circumtropical (at least historically), but much more restricted now because of localised extinctions through much of its range; to depths of at least 26 m. In PNG, confirmed from Western, Gulf, Central, Milne Bay, East Sepik, Madang, East New Britain, Manus and Bougainville provinces.

Habitat and biology: Occurs in coastal marine habitats, estuaries and freshwater rivers, lakes and floodplain waterholes; juveniles found well upstream in freshwater rivers, where they remain until close to maturation. Diet consists of bony fishes, crustaceans and molluscs. In Lake Nicaragua, found to have a 5-month gestation period.

Utilisation: Caught as bycatch in the Gulf of Papua prawn trawl fishery, and in coastal fisheries in Western and Gulf provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported; rostra sold as curios.

Remarks: Has undergone severe declines globally and is considered extinct in many former range states. In northern Australia, estimated to attain a maximum age of 35 years, with both sexes mature at 8–10 years.

Similar species: Most similar to *P. clavata* but differs in having first dorsal-fin origin well in front of pelvic fins (vs. first dorsal-fin origin about level with pelvic-fin origins) and pair of rostral teeth at snout tip curved outwards (vs. not curved outwards).

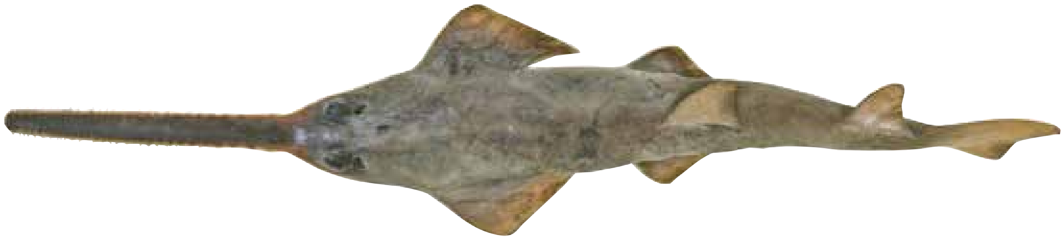
Large male in the bycatch in the Gulf of Papua prawn trawl fishery

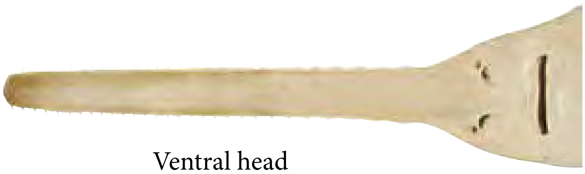
Front half of a dried rostrum, showing outermost rostral teeth curving outwards

Image details: Dorsal and ventral head: Queensland, Australia (female 108 cm TL). Fresh specimen: Gulf of Papua, PNG (male 349 cm TL). Rostrum: Daru, PNG (317 cm TL).

GREEN SAWFISH

Pristis zijsron Bleeker, 1851





Ventral head

CR

BIOLOGY

Maximum size: Possibly to 730 cm TL, mostly less than 600 cm TL

Maturity size: Possibly close to 430 cm TL

Birth size: ~80 cm TL

Litter size: ~12 pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- First dorsal-fin origin slightly behind pelvic-fin origins
- No obvious ventral caudal-fin lobe
- Rostral saw moderately long and slender, with teeth much closer together near tip than at mid-length of saw
- Widely spaced rostral teeth present near base of saw
- Body covered entirely in rough denticles
- Rostral teeth 23–37 (vs. 14–26 in other pristid species in region)

Colour: Dorsal surfaces olive to greenish brown. No distinct fin markings. Rostral teeth white. Ventral surfaces white.

Distribution: Found in the Indo–west Pacific, from South Africa to eastern Australia and PNG, to depths of at least 70 m. In PNG, confirmed from Western, Gulf, Central and East Sepik provinces.

Habitat and biology: Found mainly inshore and in estuaries, but also on the upper continental shelf. Diet probably dominated by bony fishes and crustaceans. Little known of its reproductive biology.

Utilisation: Caught in coastal fisheries in Western and Gulf provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported; rostra sold as curios.

Remarks: One large caudal fin examined in this study from Gulf Province was estimated to be from a ~6.7 m individual, making it one of the largest records of this species. Has undergone severe population declines throughout much of its range, and it is likely that many localised extinctions have occurred in former range states.

Similar species: Similar to *P. clavata* and *P. pristis* but differs in having the rostral teeth closer together at tip, becoming widely separated near base (vs. rostral teeth evenly spaced on saw) and having a greenish-brown colour (vs. mostly yellowish brown). Differs from *Anoxypristis cuspidata* in having only a short lower lobe on caudal fin (vs. a pronounced lower lobe on caudal fin) and teeth present at base of saw (vs. a large toothless area at base of saw).

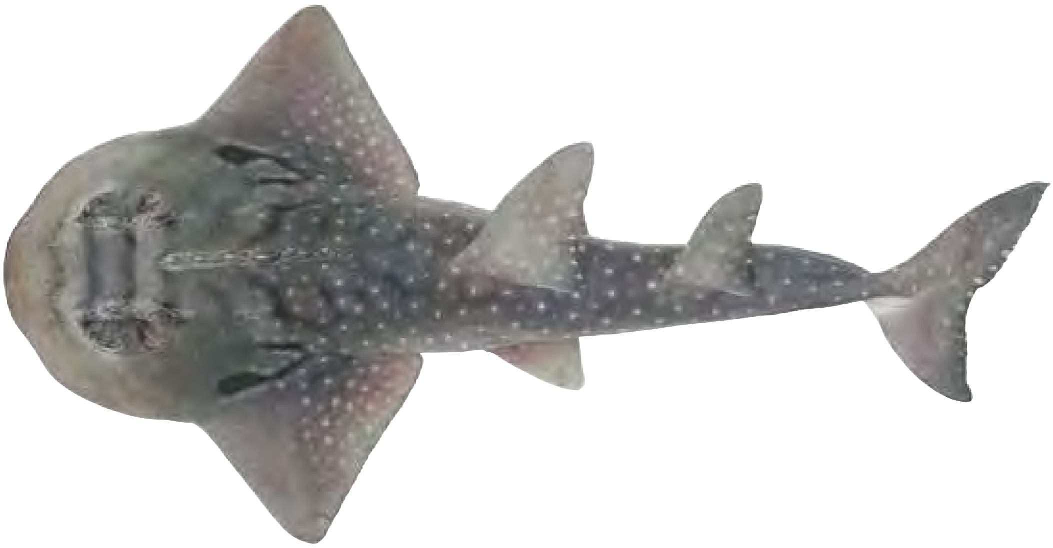
Dried caudal fin from coastal fishery catches in Western Province

Dried rostrum, highlighting the change of spacing between rostral teeth, from widely separated at the base to close together at the tip

Image details: Dorsal and ventral head: Queensland, Australia (juvenile male 93 cm TL). Fresh specimen: Gulf of Papua, PNG (male 349 cm TL). Rostrum: Daru, PNG (317 cm TL).

SHARK RAY

Rhina ancylostoma Bloch & Schneider, 1801



VU

BIOLOGY

Maximum size: 270 cm TL

Maturity size: Females at ~180 cm TL, males at 150–175 cm TL

Birth size: 46–48 cm TL

Litter size: 2–11 pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- First dorsal-fin origin slightly forward of pelvic-fin origins
- Caudal fin lunate; upper and lower lobes almost same size
- Snout short and very broadly rounded
- Spiracles without skin folds on posterior margin
- Ridges above orbits, and on mid-body and shoulders bearing clusters of strong thorns
- Lower jaw strongly trilobed

Colour: Dorsal surfaces bluish grey to brownish, with numerous large white spots (including on fins). Black pectoral markings in juveniles (faint or absent in adults). Dark bands between eyes and spiracles. Ventral surfaces white.

Distribution: Found in the Indo–west Pacific, from South Africa to New Caledonia, to depths of at least 90 m. In PNG, confirmed from Western, Gulf, Milne Bay, East Sepik and Bougainville provinces, but probably widespread.

Habitat and biology: Found mainly on coastal and offshore reefs. Diet consists of bony fishes, crustaceans (prawns and crabs), cephalopods and other molluscs. Little known of its reproductive biology.

Utilisation: Caught in coastal fisheries in Western and Gulf provinces, and possibly elsewhere. Meat possibly used for human consumption when caught, and dried fins sold to local buyers and subsequently exported.

Remarks: An unusual species that is not particularly common where it occurs. Popular in public aquaria. The ridges of large thorns on the head and body make them very difficult to handle when caught, particularly in trawl nets.

Similar species: A very distinctive species, closest to *Rhynchobatus* species, but differs in having a broadly rounded head (vs. head triangular), a trilobed mouth (vs. not trilobed) and strong ridges of thorns on head and back (vs. no ridges of enlarged thorns).

Ventral head and pectoral fins

Lateral head, highlighting ridges of thorns

Image details: Dorsal and ventral head: Bali, Indonesia (juvenile male 83 cm TL). Lateral head: Central Java, Indonesia (newborn 51 cm TL).

BOTTLENOSE WEDGEFISH

Rhynchobatus australiae Whitley, 1939

Ventral head

VU

BIOLOGY

Maximum size: ~300 cm TL

Maturity size: Males at 110–130 cm TL, females much larger

Birth size: 46–50 cm TL

Litter size: 7–19 pups

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- First dorsal-fin origin slightly behind pelvic-fin origins
- Caudal fin with a well-developed lower lobe
- Dorsal fins falcate; first much larger than second
- Snout long and bottle-shaped (constricted slightly near tip)
- A black spot on each pectoral fin, surrounded by white spots
- Body mainly pale (large adults can become blackish) with a sparse coverage of white spots

Colour: Dorsal surfaces pale grey to yellowish brown with sparse covering of white spots (occasionally also on dorsal fins); almost uniformly blackish in some large adults. A black pectoral spot in juveniles and subadults (faint or absent in adults), bordered by a diagonal row of usually three white spots above and two white spots below. Ventral surfaces white; often with a small dark blotch at snout tip.

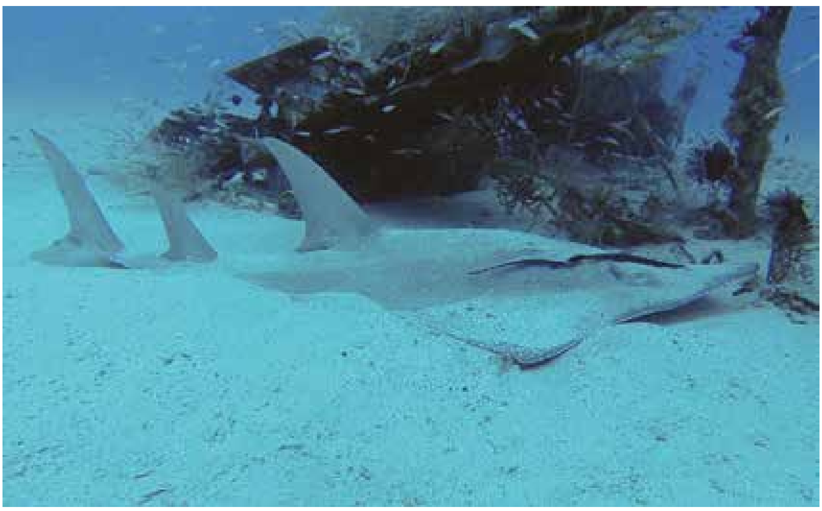
Distribution: Found in the Indo–west Pacific, from Mozambique to eastern Australia and PNG, to depths of at least 60 m. In PNG, confirmed from Milne Bay, East Sepik and New Ireland provinces, but probably more widespread.

Habitat and biology: Found mainly on sandy substrate close to reefs or inshore on soft bottoms; in PNG, not observed in catches of the Gulf of Papua prawn trawl fishery and usually observed close to reef. Diet consists of bony fishes, crustaceans and molluscs. Little known of its reproductive biology.

Utilisation: Caught in coastal fisheries in some provinces, including Gulf, Milne Bay and East Sepik provinces, and probably elsewhere. Meat used for human consumption when caught, and dried fins sold to local buyers and subsequently exported.

Remarks: Previously placed in a separate family, Rhynchobatidae, but recent phylogenetic research has shown they belong in the same family as *Rhina ancylostoma*. Fins are highly sought-after, but severe population declines have been reported in some parts of its range.

Similar species: Similar to *R. palpebratus* but differs in having a bottle-shaped snout (vs. snout not constricted near tip) and lacking black markings on head (vs. two eyebrow-like black markings often present).



Specimen resting on sand next to a wreck off Kavieng in New Ireland

Image details: Dorsal and ventral head: Bali, Indonesia (juvenile male 54 cm TL). Underwater: New Ireland, PNG (by D. Borcherds).

EYEBROW WEDGEFISH

Rhynchobatus palpebratus Compagno & Last, 2008

Ventral head

Juvenile

NE

BIOLOGY

Maximum size: At least 262 cm TL

Maturity size: Males at ~103 cm TL, females unknown

Birth size: Probably about 40 cm TL (based on neonate size)

Litter size: Unknown

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- First dorsal-fin origin over pelvic-fin origins
- Caudal fin with a well-developed lower lobe
- Dorsal fins semi-falcate; first much larger than second
- Snout long, broad, not constricted near tip
- A prominent black spot on each pectoral fin, usually surrounded by 4 white spots
- Body darkish grey with 2–4 rows of white spots on trunk
- Dark eyebrow markings usually present above eyes

Colour: Dorsal surfaces yellowish brown to greyish with variable covering of white spots. A black pectoral spot present on each side, surrounded by typically four white spots. Orbital membrane usually with two curved black markings. A short white bar on midline in front of eyes. Tail behind pelvic fins usually without spots and with a white stripe. Ventral surfaces white; sometimes with dark blotches near snout tip.

Distribution: Found only in northern Australia and PNG, at depths of 5–61 m. In PNG, confirmed from Gulf and East Sepik provinces.

Habitat and biology: Found mainly on soft bottoms; common on trawl grounds such as the Gulf of Papua. Diet probably consists mainly of bony fishes and crustaceans. Little known of its reproductive biology; neonates found in the Gulf of Papua in December, indicating birth may be occurring just before this time.

Utilisation: Common in the bycatch of the Gulf of Papua prawn trawl fishery and possibly in coastal fisheries catches in Gulf Province. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

Remarks: Previously thought to be conspecific with *R. laevis*, which has not been recorded from PNG.

Similar species: Similar to *R. australiae* but differs in having a snout without constrictions near the tip (vs. snout constricted near tip, bottle-shaped) and having black eyebrow-like markings on head (vs. no dark markings on head).

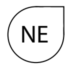
Fresh specimens from the bycatch of the Gulf of Papua prawn trawl fishery

Image details: Dorsal: Gulf of Papua, PNG (126 cm TL). Ventral head: Gulf of Papua, PNG (juvenile female 65 cm TL). Juvenile: Gulf of Papua, PNG (female 43 cm TL). Fresh specimens: Gulf of Papua, PNG (top: adult male 126 cm TL; middle: adult male 106 cm TL; bottom: juvenile male 87 cm TL).

PAPUAN GUITARFISH

Rhinobatos manai White, Last & Naylor, 2016

Ventral head



BIOLOGY

Maximum size: At least 73 cm TL

Maturity size: A 73 cm TL specimen was mature

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Probably viviparous, with yolk-sac dependency

KEY FEATURES

- First dorsal-fin origin well behind pelvic-fin rear tips
- Caudal fin without a distinct lower lobe
- Snout moderately long, 4–5 times orbit diameter
- Anterior nasal opening circular
- No thorns, and enlarged denticles along dorsal midline
- Upper body brown with many rusty brown spots and blotches, and faint grey-edged white spots

Colour: Dorsal surfaces brown with numerous rusty brown spots and blotches, and faint grey-edged white spots. Ventral surfaces white.

Distribution: Known only from a single adult male specimen caught north-west of Kavieng in New Ireland at a depth of 191–290 m.

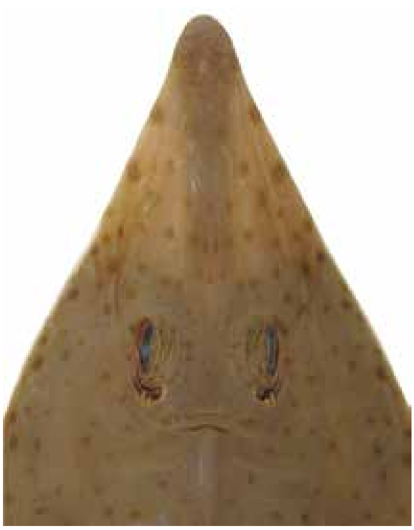
Habitat and biology: Found on the outer continental shelf and/or upper continental slope. Diet probably consists of bony fishes and crustaceans. Nothing known of its reproductive biology.

Utilisation: Not encountered by present fisheries in PNG.

Remarks: Only known from a single specimen trawled off New Ireland and is possibly endemic to PNG.

Similar species: Similar to *R.* cf. *schlegelii* but differs in having a colour pattern of rusty brown and faint white spots (vs. uniformly brown).

Oronasal region, highlighting the circular anterior nasal openings (arrows)



Dorsal head, highlighting the long snout, and numerous rusty brown spots and very faint greyish-white spots

Caudal fin, highlighting the distinct upper lobe but no distinct lower lobe

Image details: All images: New Ireland, PNG (adult male 73 cm TL).

ENIGMA GUITARFISH

Rhinobatos cf. *schlegelii*

Ventral head

NE

BIOLOGY

Maximum size: At least 70 cm TL

Maturity size: Unknown

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Probably viviparous, with yolk-sac dependency

KEY FEATURES

- First dorsal-fin origin well behind pelvic-fin rear tips
- Caudal fin without a distinct lower lobe
- Snout moderately long, about 4.8 times orbit diameter
- Anterior nasal opening circular
- No thorns, and enlarged denticles along dorsal midline
- Upper body uniform brown, without distinct markings

Colour: Dorsal surfaces uniformly brown; no other markings on body. Ventral surfaces white.

Distribution: Known only from a single, probably adult, female specimen, but locality unknown.

Habitat and biology: Unknown.

Utilisation: Unknown.

Remarks: Known only from a single female specimen deposited in the fish collection at Museum Victoria in Melbourne, Australia. No location is provided on the collection data, but it is listed as being collected by Andrew Goldie in 1890. Andrew Goldie collected various vertebrates from PNG at this time and in the two decades before, and operated mostly within Central Province, as well as Milne Bay Province. This specimen is very similar to *R. schlegelii* from the north-west Pacific. Given that collections in the 1800s would have been restricted to coastal areas (not deep water), it is unusual for a member of this genus to be found in such shallow waters. It also has not been collected since 1890. It is possible that this specimen may have been collected from elsewhere, and not in PNG, but it is included tentatively in this guide in case additional specimens are found in the future.

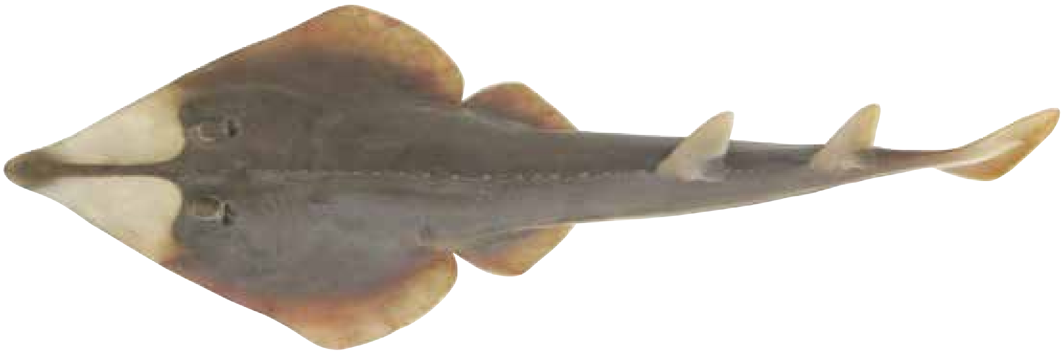
Similar species: Similar to *R. manai* but differs in having a uniform brown colour (vs. a colour pattern of rusty brown and faint white spots).

Oronasal region, highlighting the circular anterior nasal openings (arrows)

Image details: All images: southern PNG (adult male 70 cm TL).

GIANT GUITARFISH

Glaucostegus typus (Bennett, 1830)



Ventral head

BIOLOGY

Maximum size: 284 cm TL

Maturity size: Females and males at 150–180 cm TL

Birth size: 38–40 cm TL

Litter size: Unknown

Reproductive mode: Viviparous, with yolk-sac dependency

KEY FEATURES

- First dorsal-fin origin well behind pelvic-fin rear tips
- Caudal fin without a distinct lower lobe
- Anterior nasal opening almost rectangular
- Snout very long, more than 5 times orbit diameter
- Small thorns and enlarged denticles along dorsal midline
- Upper body greyish brown, without spots

Colour: Dorsal surfaces uniformly yellowish to greyish brown, sometimes with variable number of irregular dark-greyish blotches. Posterior margins of paired fins paler yellowish. Snout whitish or translucent (except for where rostral cartilage runs along midline to snout tip). Ventral surfaces white; snout tip usually with a black blotch.

Distribution: Found in the Indo–west Pacific, from India to PNG and northwards to Taiwan, from the intertidal to depths of at least 100 m. In PNG, confirmed from Western, Gulf, Central, Milne Bay, East Sepik and Bougainville provinces; probably widespread.

Habitat and biology: Found in very shallow bays, mangrove swamps and estuaries, including brackish waters; also offshore on the continental shelf. Diet consists mainly of crustaceans (prawns and crabs), but also bony fishes and molluscs. Little known of its reproductive biology; birth appears to occur throughout the year without a clear cycle.

Utilisation: Common in the bycatch of the Gulf of Papua prawn trawl fishery and in coastal fisheries catches in some provinces, including Western, Gulf, Milne Bay and East Sepik provinces. Meat used for human consumption, and dried fins sold to local buyers and subsequently exported.

Remarks: Previously placed in the family Rhinobatidae but recently separated and placed into Glaucostegidae. Adults and juveniles move into very shallow waters near the shore at night, probably searching for prey (juvenile prawns preferred).

Similar species: Differs from the morphologically similar *Rhinobatos* in having large rectangular-shaped anterior nasal openings (vs. anterior nasal openings circular).

Fresh specimen from the bycatch of the Gulf of Papua prawn trawl fishery

Oronasal region, highlighting the almost rectangular anterior nasal openings (arrows)

Image details: Dorsal, ventral head and oronasal region: Mullins Harbour, PNG (juvenile female 41 cm TL). Fresh specimen: Gulf of Papua, PNG (adult male 200 cm TL).

PLAIN NUMBFISH

Narcinops cf. *nelsoni*

NE

BIOLOGY

Maximum size: At least 14 cm TL

Maturity size: Unknown

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Presumably viviparous, with yolk sac

KEY FEATURES

- Disc shovel-shaped, much shorter than tail
- Eyes small, slightly larger than spiracles
- 2 similar-sized dorsal fins
- Skin very smooth, without denticles or thorns
- First dorsal-fin origin well behind pelvic-fin rear tips
- Body uniformly yellowish brown, without spots or blotches

Colour: Dorsal surfaces uniformly brown, without any distinct markings; snout slightly paler. Dorsal and caudal fins almost translucent. Ventral surfaces white.

Distribution: Known from five specimens caught during deepwater trawl surveys in Sandaun, East Sepik and Morobe provinces, at depths of 280–345 m.

Habitat and biology: Found on the upper continental slope. Biology unknown; probably feeds on small benthic invertebrates such as polychaetes.

Utilisation: Not encountered by present fisheries in PNG.

Remarks: First record of this family in PNG. Similar to *N. lasti* and *N. nelsoni* from north-western and north-eastern Australia, respectively. Differs from *N. lasti* on a genetic level (based on NADH2 marker sequences); no genetic samples currently available for *N. nelsoni*. Adult specimens required to determine whether a distinct species or a significant range extension of *N. nelsoni.* Large kidney-shaped electric organs present on pectoral fins, usually just visible on both sides; capable of delivering a low-intensity electric shock to warn off predators.

Similar species: Only member of this family in PNG; closest relative is *Tetronarce formosa*, which it can be easily separated from based on its much longer tail and its similar-sized dorsal fins (vs. first dorsal fin much larger).

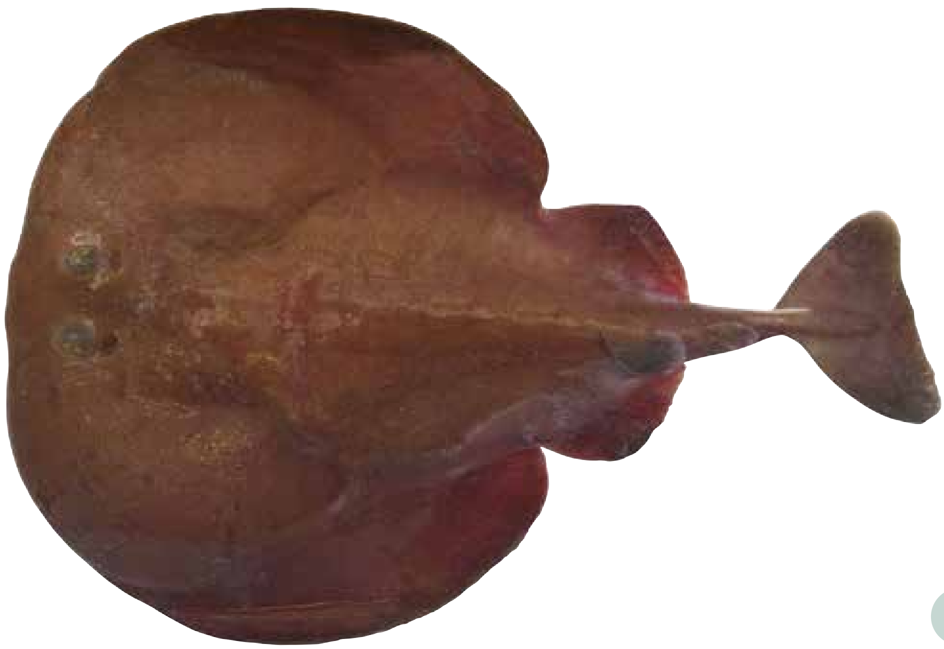
Eyes and spiracles

Oronasal region

Image details: Dorsal: Sandaun Province, PNG (juvenile male 13 cm TL). Oronasal region, and eyes and spiracles: West Sepik Province, PNG (female 9 cm TL).

TAIWANESE TORPEDO

Tetronarce formosa (Haas & Ebert, 2006)



DD

BIOLOGY

Maximum size: At least 62 cm TL

Maturity size: Unknown

Birth size: ~20–25 cm TL

Litter size: Unknown

Reproductive mode: Viviparous, with yolk sac

KEY FEATURES

- Disc almost circular, wider than long
- Tail short, about one-third of TL
- Spiracle margin smooth (not papillate)
- First dorsal fin much larger than second; tips of both rounded
- First dorsal-fin rear tip not extending past pelvic-fin rear tips
- Posterior margin of caudal fin almost straight

Colour: Dorsal surfaces uniformly purplish brown to dark brown; darker around disc edge and on fins. Ventral surfaces white or creamy.

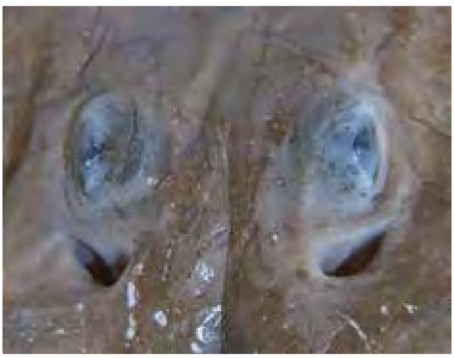
Distribution: Found only off Taiwan and PNG, to depths of 340 m. In PNG, known from a single juvenile male collected off Kavieng in New Ireland at a depth of 335–340 m.

Habitat and biology: Found on the upper continental slope. Biology unknown.

Utilisation: Not encountered by present fisheries in PNG.

Remarks: First record of this family in PNG; represents a significant range extension for this species, which was previously considered to be endemic to Taiwan. Identification confirmed at a genetic level (based on NADH2 marker sequences). Large kidney-shaped electric organs present on pectoral fins are capable of delivering a powerful shock to stun prey or as a defence.

Similar species: Only member of this family in PNG; closest relative is *Narcinops* cf. *nelsoni*, which it can be easily separated from based on its much shorter tail and its first dorsal fin being much larger than the second (vs. dorsal fins similar sized).



Eyes and spiracles

Oronasal region

Image details: All images: New Ireland, PNG (juvenile male 26 cm TL).

PAPUAN VELVET SKATE

Notoraja sereti White, Last & Mana, 2017

NE

BIOLOGY

Maximum size: At least 46 cm TL

Maturity size: Unknown; a 36 cm TL male was adolescent

Hatching size: Unknown

Litter size: Unknown

Reproductive mode: Presumably oviparous

KEY FEATURES

- Snout soft, with a thin and flexible rostral cartilage
- Pelvic fin divided into two lobes; anterior lobe finger-like
- Snout relatively short; preorbital length 2.4–3.0 times orbit length
- Two similar-sized dorsal fins near end of tail
- Both upper and lower discs covered in fine denticles (skin velvet-like)

Colour: Dorsal surfaces uniformly medium brown to bluish grey. Anterior third of tail darker brown with a dark stripe on the midline. Ventral surfaces medium to pale brownish.

Distribution: Known only from three specimens collected off Madang Province, at depths of 800–890 m.

Habitat and biology: Found on the lower continental slope. Biology unknown; no adult specimens observed.

Utilisation: Not encountered by present fisheries in PNG.

Remarks: First record of this family in PNG. Recently described as a new species based on the three Madang specimens. Presence of fine denticles on the ventral surface is a useful diagnostic character for this genus and possibly indicates it occurs on hard substrates.

Similar species: Only member of this family in PNG; closest relative is *Dipturus* sp., which it can be easily separated from based on the dense covering of fine denticles (vs. no fine denticles, skin mostly smooth), no enlarged thorns (vs. row of enlarged thorns along midline of tail and on orbits), and snout soft and flexible (vs. snout with a stiff rostral cartilage, not flexible).

Posterior tail, highlighting the two dorsal fins near the tail tip

Oronasal region

Eye and spiracle region, highlighting the fine denticles covering the skin

Image details: All images: Madang, PNG (female 46 cm TL).

LUANAH'S SKATE

Dipturus sp. 1

NE

BIOLOGY

Maximum size: Largest known specimen 38 cm TL

Maturity size: Unknown; a 38 cm TL male was adolescent

Hatching size: Unknown

Litter size: Unknown

Reproductive mode: Presumably oviparous

KEY FEATURES

- Snout firm, with a hard rostral cartilage (not easily bent)
- Pelvic fin divided into two lobes; anterior lobe finger-like
- Snout moderately long; preorbital length 3.6–3.7 times orbit length
- Two similar-sized dorsal fins near end of tail
- A single row of thorns along midline of tail

Colour: Dorsal surfaces uniformly greyish brown; dorsal and caudal fins mostly darker, but dorsal fins with pale posterior margins. Ventral surfaces pale brownish.

Distribution: Known only from five specimens collected off Madang and Sandaun provinces, at depths of 440–620 m.

Habitat and biology: Found on the mid-continental slope. Biology unknown; no adult specimens observed.

Utilisation: Not encountered by present fisheries in PNG.

Remarks: First record of this family in PNG. Currently being described as a new species. Adult specimens required to allow comparison with juvenile and subadult specimens collected to date.

Similar species: Only member of this family currently known from PNG; closest relative is *Notoraja sereti*, which it can be easily separated from based on the skin being mostly smooth, without fine denticles (vs. dense covering of fine denticles, skin velvety), row of enlarged thorns along midline of tail and on orbits (vs. no enlarged thorns on body) and snout with a stiff rostral cartilage, not flexible (vs. snout soft and flexible).

Posterior tail, highlighting the two dorsal fins near the tail tip

Oronasal region

Eye and spiracle region

Image details: All images: Sandaun Province, PNG (adolescent male 38 cm TL).

PAPUAN LEGSKATE

Sinobatis sp. 1

NE

BIOLOGY

Maximum size: Only known from a ~20 cm TL specimen

Maturity size: Unknown

Hatching size: Unknown

Litter size: Unknown

Reproductive mode: Presumably oviparous

KEY FEATURES

- Tail relatively short, thin and filamentous
- No dorsal fins
- Snout long; preorbital length more than 8 times eye diameter
- Pelvic fin divided into two lobes; anterior lobe leg-like
- Tail not bulbous near tip
- Upper and lower surfaces smooth, without denticles or thorns

Colour: Both dorsal and ventral surfaces dark purplish grey, fading to brown after death. Belly and central disc above abdomen paler. Tail pale greyish.

Distribution: Known only from a single, presumably juvenile specimen collected off Madang Province, at a depth of 800–860 m.

Habitat and biology: Found on the lower continental slope. Biology unknown; no adult specimens observed.

Utilisation: Not encountered by present fisheries in PNG.

Remarks: First record of this family in PNG. More specimens required to determine whether an undescribed species or a juvenile of an already known species.

Similar species: Only member of this family currently known from PNG. Differs from the other families of skates in having a filamentous tail without dorsal fins and no, or only a rudimentary, caudal fin (vs. dorsal and caudal fins distinct), and long, leg-like anterior pelvic-fin lobes (vs. anterior pelvic-fin lobes not leg-like).

Dorsal view (with folded-up pectoral fins) of freshly landed specimen, highlighting the filamentous tail and dark colouration

Ventral view of freshly landed specimen, highlighting the leg-like anterior pelvic-fin lobes, the dark colouration and the pale belly

Image details: All images: Madang Province, PNG (female 19.6 cm TL).

SIXGILL STINGRAY

Hexatrygon bickelli Heemstra & Smith, 1980

LC

BIOLOGY

Maximum size: 170 cm TL

Maturity size: Females at ~113 cm TL, males at ~110 cm TL

Birth size: ~45–48 cm TL

Litter size: 2–3 pups

Reproductive mode: Viviparous, histotrophic

KEY FEATURES

- Disc soft, heart-shaped and very flabby
- Snout long, triangular and gelatinous
- 6 pairs of small gill slits on ventral head
- Tail short with one or two stings and a well-developed caudal fin
- Eyes small and widely separated
- Spiracles large and obliquely oriented

Colour: Dorsal surfaces pinkish to reddish brown; posterior margins dark. Snout much paler, often whitish. Caudal fin brownish black. Ventral surface whitish. Ventral surfaces of pectoral and pelvic fins with broad dusky to blackish margins, often mottled.

Distribution: Found in the Indo–west and central Pacific, from South Africa to Hawaii, at depths of 360–1,120 m. In PNG, known only from a single specimen trawled off New Hanover, New Ireland, at a depth of 840–865 m.

Habitat and biology: Found on both soft and rocky bottoms on the continental slope. Feeds on benthic invertebrates, mainly shrimps. Little known of its reproductive biology.

Utilisation: Not encountered by present fisheries in PNG.

Remarks: First record of this family in PNG. Possesses a tube-like protractile mouth that it uses to ingest its primarily crustacean prey. The gelatinous snout is highly dexterous and likely used as a sensory organ to detect its prey in the substrate.

Similar species: A very distinctive species, unlikely to be confused with other rays; the long gelatinous snout and six pairs of gill openings are unique.

Ventral view of freshly landed specimen, highlighting the six pairs of gill slits and the long, gelatinous snout

Image details: Dorsal: Taiwan (female 118 cm TL). Ventral: New Ireland, PNG (juvenile male).

AUSTRALIAN BUTTERFLY RAY

Gymnura australis (Ramsay & Ogilby, 1886)

LC

BIOLOGY

Maximum size: 94 cm DW

Maturity size: Females at 44–46 cm DW, males at 35–42 cm DW

Birth size: 22–25 cm DW

Litter size: 1–6 pups

Reproductive mode: Viviparous, with lipid histotrophy

KEY FEATURES

- Disc very broad, about 1.5 times wider than long
- Tail short and filamentous
- Small dorsal fin and caudal sting present or absent on tail
- A small tentacular skin flap present on inner rear margin of each spiracle
- Snout short
- Skin smooth, without denticles or thorns

Colour: Dorsal surfaces greenish, greyish or pale to dark brown; usually with a peppering of small black spots over a mosaic pattern (sometimes faint or absent). An irregular dark blotch usually present near each pectoral-fin insertion. Ventral surface whitish to coppery. Tail with alternating black and white bands.

Distribution: Found only in northern Australia and New Guinea, to depths of at least 250 m. In PNG, previously only recorded from the southern coastline but also recorded off East Sepik in this study; not recorded from the outer island chains.

Habitat and biology: Found on sandy and muddy bottoms from intertidal zones, including estuaries, to well offshore. Feeds almost exclusively on bony fishes, often ingesting very large fishes for its size; diet also includes small quantities of polychaetes, hemichordates, crustaceans and molluscs. Little known of its reproductive biology.

Utilisation: Caught in large numbers by the Gulf of Papua prawn trawl fishery and by coastal fisheries in some areas (e.g. the trap fishery off Wewak). Meat from larger individuals used for human consumption if retained; sometimes discarded.

Remarks: The presence of the skin flaps at the rear of the spiracles differentiates this from other *Gymnura* species found in adjacent regions, which lack them.

Similar species: A very distinctive species with a very broad disc and a short, filamentous tail.

Dorsal view of head, highlighting the small skin flap behind spiracles (arrows) and the short snout

Oronasal region

Image details: Dorsal: Gulf of Papua, PNG (adult male 43 cm DW). Dorsal head: Gulf of Papua, PNG (male 28 cm DW).

MERAUKE STINGRAY

Hemitrygon longicauda (Last & White, 2013)

NE

BIOLOGY

Maximum size: At least 31 cm DW (106 cm TL)

Maturity size: Unknown, no adults recorded to date

Birth size: ~12 cm DW

Litter size: Unknown

Reproductive mode: Presumably viviparous, with histotrophy

KEY FEATURES

- Tail extremely long and whip-like, more than 3 times disc width, with a long, low ventral skin fold
- Disc almost circular to weakly rhombic
- Eyes very small and spaced well apart
- A median row of enlarged thorns on midline of disc and tail
- Snout broadly triangular and relatively short
- Tail base slightly depressed and oval in cross-section

Colour: Dorsal surface greyish brown to medium brown; slightly paler along disc margin. Tail almost black beyond sting. Ventral surface white, without dark margin.

Distribution: Found only in southern New Guinea. In PNG, confirmed from Western and Gulf provinces only, and possibly confined to these regions.

Habitat and biology: Found on muddy bottoms in shallow coastal waters; common in the intertidal zone. Biology unknown.

Utilisation: Caught in the Gulf of Papua prawn trawl fishery and by coastal fisheries in Western and Gulf provinces, mainly in drag nets targeting prawns. Meat from larger individuals used for human consumption if retained.

Remarks: Has a very restricted distribution, but western limits in West Papua unknown. As with some other stingrays, the denticles on the mid-disc and head develop with increasing size; newborns with no, or only a single, enlarged thorn on disc, developing into a continuous single row along midline of disc and tail. Previously placed in the genus *Dasyatis*.

Similar species: The row of enlarged thorns can lead to confusion with *Pateobatis jenkinsii*; differs from that species in having a compressed tail base (vs. tail base circular in cross-section). Caught with *Pateobatis hortlei* but has a much shorter snout than that species.

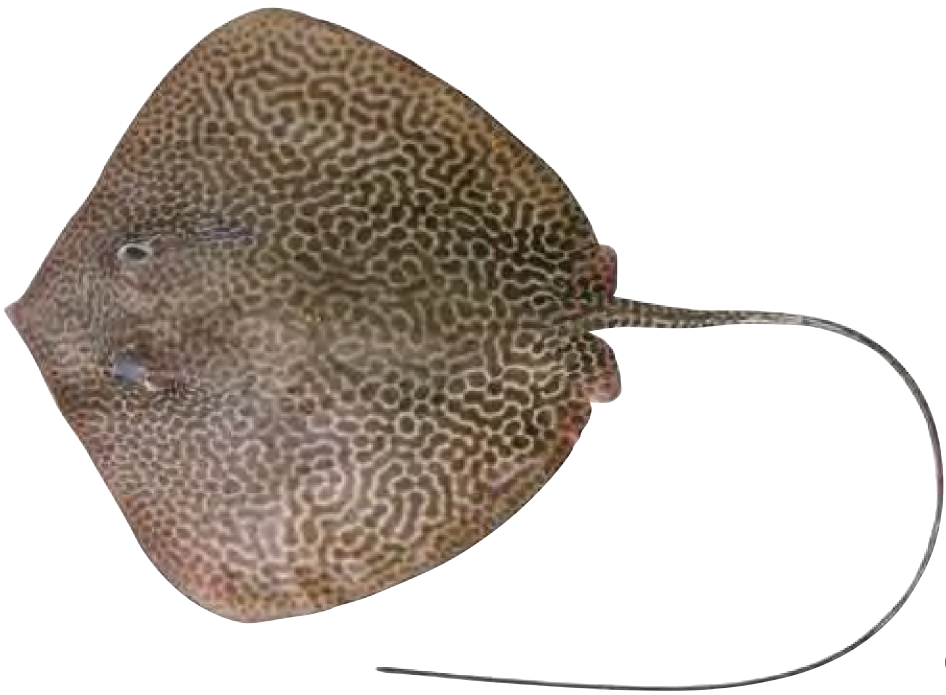
Denticles and enlarged thorn patterns on central disc with increasing size

Dorsal head, highlighting the small eyes and the broadly triangular snout

Image details: Dorsal and dorsal head: Gulf of Papua, PNG (female 31 cm DW). Central disc denticles: Gulf of Papua, PNG (females; top—14 cm DW, middle—25 cm DW, bottom—31 cm DW).

AUSTRALIAN WHIPRAY

Himantura australis Last, White & Naylor, 2016



NE

BIOLOGY

Maximum size: 183 cm DW (350 cm TL)

Maturity size: Males at ~112 cm DW

Birth size: ~29–30 cm DW

Litter size: 2–4 pups

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Tail long, whip-like and variably banded, without skin folds
- Base of tail not depressed, circular in cross-section
- Disc broad and weakly rhombic
- Snout relatively short and broadly triangular
- Denticle band on disc well developed in adults
- Strong colour pattern of dark reticulations or small spots

Colour: Dorsal surface yellowish to pale brownish with a dense covering of dark-brown spots, speckles or reticulations. Newborns with dense pattern of closely spaced dark spots; spots coalescing to form a reticulate or honeycomb pattern in larger specimens. Tail densely spotted or reticulate near sting, blackish or marbled beyond sting. Ventral surface white, with broad dark margin sometimes containing dark spots.

Distribution: Found only in northern Australia and PNG, but possibly more widely spread in the south-west Pacific, to at least 45 m depth. In PNG, confirmed from Western, Gulf, Central and New Ireland provinces; probably widespread.

Habitat and biology: Found on sandy and muddy bottoms, sometimes close to rocky reefs, in shallow coastal waters and estuaries. Feeds mostly on crustaceans (mainly prawns and crabs), but also polychaetes. Reproductive biology little known.

Utilisation: Caught in the Gulf of Papua prawn trawl fishery and by coastal fisheries in some provinces. Meat used for human consumption if retained.

Remarks: Previously considered to be conspecific with *H. uarnak*, but a recent study showed that the Australian and PNG populations are a separate species. The changes and variability in colour pattern of this species make it difficult to identify in the field at times, especially with juveniles.

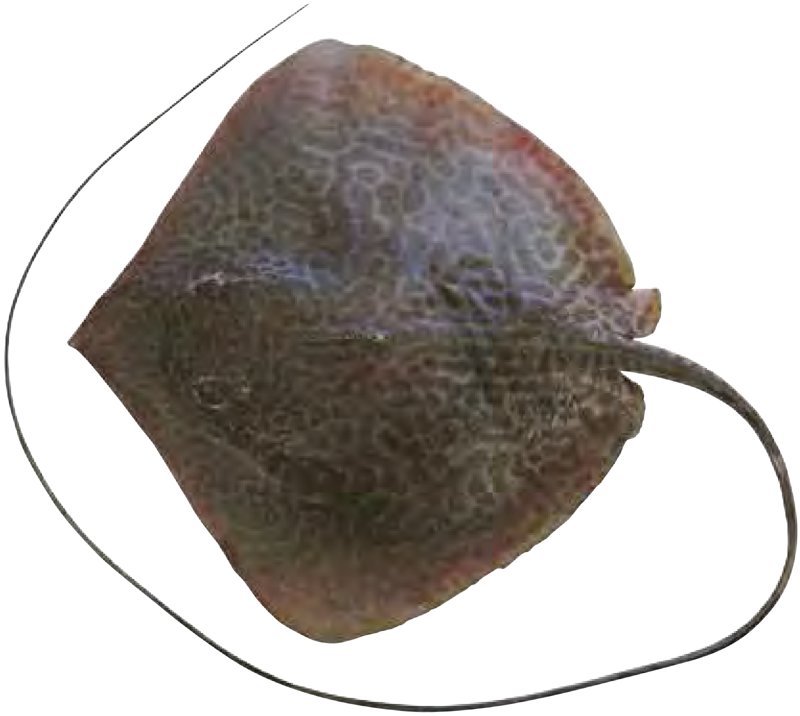
Similar species: Very similar to *H. leoparda* but differs in having smaller, more closely spaced dark spots in juveniles (vs. spots larger and further apart), pattern of speckles or reticulations in larger specimens (vs. pattern of dark rings), and snout with a less pointed tip (vs. snout tip pointed). Spotted individuals sometimes confused with *Maculabatis astra* but differ in tail being not strongly banded (vs. tail strongly banded).

Spotted colour pattern of juveniles (left) and reticulated pattern of adults (right); reticulations in adults formed by coalescing of small dark spots to form reticulated lines

Image details: Dorsal: Daru, PNG (juvenile male 41.5 cm DW). Juvenile: Daru, PNG (male 24 cm DW). Adult: Gulf of Papua, PNG (female 140 cm DW).

LEOPARD WHIPRAY

Himantura leoparda Manjaji-Matsumoto & Last, 2008



VU

BIOLOGY

Maximum size: At least 140 cm DW (410 cm TL)

Maturity size: Males at 70–85 cm DW

Birth size: ~20 cm DW

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Tail long, whip-like and variably banded, without skin folds
- Base of tail not depressed, circular in cross-section
- Disc broad and weakly rhombic
- Snout relatively short and broadly triangular, with pointed tip
- Denticle band on disc well developed in adults
- Strong colour pattern of leopard-like ocelli in adults (large blackish spots in juveniles)

Colour: Dorsal surface pale to yellowish brown with dense pattern of dark, medium-sized rings in adults. Juveniles with medium-sized spots, which become rings with increasing size. Tail with ring-like markings before sting, usually banded beyond sting. Ventral surface white, often with a broad dark margin on posterior disc.

Distribution: Found in the Indo–west Pacific, from South Africa to PNG and north to southern Japan, to at least 70 m depth. In PNG, only confirmed from Gulf Province; probably more widespread.

Habitat and biology: Found on sandy and muddy bottoms on the coastal and continental shelves. Biology little known.

Utilisation: Caught in the Gulf of Papua prawn trawl fishery; possibly also landed by coastal fisheries where it occurs. Meat used for human consumption if retained.

Remarks: First record of this species in PNG. The change in colour pattern with increasing size makes identification of this species difficult at certain sizes.

Similar species: Very similar to *H. australis* but differs in having larger and more widely spaced dark spots in juveniles (vs. spots smaller, more closely spaced), pattern of dark rings in larger specimens (vs. pattern of speckles or reticulations), and snout with a pointed tip (vs. snout tip less pointed). Some colour variations are difficult to distinguish from *H. australis*, and genetic data are often needed to get an accurate identification.

Spotted colour pattern of juveniles (left) and pattern of dark-brown rings in adults (right)

Image details: Dorsal: Gulf of Papua, PNG (subadult male 42 cm DW). Juvenile: Gulf of Papua, PNG (male 40 cm DW). Adult: Gulf of Papua, PNG (female 88 cm DW).

BLACKSPOTTED WHIPRAY

Maculabatis astra (Last, Manjaji-Matsumoto & Pogonoski, 2008)

BIOLOGY

Maximum size: 92 cm DW (180 cm TL)

Maturity size: Females at ~67 cm DW, males at ~44 cm DW

Birth size: 15–21 cm DW

Litter size: 1–3 pups

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Tail long, whip-like and banded, without skin folds
- Base of tail not depressed, circular in cross-section
- Disc broad and rhombic
- Snout relatively short and triangular
- Denticle band on disc well developed in adults
- Greyish brown with variable number of small black spots

Colour: Dorsal surface greyish brown with a pattern of black spots, sometimes very dense; each dark spot usually surrounded by a ring of faint white spots; faint white spots also sometimes present between dark spots. Tail with alternating black and white bands. Ventral surface uniformly white.

Distribution: Found only in northern Australia and southern New Guinea, to at least 140 m depth. In PNG, recorded from Western, Gulf, Central, Milne Bay and East Sepik provinces, and near New Britain.

Habitat and biology: Found on sandy and muddy bottoms, from mangrove flats to offshore on the continental shelf. Diet consists mostly of prawns and crabs. Reproductive biology little known.

Utilisation: Common in the catches of the Gulf of Papua prawn trawl fishery and also caught by coastal fisheries in some provinces. Meat used for human consumption if retained.

Remarks: Colour pattern varies from densely spotted to very sparsely spotted (see image below right). Not separable from *M. toshi* using molecular data and possibly just a colour variant of that species. Previously placed in the genus *Himantura*.

Similar species: Very similar to *M. toshi* but differs in having a pattern, often dense, of black spots on the dorsal surface (vs. no black spots). Occasionally confused with *Himantura australis* in PNG but differs in having a strongly banded tail (vs. not banded) and colour pattern less dense.

Pregnant female with two aborted late-term embryos from the Gulf of Papua trawl fishery

Adult male, highlighting the sparsely spotted colour variation

Image details: Dorsal: Gulf of Papua, PNG (female 48 cm DW). Pregnant female: Gulf of Papua, PNG (female 76 cm DW). Colour variant: Gulf of Papua, PNG (adult male 75 cm DW).

BROWN WHIPRAY

Maculabatis toshi (Whitley, 1939)

LC

BIOLOGY

Maximum size: ~82 cm DW (~170 cm TL)

Maturity size: Males at ~50 cm DW

Birth size: ~14 cm DW

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Tail long, whip-like and banded, without skin folds
- Base of tail not depressed, circular in cross-section
- Disc broad and rhombic
- Snout relatively short and broadly triangular
- Denticle band on disc well developed in adults
- Upper disc uniformly brown; adults sometimes with faint whitish spots and flecks

Colour: Dorsal surface brown to greenish brown; adults with many small, faint (often very faint) white spots. Tail mostly dark, banded beyond sting in juveniles. Ventral surface uniformly white; margin sometimes dusky.

Distribution: Found only in northern Australia and southern PNG. In PNG, confirmed only from Western Province; possibly restricted to the south-western reaches of PNG if a valid species.

Habitat and biology: Found on sandy and muddy bottoms, including mangrove flats and estuaries. Diet consists mostly of prawns and crabs, but also small bony fishes. Reproductive biology little known.

Utilisation: Caught occasionally by the coastal fisheries in Western Province. Meat used for human consumption if retained.

Remarks: Not separable from *M. astra* using molecular data and possibly represents a single species. The blackspotted whipray, *M. astra*, is commonly caught in trawl grounds slightly offshore, while *M. toshi* was only seen in very shallow coastal waters; if a single species, the colour variation possibly relates to the environment they occur in. Previously placed in the genus *Himantura*.

Similar species: Very similar to *M. astra* but differs in having a mostly plain brownish dorsal disc without dark spots (vs. colour pattern of mostly dense black spots). Likely to be confused with *Pateobatis fai*, which was observed in the same catches as this species off Daru; both species are brown without distinct markings, but *P. fai* has a much less pointed and shorter snout.

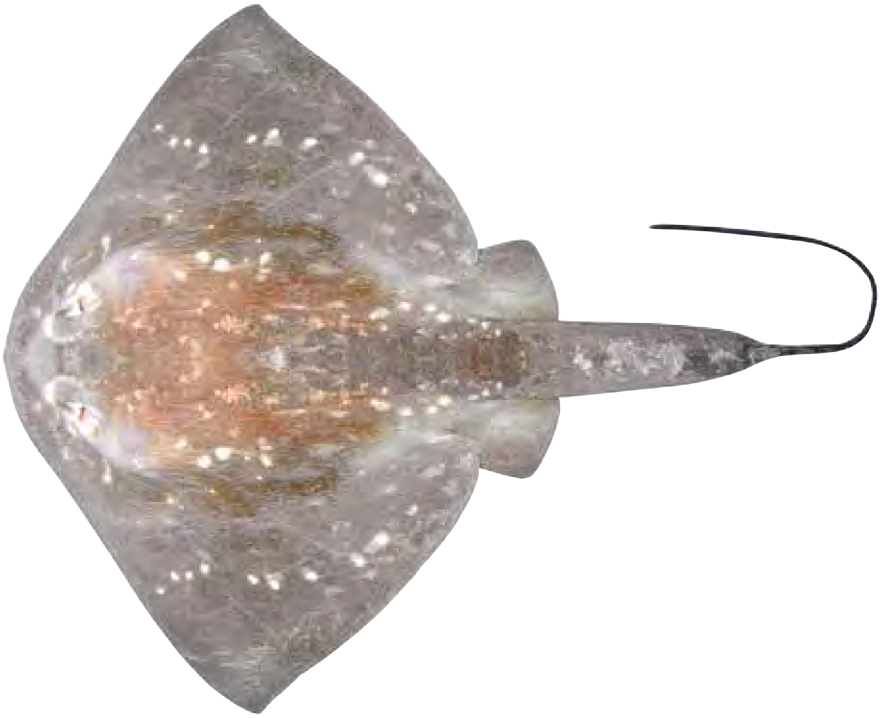
Central disc, showing enlarged denticles along midline and the small, faint white spots

Oronasal region

Image details: All images: Daru, PNG (female 82 cm DW).

SMALLEYE STINGRAY

Megatrygon microps (Annandale, 1908)



DD

BIOLOGY

Maximum size: At least 222 cm DW (more than 300 cm TL)

Maturity size: Unknown

Birth size: ~33 cm DW

Litter size: Single pup

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Disc very broad, its width >1.2 times disc length
- Well-developed skin fold on ventral surface of tail
- Tail base depressed and very broad, oval in cross-section
- Tail tapering rapidly near sting and without bands
- Eyes very small, 3 times smaller than spiracle
- Covered in numerous minute denticles

Colour: Dorsal surface brownish to pinkish with a diagonal row of white spots on each pectoral fin base. Tail blackish beyond sting. Ventral surface white; margins of disc dusky.

Distribution: Found in the Indo-Pacific, from Mozambique to PNG. In PNG, only confirmed from the Gulf of Papua.

Habitat and biology: Benthopelagic and pelagic on coastal and continental shelves; sometimes found swimming actively in open water rather than resting on bottom. Biology unknown.

Utilisation: Caught occasionally in the Gulf of Papua prawn trawl fishery. Meat probably used for human consumption if retained; possibly discarded because of its large size.

Remarks: Possibly swims great distances, based on its observed swimming behaviour, but its ecology is poorly known. Recent molecular data suggest this species may be more closely related to the freshwater stingrays (Potamotrygonidae) and round rays (Urotrygonidae) from the Americas than to the true stingrays; specimens required to allow a more detailed taxonomic study. Previously placed in the genus *Dasyatis*.

Similar species: A very distinctive stingray, unlikely to be confused with other species based on its very broad disc, and tail that is very thick based and tapers rapidly near sting.

Large adult specimen caught in a trawl set in the Gulf of Papua, highlighting the brownish colour of fresh specimens, small eyes and very broad disc

Image details: Dorsal: Mozambique (>100 cm DW). Fresh specimen: Gulf of Papua, PNG.

PLAIN MASKRAY

Neotrygon annotata (Last, 1987)

NT

BIOLOGY

Maximum size: 30 cm DW (at least 45 cm TL)

Maturity size: Females at 26 cm DW, males at 22 cm DW

Birth size: 12–14 cm DW

Litter size: 1–3 pups

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Snout pointed, with black, mask-like bar through eyes
- Tail not whip-like, with broad black and white bands
- Tail base broad and depressed (oval in cross-section)
- Skin folds present on dorsal and ventral surfaces of tail
- Short thorns on midline of disc and tail
- Upper disc plain, without spots or ocelli

Colour: Dorsal surface brownish to greyish green. A dark, mask-like marking across eyes. A pair of dark blotches on the mid-disc. Tail with black and white bands beyond sting, sometimes faint. Ventral surface dusky.

Distribution: Found only in northern Australia, eastern Indonesia and southern PNG at depths of 10–60 m. In PNG, confirmed from Western, Gulf and Central provinces; possibly restricted to the southern mainland PNG coastline.

Habitat and biology: Found on sandy and muddy bottoms on the coastal and continental shelves. Diet consists mostly of polychaetes, crustaceans and small bony fishes. Reproductive biology little known.

Utilisation: Caught in the Gulf of Papua prawn trawl fishery. Meat used for human consumption if retained; possibly discarded because of its small size.

Remarks: Maximum age of north-eastern Australian populations reported for males and females as 9 and 13 years, respectively.

Similar species: Possibly confused with *Hemitrygon longicauda* based on its plain colouration and row of thorns on midline of tail and disc, but differs in having a much shorter, banded tail (vs. tail very long and not banded), thorns on midline short (vs. thorns on midline very long), and eyes large (vs. eyes very small). Differs from other *Neotrygon* species in having a uniform colouration (vs. strong pattern of spots or reticulations).

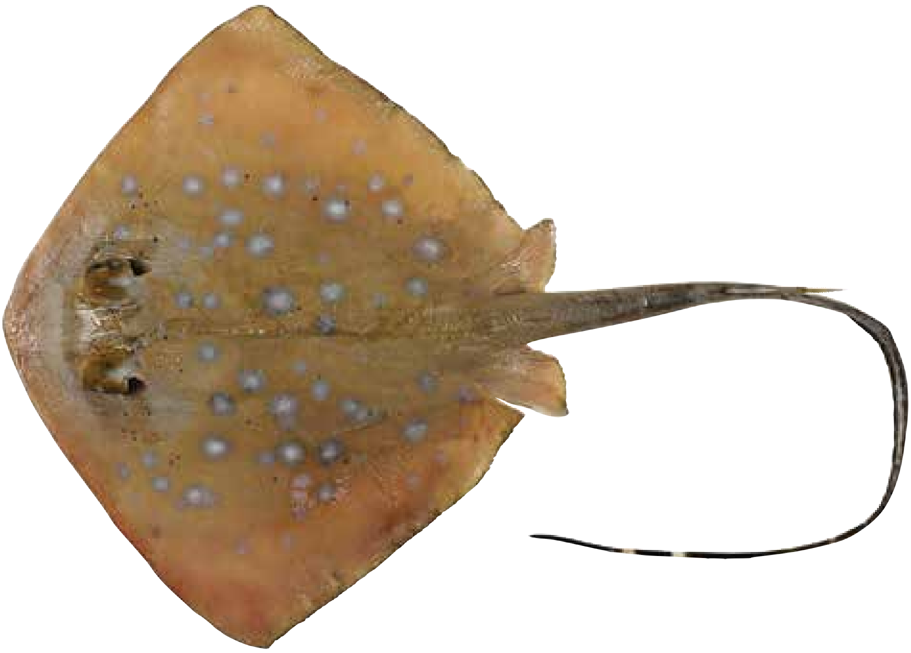
Dorsal view of head, highlighting the dark mask-like marking across the eyes

Ventral view of head, highlighting the dusky ventral colouration and pointed snout

Image details: Dorsal and dorsal head: Gulf of Papua, PNG (female 29 cm DW). Ventral head: Gulf of Papua, PNG (adult male 23 cm DW).

AUSTRALIAN BLUESPOTTED MASKRAY

Neotrygon australiae Last, White & Séret, 2016



NE

BIOLOGY

Maximum size: 47 cm DW (at least 61 cm TL)

Maturity size: Males at 28–34 cm DW

Birth size: ~14 cm DW

Litter size: Unknown; probably 1 or 2 pups

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Snout broadly rounded, with a faint dark, mask-like bar through eyes
- Tail not whip-like, with broad black and white bands
- Tail base broad, depressed (oval in cross-section)
- Skin folds present on dorsal and ventral surfaces of tail
- Short thorns on midline of disc and tail
- Upper disc with many large blue ocellate spots

Colour: Dorsal surface pale yellowish brown with large blue spots; spots bluish white surrounded by a greyish blue ring; spots present along midline of disc, as well as on pectoral fins. Small dark speckles concentrated on mask, sparse over disc. Tail with black and white bands near tip. Ventral surface white with greyish margins.

Distribution: Found only in northern Australia (not off eastern Queensland coast), eastern Indonesia and south-western PNG, at depths of 25–90 m. In PNG, only confirmed from the Daru region of Western Province; probably restricted to Western Province.

Habitat and biology: Found on sandy bottoms among and adjacent to reefs. Biology little known.

Utilisation: Caught in coastal fisheries in Western Province, mostly by spear. Meat used for human consumption.

Remarks: The blue-spotted maskrays were, until recently, considered to be a single widespread species, *N. kuhlii*. Genetic and morphological data confirmed they were a species complex, with colour pattern the main way to distinguish its species.

Similar species: Easily confused with the other blue-spotted species but differs in having large blue spots that are also present along the central band of the disc (vs. spots either small, or large and not present in the central band).

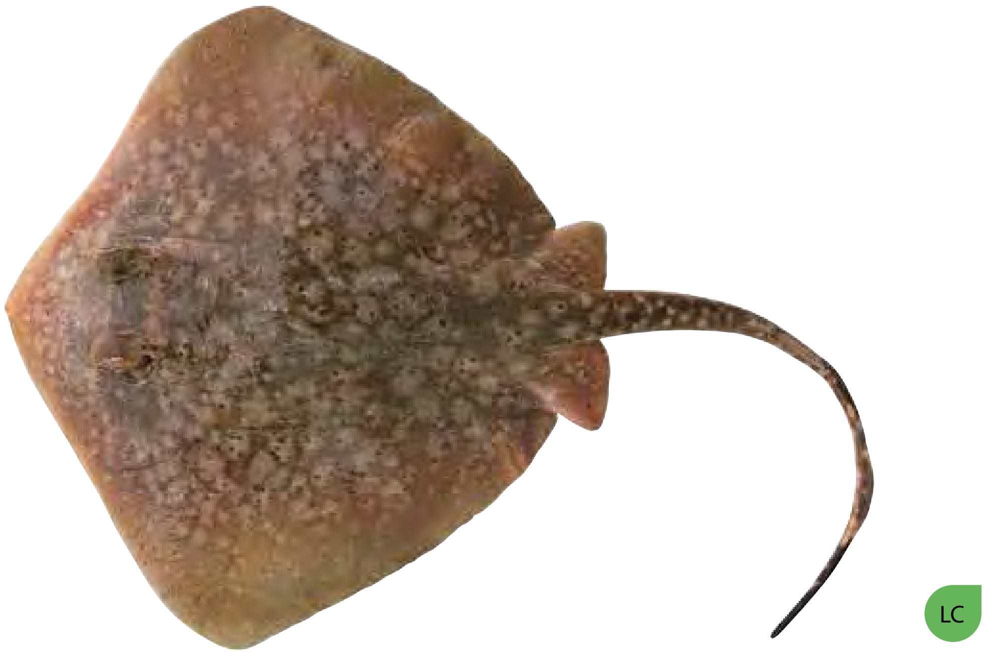
Adult male specimen, highlighting the large blue spots on the dorsal disc, including near the midline.

Dorsal view of head, highlighting the dark, mask-like marking across eyes

Image details: Dorsal: Gulf of Carpentaria, Australia (juvenile male 23.5 cm DW). Adult male and dorsal head: Daru, PNG (30 cm DW).

SPECKLED MASKRAY

Neotrygon picta Last & White, 2008



BIOLOGY

Maximum size: 32 cm DW (at least 60 cm TL)

Maturity size: Both sexes at ~17–18 cm DW

Birth size: ~10 cm DW

Litter size: 1–3 pups

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Snout broadly triangular, with a dark, mask-like bar through eyes
- Tail not whip-like, variably banded black and white near tip
- Tail base broad and depressed (oval in cross-section)
- Skin folds present on dorsal and ventral surfaces of tail
- Disc mostly smooth, with thorns only in a row on mid-disc and no thorns or denticles on tail
- Upper disc with coarse pattern of dark reticulations and speckles

Colour: Dorsal surface pale brownish with a coarse reticulate pattern and numerous small dark spots. Mask-like marking across eyes formed by clusters of small dark spots. Tail with black and white bands near tip. Ventral surface white, sometimes with faint yellowish to brownish margins.

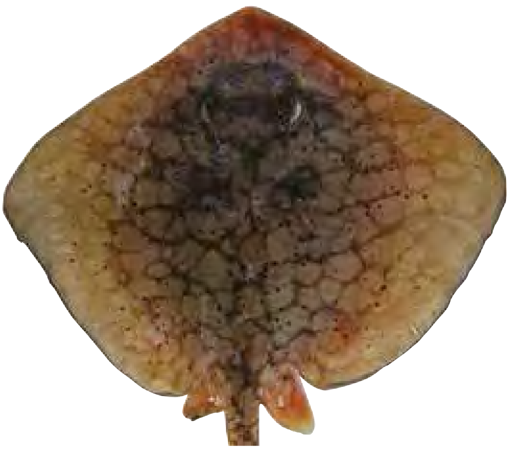
Distribution: Found only in north-eastern Australia and southern PNG, to depths of 100 m (mostly less than 25 m). In PNG, confirmed from Western and Gulf provinces; possibly restricted to Western Province and western Gulf Province.

Habitat and biology: Found on sandy bottoms on coastal and continental shelves. Feeds mostly on crustaceans and polychaetes, but also molluscs and small bony fishes. Reproductive biology little known.

Utilisation: Caught in the Gulf of Papua prawn trawl fishery and by coastal fisheries in Western Province. Meat used for human consumption if retained; possibly discarded.

Remarks: Likely only occurs in the south-western-most reaches of PNG, with the river outflows into the Gulf of Papua possibly acting as a dispersal barrier further eastwards.

Similar species: The strong reticulate pattern distinguishes this species from the other *Neotrygon* species. The banded tail tip and small size make it easily distinguishable from other stingrays in the region.



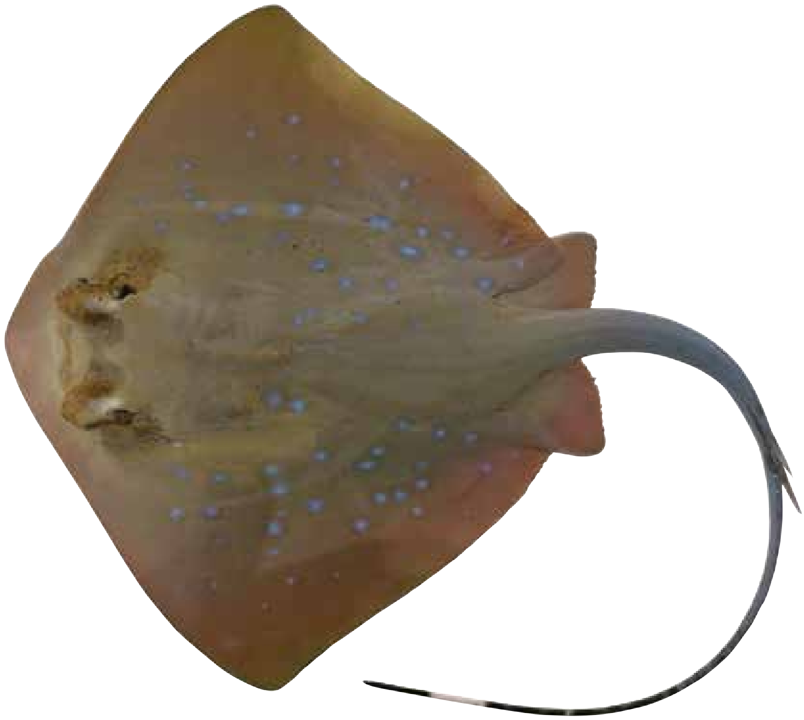
Dorsal disc of a juvenile, highlighting the more network-like colour pattern and dark-edged disc

Oronasal region

Image details: Dorsal and oronasal region: Daru, PNG (female 20 cm DW). Juvenile: Gulf of Papua, PNG (male 14 cm DW).

PAPUAN MASKRAY

Neotrygon cf. *trigonoides*



NE

BIOLOGY

Maximum size: At least 28 cm DW

Maturity size: Males at 26–28 cm DW

Birth size: Unknown

Litter size: Unknown; probably less than 3 pups

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Snout broadly triangular, with a dark, mask-like bar through eyes
- Tail not whip-like, with broad black and white bands
- Tail base broad and depressed (oval in cross-section)
- Skin folds present on dorsal and ventral surfaces of tail
- Short thorns on midline of disc and tail
- Upper disc with few smallish blue ocellate spots

Colour: Dorsal surface yellowish brown with many blue spots; spots bluish white surrounded by a blue ring, relatively small; spots sparser but still present on the central band of the disc. Small dark speckles concentrated on mask, sparse over disc. Tail with black and white bands near tip. Ventral surface white with faint greyish margins.

Distribution: Only known from PNG; possibly widespread but confirmed only from Central Province.

Habitat and biology: Found on sandy bottoms on coastal and continental shelves, usually near reef. Biology unknown; probably feeds mostly on crustaceans and polychaetes.

Utilisation: Unknown; possibly caught by coastal fisheries where it occurs. Meat likely used for human consumption if retained.

Remarks: Similar in colour pattern to *N. trigonoides*, also found in the Coral Sea off eastern Australia and New Caledonia; preliminary genetic data suggest it may be a separate species; more specimens required to determine whether it is a distinct species. Underwater images from New Ireland and Milne Bay Province have the same colour pattern and could be conspecific, but this needs to be confirmed and compared with *N.* cf. *westpapuensis*.

Similar species: Easily confused with the other blue-spotted species but differs in having small blue spots (vs. spots larger) and spots often more sparsely distributed on disc.

Specimen swimming over sand/rock habitat, highlighting the dark, mask-like bar across eyes and small blue ocellate spots on the disc

Image details: Dorsal: Bootless Bay, PNG (female 27.5 cm DW). Underwater: Kavieng, New Ireland, PNG (by D. Amon).

WEST PAPUAN MASKRAY

Neotrygon cf. *westpapuensis*

NE

BIOLOGY

Maximum size: At least 37 cm DW

Maturity size: A 37 cm DW male was mature

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Snout broadly rounded, with a dark, mask-like bar through eyes
- Tail not whip-like, with broad black and white bands
- Tail base broad and depressed (oval in cross-section)
- Skin folds present on dorsal and ventral surfaces of tail
- Short thorns on midline of disc and tail
- Upper disc with moderately large blue ocellate spots, but spots absent from central band (area from spiracles through to pectoral-fin insertions)

Colour: Dorsal surface yellowish brown with many blue spots; spots pale bluish surrounded by a bright blue ring, relatively large; spots absent on the central band of the disc. Small dark speckles concentrated on mask, very few over disc. Tail with black and white bands near tip. Ventral surface white with broad faint greyish margins.

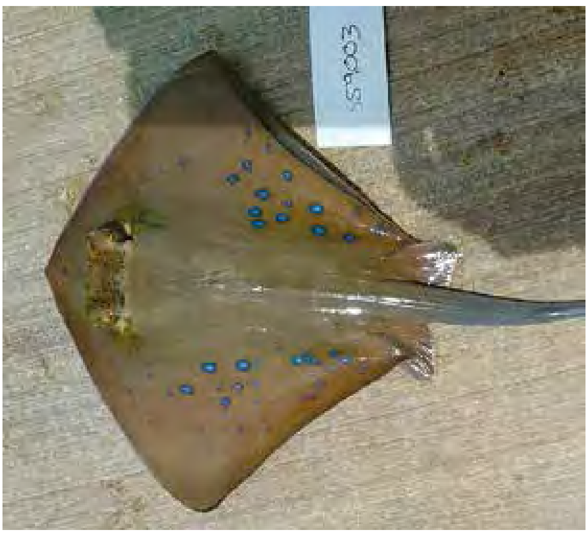
Distribution: Poorly known; only known from Wewak off PNG; possibly restricted to northern PNG only.

Habitat and biology: Probably found on soft bottoms in mostly coastal waters. Biology unknown; probably feeds mostly on crustaceans and polychaetes.

Utilisation: Caught by coastal fisheries off Wewak, particularly in the trap fishery. Meat used for human consumption.

Remarks: Part of the *N. kuhlii* complex; based on genetic data, closest to *N. westpapuensis*, recently described from Cenderwasih Bay in northern West Papua. Specimens required from throughout PNG to determine the ranges of the three blue-spotted species confirmed from PNG and whether any additional species may occur across the complex island chains.

Similar species: Easily confused with the other blue-spotted species but differs in having moderately large blue spots that are absent from the central band of the disc (vs. large or relatively small spots also present along central band).



Freshly caught specimen from Wewak

Image details: Dorsal: Wewak, PNG (adult male 37 cm DW). Fresh: Wewak, PNG (female 22 cm DW).

BROAD COWTAIL RAY

Pastinachus ater (Macleay, 1883)

LC

BIOLOGY

Maximum size: ~200 cm DW (more than 300 cm TL)

Maturity size: Males at 96–98 cm TL

Birth size: 18–28 cm DW

Litter size: 2 pups

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Disc profile quadrangular, with a short, rounded snout
- Ventral skin fold terminating well before tail tip, blackish and very deep (maximum depth >3.5 times height of tail above)
- Tail relatively broad based
- Sting situated well back on tail
- No thorn row along middle of tail

Colour: Dorsal surface uniformly greyish to greenish brown; tail fold and tip blackish. Ventral surface white, often with a fine black margin to disc and pelvic fins.

Distribution: Found in the Indo–west Pacific, from Madagascar to New Caledonia and northwards to Taiwan. In PNG, confirmed from Western, Gulf, Central, Milne Bay, Manus and New Britain provinces; probably widespread.

Habitat and biology: Found on sandy bottoms on coastal and continental shelves, but also in estuaries and fresh water. Feeds on crustaceans, polychaetes and gastropods, probably also some small bony fishes. Reproductive biology little known.

Utilisation: Caught in the Gulf of Papua prawn trawl fishery and by coastal fisheries in some areas. Meat likely used for human consumption if retained.

Remarks: Recently found to be a complex of species that differ in their disc morphology, arrangement of enlarged denticles on midline, and depth and colour of the ventral skin fold on the tail. The name *P. sephen* was previously used for this species.

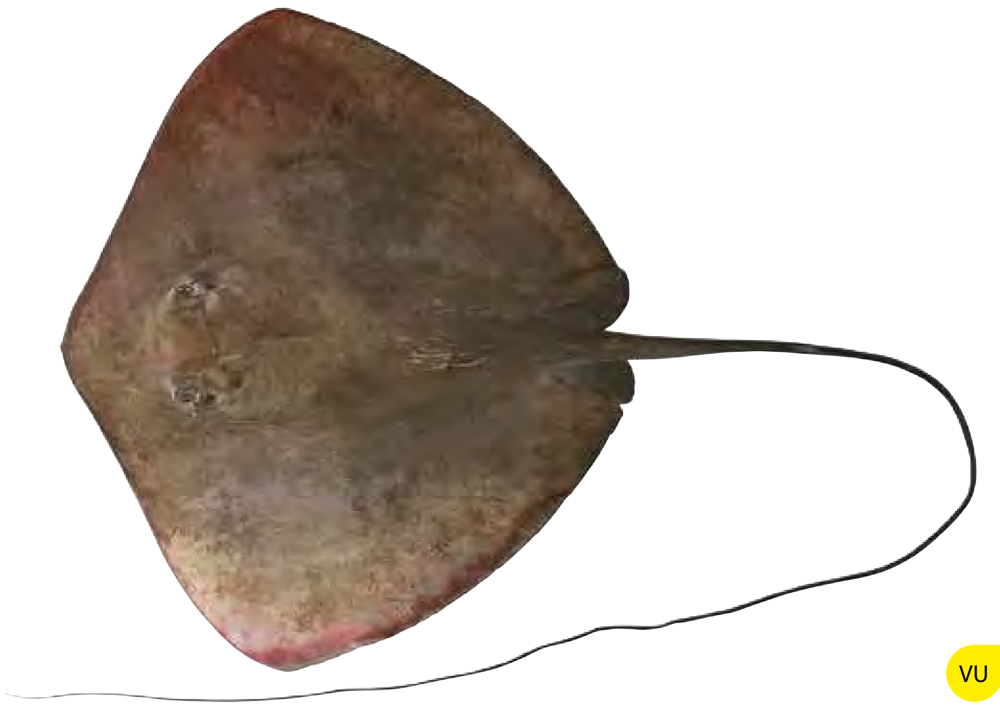
Similar species: A distinct stingray with a very broad skin fold on the ventral surface of the tail and with the caudal sting positioned well back on the tail.

Specimen on sandy substrate, highlighting the uniform brown colouration and the very deep ventral skin fold on the tail

Image details: Dorsal: Jakarta, Indonesia (juvenile female). Underwater: PNG (by B. Halstead).

PINK WHIPRAY

Pateobatis fai (Jordan & Seale, 1906)



BIOLOGY

Maximum size: At least 170 cm DW (more than 308 cm TL)

Maturity size: Males at ~112 cm DW

Birth size: ~30 cm DW

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Disc profile quadrangular, with a short, broad snout
- No skin folds on tail
- No obvious band of denticles on central disc
- Tail long, whip-like and uniformly dark beyond sting (not banded)
- Midline of tail before sting without enlarged thorny denticles
- Dorsal surface uniformly yellowish or pinkish grey

Colour: Dorsal surface uniformly pinkish brown to brown. A small white patch usually present in front of orbits. Tail black beyond sting. Ventral surface white with broad dark margin on most of disc, except in front of mouth.

Distribution: Found in the Indo–west and central Pacific, from South Africa to central Pacific islands and northwards to Okinawa, to depths of at least 70 m. In PNG, confirmed from Western and East Sepik provinces only, but probably widespread.

Habitat and biology: Found mainly on sandy and coral rubble bottoms, but also on intertidal flats. Feeds mainly on crustaceans and small bony fishes. Reproductive biology little known.

Utilisation: Caught by coastal fisheries in some areas. Meat used for human consumption.

Remarks: Aggregations of up to 25 individuals have been recorded from some areas; has been reported to 'piggy-back' on larger rays, whereby they rest on top of a swimming larger ray.

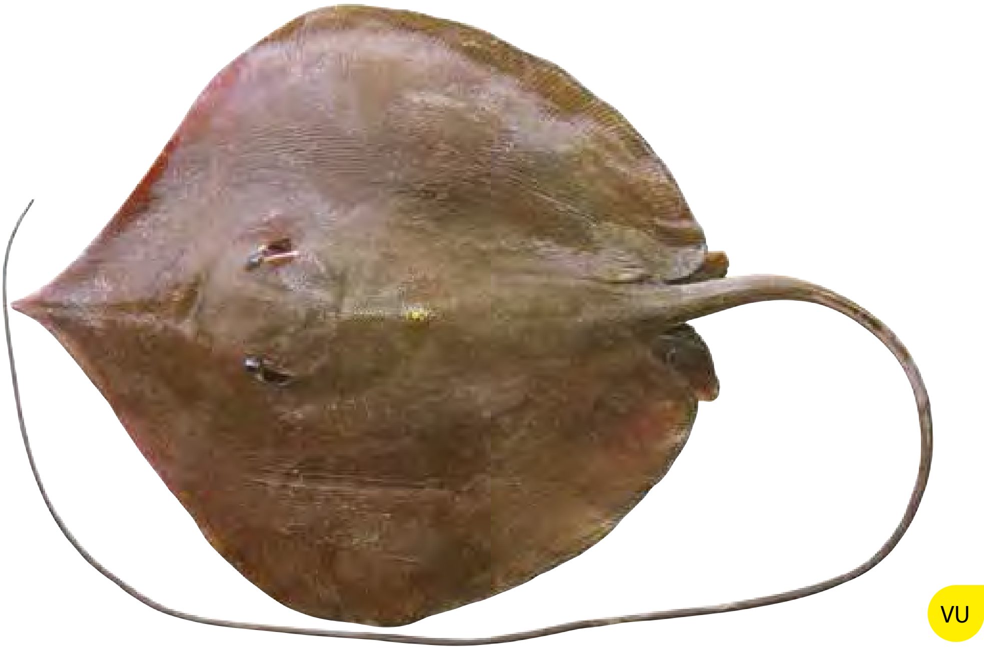
Similar species: Often misidentified because of the lack of distinguishing features; distinguishable from other plain stingrays with a rhombic-shaped disc in having a black tail (vs. banded in *Maculabatis toshi*), no row of enlarged thorns on midline (vs. a distinct row of enlarged thorns on midline of disc and tail in *P. jenkinsii* and *Hemitrygon longicauda*), the tail base round in cross-section, not compressed (vs. compressed and oval in *Hemitrygon longicauda* and *Pastinachus ater*), and the snout short (vs. long in *P. hortlei*).

A very large adult specimen caught in a trawl net in the Gulf of Papua (right side of ray out of view); largest recorded specimen of this species

Image details: Dorsal: Daru, PNG (female 64 cm DW). Fresh: Gulf of Papua, PNG (adult male ~170 cm DW).

HORTLE'S WHIPRAY

Pateobatis hortlei (Last, Manjaji-Matsumoto & Kailola, 2006)



BIOLOGY

Maximum size: 112 cm DW (more than 240 cm TL)

Maturity size: Females at ~100 cm DW

Birth size: 16–20 cm DW

Litter size: One pregnant female contained a single pup

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Profile of disc oval to rounded
- Snout very elongate and narrow
- Eyes relatively small
- Tail narrow-based and circular in cross-section
- No skin fold on ventral surface of tail
- Larger individuals yellowish on both surfaces; juveniles brownish above

Colour: Dorsal surface uniformly dark greenish brown (juveniles) to yellowish or brownish orange (adults); tail brown. Ventral surface white to vivid yellow, particularly when fresh.

Distribution: Found in New Guinea and northwestern Australia. In PNG, confirmed from Western, Gulf and East Sepik provinces; probably widespread around mainland PNG but likely absent from the outer island chains.

Habitat and biology: Found inshore on sandy and muddy bottoms, usually in the vicinity of river mouths and estuaries. Probably feeds on crustaceans and small bony fishes. Reproductive biology unknown.

Utilisation: Caught in the Gulf of Papua prawn trawl fishery and by coastal fisheries in some areas. Meat used for human consumption if retained.

Remarks: First discovered in southern West Papua, but found to be common in southern PNG during this study; also recorded in the bycatch of the trap fishery operating off Wewak.

Similar species: Differs from other plain-coloured stingrays in having a very long snout and small eyes (vs. snout much shorter and eyes larger).

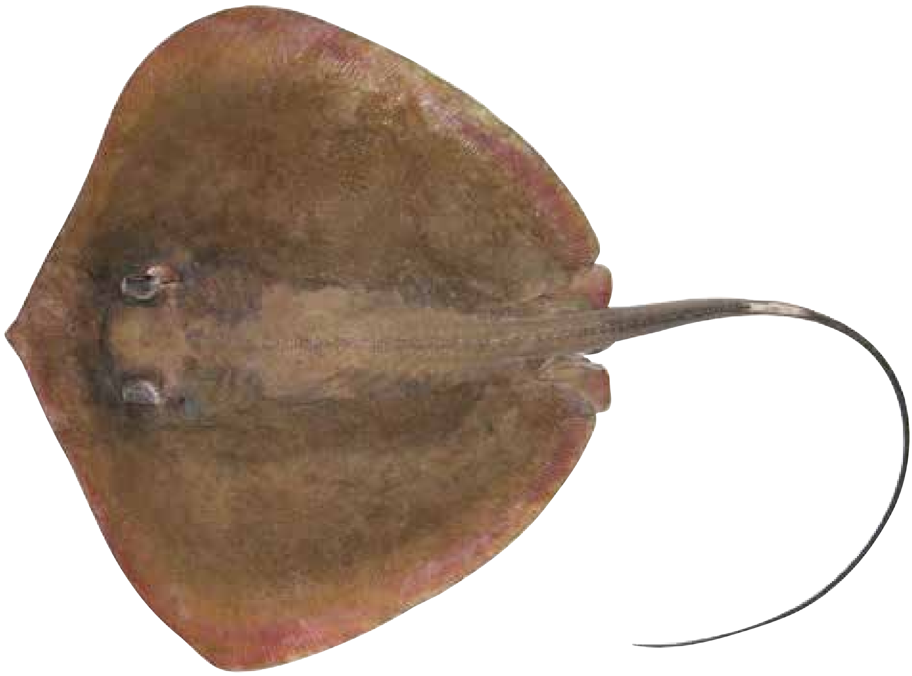
Fresh adult specimen landed in a trawl set, highlighting the uniform yellowish-brown colour and small eyes

Late-term embryo, highlighting the pale greyish-brown colour

Image details: Dorsal: Gulf of Papua, PNG (subadult male 37 cm DW). Adult: Gulf of Papua, PNG (adult female 112 cm DW). Embryo: Gulf of Papua, PNG (male 16 cm DW).

JENKINS' WHIPRAY

Pateobatis jenkinsii (Annandale, 1909)



VU

BIOLOGY

Maximum size: ~150 cm DW (more than 300 cm TL)

Maturity size: Males at ~70 cm DW

Birth size: ~23 cm DW

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Disc profile quadrangular, with a short, broad snout
- No skin folds on tail
- Band of denticles on central disc
- Tail moderately long, whip-like and uniformly dark (not banded)
- Midline of central disc and tail with a row of upright thorns
- Dorsal surface uniformly yellowish brown

Colour: Dorsal surface uniformly yellowish brown; tail blackish beyond sting. Ventral surface white.

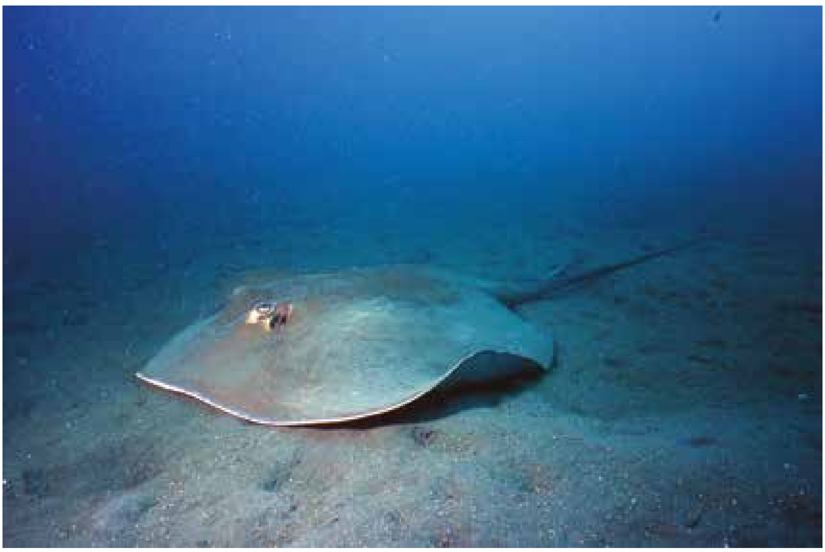
Distribution: Found in the Indo–west Pacific, from South Africa to PNG and northwards to the Philippines, to depths of ~90 m. In PNG, confirmed only from an underwater image; possibly widespread.

Habitat and biology: Found on sandy bottoms, sometimes close to reefs, on coastal and continental shelves. Probably feeds on crustaceans and small bony fishes. Reproductive biology unknown.

Utilisation: Possibly caught by coastal fisheries in some areas. Meat probably used for human consumption if caught and retained.

Remarks: As with many other stingrays in PNG, no significant target fishing occurs in PNG, and thus exploitation is likely to be relatively low, the exception being in trawl grounds, which are currently restricted to the Gulf of Papua. Previously placed in the genus *Himantura*.

Similar species: Most similar to *P. fai* and often misidentified as this species, but differs in having a distinct row of enlarged thorns along the dorsal midline of the disc and tail.



Specimen on sandy substrate, highlighting the uniform brownish colouration

Image details: Dorsal: Jakarta, Indonesia (juvenile male 54 cm DW). Underwater: PNG (by B. Halstead).

PELAGIC STINGRAY

Pteroplatytrygon violacea (Bonaparte, 1832)

LC

BIOLOGY

Maximum size: ~80 cm DW (usually less than 60 cm DW)

Maturity size: Females at 39–50 cm DW, males at 35–38 cm DW

Birth size: ~14–20 cm DW

Litter size: 2–9 pups

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Anterior profile of disc strongly convex and obtuse
- Outer edge of disc angular
- Row of small thorns along midline of disc
- Tail whip-like and broad-based (oval in cross-section)
- Ventral skin fold on tail very low, terminating well before tail tip
- Dorsal and ventral surfaces dark brownish to black (often with a purplish tinge)

Colour: Dorsal surface uniformly dark brownish to black (often with a purplish tinge). Tail blackish. Ventral surface dark brownish, blackish or greyish, only slightly paler than dorsal surface.

Distribution: Circumglobal in all tropical and temperate oceans, from surface to at least 238 m depth. In PNG, confirmed from the Coral Sea, but very likely widespread in pelagic waters.

Habitat and biology: Pelagic in oceanic waters. Feeds mainly on jellyfishes, squids, crustaceans and bony fishes. Gestation period of 2–4 months.

Utilisation: Caught as bycatch in the offshore longline fisheries and in the purse seine fishery. Typically discarded.

Remarks: The only truly pelagic and oceanic stingray species. Not much known about the population structure of this species throughout its range, but catch data suggest they segregate by sex. Known to migrate in some areas, either pupping in warmer water and then moving to cooler water, or vice versa in other locations. Mortality of hooked individuals reported to be very low, suggesting post-release survivability may be high.

Similar species: A distinctive stingray with a flattened cone-shaped disc that is uniformly dark on both dorsal and ventral surfaces.

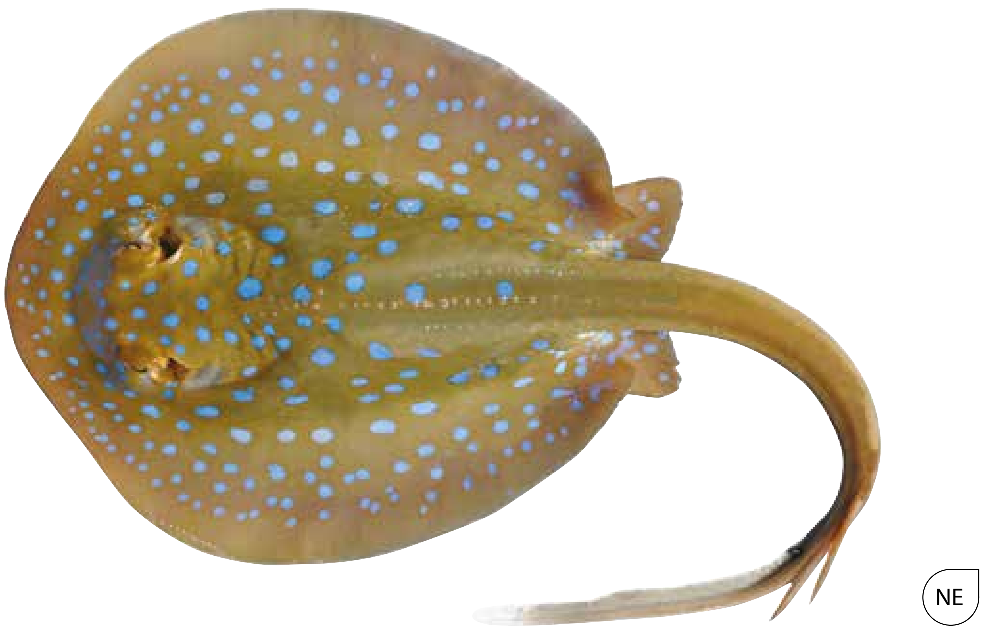
Fresh specimen landed on a tuna longline south-east of Port Moresby

Ventral disc, highlighting the dark colouration and the convex anterior disc

Image details: Dorsal: Lombok, Indonesia (female 47 cm DW). Fresh: Coral Sea, PNG (adult male 50 cm DW). Ventral: Bali, Indonesia (female 53 cm DW).

OCEANIA FANTAIL RAY

Taeniura lessoni Last, White & Naylor, 2016



BIOLOGY

Maximum size: At least 22 cm DW (~56 cm TL)

Maturity size: Males at ~21 cm DW (immature at 18.5 cm DW)

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Profile of disc oval
- Dorsal surface almost smooth to granular (denticles very small)
- Ventral skin fold on tail relatively deep, extending to tail tip
- 1 or 2 stings present, located beyond midlength of tail
- Tail short, without blue stripes
- Posterior tail and skin fold pale
- Upper surface with numerous bright blue spots

Colour: Dorsal surface yellowish brown to orange with dense coverage of bright blue spots. No blue stripes on tail. Ventral skin fold pale. Tail tip white. Ventral surface white with a broad, well-defined yellowish margin on disc and posterior tips of pelvic fins.

Distribution: Known only from a restricted range in the south-west Pacific, from PNG, Solomon Islands and Fiji, at depths less than 20 m. In PNG, confirmed only from New Ireland and East New Britain; probably restricted to the outer island chains.

Habitat and biology: Found in caves and under ledges on coral reefs. Biology unknown; probably feeds mostly on benthic invertebrates.

Utilisation: Unknown; probably caught by some coastal fishers where it occurs.

Remarks: More active at night where it forages over shallow coral reefs. Previously considered to be conspecific with the wide-ranging *T. lymma* but recently described as a new species; PNG appears to be the only country where both members of the genus occur, although without overlapping distributions. Confirmed from New Ireland and East New Britain from underwater photographs.

Similar species: Similar to *T. lymma* but differs in lacking two blue stripes either side of the midline of the posterior disc and tail (vs. two mid-lateral blue stripes present) and ventral skin fold on tail pale (vs. bright blue).

Specimen in a rocky crevice on shallow coral reef near Kavieng in New Ireland, highlighting the plain tail base, lacking a blue lateral stripe on either side

Image details: Dorsal: Solomon Islands (female 22 cm DW). Underwater: New Ireland, PNG (by D. Amon).

BLUESPOTTED FANTAIL RAY

Taeniura lymma (Forsskål, 1775)

BIOLOGY

Maximum size: ~35 cm DW (~75 cm TL)

Maturity size: Males at ~20 cm DW

Birth size: 13–14 cm DW

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Profile of disc oval
- Dorsal surface almost smooth to granular (denticles very small)
- Ventral skin fold on tail relatively deep, extending to tail tip
- Stings present (usually 2), located beyond midlength of tail
- Tail short, with blue stripe on each side before sting
- Posterior tail and skin fold bluish
- Upper surface with numerous bright blue spots

Colour: Dorsal surface yellowish brown to orange with dense coverage of bright blue spots. Tail with a pair of mid-lateral blue stripes before sting, extending onto posterior disc. Ventral skin fold bright blue. Tail tip white. Ventral surface white, often with a broad, well-defined yellowish margin on disc.

Distribution: Found in the Indo–west Pacific, from South Africa to PNG and northwards to the Philippines, at depths less than 20 m. In PNG, confirmed from Western, Central, Milne Bay, Madang and Manus provinces; probably widespread on the mainland of PNG.

Habitat and biology: Found mostly in caves and under ledges on coral reefs, also sometimes around mangrove flats. Feeds mostly on bivalves, prawns and marine worms. Reproductive biology little known.

Utilisation: Caught occasionally by coastal fisheries where it occurs. Meat used for human consumption if retained.

Remarks: More active at night where it forages over shallow coral reefs. A commonly observed species on shallow coral reefs, yet very little known about the life history of this species.

Similar species: Similar to *T. lessoni* but differs in having two mid-lateral blue stripes on the posterior disc and tail (vs. no blue stripes on tail or disc) and ventral skin fold on tail bright blue (vs. pale).

Specimen swimming, highlighting the blue stripes on the tail and blue ventral skin fold on the tail

Image details: Dorsal: Milne Bay, PNG (female 18 cm DW). Underwater: Milne Bay, PNG (by M. Erdmann).

BLOTCHED FANTAIL RAY

Taeniurops meyeni (Müller & Henle, 1841)

BIOLOGY

Maximum size: ~180 cm DW (~330 cm TL)

Maturity size: Males at 100–110 cm DW

Birth size: 30–35 cm DW

Litter size: Up to 7 pups

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Profile of disc circular
- Dorsal surface almost smooth (denticles very small)
- Ventral skin fold on tail deep, extending to tail tip
- Large sting present (usually 1)
- Tail uniformly black posterior to sting
- Upper surface grey with dark blotches and mottling (often faint)

Colour: Dorsal surface grey with variable-sized, irregular black blotches; blotching often forms a mottled black and grey appearance. Tail and ventral skin fold black beyond sting. Ventral surface pale with margin greyish to blackish (most evident in juveniles).

Distribution: Found in the Indo–west Pacific, from South Africa to New Caledonia and northwards to southern Japan and China, to depths of at least 439 m. In PNG, confirmed from Bougainville, New Ireland and Milne Bay provinces; probably widespread.

Habitat and biology: Found on sand bottoms (adjacent to reefs) and coral reef habitats from close inshore to the continental slope. Feeds on benthic invertebrates and bony fishes. Reproductive biology little known.

Utilisation: Unknown; possibly caught by spearfishers if targeting rays on reefs.

Remarks: Previously placed in the genus *Taeniura.* The most commonly observed large stingray on coral reef habitat, including on ledges and caves on vertical reef walls and on top of large coral bommies.

Similar species: A distinctive ray, unlikely to be confused with other stingrays based on its mottled colour pattern and the almost circular disc.

Specimen on rocky bommie substrate, highlighting the marbled colouration

Image details: Dorsal: Bali, Indonesia (female 50 cm DW). Underwater: PNG (by B. Halstead).

MUMBURARR WHIPRAY

Urogymnus acanthobothrium Last, White & Kyne, 2016

NE

BIOLOGY

Maximum size: At least 161 cm DW

Maturity size: Males at ~110 cm DW

Birth size: Largest embryo ~28 cm DW

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Profile of disc oval
- Very small eyes in front of large spiracles
- Denticle band well developed
- No enlarged thorns on body
- Tail long, whip-like and narrow-based
- Upper disc brownish to yellowish grey, often with fine greyish speckles

Colour: Dorsal surface yellowish brown, sometimes with a greenish tinge; sometimes with irregular covering of greyish speckles. Tail pale, almost white beyond sting. Ventral surface white.

Distribution: Found only in northern Australia and southern PNG, to depths of at least 60 m. In PNG, known only from the Gulf of Papua.

Habitat and biology: Found on sandy and muddy bottoms on the coastal and upper continental shelves; also in estuaries and brackish reaches of tidal rivers. Biology unknown; probably gives birth in freshwater rivers.

Utilisation: Caught occasionally in the Gulf of Papua prawn trawl fishery. Meat possibly used for human consumption if retained.

Remarks: First discovered off northern Australia more than 20 years ago, but first specimens collected only in the past few years and subsequently described as new. Juveniles found in some brackish rivers in northern Australia; possibly found throughout the vast riverine and estuarine systems that flow into the Gulf of Papua.

Similar species: Similar to *Pateobatis hortlei*, and can be found in the same trawl catches, but differs in having a much thicker disc (vs. disc thin), a whitish tail (vs. tail darker than disc) and shorter snout (vs. snout very long). Also close to *U. granulatus* but differs in lacking white flecks on the dorsal surface (vs. covered in small white flecks).

Fresh, large specimen, highlighting the yellowish brown disc and very small eyes in front of very large spiracles

Image details: Dorsal: Western Australia (juvenile male 67 cm DW, by P. Kyne). Fresh: Gulf of Papua, PNG (female 114 cm DW).

PORCUPINE WHIPRAY

Urogymnus asperrimus (Bloch & Schneider, 1801)

VU

BIOLOGY

Maximum size: 147 cm DW

Maturity size: Females at ~100 cm DW, males at ~90 cm DW

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Profile of disc almost circular, very thick
- Dorsal surface very rough, covered with long, sharp thorns
- Base of tail narrow and rounded in cross-section
- Tail short, without skin folds or stinging spines
- Posterior half of tail blackish
- Upper surface uniformly brownish, yellowish or greyish

Colour: Dorsal surface uniformly brownish, yellowish or greyish; thorns on disc often paler. Ventral surface white.

Distribution: Found in the Indo–west Pacific, from South Africa to Marshall Islands and northwards to Taiwan, and possibly the eastern Atlantic, to depths of at least 30 m. In PNG, confirmed from Western, Central, Milne Bay, New Britain and Bougainville provinces; probably widespread.

Habitat and biology: Found on sandy and muddy bottoms, mostly in coastal areas, including in mangrove habitats. Feeds mainly on marine worms, bivalves and crustaceans. Reproductive biology little known.

Utilisation: Caught occasionally by coastal fisheries in some provinces. Meat used for human consumption.

Remarks: Uses blasts of water taken in through the large spiracles to excavate into the soft sediment searching for prey; resulting feeding pits are typically deeper than for most other stingrays. Common around very shallow, muddy areas near mangroves, but rarely observed because of the high turbidity at those locations.

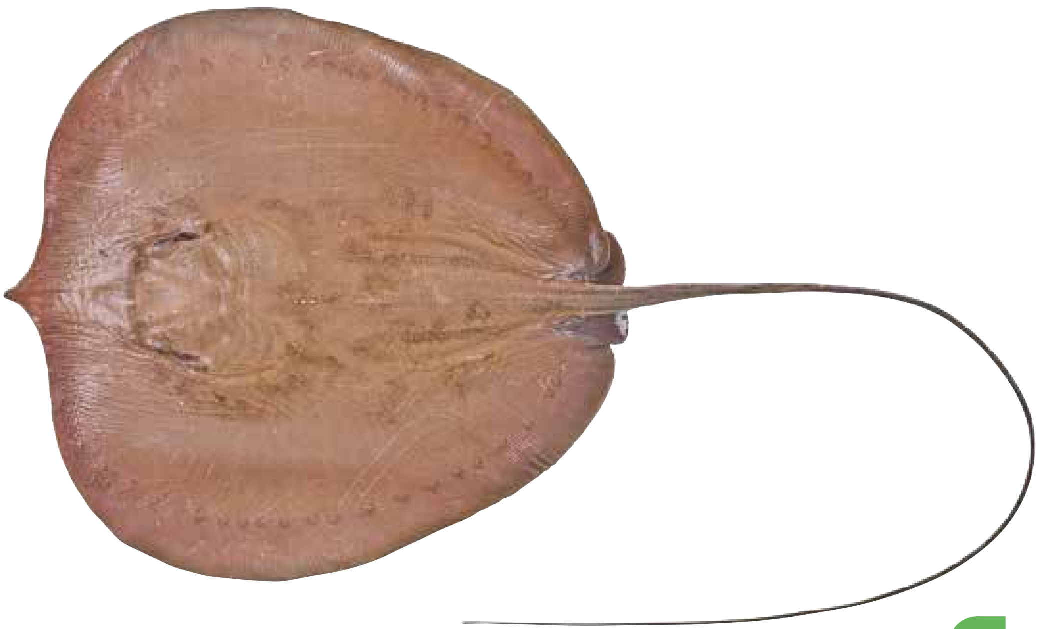
Similar species: Similar in size and shape to other *Urogymnus* species but differs in having enlarged sharp thorns over dorsal disc and tail, and in lacking a caudal sting (present in all other stingrays).

Two adult specimens on sandy substrate adjacent to a coral reef patch

Image details: Dorsal: Daru, PNG (juvenile male 52 cm DW). Underwater: Milne Bay, PNG (by B. Halstead).

FRESHWATER WHIPRAY

Urogymnus dalyensis (Last & Manjaji-Matsumoto, 2008)



LC

BIOLOGY

Maximum size: At least 124 cm DW (more than 270 cm TL)

Maturity size: Males at ~90 cm DW

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Disc profile almost circular with long, sharply pointed tip
- No skin folds on tail
- Tail long, whip-like, narrow-based and blackish (not banded)
- Central disc with 2–4 heart-shaped thorns
- Midline of tail before sting lacking enlarged thorns
- White below, with very broad dark margin

Colour: Dorsal surface uniformly greyish to yellowish brown; tail blackish beyond sting. Ventral surface white with a broad dark greyish to brownish margin; irregular dark spots centrally, mainly near dark margin, giving it a mottled appearance.

Distribution: Found only in northern Australia and southern PNG. In PNG, only known from a single record from Lake Murray in the Fly River Basin.

Habitat and biology: Found on the bottom in rivers, estuaries and brackish coastal environments. Feeds mainly on small fishes and prawns. Reproductive biology unknown.

Utilisation: Unknown.

Remarks: In northern Australia, has been observed to actively chase prey and occasionally beach itself to enable prey capture. Previously placed in the genus *Himantura* and considered to be conspecific with *Himantura chaophraya* (now *Urogymnus polylepis*). PNG record from Lake Murray based on images; specimens required to confirm it is this species.

Similar species: Differs from other *Urogymnus* species in having an almost straight anterior margin to the disc, with a distinct, sharply pointed tip.

Live specimen, highlighting the sharply pointed snout tip

Ventral disc, highlighting the broad dark margin

Image details: Dorsal: Queensland, Australia (female 45 cm DW). Live specimen: Northern Territory, Australia (by H. Larson). Ventral: Western Australia (juvenile male 62 cm DW).

MANGROVE WHIPRAY

Urogymnus granulatus (Macleay, 1883)

VU

BIOLOGY

Maximum size: At least 141 cm DW (more than 350 cm TL)

Maturity size: Males at 55–65 cm DW

Birth size: ~14 cm DW

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Disc almost circular in profile
- Snout broadly triangular and short
- No skin folds on tail
- Tail moderately long, whip-like and whitish behind sting
- Sting situated anteriorly on tail
- Upper surface greyish with small white flecks (often with a layer of dark mucus when alive)

Colour: Dorsal surface dark greyish to yellowish brown, covered with small white flecks (dark-grey colour a mucus layer, which, when removed, reveals the yellowish brown colour). Tail white beyond sting. Ventral surface white with dense black blotches in adults; a broad dusky margin around most of disc and outer pelvic fins.

Distribution: Found in the Indo–west Pacific, from the Red Sea to Oceania, to depths of at least 85m. In PNG, confirmed from Gulf, Central, Milne Bay and Oro provinces; also recorded historically from the 'northern Bismarck Archipelago'.

Habitat and biology: Juveniles found on sandy and muddy bottoms around mangroves and estuaries; adults mostly on coral reefs. Feeds mainly on prawns and crabs. Reproductive biology unknown.

Utilisation: Unknown; probably caught occasionally by coastal fisheries in some provinces.

Remarks: Juveniles reported to mostly stay within intertidal bays at high tide, moving to coral reef habitat during low tide. Originally described from the Port Moresby area in 1883.

Similar species: Similar to *U. acanthobothrium* but differs in having the dorsal disc covered in small white flecks (vs. disc without white flecks).

Large specimen on rocky substrate, highlighting the dark colouration of live animals, with numerous white flecks and white tail beyond sting

Image details: Dorsal: Mullins Harbour, PNG (female 31 cm DW). Underwater: Tufi Lagoon, PNG (by D. Harasti).

NEW IRELAND STINGAREE

Spinilophus armatus (Valenciennes, 1841)

DD

BIOLOGY

Maximum size: Unknown; only known from 17 cm TL juvenile male

Maturity size: Unknown

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Presumably viviparous, with histotrophy

KEY FEATURES

- Tail with a very long and slender caudal fin (not evident in image)
- Disc broad, much wider than long
- No dorsal fin on tail
- Upper disc with some denticles, an enlarged thorn centrally and about 4 rows of sharp spinules on posterior half of disc
- Snout fleshy; tip extended
- Eyes very small

Colour: Based on only known specimen, which has been in preservative for >150 years: dorsal surface brownish with slightly darker blotches. Ventral surface paler with dark disc margins.

Distribution: Only known from a single specimen caught off southern New Ireland.

Habitat and biology: Unknown.

Utilisation: Unknown; possibly out of range of current fishing activities.

Remarks: Only known from a single specimen collected by Lesson and Garnot off New Ireland before 1841. Assuming the collector and New Ireland location for the specimen are correct, it is most likely the specimen was collected from Port Praslin, just north of Tawanlik Cape and south of Lambom; this site was visited during the Voyage Autour du Monde on-board *La Coquille* on 12 August 1823. However, this species was never mentioned in the fish descriptions by Lesson following the voyage.

Similar species: Similar to *Urolophus bucculentus* but differs in lacking a dorsal fin (vs. small dorsal fin present), and having small thorns and denticles on dorsal disc (vs. disc entirely smooth).

Map of the southern tip of New Ireland, showing the location of Port Praslin where the holotype of this species was possibly collected

Image details: Dorsal: New Ireland, PNG (juvenile male 17 cm TL). Map: GoogleEarth @ 2017 DigitalGlobe, Landsat/Copernicus.

SANDYBACK STINGAREE

Urolophus bucculentus Macleay, 1884

VU

BIOLOGY

Maximum size: 89 cm TL

Maturity size: Females at ~50 cm TL, males at ~40 cm TL

Birth size: ~17 cm TL

Litter size: 1–5 pups

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Tail with a short and broad caudal fin (missing in image)
- Disc broad, much wider than long
- A dorsal fin present on tail (visible in image)
- Upper disc smooth, without denticles
- Snout fleshy; tip only weakly extended
- Upper disc plain yellowish brown, sometimes with complex pattern of yellowish rings and reticulations

Colour: Dorsal surface dark yellowish to brownish; often with light flecks or fine reticulations, mostly on mid-disc. Ventral surface white.

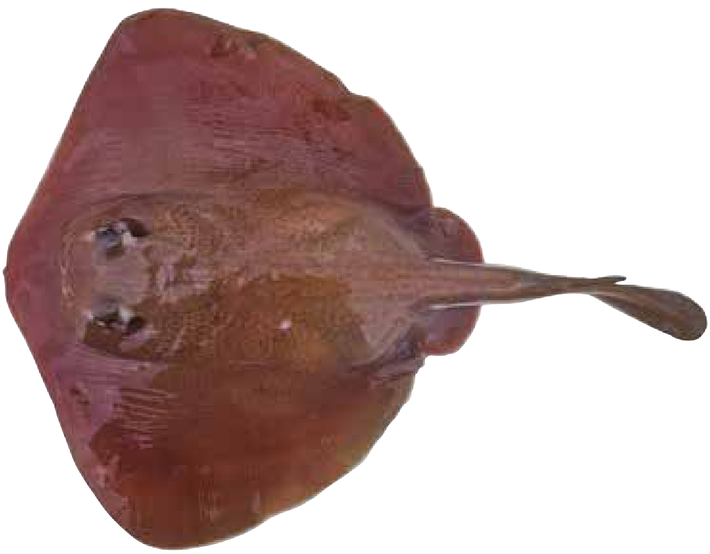
Distribution: Found off eastern Australia and PNG at depths of 65–274 m. In PNG, known from a single specimen collected west of New Hanover, New Ireland, at a depth of 269–274 m.

Habitat and biology: Found on the continental shelf and upper continental slope. Feeds mainly on crustaceans. Gives birth every 2 years after a 14–19-month gestation period.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: Previously thought to be restricted to temperate south-eastern Australia, but recently recorded off Swain Reefs off Queensland and off New Ireland in PNG. Specimens off Queensland have a stronger colour pattern, more similar to *U. flavomosaicus* than to southern populations. The PNG specimen is not strongly patterned. More investigation is required to better understand the differences between tropical populations of this species and *U. flavomosaicus*.

Similar species: Similar to *Spinilophus armatus* but differs in having a small dorsal fin (vs. no dorsal fin) and an entirely smooth disc (vs. dorsal disc with small thorns and denticles).



Whole specimen from New South Wales, highlighting the short tail with broad caudal fin

Image details: Dorsal: New Ireland, PNG (female 21 cm DW). Whole dorsal: New South Wales, Australia (~28 cm TL).

BLUEBANDED EAGLE RAY

Aetomylaeus caeruleofasciatus White, Last & Baje, 2015

juvenile

LC

BIOLOGY

Maximum size: At least 59 cm DW

Maturity size: Females at ~59 cm DW, males at 43 cm DW

Birth size: 19–22 cm DW

Litter size: One pregnant female contained 4 pups

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Pectoral fins joining head just below eyes
- Tail without stings
- Dorsal-fin origin about opposite pelvic-fin insertions
- Spiracles lateral on head
- Edge of nasal curtain near mouth almost straight
- Upper disc yellowish brown with 5–8 bluish bands (often faint)

Colour: Dorsal surface greenish brown with 5–8 broad bluish transverse bands (more distinct in juveniles). Ventral surface white.

Distribution: Found only off northern Australia and southern New Guinea at depths of 10–115 m. In PNG, confirmed from Gulf, Central and southern Milne Bay provinces; possibly restricted to southern mainland PNG.

Habitat and biology: Pelagic over soft bottoms on the coastal and inner continental shelves. Biology little known; probably feeds on hard-shelled invertebrates.

Utilisation: Common catch in the Gulf of Papua prawn trawl fishery. Meat used for human consumption if retained; small specimens discarded.

Remarks: Previously considered to be conspecific with the wider-ranging *A. nichofii* but recently separated out as a new species.

Similar species: Similar to *A. vespertilio* but differs in having a series of blue bands on the dorsal disc (vs. pattern of dark reticulations, lines and rings) and attains a much smaller size. Similar morphologically to *Aetobatus ocellatus* but differs in having a straight nasal curtain outer edge (vs. deeply notched, V-shaped) and pectoral fins joining head just below eyes (vs. above eye level).

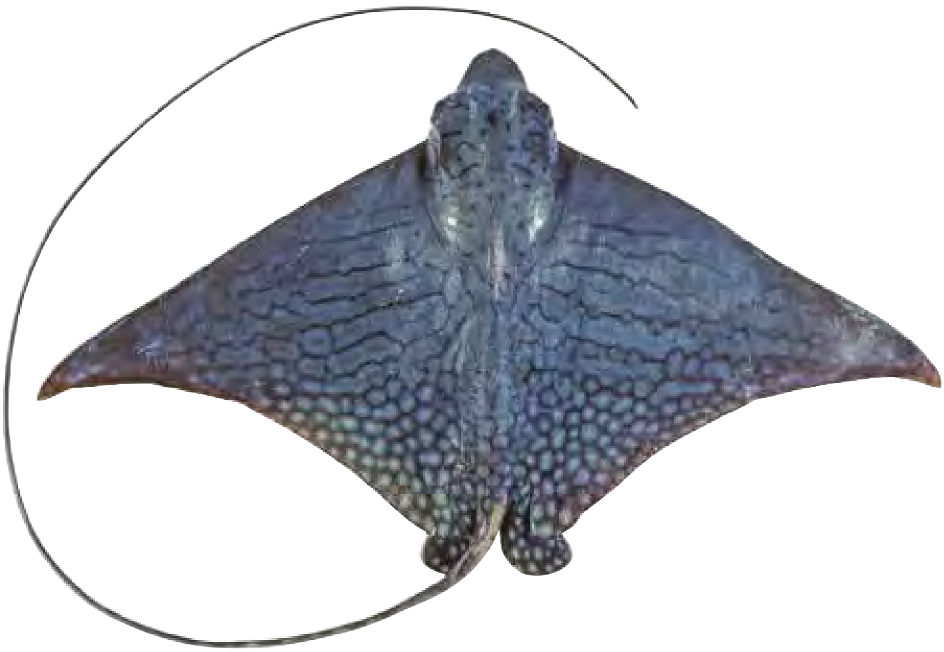
Ventral head, highlighting the straight nasal curtain rear edge

Lateral head view of an adult male, highlighting the short horn above anterior orbit, which males develop as they mature

Image details: Dorsal and lateral head: Gulf of Papua, PNG (adult male 43 cm DW). Ventral head: Gulf of Papua, PNG (juvenile male 25 cm DW).

ORNATE EAGLE RAY

Aetomylaeus vespertilio (Bleeker, 1852)



EN

BIOLOGY

Maximum size: At least 300 cm DW, possibly to 350 cm DW (up to 600 cm TL)

Maturity size: Females unknown; males at ~170 cm DW

Birth size: Unknown

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Pectoral fins joining head at about level of eyes
- Tail without stings
- Dorsal-fin origin behind pelvic-fin insertions
- Spiracles lateral on head
- Edge of nasal curtain near mouth almost straight
- Upper disc with thin dark lines, rings and reticulations

Colour: Dorsal surface brown to bluish grey with black transverse lines on anterior disc, and black lines forming a network of reticulations and rings on posterior disc. Ventral surface white.

Distribution: Found in the Indo–west Pacific, from Mozambique to northern Australia and northwards to southern China, to depths of at least 110 m. Confirmed from PNG based on image below (without a location) and also recently from off East Sepik Province.

Habitat and biology: Pelagic over coral reefs and inshore muddy bays on the coastal and inner continental shelves. Biology little known; probably feeds on hard-shelled invertebrates.

Utilisation: Unknown; possibly caught by coastal fisheries on rare occasions.

Remarks: Poorly known as it tends to be rare where it occurs; most records of this species are of single specimens.

Similar species: Similar to *A. caeruleofasciatus* but differs in having a pattern of dark reticulations, lines and rings on the dorsal disc (vs. a series of blue bands on dorsal disc) and attains a much larger size. Similar morphologically to *Aetobatus ocellatus* but differs in having a straight nasal curtain outer edge (vs. deeply notched, V-shaped) and pectoral fins joining head just below eyes (vs. above eye level).

Freshly caught specimen from either the 1960s or 1970s

Ventral head, highlighting the straight nasal curtain rear edge

Image details: Dorsal and ventral head: Queensland, Australia (female 84.5 cm DW). Fresh: PNG (by L.W.C. Filewood).

SPOTTED EAGLE RAY

Aetobatus ocellatus (Kuhl, 1823)

VU

BIOLOGY

Maximum size: 300 cm DW (880 cm TL)

Maturity size: Females at 150–160 cm DW, males at 100–130 cm DW

Birth size: Variable, 18–50 cm DW

Litter size: Up to 10 pups, usually 1–4

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Pectoral fins joining head above level of eyes
- Sting(s) present on tail (removed in individual pictured)
- Dorsal fin raked back, its origin behind pelvic-fin insertions
- Spiracles dorsolateral on head (openings visible in dorsal view)
- Edge of nasal curtain deeply notched and V-shaped
- Upper surface dark brown, blackish or greenish black, usually with many whitish spots (sometimes sparse)

Colour: Dorsal surface dark brown, blackish or greenish black with numerous small whitish to bluish spots. Some individuals have ocelli rather than spots, and some individuals can be plain or with only very few spots on posterior disc. Ventral surface white with darker anterior margin to disc.

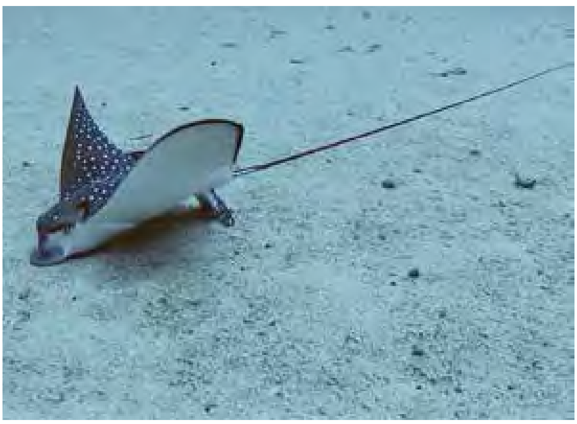
Distribution: Found in the Indo–west and central Pacific, from South Africa to the central Pacific islands. In PNG, confirmed from Western, Gulf, Central, Milne Bay, East Sepik, Manus and New Ireland provinces; probably widespread.

Habitat and biology: Pelagic both inshore and offshore on the coastal and inner continental shelves, occasionally entering estuaries. Feeds mainly on hard-shelled invertebrates such as hermit crabs, oysters, clams and whelks. Reproductive biology little known; a gestation period of 11 months was reported for a female in an aquarium.

Utilisation: Caught in the Gulf of Papua prawn trawl fishery and by coastal fisheries. Meat used for human consumption if retained.

Remarks: Males observed biting the rear edge of one of the pectoral fins to enable mating to occur in aquarium-kept specimens. Often found in small groups.

Similar species: Similar morphologically to the two *Aetomylaeus* species but differs in having a deeply notched nasal curtain outer edge (vs. outer edge of nasal curtain nearly straight) and pectoral fins joining head above eye level (vs. just below eye).



Foraging specimen off Kavieng, highlighting the very long tail this species has when undamaged

Ventral head, highlighting the deeply notched (V-shaped) nasal curtain rear edge

Image details: Dorsal and ventral head: Daru, PNG (adult male 88 cm DW). Underwater: New Ireland, PNG (by D. Borcherds).

AUSTRALIAN COWNOSE RAY

Rhinoptera neglecta Ogilby, 1912

DD

BIOLOGY

Maximum size: 140 cm DW

Maturity size: Males at ~115 cm DW

Birth size: ~31 cm DW

Litter size: Unknown

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Snout strongly notched medially to form two lobes
- Dorsal-fin origin just forward of pelvic-fin insertions
- Tail long and whip-like, about twice maximum width (often damaged)
- Disc broad and short
- Head thick and broad
- Dorsal-fin posterior margin upright

Colour: Dorsal surface uniformly greyish brown to greenish grey. Ventral surface white.

Distribution: Found only in northern Australia and PNG. In PNG, confirmed from Western, Madang and East Sepik provinces; probably widespread, at least on the mainland; possibly absent from the outer island chains.

Habitat and biology: Pelagic, mostly over soft bottoms on the coastal and inner continental shelves; often form large aggregations. Biology little known.

Utilisation: Caught in the Gulf of Papua prawn trawl fishery and by coastal fisheries; caught in large numbers by the trap fishery off Wewak at times. Meat used for human consumption if retained.

Remarks: Often found in shallow, muddy coastal areas; strandings on tidal mudflats have been recorded. More specimens are needed from around PNG to verify if only a single species of this genus occurs here.

Similar species: The bilobed snout of this species is distinctive, and the species unlikely to be confused with other species in PNG.

Lateral head, showing the unusual side head profile that the fleshy rostral lobes produce

Ventral head, highlighting the notched snout forming the two lobes

Image details: All images: Gulf of Papua, PNG (juvenile male 50 cm DW).

REEF MANTA RAY

Mobula alfredi (Krefft, 1868)

VU

BIOLOGY

Maximum size: ~550 cm DW

Maturity size: Females at ~390 cm DW, males at ~300 cm DW

Birth size: 130–150 cm DW

Litter size: Unconfirmed, but probably a single pup

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Mouth at front of head (terminal)
- No calcified mass or spine behind dorsal fin
- Front margins of white shoulder patches curving rearwards (not parallel with front of head)
- A small black, semicircular spot coming out of fifth gill slits
- Spiracles slit-like, on dorsal surface behind eyes
- Disc covered with small, non-overlapping denticles

Colour: Dorsal surface black with two distinct pale or white shoulder patches; anterior margins of shoulder patches curving inwards (not parallel with front of head). Ventral surface mostly white (black in melanistic forms, but rare) with variable dark markings. A small black, semicircular spot extending out of fifth gill slits.

Distribution: Found in the tropical eastern Atlantic and Indo–west and central Pacific. In PNG, confirmed from the Gulf of Papua and Milne Bay Province, but probably widespread.

Habitat and biology: Pelagic, mainly occurring inshore around coral and rocky reefs, usually where there are upwellings. Feeds on planktonic organisms and probably also small bony fishes. Gestation period 12–13 months.

Utilisation: One specimen observed in the catch of a prawn trawler in the Gulf of Papua, but probably a rare encounter; possibly in the bycatch of the purse seine fishery.

Remarks: Previously thought to be a single manta ray species, *Mobula birostris*, but found to be a distinct species, which is mostly found around inshore reef habitats near upwellings (vs. more offshore and oceanic). The most commonly observed manta ray by divers. Previously placed in the genus *Manta*.

Similar species: Very similar to *M. birostris* but differs in having the anterior margins of the white shoulder patches not running parallel with front of head (vs. running parallel with front of head) and no calcified mass behind dorsal fin (vs. a calcified mass with embedded sting behind dorsal fin).

Normal (right) and melanistic (left) forms of this species with diver beneath

Image details: Dorsal: Queensland, Australia (from underwater image). Underwater: PNG (by B. Halstead).

GIANT MANTA RAY

Mobula birostris (Walbaum, 1792)

VU

BIOLOGY

Maximum size: At least 700 cm DW, possibly up to 910 cm DW

Maturity size: Females at 410–470 cm DW, males at 375–400 cm DW

Birth size: Unknown

Litter size: Unconfirmed, but probably only a single pup

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Mouth at front of head (terminal)
- A calcified mass containing an embedded spine behind dorsal fin
- Front margins of white shoulder patches running parallel with front of the head
- A large black, semicircular spot coming out of fifth gill slits
- Spiracles slit-like, on dorsal surface behind eyes
- Disc covered with prominent, strongly overlapping denticles

Colour: Dorsal surface black with two distinct pale or white shoulder patches; anterior margins of shoulder patches running parallel with front of head. Ventral surface mostly white (black in melanistic forms, but rare) with variable dark markings. A moderately large black, semicircular spot extending out of fifth gill slits.

Distribution: Circumtropical between latitudes 40 °N and 40 °S. Probably widespread in PNG.

Habitat and biology: Pelagic, mainly occurring along coastlines with regular upwellings, oceanic islands and offshore seamounts. Feeds on planktonic organisms and small bony fishes. Gestation period unknown.

Utilisation: Caught occasionally by the purse seine fishery but typically released; post-capture survivability not known.

Remarks: Previously thought to be the only manta ray species but recently separated into two species; this species more likely to encounter the offshore fisheries targeting pelagic fishes. Previously placed in the genus *Manta*.

Similar species: Very similar to *M. alfredi* but differs in having the anterior margins of the white shoulder patches running parallel with front of head (vs. curving inwards, not parallel with front of head) and a distinct calcified mass with embedded sting behind dorsal fin (vs. no calcified mass behind dorsal fin).

Cruising specimen off West Papua, highlighting the white shoulder patches with their anterior margins parallel with the front of the head

Image details: Dorsal: Lombok, Indonesia (female 338 cm DW). Underwater: West Papua, Indonesia (by M. Erdmann).

PYGMY DEVILRAY

Mobula kuhlii (Valenciennes, 1841)

BIOLOGY

Maximum size: At least 135 cm DW

Maturity size: Females at ~134 cm DW, males at ~115 cm DW

Birth size: 31–34 cm DW

Litter size: Single pup

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Mouth subterminal on head
- Anterior margins of pectoral fins nearly straight
- Dorsal fin with or without a white tip
- Tooth bands wide, about 75% of mouth width
- Spiracles small, circular, below plane of the pectoral fins
- Base of tail quadrangular in cross-section

Colour: Dorsal surface blackish to greyish. A dark transverse band often present behind spiracles in live specimens. Dorsal fin uniformly coloured or with a white tip. Ventral surface mostly white.

Distribution: Found in the Indo–west Pacific, from South Africa to eastern Australia and northwards to the Philippines. In PNG, confirmed from Central, Milne Bay, Madang, East Sepik and New Ireland provinces; probably widespread.

Habitat and biology: Pelagic, mainly in coastal waters or inshore. Biology unknown; probably feeds on planktonic organisms and small bony fishes.

Utilisation: Caught occasionally by coastal fishers in some provinces (e.g. in the trap fishery off Wewak), and possibly caught by the purse seine fishery. Meat used for human consumption if retained.

Remarks: The most common devilray species observed by divers in PNG. A long-horned species, *M. eregoodootenke*, was recently suggested to be the same species since the key character used to distinguish the two species was the length of the cephalic lobes, which was found to be a variable character; some differences in ventral colour also exist, but comprehensive molecular data suggest they are a single species.

Similar species: Similar to *M. mobular* and *M. tarapacana* but differs in having a circular spiracular opening below the plane of the pectoral fin (vs. slit-like spiracles above the plane of the pectoral fins) and much smaller in size.

Cruising specimen, highlighting the dark band behind the head that is often apparent in live and freshly caught specimens.

Image details: Dorsal: Central Java, Indonesia (adult male 115 cm DW). Underwater: New Ireland, PNG (by D. Amon).

GIANT DEVILRAY

Mobula mobular (Bonnaterre, 1788)

NE

BIOLOGY

Maximum size: At least 520 cm DW, usually less than 310 cm DW

Maturity size: Females at ~236 cm DW, males at 198–205 cm DW

Birth size: ~90 cm DW

Litter size: Single pup

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Mouth subterminal on head
- Pectoral fins moderately falcate
- A small, serrated caudal spine present
- A weak bony ridge present along dorsal midline
- Spiracles slit-like, on dorsal surface behind eyes
- Dorsal fin with a distinct white tip

Colour: Dorsal surface bluish black to black. A dark transverse band often present behind spiracles in live specimens. Dorsal fin with a distinct white tip. Embryos with white transverse bar behind spiracles and a bat/bird-shaped white margin on central anterior disc. Ventral surface mostly white.

Distribution: Circumglobal in warm seas. Not confirmed with specimens in PNG, but recorded in the purse seine fishery and identification likely correct.

Habitat and biology: Pelagic, occurring both inshore and well offshore. Feeds mainly on planktonic crustaceans and small bony fishes. Reproductive biology little known.

Utilisation: Caught in the purse seine fishery; mostly discarded or released alive.

Remarks: A common species in the bycatch of pelagic fisheries. Previously referred to as *M. japanica* in this region; recently revised as belonging to a single global species, *M. mobular*, which was previously thought to be endemic to the eastern Atlantic, primarily in the Mediterranean Sea.

Similar species: Similar to *M. kuhlii* but differs in having a slit-like spiracular opening above the plane of the pectoral fin (vs. circular spiracles below the plane of the pectoral fins) and much larger in size. Also similar to *M. tarapacana* but differs in having moderately falcate pectoral fins (vs. strongly falcate), no strong ridge on disc midline (vs. a strong ridge on midline) and a white-tipped dorsal fin (vs. dorsal fin plain).

Ventral head, highlighting the subterminal mouth

Late-term embryo, highlighting the white shoulder patches and pectoral fins pale centrally

Image details: Dorsal: Lombok, Indonesia (female 187 cm DW). Ventral head: Bali, Indonesia (female 108 cm DW). Embryo: West Java, Indonesia (~50 cm DW).

CHILEAN DEVILRAY

Mobula tarapacana (Philippi, 1892)

VU

BIOLOGY

Maximum size: At least 370 cm DW

Maturity size: Males at 234–252 cm DW

Birth size: 105–139 cm DW

Litter size: Unknown, probably a single pup

Reproductive mode: Viviparous, with histotrophy

KEY FEATURES

- Mouth subterminal on head
- Pectoral fins strongly falcate
- No spine present on tail
- A strong bony ridge present along dorsal midline
- Spiracles slit-like, on dorsal surface behind eyes
- Dorsal fin plain, without a white tip

Colour: Dorsal surface uniformly greyish green to greyish brown. Dorsal fin plain (not white-tipped). Ventral surface mostly white.

Distribution: Patchy but probably circumglobal in warm seas. Not confirmed with specimens in PNG, but recorded in the purse seine fishery and identification likely correct.

Habitat and biology: Pelagic, occurring both inshore and well offshore. Feeds mainly on small bony fishes, but also planktonic crustaceans. Reproductive biology little known.

Utilisation: Caught in the purse seine fishery; mostly discarded or released alive.

Remarks: A relatively uncommon species, typically not encountered in large numbers. Differs from other *Mobula* species in having fused branchial filter plates.

Similar species: Similar to *M. kuhlii* but differs in having a slit-like spiracular opening above the plane of the pectoral fin (vs. circular spiracles below the plane of the pectoral fins) and much larger in size. Also similar to *M. mobular* but differs in having strongly falcate pectoral fins (vs. moderately falcate), a strong ridge on disc midline (vs. no strong ridge on midline) and a plain dorsal fin (vs. dorsal fin white-tipped).

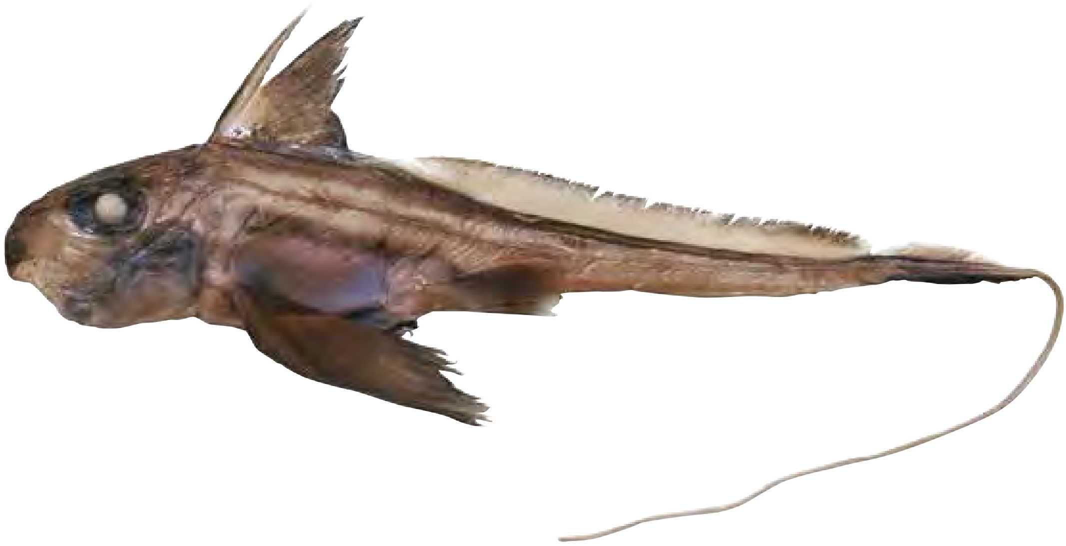
Dorsolateral view of head, highlighting the slit-like spiracle located on the dorsal surface, above the plane of the pectoral fin

Close-up of the gill filaments on the gill arches, which filter food out of engulfed water

Image details: Dorsal: Lombok, Indonesia (female 151 cm DW). Dorsolateral head: Lombok, Indonesia (male 183 cm DW). Gill filaments: Lombok, Indonesia (adult).

OGILBY'S CHIMAERA

Chimaera ogilbyi Waite, 1898



VU

BIOLOGY

Maximum size: 60 cm body length (104 cm TL)

Maturity size: Males at ~32.5 cm body length

Hatching size: ~7 cm body length (14 cm TL)

Egg cases: Unknown

Reproductive mode: Oviparous

KEY FEATURES

- No anal fin
- Body silvery (juveniles sometimes with several dark stripes)
- Lateral line very wavy
- First dorsal fin usually uniformly dark
- Snout relatively long and narrow
- Second dorsal fin long and low, with a blackish outer margin

Colour: Pale silvery white, sometimes with faint blotches on sides (more distinct when dead). Juveniles with several dark-brown stripes on sides. First dorsal fin dusky to blackish; second dorsal fin pale with a blackish outer margin; caudal filament whitish.

Distribution: Found in Australia, PNG and eastern Indonesia at depths of 139–872 m (mostly 200–500 m). In PNG, only known from two specimens collected off East Sepik Province at depths of 378–495 m.

Habitat and biology: Found near the bottom on the outer continental shelf, and upper and mid continental slope. Biology little known.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: The two specimens collected off East Sepik Province differed from this species in eastern Australia based on mitochondrial DNA data; a detailed taxonomic study found no morphological differences, and comprehensive nuclear DNA data also found no significant differences. Represents a significant range extension for this species, which was once considered an Australian endemic species. Previously placed in the genus *Hydrolagus* based on absence of an anal fin, but anal fins can be both present or absent in some species; thus not a strong character.

Similar species: Similar to *Hydrolagus* cf. *mitsukurii* but differs in having a very wavy lateral line (vs. lateral line mostly straight).

Lateral anterior view of an adult specimen, highlighting the wavy lateral line (below first dorsal fin), dark first dorsal fin and second dorsal fin with a black outer margin

Image details: Lateral: East Sepik, PNG (female 14.6 cm PCL). Lateral anterior: Victoria, Australia (female 93 cm TL).

PAPUAN GHOSTSHARK

Hydrolagus cf. *mitsukurii*

NE

BIOLOGY

Maximum size: Unknown, only known from an 11 cm body length (29 cm TL) juvenile specimen

Maturity size: Unknown

Hatching size: Unknown

Egg cases: Unknown

Reproductive mode: Presumably oviparous

KEY FEATURES

- No anal fin
- Body dark brown
- Lateral line straight to slightly undulating, not wavy
- First dorsal fin uniformly dark
- Snout relatively short
- Second dorsal fin long and low; outer half dark

Colour: Probably mostly dark brown when alive; specimen probably faded posteriorly. Fins mostly dark; second dorsal fin pale near base, with a darker outer half.

Distribution: Only known from a single specimen collected in Astrolabe Bay, Madang Province, at a depth of 520–575 m.

Habitat and biology: Unknown.

Utilisation: Not encountered by current fisheries in PNG.

Remarks: The single specimen most closely resembles *H. mitsukurii* from the north-west Pacific, and mitochondrial DNA data confirm it is close to this species. More specimens required to determine its identity.

Similar species: Similar to *Chimaera ogilbyi* but differs in having a nearly straight lateral line (vs. lateral line very wavy) and mostly dark colouration (vs. mostly pale colouration).

Lateral anterior view of an adult specimen, highlighting the nearly straight lateral line and short snout

Image details: Lateral and lateral anterior: Madang, PNG (female 28 cm PCL).

Fin identification

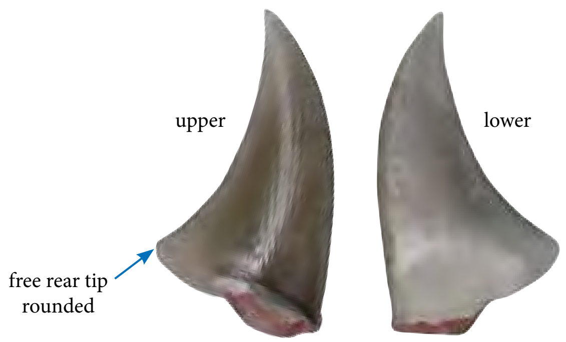
This guide covers the fins of shark and shark-like ray species encountered in the batches of dried fins examined during the ACIAR shark and ray project. Examination of dried fins was found to be crucial for understanding the size and species composition of shark and ray catches at various locations. In some provinces, travel to remote locations yielded data on only a small number of whole sharks, but examination of dried fins at fish buyers at key locations yielded substantially more species composition data.

Different fin types

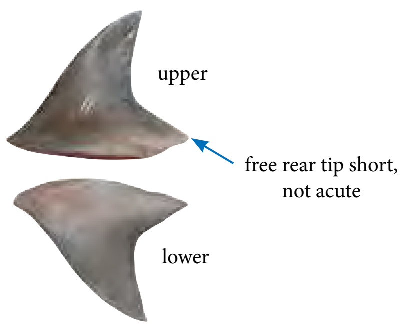
Batches of dried fins usually comprise all the different fins of sharks. To assess catch composition, it is important to be able to separate the different fin types, particularly all the first dorsal fins and any whole caudal fins. The different fin types of a typical shark are described below (examples given from an adult male *Hemipristis elongata*, see p. 124), with notes on distinguishing them from each other.

Pectoral and pelvic fins

Upper (dorsal) surface is distinctly darker than lower (ventral surface); free rear tips often short and rounded, usually not long and acute.



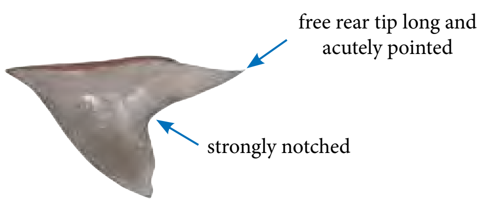
Pectoral fin



Pelvic fin

Anal fin

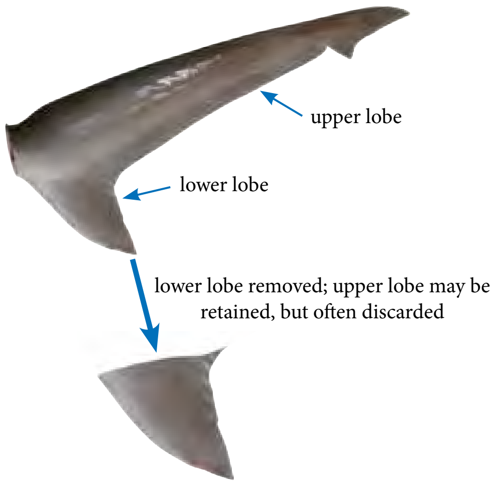
Pale in colour (vs. dorsal fins usually dark); free rear tip usually long and pointed (often acutely); typically low and deeply notched or falcate.



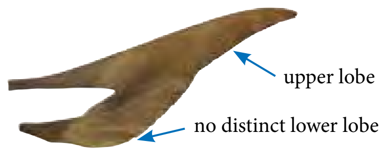
Anal fin

Caudal fin

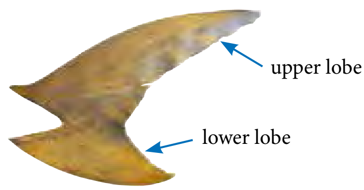
Same colour on both sides. When whole, distinctive and easily distinguished; usually (but not in some species) with a distinct upper and lower lobe. The caudal fin of the shark-like rays (wedgefishes, guitarfishes and sawfishes) is typically retained and dried whole. For sharks, usually only the lower lobe is retained.



Typical shark caudal fin



Guitarfish caudal fin



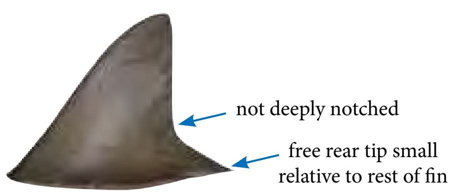
Wedgefish caudal fin

The lower caudal-fin lobe of sharks can be very similar in shape to the first dorsal fin. However, it can be readily distinguished from dorsal fins in lacking the free rear tip—that is, with the internal fin structure visible along the entire base and lacking a free rear tip (covered with skin and denticles).

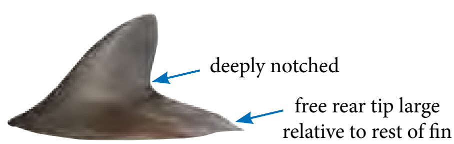
Dorsal fins

Same colour on both sides; typically greyish or brownish (not very pale or white); free rear tip relatively long and pointed (often acutely).

First dorsal fin typically not deeply notched (second usually deeply notched); first dorsal-fin rear tip small relative to the rest of the fin (second dorsal-fin rear tip large relative to rest of fin).



First dorsal fin

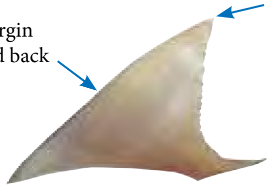


Second dorsal fin

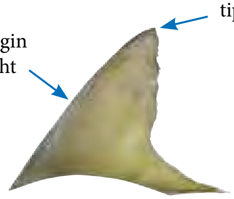
In most shark species, the second dorsal fin is much smaller than the first and deeply notched, and thus they can be readily separated from each other. However, some species have larger second dorsal fins, sometimes almost the same shape and height. The shark-like rays (wedgefishes, guitarfishes and sawfishes) have similar-sized and shaped dorsal fins. In these cases, every two dorsal fins found should be considered to represent a single individual.

Narrow sawfish *Anoxypristis cuspidata*

The lemon shark, *Negaprion acutidens*, has dorsal fins that are similar in height, but differ morphologically (see below). Thus, the dorsal fins can be separated based on their morphology rather than size.



First dorsal fin



Second dorsal fin

Species coverage in this guide

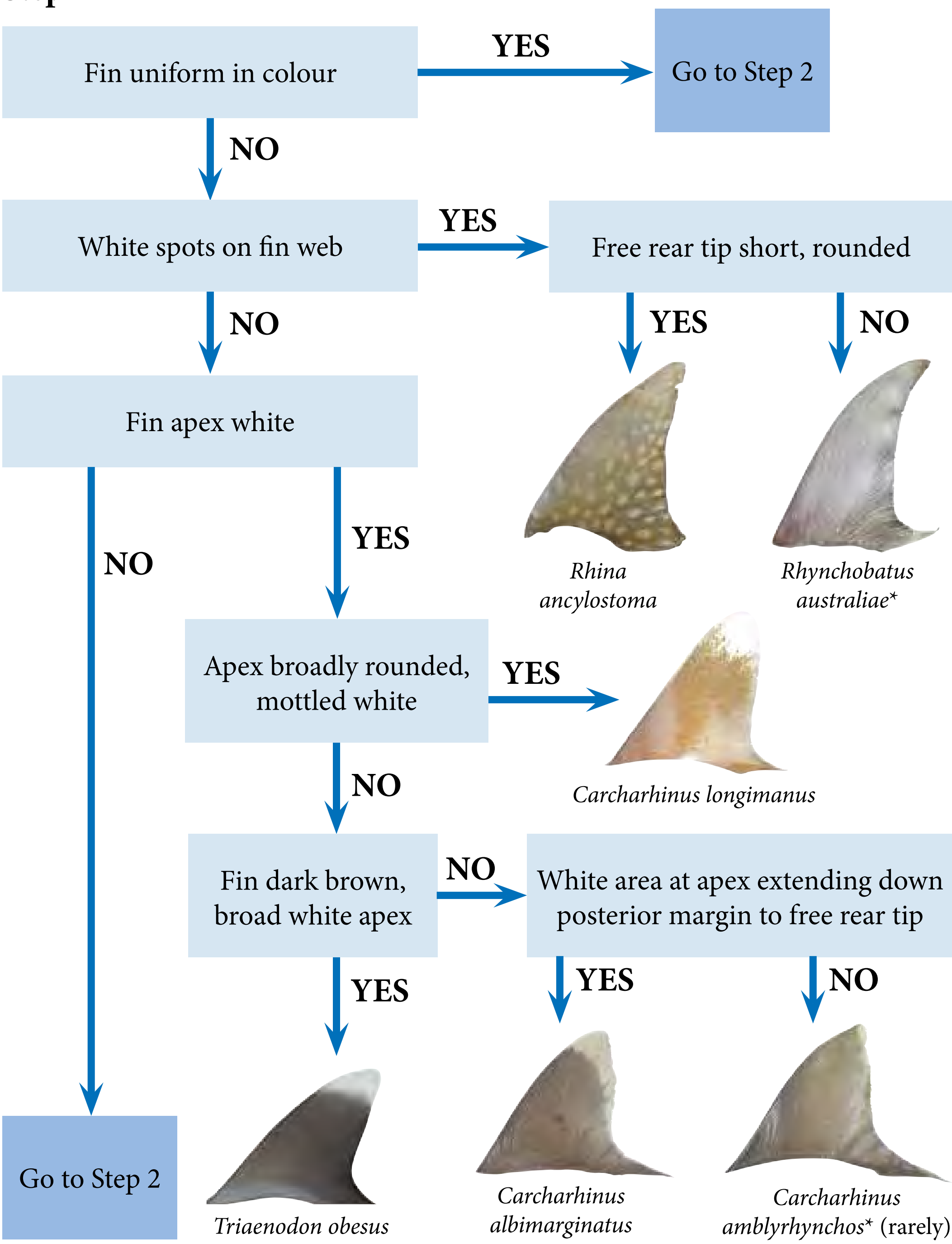
The species covered in the following fin identification guide follow the species composition of the batches of dried fins examined during this study (>1,000 first dorsal fins). Images of fresh fins have been used for several species for which dried fins were not observed, but the species are confirmed from PNG fisheries during this project. The species for which fresh images of the first dorsal fin were used are *Alopias pelagicus*, *Carcharhinus fitzroyensis*, *Carcharhinus longimanus*, *Glyphis glyphis*, *Prionace glauca*, *Triaenodon obesus*, *Pristis clavata* and *Pristis pristis*. Species not included in this guide that are possibly represented in batches of dried fins in PNG are *Alopias superciliosus, Isurus paucus* and *Carcharhinus cautus*. Also, several small species that are typically not finned may be represented in some areas (although not observed in this study), namely *Carcharhinus macloti*, *Loxodon macrorhinus* and *Rhizoprionodon* spp.

Dried caudal fins were used for all the large shark-like rays encountered, except for *Pristis pristis*, where a caudal fin from a preserved specimen was used.

Key to first dorsal fins

Identification of sharks from a single fin is difficult and, as a result, some species are repeated at different steps in the key and not all species are identified to species level. Species marked with an asterisk (*) appear more than once in this key.

Step 1



Step 2

Large black blotch at tip; fin web distinctly pale beneath blotch

YES

Carcharhinus melanopterus

NO

Fin black-tipped (often faint)

YES

Carcharhinus amblyrhynchoides

Carcharhinus brevipinna

Carcharhinus sorrah

Carcharhinus limbatus

Carcharhinus tilstoni

NO

Fin very tall and narrow, fin height > fin length

YES

Free rear tip not pointed, enlarged denticles on anterior third of fin

NO

Anterior margin black-edged

YES

Eusphyra blochii

YES

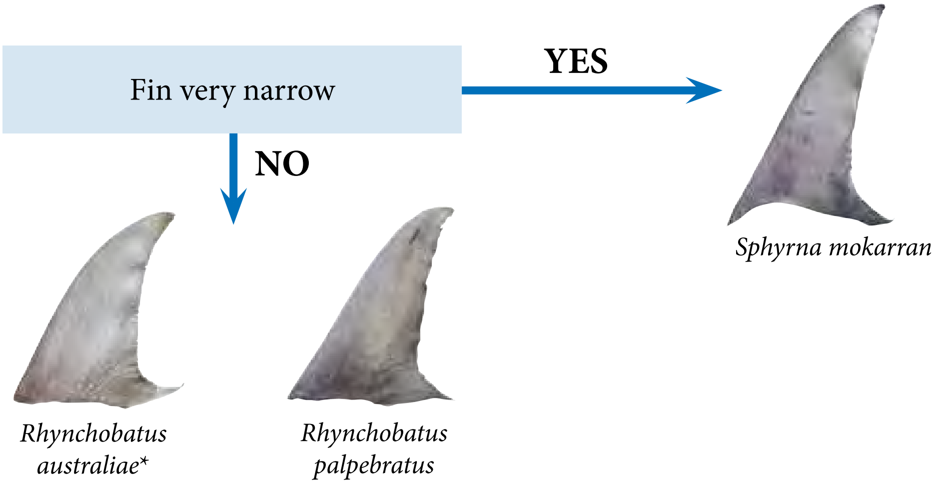
Glaucostegus typus

NO

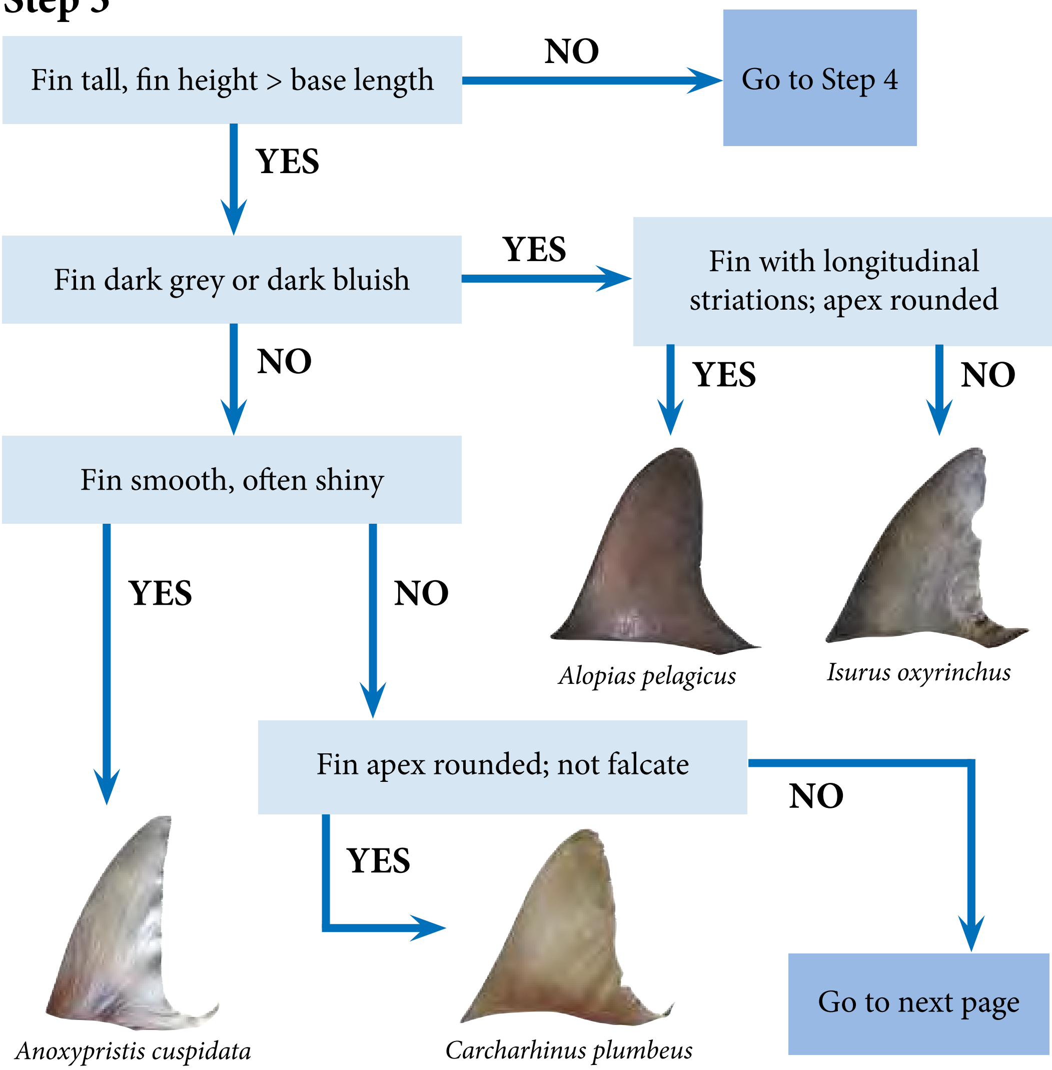
Go to next page

NO

Go to Step 3

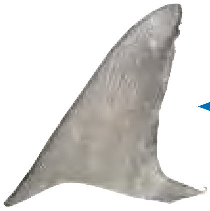

Fin very narrow
YES
Sphyrna mokarran
NO
Rhynchobatus australiae*
Rhynchobatus palpebratus

Step 3


Fin tall, fin height > base length
NO
Go to Step 4
YES
Fin dark grey or dark bluish
YES
Fin with longitudinal striations; apex rounded
YES
NO
Alopias pelagicus
Isurus oxyrinchus
NO
Fin smooth, often shiny
YES
NO
Anoxypristis cuspidata
Fin apex rounded; not falcate
YES
Carcharhinus plumbeus
NO
Go to next page

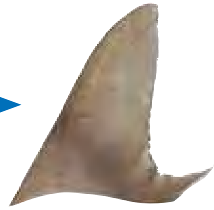
Fin usually brown, relatively broad

NO



Sphyrna zygaena

YES



Sphyrna lewini

Step 4

Fin low and long, fin length >1.6 times fin height

YES → Anterior margin strongly raked back, posterior margin vertical; fin web yellowish

YES

Negaprion acutidens

NO → Denticles large and not overlapping, giving fin a rough texture

YES

Galeocerdo cuvier

NO → Fin length ~1.8 times fin height

YES

Glyphis glyphis

NO ~1.6 times fin height → Fin grey; fin raked back, apex over free rear tip

YES

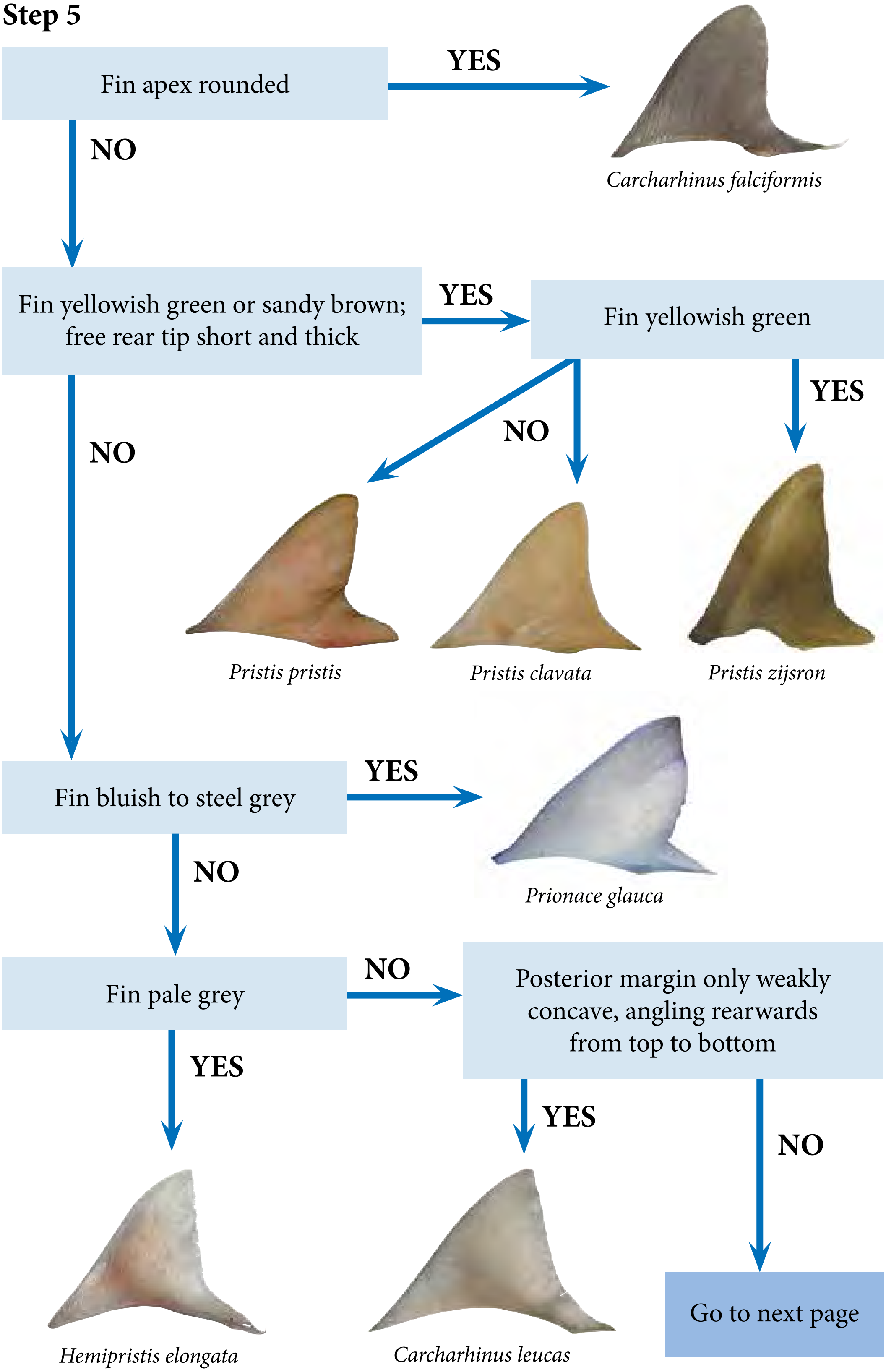
Carcharhinus fitzroyensis

NO

Glyphis garricki

NO → Go to Step 5

Step 5


Fin apex rounded
YES
NO
Carcharhinus falciformis
Fin yellowish green or sandy brown; free rear tip short and thick
YES
Fin yellowish green
NO
NO
YES
Pristis pristis
Pristis clavata
Pristis zijsron
Fin bluish to steel grey
YES
Prionace glauca
NO
Fin pale grey
NO
Posterior margin only weakly concave, angling rearwards from top to bottom
YES
YES
NO
Hemipristis elongata
Carcharhinus leucas
Go to next page

Inner margin short; fin relatively dark

YES

Carcharhinus amboinensis

NO

Fin small—max. fin height ~9 cm; max. fin length 14 cm

YES

Carcharhinus coatesi

NO
fins larger except in smallest juveniles

Apex narrowly to moderately rounded

YES

Carcharhinus altimus

NO
apex more angular

*Carcharhinus amblyrhynchos**

Key to whole caudal fins

As mentioned above, batches of dried fins typically only included the lower lobe of shark caudal fins but included whole caudal fins of the shark-like rays (wedgefishes, guitarfishes and sawfishes). The lower caudal-fin lobe alone is not adequate for identification in most instances and thus was not used in this study. The whole caudal fins of the shark-like rays were useful, and a rough guide to their identification is provided below.

Step 1

Lower lobe very long, almost or more than half length of upper lobe

YES → Go to Step 2

NO → Lower lobe absent; upper half with enlarged denticles

YES →

Glaucostegus typus

NO
lower lobe short

→ *Pristis* spp.

Pristis pristis (juvenile)

Pristis clavata (adult)

Pristis zijsron (adult)

Go to Step 2

Step 2

Posterior margin deeply and evenly concave; lower lobe very broad, tip not pointed

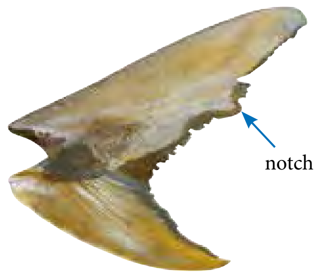
YES →

Rhina ancylostoma

NO ↓

Lower lobe more than half length of upper lobe; a distinct notch usually visible on posterior margin

YES →



Anoxypristis cuspidata

NO
lower lobe less than half length of upper lobe ↓

Rhynchobatus spp.

Rhynchobatus australiae

Rhynchobatus palpebratus

Acknowledgments

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Checklist of PNG sharks and rays

Order Hexanchiformes: cowsharks

Family Hexanchidae: cowsharks

- ☐ *Hexanchus griseus* — Bluntnose sixgill shark

Order Squaliformes: dogfish sharks

Family Squalidae: dogfishes

- ☐ *Squalus crassispinus* — Fatspine spurdog
- ☐ *Squalus* cf. *edmundsi* — Papuan spurdog
- ☐ *Squalus montalbani* — Philippine spurdog

Family Centrophoridae: gulper sharks

- ☐ *Centrophorus atromarginatus* — Dwarf gulper shark
- ☐ *Centrophorus granulosus* — Gulper shark
- ☐ *Centrophorus longipinnis* — Longfin gulper shark
- ☐ *Centrophorus moluccensis* — Endeavour dogfish
- ☐ *Deania quadrispinosa* — Longsnout dogfish

Family Etmopteridae: lanternsharks

- ☐ *Etmopterus evansi* — Blackmouth lanternshark
- ☐ *Etmopterus fusus* — Pygmy lanternshark
- ☐ *Etmopterus samadiae* — Papuan lanternshark

Family Dalatiidae: kitefin sharks

- ☐ *Isistius brasiliensis* — Cookiecutter shark

Order Orectolobiformes: carpet sharks

Family Orectolobidae: wobbegongs

- ☐ *Eucrossorhinus dasypogon* — Tasselled wobbegong
- ☐ *Orectolobus ornatus* — Ornate wobbegong
- ☐ *Orectolobus wardi* — Northern wobbegong
- ☐ *Orectolobus* sp. 1 — Papuan wobbegong

Family Hemiscylliidae: longtail carpetsharks

- ☐ *Chiloscyllium plagiosum* — Whitespotted bambooshark
- ☐ *Chiloscyllium punctatum* — Brownbanded bambooshark
- ☐ *Hemiscyllium hallstromi* — Papuan epaulette shark

- ☐ *Hemiscyllium michaeli* — Leopard epaulette shark
- ☐ *Hemiscyllium strahani* — Hooded carpetshark

Family Ginglymostomatidae: nurse sharks

- ☐ *Nebrius ferrugineus* — Tawny shark

Family Stegostomatidae: zebra sharks

- ☐ *Stegostoma fasciatum* — Zebra shark

Family Rhincodontidae: whale sharks

- ☐ *Rhincodon typus* — Whale shark

Order Lamniformes: mackerel sharks

Family Alopiidae: thresher sharks

- ☐ *Alopias pelagicus* — Pelagic thresher
- ☐ *Alopias superciliosus* — Bigeye thresher

Family Lamnidae: mackerel sharks

- ☐ *Isurus oxyrinchus* — Shortfin mako
- ☐ *Isurus paucus* — Longfin mako

Family Odontaspididae: sandtiger sharks

- ☐ *Carcharias taurus* — Sandtiger shark

Family Pseudocarchariidae: crocodile sharks

- ☐ *Pseudocarcharias kamoharai* — Crocodile shark

Order Carcharhiniformes: ground sharks

Family Scyliorhinidae: catsharks

- ☐ *Atelomycterus marmoratus* — Coral catshark
- ☐ *Atelomycterus marnkalha* — Eastern banded catshark
- ☐ *Cephaloscyllium stevensi* — Steven's swellshark

Family Pentanchidae: deepwater catsharks

- ☐ *Apristurus macrostomus* — Broadmouth catshark
- ☐ *Apristurus nakayai* — Milk-eye catshark
- ☐ *Apristurus yangi* — Yang's longnose catshark
- ☐ *Apristurus* sp. 1 — Papuan shortnose catshark
- ☐ *Galeus corriganae* — Corrigan's catshark
- ☐ *Parmaturus lanatus* — Velvet catshark

☐ *Parmaturus* sp. 1	Whitefin catshark
Family Triakidae: houndsharks	
☐ *Gogolia filewoodi*	Sailback houndshark
☐ *Hemitriakis* sp. 1	Papuan houndshark
☐ *Iago garricki*	Longnose houndshark
Family Hemigaleidae: weasel sharks	
☐ *Hemigaleus australiensis*	Australian weasel shark
☐ *Hemipristis elongata*	Snaggletooth shark
Family Carcharhinidae: whaler sharks	
☐ *Carcharhinus albimarginatus*	Silvertip shark
☐ *Carcharhinus altimus*	Bignose shark
☐ *Carcharhinus amblyrhynchoides*	Graceful shark
☐ *Carcharhinus amblyrhynchos*	Grey reef shark
☐ *Carcharhinus amboinensis*	Pigeye shark
☐ *Carcharhinus brevipinna*	Spinner shark
☐ *Carcharhinus cautus*	Nervous shark
☐ *Carcharhinus coatesi*	Australian blackspot shark
☐ *Carcharhinus falciformis*	Silky shark
☐ *Carcharhinus fitzroyensis*	Creek whaler
☐ *Carcharhinus leucas*	Bull shark
☐ *Carcharhinus limbatus*	Common blacktip shark
☐ *Carcharhinus longimanus*	Oceanic whitetip shark
☐ *Carcharhinus macloti*	Hardnose shark
☐ *Carcharhinus melanopterus*	Blacktip reef shark
☐ *Carcharhinus obscurus*	Dusky shark
☐ *Carcharhinus plumbeus*	Sandbar shark
☐ *Carcharhinus sorrah*	Spot-tail shark
☐ *Carcharhinus tilstoni*	Australian blacktip shark
☐ *Glyphis garricki*	Northern river shark
☐ *Glyphis glyphis*	Speartooth shark
☐ *Loxodon macrorhinus*	Slit-eye shark
☐ *Negaprion acutidens*	Sicklefin lemon shark
☐ *Prionace glauca*	Blue shark

- ☐ *Rhizoprionodon acutus* — Milk shark
- ☐ *Rhizoprionodon oligolinx* — Grey sharpnose shark
- ☐ *Rhizoprionodon taylori* — Australian sharpnose shark
- ☐ *Triaenodon obesus* — Whitetip reef shark

Family Galeocerdidae: tiger sharks

- ☐ *Galeocerdo cuvier* — Tiger shark

Family Sphyrnidae: hammerhead sharks

- ☐ *Eusphyra blochii* — Winghead shark
- ☐ *Sphyrna lewini* — Scalloped hammerhead
- ☐ *Sphyrna mokarran* — Great hammerhead
- ☐ *Sphyrna zygaena* — Smooth hammerhead

Order Rhinopristiformes: shark-like rays

Family Pristidae: sawfishes

- ☐ *Anoxypristis cuspidata* — Narrow sawfish
- ☐ *Pristis clavata* — Dwarf sawfish
- ☐ *Pristis pristis* — Largetooth sawfish
- ☐ *Pristis zijsron* — Green sawfish

Family Rhinidae: wedgefishes

- ☐ *Rhina ancylostoma* — Shark ray
- ☐ *Rhynchobatus australiae* — Bottlenose wedgefish
- ☐ *Rhynchobatus palpebratus* — Eyebrow wedgefish

Family Rhinobatidae: guitarfishes

- ☐ *Rhinobatos manai* — Papuan guitarfish
- ☐ *Rhinobatos* cf. *schlegelii* — Enigma guitarfish

Family Glaucostegidae: giant guitarfishes

- ☐ *Glaucostegus typus* — Giant guitarfish

Order Torpediniformes: electric rays

Family Narcinidae: numbfishes

- ☐ *Narcinops* cf. *nelsoni* — Plain numbfish

Family Torpedinidae: torpedo rays

- ☐ *Tetronarce formosa* — Taiwanese torpedo

Order Rajiformes: skates

Family Arhynchobatidae: softnose skates

- ☐ *Notoraja sereti* — Papuan velvet skate

Family Rajidae: hardnose skates

- ☐ *Dipturus* sp. 1 — Luanah's skate

Family Anacanthobatidae: leg skates

- ☐ *Sinobatis* sp. 1 — Papuan legskate

Order Myliobatiformes: stingrays

Family Hexatrygonidae: sixgill stingrays

- ☐ *Hexatrygon bickelli* — Sixgill stingray

Family Gymnuridae: butterfly rays

- ☐ *Gymnura australis* — Australian butterfly ray

Family Dasyatidae: stingrays

- ☐ *Hemitrygon longicauda* — Merauke stingray
- ☐ *Himantura australis* — Australian whipray
- ☐ *Himantura leoparda* — Leopard whipray
- ☐ *Maculabatis astra* — Blackspotted whipray
- ☐ *Maculabatis toshi* — Brown whipray
- ☐ *Megatrygon microps* — Smalleye stingray
- ☐ *Neotrygon annotata* — Plain maskray
- ☐ *Neotrygon australiae* — Australian bluespotted maskray
- ☐ *Neotrygon picta* — Speckled maskray
- ☐ *Neotrygon* cf. *trigonoides* — Papuan maskray
- ☐ *Neotrygon* cf. *westpapuensis* — West Papuan maskray
- ☐ *Pastinachus ater* — Broad cowtail ray
- ☐ *Pateobatis fai* — Pink whipray
- ☐ *Pateobatis hortlei* — Hortle's whipray
- ☐ *Pateobatis jenkinsii* — Jenkins' whipray
- ☐ *Pteroplatytrygon violacea* — Pelagic stingray
- ☐ *Taeniura lessoni* — Oceania fantail ray
- ☐ *Taeniura lymma* — Bluespotted fantail ray
- ☐ *Taeniurops meyeni* — Blotched fantail ray
- ☐ *Urogymnus acanthobothrium* — Mumburarr whipray
- ☐ *Urogymnus asperrimus* — Porcupine whipray

☐	*Urogymnus dalyensis*	Freshwater whipray
☐	*Urogymnus granulatus*	Mangrove whipray

Family Urolophidae: stingarees

☐	*Spinilophus armatus*	New Ireland stingaree
☐	*Urolophus bucculentus*	Sandyback stingaree

Family Myliobatidae: eagle rays

☐	*Aetomylaeus caeruleofasciatus*	Bluebanded eagle ray
☐	*Aetomylaeus vespertilio*	Ornate eagle ray

Family Aetobatidae: pelagic eagle rays

☐	*Aetobatus ocellatus*	Spotted eagle ray

Family Rhinopteridae: cownose rays

☐	*Rhinoptera neglecta*	Australian cownose ray

Family Mobulidae: devilrays

☐	*Mobula alfredi*	Reef manta ray
☐	*Mobula birostris*	Giant manta ray
☐	*Mobula kuhlii*	Pygmy devilray
☐	*Mobula mobular*	Giant devilray
☐	*Mobula tarapacana*	Chilean devilray

Order Chimaeriformes: chimaeras

Family Chimaeridae: ghost sharks

☐	*Chimaera ogilbyi*	Ogilby's chimaera
☐	*Hydrolagus* cf. *mitsukurii*	Papuan ghostshark

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Common names index

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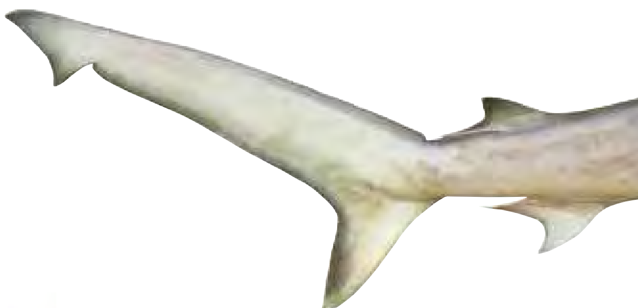
Sharks and Rays of Papua New Guinea

This full-colour field guide is the result of a collaborative project between the Papua New Guinea National Fisheries Authority and the Commonwealth Scientific and Industrial Research Organisation in Australia, and funded by the Australian Centre for International Agricultural Research.

The first comprehensive reference on the sharks and rays of Papua New Guinea, it contains everything you need to know about recognising and identifying the sharks, rays and chimaeras found in Papua New Guinean waters, both marine and freshwater. Its user-friendly layout contains information on identifying features, size, distribution, habitat, biology and conservation status of 132 species. It is an essential reference for all shark and ray enthusiasts—including local fishers and consumers, divers, fisheries and conservation officers, and scientists.



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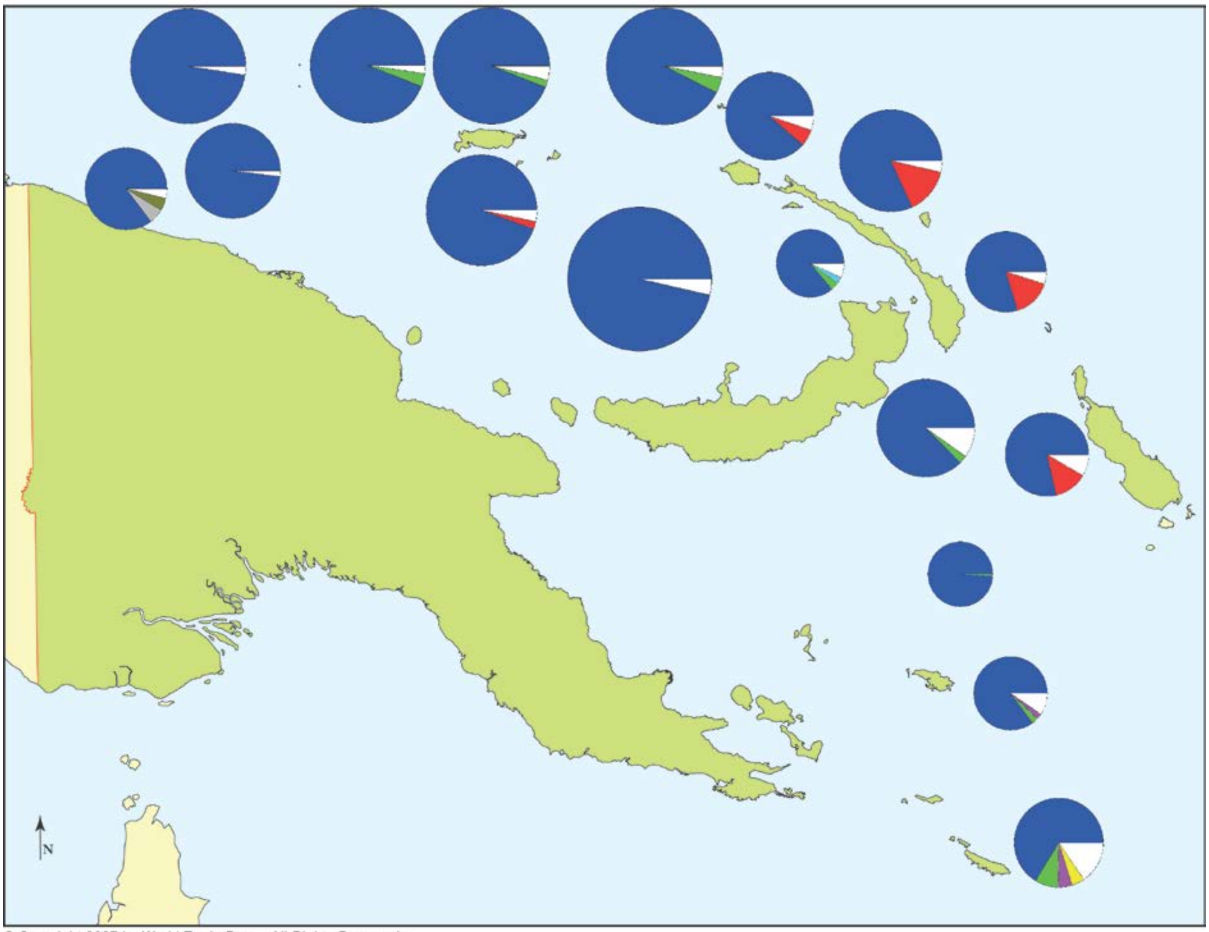
Papua New Guinea
National Fisheries Authority

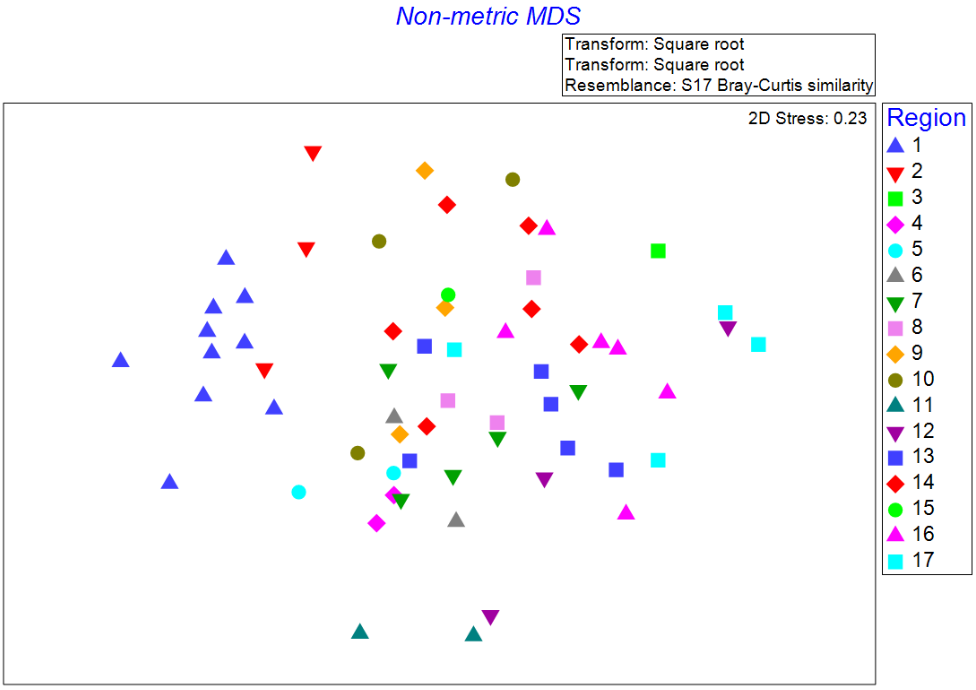
UPNG

Australian Government
Australian Centre for
International Agricultural Research

Figures and Tables for Target Longline fishery paper in preparation



Map of the 17 regions covered by the target longline trips with the pie charts sized relative to the CPUE (i.e. largest one with the highest catches of sharks per ‘000 hooks); blue shading represents silky sharks; red – grey reef sharks; green – scalloped hammerheads; white – other species.



MDS plot of the catch compositions within each of the 17 regions. Highlights that catch composition did not vary greatly between regions except for region 1 (south Milne Bay Province) which was more species diverse than other areas.

Table 1. Observer trip identifier and fishing vessel with number of longline sets deployed on each trip.

Observer trip	Vessel name	# sets
DAS 14-01*	Feng Jung Jinn No. 981	59
JCM 14-01	Hsin Chi Yu No. 11	53
MMJ 14-01	Shung Fu-1	49
NOL 14-01	Neptune 23	56
PPP 14-01	Feng Jung No. 16	57
TOP 14-01	Neptune 898	57
UJO 14-01	Ching Li No.118	46
Total		377

*Note the data from this observer was not used for calculations of CPUE or in analyses of species composition and regional differences due to incorrect data acquisition.

Table 2. Catch summaries and CPUE (number of sharks / '000 hooks) within each of the 17 defined biogeographic regions (excluding DAS 14-01 data).

Region	# sets	# hooks	# sharks	# sharks/ '000 hooks	Biomass sharks (t)	Biomass (t)/ '000 hooks
1–Southern Milne Bay Province	51	57,548	2,251	39.1	97.6	1.7
2–Northern Milne Bay Province	15	18,284	613	33.5	26.1	1.4
3–Central Solomon Sea	3	3,704	103	27.8	3.6	1.0
4–Western Bougainville (Solomon Sea)	12	13,424	494	36.8	16.8	1.3
5–Southern New Ireland/eastern New Britain	13	12,376	529	42.7	15.3	1.2
Solomon Sea subtotal	**94**	**105,336**	**3,990**	**37.9**	**159.5**	**1.5**
6–Southeastern New Ireland	10	12,340	445	36.1	12.3	1.0
7–Northern New Ireland	28	35,596	1,605	45.1	35.8	1.0
8–New Hanover	16	18,256	732	40.1	18.1	1.0
9–Emirau Island west towards Manus	17	18,972	1,026	54.1	23.6	1.2
NE Bismarck Archipelago subtotal	**71**	**85,164**	**3,808**	**44.7**	**89.8**	**1.1**
10–Eastern Bismarck Sea	15	12,708	370	29.1	10.7	0.8
11–Sepik coast	8	9,820	356	36.3	11.1	1.1
12–Central Bismarck Sea	10	9,240	604	65.4	18.2	2.0
central Bismarck Sea subtotal	**33**	**31,768**	**1,330**	**41.9**	**39.9**	**1.3**
13–Southern Manus Island	33	31,796	1,518	47.7	37.5	1.2
14–Northern Manus Island	30	23,408	1,042	44.5	26.6	1.1
15–Northwest of Manus Island	5	4,404	219	49.7	6.3	1.4
16–Nigoherm Islands	33	38,052	1,593	41.9	49.6	1.3
17–South of Nigoherm Islands	19	22,704	1,070	47.1	29.8	1.3
NW Bismarck Archipelago subtotal	**120**	**120,364**	**5,442**	**45.2**	**149.7**	**1.2**
Total	**318**	**342,632**	**14,570**	**42.5**	**439**	**1.3**

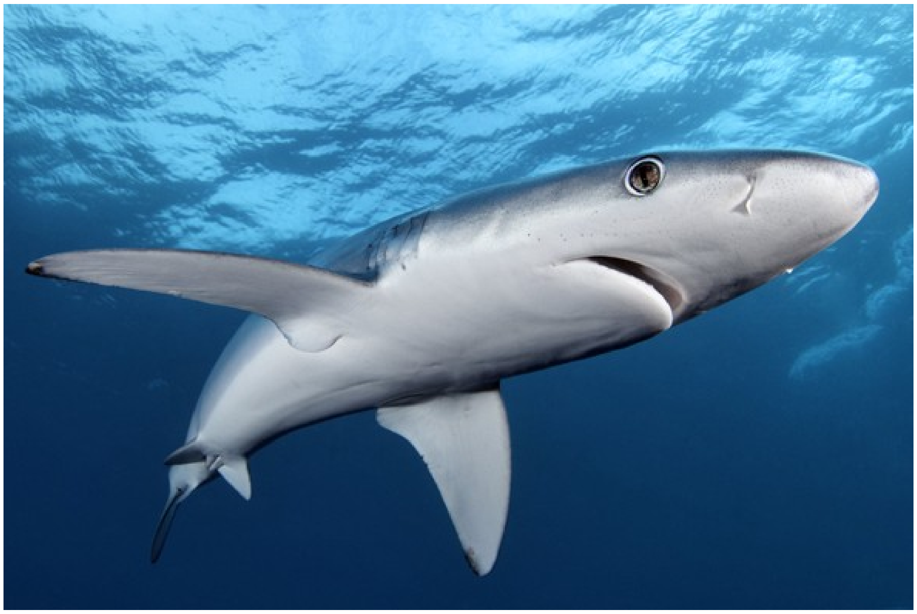
Table 3. Number, size and biomass summaries for each of the species caught in the target longline fishery.

Species	#	# (%)	Biomass (tonnes)	TL range (cm)	Average TL (cm)	Weight range (kg)	Average weight (kg)	% Alive	% Injured or dying	% Dead
Alopiidae										
Alopias pelagicus	150	1.0	10.8	152–393	300	13–136	71.9	11	14	75
Alopias superciliosus	82	0.6	9.1	203–494	324	35–311	110.6	6	28	65
Lamnidae										
Isurus oxyrinchus	55	0.4	5.7	116–285	224	12–209	102.8	6	19	76
Isurus paucus	15	0.1	2.0	138–311	240	21–275	134.6	13	20	67
Carcharhinidae										
Carcharhinus albimarginatus	77	0.5	2.9	93–250	173	5–112	38.0	22	30	47
Carcharhinus amblyrhynchos	614	4.2	11.5	88–200	138	5–54	18.7	31	24	46
Carcharhinus altimus	25	0.2	1.3	132–250	196	13–105	51.6	24	36	40
Carcharhinus brevipinna	94	0.6	4.1	115–231	182	8–87	43.7	26	48	27
Carcharhinus falciformis	12,733	86.7	359.7	11–306	155	1–215	28.2	28	27	45
Carcharhinus leucas	3	0.0	0.5	211–304	266	74–256	174.1	-	100	-
Carcharhinus limbatus	79	0.5	1.5	101–249	150	5–61	18.6	18	50	32
Carcharhinus longimanus	145	1.0	4.2	76–248	174	3–71	28.5	17	21	62
Carcharhinus obscurus	19	0.1	0.8	125–305	182	13–160	42.6	26	37	37
Carcharhinus plumbeus	43	0.3	2.6	121–268	193	14–155	60.0	33	16	51
Loxodon macrorhinus	4	0.0	0.0	87–91	88	1–2	1.5	-	-	100
Prionace glauca	144	1.0	8.5	134–338	247	8–150	59.3	32	24	44
Galeocerdidae										
Galeocerdo cuvier	34	0.2	4.4	169–365	272	23–283	128.1	30	36	33
Sphyrnidae										
Sphyrna lewini	370	2.5	13.6	67–303	190	1–132	36.7	23	30	47
Total	**14,686**		**443.1**					**27**	**27**	**46**

Table S1. Length (cm) to weight (kg) conversions with the source of the parameters used for each of the species recorded in the target longline fishery.

Species	***a***	***b***	**Source**
Alopias pelagicus	0.0461	2.49	Liu *et al.* (1999)
Isurus oxyrinchus	0.0052	3.14	Kohler *et al.* (1987)
Carcharhinus albimarginatus	0.00201	3.23	Branstetter (1987)
Carcharhinus amblyrhynchos	0.00746	2.98	Stevens & McLoughlin (1991)
Carcharhinus brevipinna	0.00317	3.1	Motta *et al.* (2013)
Carcharhinus falciformis	0.00201	3.23	Branstetter (1987)
Carcharhinus leucas	0.0111	2.923	www.fishbase.org (for Mexico)
Carcharhinus limbatus	0.00251	3.125	Castro (1996)
Carcharhinus longimanus	0.0254	2.691	Kohler *et al.* (1987)
Carcharhinus plumbeus	0.00142	3.31	Stevens & McLoughlin (1991)
Carcharhinus obscurus	0.0324	2.786	Kohler *et al.* (1987)
Loxodon macrorhinus	0.00002	4.043	W. White, unpubl. data
Prionace glauca	0.00318	3.13	Kohler *et al.* (1987)
Galeocerdo cuvier	0.00141	3.24	Randall (1992)
Sphyrna lewini	0.00399	3.03	Stevens & Lyle (1989)

Age and growth of blue sharks *(Prionace glauca)* from Papua New Guinea.



Minor Project report by Sushmita Mukherji

MSc. Marine Biology and Ecology

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Supervisors: Prof. Colin Simpfendorfer & Dr. Andrew Chin

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Statement of Work: The samples for this study were collected by the National Fisheries Authority observer team in Papua New Guinea. Vertebral samples were read individually by me and Ms. Brooke D'Alberto. Some R scripts were written by Dr. Jonathan Smart and Mr. Donald McKnight, and all other data analysis was done by me. Report was written by me, and edited by my supervisor (Prof. Colin Simpfendorfer)

JAMES COOK UNIVERSITY AUSTRALIA

Centre for Sustainable Tropical Fisheries & Aquaculture

Age and growth of blue sharks *(Prionace glauca)* from Papua New Guinea.

ABSTRACT

Blue sharks *(Prionace glauca)* are widely distributed, found circumglobally in tropical and temperate waters. In the Western and Central Pacific Ocean (WCPO), they form 69-91% of the total shark catch. In this study, 81 vertebral samples (57 males and 24 females) from Papua New Guinea (PNG) in the WCPO were examined to produce age and growth estimates of blue sharks caught by longline fisheries. A multi-model approach incorporating the Akaike's Information Criterion was used to select the best fit model for length-at-age data. The Gompertz model provided for the best fit growth model for both sexes for the back-calculated data, with male parameter estimates of asymptotic length (L_∞) = 336.4 cm, length at birth (L_0) = 45.8 cm and growth coefficient (gGom) = 0.12 year^{-1}. Female growth parameter estimates were L_∞ = 322.1 cm, L_0 = 48 cm and gGom = 0.11 year^{-1}. Comparison of the growth parameters for *P. glauca* in PNG to studies in other regions, suggest that there is considerable variation in their life history traits and populations in PNG grow very differently. Ages for the sample ranged from 10-25 years, with the oldest ages for *P. glauca* estimated to be 25 years for males and 22 years for females. To compensate for the lack of juveniles in the sample back-calculation techniques were used, to increase the number of length at age data points for younger age classes. The required number of individuals to be back-calculated to produce biologically relevant growth parameters was also investigated. It was found that sample sizes from 10 (Logistic) to 50 (VBGF) provided estimates that did not significantly differ from the full data set depending on the growth function used, thus demonstrating that all individuals in a sample are not required to be back-calculated to produce biologically relevant growth parameters for the population. The results from the study provide

essential regional life history information that would be beneficial to inform management of the fisheries in the WCPO.

Additional Keywords*:* Pelagic shark fisheries, Gompertz growth function, life history, Dahl-Lea back-calculation technique.

INTRODUCTION

Understanding the life history characteristics (e.g. age, growth, mortality and reproduction) of a species builds a foundation for demographic studies, as it provides an insight into its biology, population dynamics and status (Jolly et al., 2013, Pratt Jr et al., 1990). Accurately describing the age, growth and demography of a species exposed to fishing, in conjugation with the available knowledge of its distribution, movement, abundance and reproduction, can be used to predict how the species may respond to fishing pressure as well as form the basis of stock assessments (Cailliet, 2015, Cailliet et al., 2005, Cortés, 2000). Thus life history information of a species is crucial for the implementation of effective management plans that consider the biological constraints of the species (Cortés, 2000, Jolly et al., 2013, Skomal and Natanson, 2003).

Life history theory states that natural selection pressures alter the life history traits so as to maximise the individual's fitness and survival (Stearns, 1992). Variation in the regional selection pressures may alter the life history traits of populations of the same species in different geographical locations. Intraspecific variation in life history traits have been found to exist between conspecific populations in different geographic locations (Carlson and Parsons, 1997, Carlson et al., 2006, Smart et al., 2015, Yamaguchi et al., 1998). Therefore, the life history information of a population in one geographical location is not necessarily representative of those in other regions (Smart et al., 2015). The use of inaccurate life history information in stock assessments of a population may lead to errors in the modelling, potentially biasing the management and leading to the overexploitation of the population (Cailliet and Goldman, 2004, Smart et al., 2015). Thus, the understanding of regional life history traits of a species is required to effectively inform sustainable management plans (D'Alberto et al., 2017, Lombardi-Carlson et al., 2003, Smart et al., 2015).

Oceanic pelagic shark species spend a significant proportion of their life away from continental land masses, in open ocean waters and are found throughout the world's oceans (Pikitch et al., 2008, Priede et al., 2006). They are wide ranging, with many species exhibiting circumglobal distributions (Compagno, 2001, Dulvy et al., 2008). Oceanic pelagic sharks are frequently caught as bycatch in longline and purse seine high seas fishing operations. Some oceanic sharks (e.g. blue, shortfin mako, silky, porbeagle and thresher sharks) are also targeted to meet the demands of their fins and meat for international trade (Clarke, 2003, Clarke et al., 2006, Dulvy et al., 2008). In comparison to the early 2000s, the global trade for shark fins has decreased slightly, however since then, the trade for shark meat has increased by 42% in volume (Dent and Clarke, 2015). Like other sharks and rays, oceanic pelagic sharks exhibit conservative life histories of slow growth, late maturation and considerable longevity, rendering them less resilient to fishing related mortality (Compagno, 2001) in comparison to the short lived and early maturing teleost (bony) fish, along with which they are frequently caught as bycatch (Dulvy et al., 2008, Schindler et al., 2002). Due to the lack of sufficient international regulations on catches, widespread exploitation of oceanic pelagic shark populations, in conjugation with their fundamentally low population growth rates, have elevated their risk of extinction (Dulvy et al., 2008, Davidson et al., 2016, Myers and Worm, 2003, Schindler et al., 2002). Formulation of effective management plans for oceanic species have been impeded due to the intrinsic difficulty in studying wide ranging species and their historically low management priority (Cortés et al., 2010, Pikitch et al., 2008). There is substantial regional variation in the quality and abundance of data available, even for the well studied oceanic species (Dulvy et al., 2008). Therefore, the reliability of the estimates produced from stock assessments is hindered due to presence of ambigious data and limited sample sizes (ICCAT, 2009). Good region specific estimates of age and growth of a species are required to provide valuable information on growth rates of fished local populations (Cailliet et al., 2005).

To adequately inform region specific age and growth estimates of oceanic pelagic species, a minimum of 200 samples are recommended to obtain unbiased estimates of age and growth for the species (Kritzer et al., 2001, Thorson and Simpfendorfer, 2009). However, this sample size is often unrealistic for rare and threatened species either due to their low abundances or gear selectivity (Thorson and Simpfendorfer, 2009). To overcome this limitation, and improve conservation and management of these rare and threatened species, back-calculation techniques are used to assist age and growth studies and produce precise estimates even with small sample sizes and where there is a lack of juveniles in the sample (Smart et al., 2013). In this technique, the length of individuals at earlier ages is estimated from the spacing of the bands on the vertebral centra for elasmobranchs or otoliths for teleost fish (Campana, 2001, Cailliet and Goldman, 2004). Back-calculation technique increases the number of length at age data points for the younger age classes, thus increasing the sample size used to model growth for the species (Cailliet and Goldman, 2004). However, applying the back-calculation technique to each vertebrae or otolith can be a tedious process. Further, all age and growth studies that have incorporated back-calculation have assumed that all the samples need to be back-calculated to produce initial parameters that are biologically relevant. To date work to estimate the required number of samples for back-calculation has not been investigated, but would provide data to optimise back calculation efforts.

The blue shark (*Prionace glauca*) is a large pelagic carcharhinid, occuring circumglobally in temperate and tropical waters (Skomal and Natanson, 2003, Tanaka et al., 1990). They are distinctive due to the characteristic indigo blue colouration of their dorsal surface, metallic blue flanks and abruptly white ventral surface. Blue sharks are a relatively large species, growing to a maximum size of 383 cm total length. Males and females within a population are known to grow to similar sizes (Nakano and Stevens, 2008). They have relatively large litter sizes, producing an average of 30 pups per litter (Castro and Mejuto, 1995, Gubanov and Grigor'yev, 1975, Nakano, 1994, Stevens, 1975). Blue sharks are one of the most abundant oceanic pelagic shark species, found worldwide in waters from 60ºN to 50ºS latitude. Peak abundances have been observed in the northern hemisphere between latitudes of 20˚ and 50˚N (Compagno, 1984, McKenzie and Tibbo, 1964). Blue sharks are highly migratory and show distinct seasonal movement patterns with higher abundances observed in high latitudes during summer and in low latitudes during winter (Compagno, 1984, Tanaka et al., 1990). Seggregation by sex and size has also been observed for this species (Nakano and Stevens, 2008). For example, off the east coast of Australia, with the increasing southerly latitude body size is observed to decrease while proportion of females is seen to increase (Stevens and Wayte, 1999).

Globally, blue shark populations have regularly been taken by fisheries, with the most common source of mortality from the oceanic longline fisheries. Historically, they were frequently caught as bycatch in the high seas fisheries targeting other species like tuna and swordfish (ISC, 2013), and also form a major component of the international shark fin trade (Clarke, 2003). A recent study in Hong Kong revealed that blue shark fins comprise of the majority (33.9-64.1%) of the modeled fin trimmings in the markets (Fields et al., 2017). Since the development of new processing techniques, new markets for the flesh have developed particularly in Asia (Clarke, 2003) and South America (Brazil) (Clarke, 2003, Dent and Clarke, 2015), increasing the targeted catch of blue sharks (ISC, 2013). Over the last five years an average of 37,333, 28,923 and 41,000 tonnes of blue sharks have been caught in the North Atlantic (NA), South Atlantic (SA) and North Pacific (NP) ocean (ICCAT, 2015). Even with the large amounts of catch, these populations are known to be biologically sustainable but insufficiently managed (Simpfendorfer and Dulvy, 2017).

Several stock assessments have been conducted for the blue sharks in the Atlantic and Pacific oceans (Clarke, 2011). Kleiber et al. (2009) presented an assessment for the North Pacific blue shark population and stated that both the reference points i.e. biomass at maximum sustainable yield (B_{MSY}) and fishing mortality at maximum sustainable yield (F_{MSY}) indicated that the population was close to the maximum sustainable yield (MSY) but not overfished. Assessments conducted on the North and South Atlantic population of blue sharks by the International Commission for the Conservation of Atlantic Tunas (ICCAT) found that the biomass of blue sharks had not exceeded their MSY reference point as of 2007 (Clarke, 2008). Recently, for the fisheries in the Atlantic Ocean, two ecological risk assessments for the longline fisheries revealed that the blue shark's vulnerability to the gear was moderate in contrast to other oceanic pelagic shark species (Cortés et al., 2010).Therefore, the blue sharks have been categorised as being at "medium" or "medium-low" ecological risk for longline fisheries operations (Clarke et al., 2011, Hobday et al., 2007). Although the current populations of blue sharks may seem resilient to fishing pressure (Simpfendorfer and Dulvy, 2017), with insufficient management practices in place and the continued exploitation of blue shark populations, there are growing concerns that the populations may not remain biologically sustainable.

Owing to their abundance and high interaction with fisheries, the life history of blue sharks has been relatively well-studied (Tanaka et al., 1990). Age and growth of blue sharks has been extensively studied in the northern hemisphere, with the most published data for the species pertaining to the North Atlantic (Henderson et al., 2001, MacNeil and Campana, 2002, Skomal and Natanson, 2003, Stevens, 1975) and the North Pacific (Cailliet et al., 1983, Harvey, 1979). The southern hemisphere has received less research attention, with only one study published in the WCPO (Manning and Francis, 2005) and two studies in the South Atlantic (Jolly et al., 2013, Lessa et al., 2004). Therefore, in comparison to the North Atlantic, life history information of blue sharks in the WCPO is limited. More research attention in this region is required in light of the growing concerns for the effective management of the blue shark populations.

Blue sharks are frequently encountered in the tuna longline fishery and the shark longline fishery in Papua New Guinea (PNG) in the WCPO (Clarke et al., 2011). The shark longline fishery of PNG developed in the 1990s (Kumoru, 2003) and mainly operated in the oceanic habitats, targeting silky sharks (*Carcharhinus falciformis*) until the mid-2014 when it closed due to a ban on their retension (Western and Central Pacific Fisheries Commission, 2013). However, blue sharks are still frequently encountered as bycatch in the tuna and billfish longline and purse seine fisheries in PNG (Clarke et al., 2011). The management of these fisheries resources in PNG is the responsibility of the National Fisheries Authority (NFA) and the Western and Central Pacific Fisheries Commission (WCPFC) (Kumoru and Lewis, 2003). The WCPFC was established in 2004 for the conservation and management of the highly migratory fish stocks (e.g. oceanic pelagic sharks) in the Western and Central Pacific Ocean. The PNG National Fisheries Authority (NFA) observer program was developed in 1996 to independently collect scientific data relating to the fisheries operations in PNG. Recently, the NFA identified the need to develop better management practices for the fisheries in PNG by incorporating the life history characteristics in demographic analysis and stock assessments for species that are frequently encountered in the fisheries (Smart et al., 2017). Blue sharks are recognised as one of the five key species recognised by the WCPFC and caught in the shark and tuna longline fishery of PNG (Kumoru and Lewis, 2003). However, no management plan for blue sharks have been formed for the regional population in the WCPO since 2003 (Clarke, 2011).

The aim of this study was to investigate the life history of blue sharks (*Prionace glauca)* caught in the WCPO in the economic exclusive zone (EEZ) around PNG using samples collected by NFA observers. Since few juvenile blue sharks were obtained, I also aimed to estimate the minimum number of individuals required to be used in back-calculation techniques to produce biologically relevant growth parameters for three commonly used growth models. This information would be used to provide region specific life history information for *P.glauca* in the WCPO, inturn providing the essential biological information to refine future management strategies. The study also takes a step forward to optimise the back-calculation efforts for age and growth studies, by establishing the required number of individuals to be back-calculated from a given sample.

MATERIALS AND METHODS

Sample collection

Vertebrae samples were obtained from the blue sharks collected by fisheries observers on board seven commercial longline vessels operated by the PNG National Fisheries Authority (NFA) under the Shark Management Plan. Sharks were captured between May and June 2014 from the Bismarck and Solomon seas by setting a maximum of 1200 hooks per set at a depth range of 35-108 m for 8-10 hours (Kumoru, 2003). Biological information collected by the observers included the stretched total length (TL), sex and maturity. The stretched TL was measured to the nearest mm and followed Francis (2006). A section of the thoracic vertebral column was removed from under the anterior margin of the first dorsal fin. The vertebral samples were cleaned of extraneous flesh and stored frozen until processed. Photographs of sharks were taken by observers using digital cameras to allow verification of species identity, minimizing the effects of species misidentification on analyses (Smart et al., 2016a).

Vertebrae preparation and processing

Vertebrae preparation and sectioning followed the standard protocols described by Cailliet and Goldman (2004). Vertebrae were defrosted and the remaining flesh along with the haemal and neural arches were removed using a scalpel. The vertebrae were then separated into individual centra and soaked in 5% sodium hypochlorite for 30 mins to further remove any remaining soft tissue. Centra were then rinsed thoroughly under running tap water and dried in an oven at 60 ˚C for 24 hours. One centrum was randomly selected from each individual to be sectioned. Centra were sectioned sagittally through the centrum focus using a low speed circular saw with twin diamond-tipped saw blades (Buehler, Illinois, USA), at a thickness of 400 µm. The sections were then mounted using Crystal Bond adhesive (SPI supplies, Pennsylvania, USA) on microscope slides for analysis.

Age determination

Counts of band pairs (adjacent opaque and translucent bands) in the corpus calcareum after the birth mark were made by examining the sectioned vertebrae using a dissecting microscope with a transmitted light source (Cailliet and Goldman, 2004). The birth mark was identified from the change in angle of the inner margin of corpus calcareum, exhibiting the transition from pre- to post-natal growth and was established as age zero. Subsequently, each band pair of opaque and translucent bands was assumed to represent one year of growth (Figure 1). Validation of the periodicity of growth band pair formation was not attempted in the current study due to the lack of sufficient sample size. Further, marginal increment analysis could not be performed as the data was obtained over the span of only three months of the year. However, the periodicity of band pair formation has been validated for blue sharks by previous studies in the North Atlantic by Skomal and Natanson (2003) and Lessa et al. (2004), supporting the assumption of annual band pair formation in the current study.

Individual sections of centra were randomly selected and the band pairs counted independently by two readers without any prior knowledge of TL or sex of the individuals to reduce bias in age estimation (Cailliet and Goldman, 2004). Samples with differing counts between readers were reexamined collaboratively by the two readers and a consensus age was agreed upon. If no consensus age could be decided, those samples were not included in the analysis. As recommended by Cailliet et al. (2006), inter-reader precision of growth band reads was measured by Average Percentage Error (APE), Chang's coefficient of variation (Chang, 1982) and Bowker's test of symmetry (Cailliet et al., 2006, Campana et al., 1995). All statistical analysis was carried out using the FSA package (Ogle, 2015) in the R program environment (R Core Team, 2016).

Back-calculation

Back-calculation was applied to the entire data set to compensate for the lack of juveniles in the sample and the low sample size (Cailliet and Goldman, 2004, Smart et al., 2013). To measure the spacing of the bands on the centra of the vertebrae, each centra was photographed using a dissecting video microscope and the distances between each band pair and the focus were measured using an image analysis software (Image Pro Plus version 6.3 for Windows; Media Cybernetics). The centrum radius was measured as a straight line from the centre of the focus to the edge of the centra (Figure 1). Along this line the distance from the focus to the birth mark and each subsequent opaque growth band was measured to the nearest 0.001 mm. A Dahl-Lea direct-proportions back-calculation technique (Carlander, 1969) was applied to the dataset:

$$Li = \left(\frac{Lc}{CRc}\right) \times CRi$$

where Li = the length at growth band pair i, Lc = the length at capture (mm, TL), CRc = the centrum radius at capture and lastly, CRi = the centrum radius at growth band pair i. To compare the results from the Dahl Lea technique, a length at birth modified Fraser Lee back-calculation technique (Campana, 1990) was also applied to the data:

$$Li = Lc\left(\frac{(CRi - CRc)(Lc - L_{birth})}{(CRc - CR_{birth})}\right)$$

where L_{birth} is the length at birth and CR_{birth} is the centrum radius at birth mark. The L_{birth} value was set at 47.9 cm, based on the length at birth values from previous studies on blue sharks. However, on visual inspection it was established that the Dahl Lea direct-proportion method produced more reasonable and comparable estimates of lengths with the available observed length at age data for the older age classes (Smart et al., 2013). The Dahl Lea direct-proportion method was used for further analysis as it provided estimates of length at birth values for the observed length at age data in contrast to the Fraser Lee method that used a fixed length at birth value.

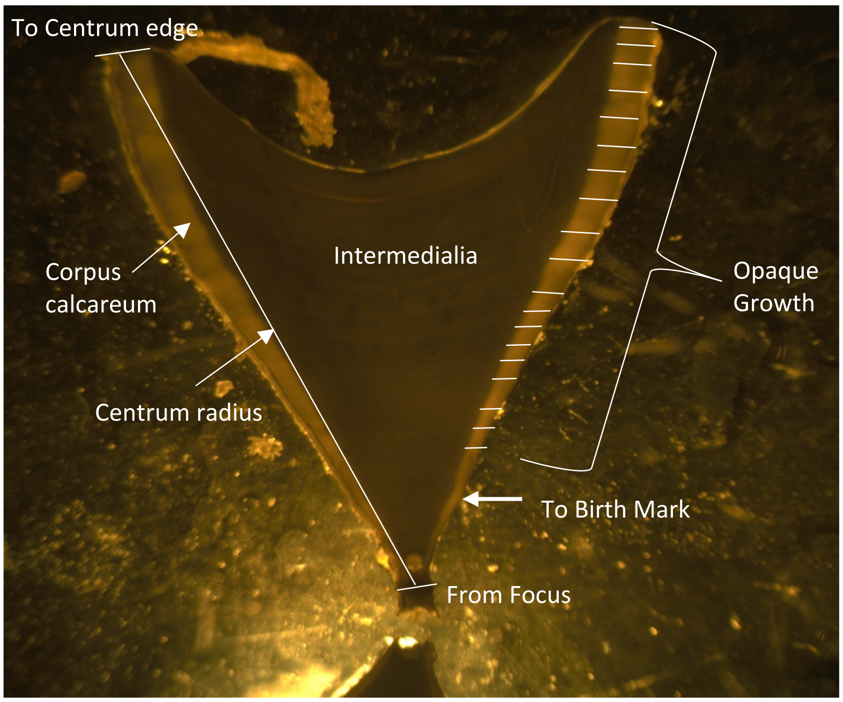


Fig. 1: Photograph of a sectioned vertebral centra of a female *Prionace glauca* aged to 18 years, measuring 282cm TL from Papua New Guinea in the Western Central Pacific Ocean. The locations of the birth mark, focus, centrum edge and vertebral bands (white dashes) are indicated. The centrum radius is measured as a straight line from the focus to the centrum edge along which back-calculation measurements were made.

Growth modelling and analysis

Growth of blue sharks from PNG was estimated using a multi-model inference (MMI) approach incorporating the Akaike's Information Criterion (AIC) to select the best fit growth model from the three most common candidate models in elasmobranch growth studies (Smart et al., 2016b). Three candidate models were selected *a priori*: von Bertalanffy growth function (VBGF), Gompertz function and logistic function (Table 1). This approach was implemented to reduce the bias generated from using only one model given that it may be inappropriate for the growth patterns of the species (Katsanevakis, 2006, Katsanevakis and Maravelias, 2008, Smart et al., 2016b). Candidate models were fit using the length at birth parameter (L_0), as it is more biologically relevant in comparison to age at length zero parameter (t_0) for elasmobranchs because they lack a larval phase and produce relatively large young (Cailliet et al., 2006). Length at birth and asymptotic length (L_∞) can be directly compared between models. However, individual growth coefficients of each model (k (VBGF), g (logistic), g (Gompertz)), cannot be compared to each other as they are mathematically different principles. The models were fit to the observed length at age data using the R statistical environment (R Core Team, 2016). The modified non-linear least-squares (nlsM) function was used to estimate best fit parameters for each growth function using R program environment (R Core, 2016). Standard errors for each parameter were calculated using the 'nlstools' package (F. Baty and M. L. Delignette-Muller, see http://cran.r-project.org/web/packages/nlstools, accessed 16 September 2015) and a bootstrapping method in the R program environment. The Akaike's information criterion with the correction for small sample size bias (AICc; Akaike, (1973)) was employed to evaluate the performance of the models relative to each other, as it has been proven to perform better when the sample size is less than 200 (Zhu et al., 2009):

$$AICc = AIC + \frac{2k(k+1)}{n-k-1}$$

where AIC can be calculated as $AIC = nlog(\sigma^2)$, k is the total number of, and n is the sample size. The most appropriate model for the length at age data was identified by the lowest AICc value (AIC_{min}). Other models were ranked using AIC difference (Δ) which was calculated for each model as:

$$\Delta = AICc, i - AIC_{min}$$

where i = 1-3. Models with a Δ value of 0-2 had the highest support, models with a Δ value of 2-10 had relatively less support, while models with a Δ value of >10 had very little or no support. AIC weights (w_i) were calculated from the AICc values to demonstrate the probability of choosing the best fit model from the three candidate models:

$$w_i = \frac{\exp(-\frac{\Delta_i}{2})}{\sum_{j=1}^{3} \exp(-\frac{\Delta_j}{2})}$$

where i = 1-3. Additionally, a likelihood ratio test was performed to determine if the growth varied significantly between the sexes (Kimura, 1980). If the growth was different, the sexes were analyzed separately. The test was performed using the method outlined by Haddon (2001) and was modified for the R program environment for the most appropriate model, determined by the AICc analysis for the back-calculated data as observed length at age data had a limited sample size. Separate growth curves were produced for data if the test detected a significant difference between male and female growth curves. Separate growth curves were produced for the best fitting model, however, if no model candidate was the best model for the data (w > 0.9), a multi-model inference was used (Katsanevakis and Maravelias, 2008).

Table 1: Model equations of the three candidate growth functions used to estimate the length at age of *P. glauca* using the multi-model approach incorporating the Akaike's information criterion. *Lt*= length at age *t*; *L*∞= asymptotic length; *L*0 =length at age 0; *k*, *gLog* and *gGom*= growth coefficients of the respective models.

Model	Growth function equation
VBGF	$L_t = L_0 + (L_\infty - L_0)(1 - \exp(-kt))$
Logistic function	$L_t = \dfrac{L_\infty * L_0(\exp(glog^t))}{L_\infty + L_0(\exp(glog^{t-1}))}$
Gompertz function	$L_t = L_0 * \exp(\ln\left(\dfrac{L_\infty}{L_0}\right)(1 - \exp(-\mathrm{gLog}^t))$

Minimum number of individuals required to be back-calculated from a sample

Since few juveniles were obtained, the minimum number of individuals from a sample, required to be used for back-calculation to produce biologically realistic model estimates was quantified. Ten unique individuals from the back-calculated dataset were randomly selected and fit to the three models, the parameters for each model was estimated using the non-linear least squares regression methods in R program environment (R Core Team, 2016). This was repeated with 100 iterations, each time randomly selecting ten unique individuals and producing model parameters for each iteration using the above describe methods. The same procedure was used for samples sizes in multiples of 10 individuals from 20 individuals to 70 individuals. A planned comparisons one-way ANOVA, followed by the Fisher LSD post hoc test compared the asymptotic length (L_∞), length at birth (L_0) and growth coefficient (k, gLog, gGom) model parameter estimates generated for the increments of ten individuals to the estimates generated for all the individuals in the sample. Plots were produced for each model parameter that compared estimates generated for each multiple of 10 individuals to the estimates generated for all individuals (n=81) in the sample.

RESULTS

Age estimation

Vertebrae samples from 81 *P. glauca* were collected, and consisted of 57 males and 24 females ranging in size from 180-350 cm TL. Between the two readers, there was high percentage of agreement (16.0%) with minimal variation around the 1:1 line (Figure 2). The average percentage error (APE) and coefficient of variation (CV) of the age estimates were 5.62% and 7.94%, respectively. No systematic bias was detected across the entire age range (Bowker's test of symmetry, d.f. = 34, $\chi^2 = 36.11$, P = 0.37). The CV reported in this study is slightly higher than the median value (7.6%) estimated by Campana (2001) across all ageing structures, including annual and daily ageing studies. However, in comparison to the other studies of sharks using vertebrae, the CV values estimated in this study were low, as most of the CV values reported for sharks exceed 10% (Campana, 2001, Cailliet et al., 2006). The estimated ages ranged from 10-25 years with male age ranges between 10-25 years and females between 12-22 years (Figure 3).

a) b)

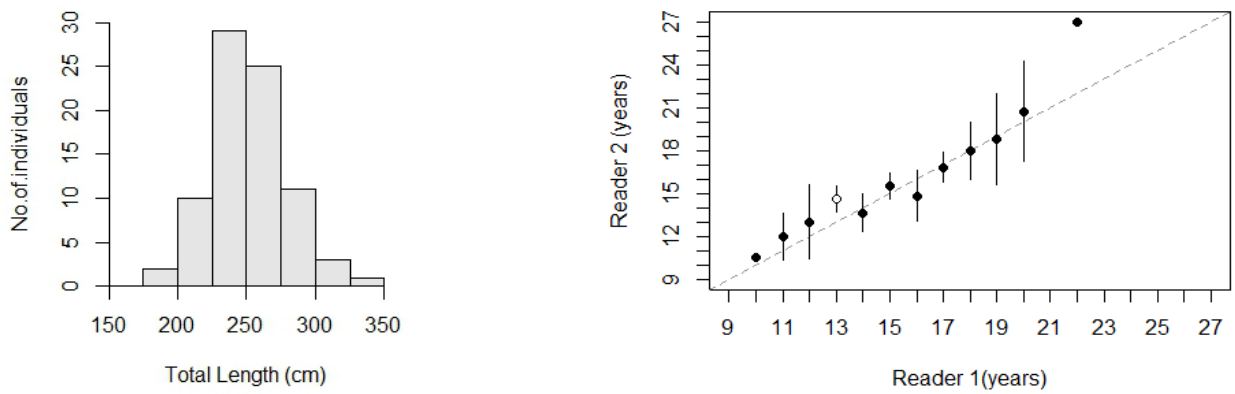


Figure 2. (a) Length frequency of for 81 vertebrae for both males and females, and (b) age bias plot for *Prionace.glauca* from Papua New Guinea.

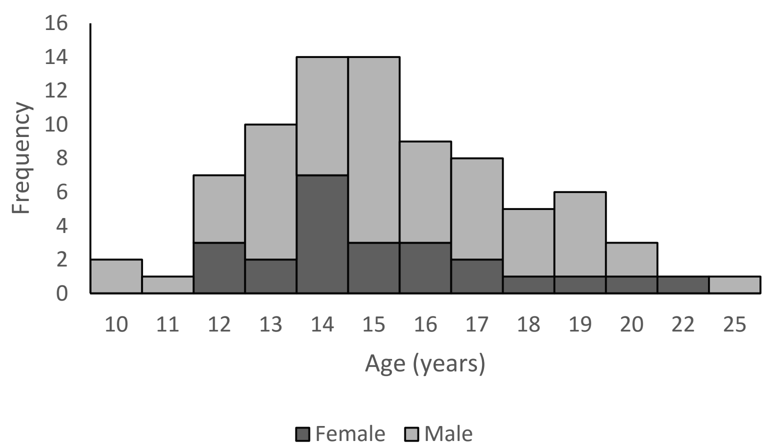


Figure 3: Age frequency for 81 vertebral centra of *Prionace glauca* from Papua New Guinea.

Growth estimates and analysis

Analyses of the observed length at age data produced equivalent *w* values for all three candidate models (Table 2). Hence, MMI was used to produce the averaged model length-at-age, L_0 and L_∞ estimates. The values produced for L_0 and L_∞ were 144 cm TL and 68,438 cm TL, respectively. However, as the growth curve for the observed data lacked a clear asymptote, a large L_∞ was expected (Figure 4a). Thus, in this instance, the estimate produced for the L_∞ parameter was not comparable to the maximum size. Further, the L_0 value produced was also considerably larger than the length at birth estimates from other studies on blue sharks (35-50 cm) (Last and Stevens, 1994, Stevens, 1975). Therefore, due to the low number of juveniles in the sample, the model parameters that were produced lacked biological realism. Hence, back-calculation techniques were used to better account for the missing size classes, and increase the number of length data points by adding interpolated length at age data.

The back-calculated length at age dataset provided more biologically relevant model estimates of L_0 and L_∞ in comparison to observed data (Table 3). The likelihood ratio test revealed that the growth for males and females was significantly different (Gompertz [χ^2=35.41, p<0.001]; Logistic [χ^2=35.76, p<0.001]; VBGF [χ^2=32.82, p<0.001]). Therefore, separate growth curves were produced for each sex (Figure 4b-c). AIC weights for the Gompertz model for males and females of $w > 0.9$ and $w > 0.7$, respectively, indicated that it was the best fit model for both the sexes. Hence, the MMI approach was not necessary for the back-calculated dataset. Comparable length at birth estimates for both sexes were produced for the Gompertz model, with both L_0 estimates within the known range (Last and Stevens, 1994, Stevens, 1975). Additionally, L_∞ estimates for both the sexes were lower than the observed data and were more comparable to the maximum size (Last and Stevens, 1994), while the growth coefficient (gGom) was higher than that estimated by the observed data, with males showing a higher gGom value in comparison to females (Table 3). Growth curves for the individual sexes did not show a pronounced asymptote, however the L_∞ values produced for males and females were within the range reported by other studies (Hsu et al., 2015, Tanaka et al., 1990,Skomal and Natanson, 2003).

Table 2: Summary of parameter estimates and Akaike's information criterion corrected for small sample size (AICc) performance of the three models used for observed length at age of *Prionace glauca* from the Western Central Pacific Ocean sampled between May and July 2014.

Sex	Model	n	Model performance			Model estimates				
			AICc	Δ	w	L0 (cm)	L∞ (cm)	k (year-1)	gGom (year-1)	gLog(year1)
Observed data										
Combined	VBGF	81	735.43	0	0.34	138 ± 58.08	134126 ± 144439100	0.0001 ± 0.06	-	-
	Gompertz	81	735.49	0.06	0.33	146 ± 42.68	845 ± 2391.6	-	0.02 ± 0.06	-
	Logistic	81	735.49	0.06	0.33	150 ± 34.47	604 ± 905.9	-	-	0.05 ± 0.06

Table 3: Summary of parameter estimates and Akaike's information criterion corrected for small sample size (AICc) performance of the three models used for back-calculated length at age of *Prionace glauca* from the Western Central Pacific Ocean sampled between May and July 2014.

Sex	Model	n	Model performance					Model estimates		
			AICc	Δ	w	L0 (cm)	L∞ (cm)	k (year-1)	gGom (year-1)	gLog (year-1)
Male	VBGF	931	8183.18	32.1	0	39.98±1.66	640.51 ±67.14	0.03±0.004	-	-
	Gompertz	**931**	**8151.08**	**0**	**0.96**	**45.81±1.31**	**336.37 ± 8.51**	**-**	**0.12 ± 0.004**	**-**
	Logistic	931	8157.39	6.31	0.04	50.525±1.153	290.33 ± 4.61	-	-	0.21±0.005
Female	VBGF	390	3385.48	9.41	0.01	43.14 ± 2.44	605.7 ± 105	0.03 ± 0.01	-	-
	Gompertz	**390**	**3376.06**	**0**	**0.71**	**48.13 ± 1.97**	**322.14± 13.74**	**-**	**0.11 ± 0.007**	**-**
	Logistic	390	3377.91	1.85	0.28	52.32 ± 1.74	278.42 ± 7.43	-	-	0.12 ± 0.008

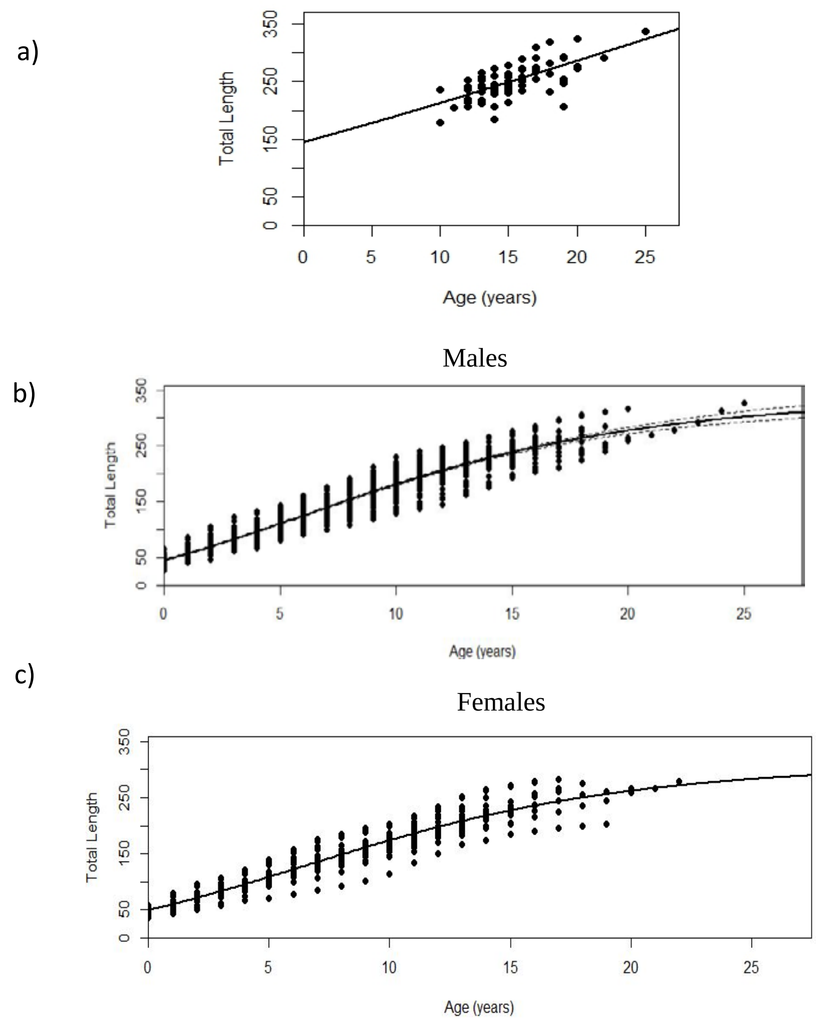


Fig.4 Length-at-age growth curves for *Prionace glauca* from the Western Central Pacific Ocean, Papua New Guinea, for (*a*) observed data with males and females combined, (*b*) back-calculated data for females and (*c*) back calculated data for males, fitted with fitted Gompertz model (solid line) and bootstrapped 95% confidence intervals (dashed line). A direct proportion Dahl Lea equation was used for the back calculation.

Minimum number of back-calculated individuals

The minimum number of individuals required to produce biologically relevant estimates varied for each model and its parameters. Results of the post hoc test for the model parameters of the von Bertalanffy growth model (VBGF), showed that for the growth coefficient (k), significant differences between estimates from 10, 30 and 40 individuals were found on comparison with all the individuals (N = 81). Similarly, significant differences between estimates of 10, 20 individuals for length at birth (L_0) and 10 individuals for asymptotic length (L_∞) in comparison to all individuals (N = 81) were presented (Figure 5). Therefore, based on results from *P.glauca* the minimum number of individuals required to estimate biologically realistic model parameters for the VBGF model was 50 individuals.

Similar trends were observed for the Gompertz model, where the minimum number of individuals required to be back-calculated varied for the three model parameters (Figure 6). The growth coefficient for the Gompertz model (gGom), showed significant differences only for 30 individuals in comparison to all individuals. Similarly, estimates for the length at birth parameter (L_0) were significantly different for 20 individuals, and for asymptotic length (L_∞) were significantly different for 10 and 20 individuals from all the individuals (N = 81). Thus, the minimum number of individuals required to be back-calculated to produce biologically relevant model parameters for *P.glauca* from the Gompertz model was 40 individuals.

In contrast to the other two models, the logistic model did not show any variation in the minimum number of individuals required to be back-calculated, for the three model parameters. All post hoc tests revealed that the growth coefficient (gLog) and length at birth (L_0) did not differ significantly from the full data set for any sample size (Figure 7). The one-way ANOVA and post hoc test for the asymptotic length (L_∞) parameter could not be performed as it produced infinite values. Based on these results, length at birth (L_0) and growth coefficient (gLog), a maximum of 10 individuals were required to produce biologically relevant model parameters for the logistic model.

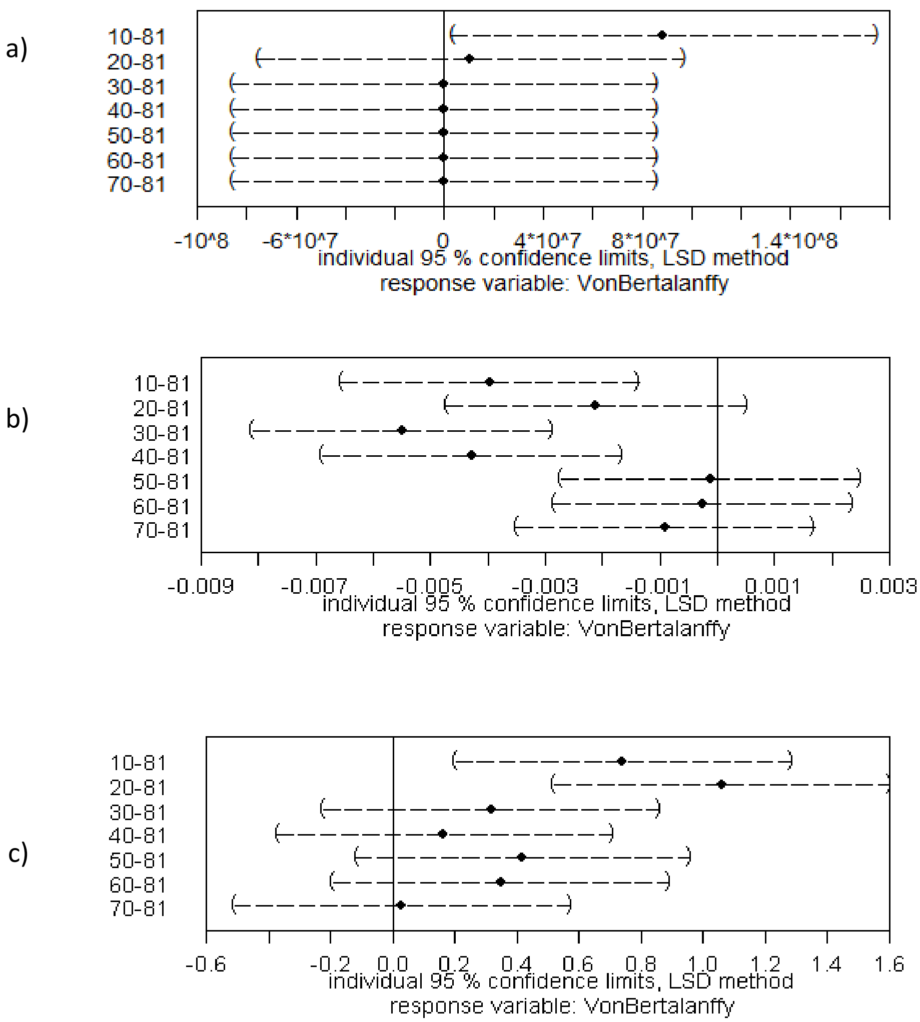
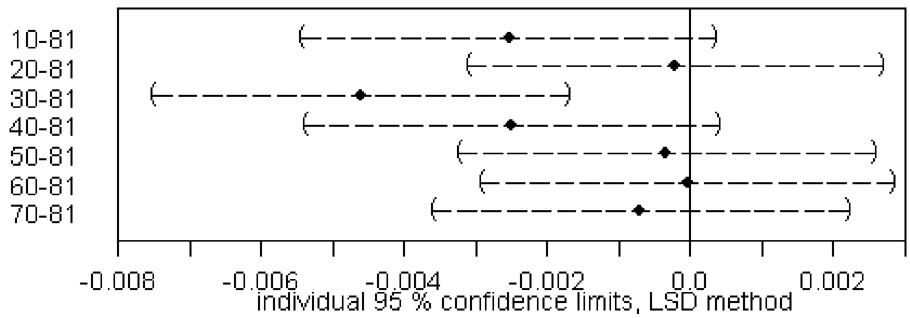
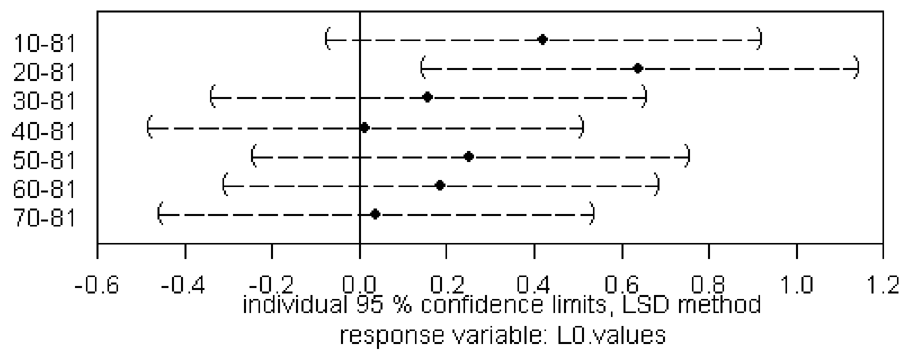


Fig 5. Plot intervals generated for model parameters of the VBGF model for different numbers of back calculated individuals. Confidence intervals for each pair were produced; where confidence intervals of the pairs did not cross zero, there were significant differences in the estimates. Fisher LSD post hoc plot intervals comparing number of individuals at intervals of 10 to the total sample (N=81) for (a) asymptotic length (b) growth coefficient, and (c) length at birth.

a)



b)



c)

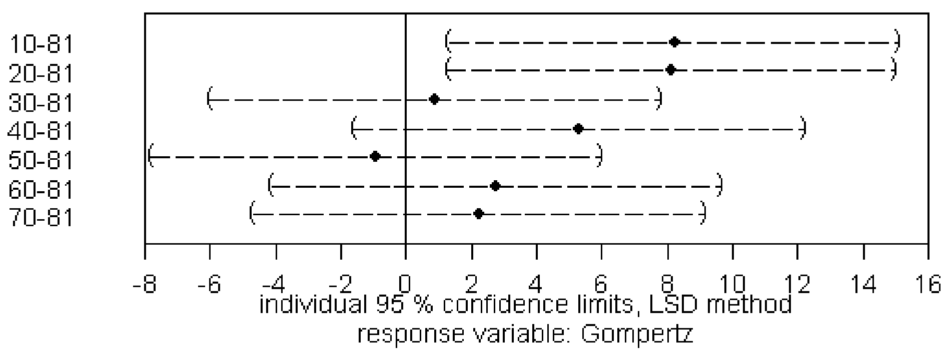
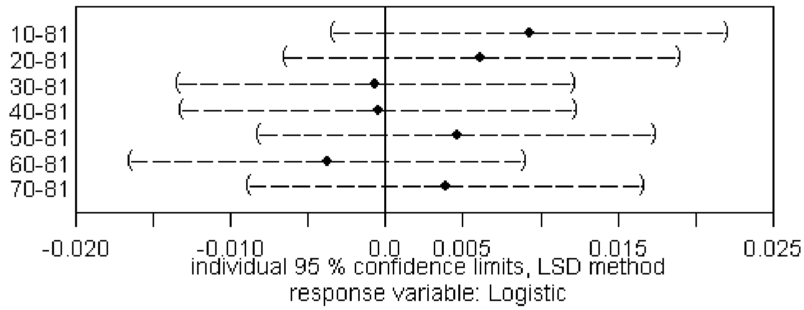


Fig 6: Plot intervals generated for model parameters of the Gompertz model for different numbers of back calculated individuals. Confidence intervals for each pair were produced; where confidence intervals of the pairs did not cross zero, there were significant differences in the estimates. Fisher LSD post hoc plot intervals comparing number of individuals at intervals of 10 to the total sample (N=81) for (a) growth co-efficient (b) length at birth, and (c) asymptotic length.

a)



b)

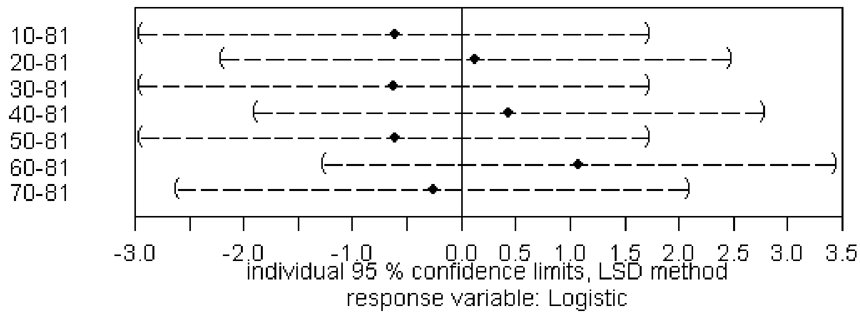


Figure 7: Plot intervals generated for model parameters of the Logistic model for different numbers of back calculated individuals. Confidence intervals for each pair were produced; where confidence intervals of the pairs did not cross zero, there were significant differences in the estimates. Fisher LSD post hoc plot intervals comparing number of individuals at intervals of 10 to the total sample (N=81) for (a) growth co-efficient (b) length at birth.

DISCUSSION

The results of this study produced some of the first estimates of growth parameters for *P.glauca* in the equatorial region of the WCPO. Unlike other studies of this species, the best fitting model was the Gompertz function, which suggests slower growth both early and later in life. This study was one of the few studies that applied the multi-model inference approach of fitting different growth functions for the blue sharks. Most of the previous studies have *a priori* selected the VBGF to fit the length at age data for blue sharks as it was assumed to sufficiently estimate the growth of sharks (Smart et al., 2016b). However, the use of a single growth model poses several risks of potentially biasing growth estimates due to the use of an inappropriate model, no convergence of the growth estimates to the true value of the population and the predictive uncertainty being an underestimate for the population (Katsanevakis, 2006, Smart et al., 2016b). Additionally, as demonstrated in this study, the VBGF produced biologically unrealistic estimates for the asymptotic length (L_∞) for both males and females which may be the result of the absence of a clear asymptote for the VBGF. This is relatively common for growth curves of larger shark species (Simpfendorfer et al., 2002, Smart et al., 2017). The Gompertz model was found produce more comparable asymptotic length estimates to the maximum size of the sharks observed in this study.

The observed length at age data consisted mainly of larger individuals (200 cm TL - 350 cm TL) and lacked juveniles (>180 cm TL) in the sample. The resultant overestimation of the length at birth (L_0) parameter for all three candidate models is a consequence of missing juveniles in the sample, as growth models are known to produce biased parameters when missing the smallest individuals in a sample (Haddon, 2001, Smart et al., 2015). This in turn biases the other model parameters, as a strong correlation exists between the model parameters while running the non-linear estimation process (Pilling et al., 2002). Hence, when the L_0 parameter is overestimated, the growth coefficient for the model would be underestimated (Pardo et al., 2013). The application of back-calculation techniques resolved this issue by compensating for the lack of juveniles in the sample, and producing more biologically realistic growth estimates for the *P. glauca* population in PNG. For back-calculated data, significant differences were found between the male and female growth curves, and hence separate growth curves were produced. The length at birth (L_0) parameter presented higher values for females in comparison to males, however, males were found to grow faster and reach a higher asymptotic length (L_∞). This result contradicts studies of *P. glauca* in other regions where female sharks are known to reach a larger mean asymptotic length in comparison to males (Jolly et al., 2013, Skomal and Natanson, 2003). However, as the other model parameters were seen to be comparable to other studies, this contradictory trend may be attributed to the lack of older female blue sharks in the sample. A similar trend was seen by Manning and Francis (2005) in New Zealand (WCPO), and was similarly ascribed to the lack of larger females in their dataset. The lack of older females in the WCPO, may be a reflection of the seasonal abundance and segregation by sex and size with areas, observed for blue shark populations globally (Jolly et al., 2013). Even though back-calculation techniques compensated for the lack of juveniles in the sample, it calculates body lengths of individuals at ages prior to age of capture (Vigliola and Meekan, 2009) and so cannot be used to compensate for the lack of fully grown individuals in the sample (Cailliet et al., 2006, Smart et al., 2015). This was shown by Branstetter (1987) for the spinner sharks *(Carcharhinus brevipinna)*, where age and growth estimates produced from a sample without old, mature individuals were found to be inaccurate on inclusion of these individuals in an analysis by Joung (2005). Hence, although back-calculation did not compensate for the lack of older females in the sample, the growth estimates produced using the back-calculated data were more biologically realistic in contrast to the observed length at age data.

Maximum ages estimated for the males and females of *P. glauca* in this study were 25 and 22 years, respectively, and provided the oldest age estimates for *P. glauca* to date globally. However, these are likely to be underestimates. A recent study by Harry (2017) noted that most age estimates, especially for older individuals of elasmobranchs are underestimated. This phenomenon occurs due to growth bands ceasing to formation, becoming unreliable or unresolvable after a certain age. It has been observed in the Porbeagle sharks *(Lamna nasus)* off New Zealand, where the species was found to live to twice as long as its age estimated using vertebral band pair counts (Francis et al., 2007, Francis et al., 2008). Further, Harry (2017) found that underestimation is a widespread phenomenon, found in at least nine genera of elasmobranchs, predominantly in two orders - Lamniformes and Carcharhiniformes - which are also the most extensively studied orders. Variation in the underestimation of age was found between intraspecific populations. For example, it occurred in the New Zealand porbeagle sharks (Francis et al., 2007), but was absent in the northwest Atlantic porbeagle sharks (Campana et al., 2002). However, conducting region-specific comprehensive age validation studies (e.g. bomb radio carbon dating or mark and recapture using injected tetracycline) to investigate underestimation of ages estimated using vertebral counts is very difficult for pelagic sharks. This can be attributed to their highly migratory nature, which makes it problematic to attain recaptures of injected animals after substantial periods or large size samples regularly throughout the year to enable marginal increment analysis (Cailliet et al., 2006). Understanding the extent of underestimation of ages and addressing it requires more data (Harry, 2017). Therefore, until more age validation studies are conducted in the WCPO, the oldest ages estimated in this study, remains as the best estimate.

Blue shark populations worldwide, show great variation in their age and growth estimates (Jolly et al., 2013). Studies in the Pacific Ocean reported that asymptotic length estimates for males and females range from 295-375 cm and 237-348 cm respectively (Table 4). Similarly, studies in the Atlantic Ocean reported that the asymptotic length estimates ranged from 282-343 cm and 310-382 cm for males and females respectively (Table 4). The male populations of *P. glauca* were found to grow to a larger average asymptotic length in the Pacific Ocean (Harvey, 1979, Cailliet et al., 1983) in comparison to the Atlantic Ocean (Castro and Mejuto, 1995, Henderson et al., 2001, MacNeil and Campana, 2002, Skomal and Natanson, 2003, Stevens, 1975). Conversely, female *P.*

glauca in the Atlantic Ocean were found to grow to a larger average asymptotic length in comparison to the Pacific Ocean (Table 4). *P. glauca* population in the western central Pacific Ocean (WCPO) presented variation in their growth parameter estimates in comparison to Atlantic and other Pacific populations. The asymptotic length parameter estimates for the males (336 cm TL) were more comparable to the Pacific population, while for the female *P. glauca*, the asymptotic length estimates (322 cm TL) were more comparable to the Atlantic Ocean, thus the male and female *P. glauca* populations from the WCPO attain a larger maximum size than their conspecifics in the Atlantic and Pacific oceans, respectively. The *P. glauca* population of PNG was found to attain a smaller asymptotic length (L_{∞}) (300 cm) at an older age, in comparison to the populations in the Atlantic and Pacific Ocean (325 cm) (Figure 8), indicating that the population in the WCPO grows differently compared to other regions. Size at birth estimates for both sexes (males: 45.8 cm and females: 48.1 cm) were within the range of that reported by the previous studies in other oceans (Table 4). These regional differences in the life history traits may be attributed to a range of factors, including: varying resiliencies to fishing pressure, population dynamics (Chin et al., 2013, Smart et al., 2015), variations in ageing techniques and methodology (Tanaka et al., 1990), or adaptations to the differing environmental conditions of the ocean basins (Jolly et al., 2013). The presence of intraspecific variation in life history traits of *P. glauca* demonstrated by this study mean that they should provide more representative life history estimates for the regional population of *P. glauca* in the EEZ of PNG in the WCPO. Their use in demographic analysis and stock assessments should enhance information for management strategies (Smart et al., 2015).

Intraspecific variation has been known to exist between conspecific populations in different geographical locations. Regional variation in the life history traits has been reported for several other elasmobranch species including cownose rays (Neer and Thompson, 2005), finetooth sharks *(Carcharhinus isodon)*, blacktip sharks *(Carcharhinus limbatus)* (Carlson et al., 2006, Smart et al., 2015), bonnethead shark *(Sphyrna tiburo)* (Lombardi-Carlson et al., 2003, Parsons, 1993), tiger sharks *(Galeocerdo cuvieri)* and blacknose sharks *(Carcharhinus* acronotus) (Neer and Thompson, 2005). Thus, conducting regional life history studies are essential for understanding the biology, population dynamics and status of a species (Jolly et al., 2013, Pratt Jr et al., 1990).

Table 4: Growth parameters for the male, female and combined sex of blue sharks (*Prionace glauca)* estimated by previous studies in the Atlantic and Pacific Ocean

Ocean	Author and Year	L ∞ Male (cm)	L ∞ Female (cm)	L ∞ Combined (cm)	K Male ($year^{-1}$)	K Female ($year^{-1}$)	K (Combined) ($year^{-1}$)	L0 combined (cm)	L0 Males (cm)	L0 Females (cm)
Pacific Ocean	Cailliet et al. (1983)	295.3	241.9	265	0.18	0.51	0.223	43.4	52.3	80.6
	Tanaka (1984)	308.2	256.1	-	0.09	0.12	-	0	27.5	36.0
	Nakano (1994)	289.7	243.3	-	0.13	0.14	-	0	26.9	28.0
	Manning and Francis (2005)	342.9	267.5	-	0.09	0.13	-	0	35.9	33.1
	Tanaka (1990)	364	304	-	0.1	0.16	-	0	46.9	45.4
	Blanco-Parra et al. (2008)	299.9	237.5	-	0.1	0.15	-	0	64.9	65.5
	Hsu et al. (2011)	375.8	317.8	-	0.12	0.17	-	0	63.8	55.1
	Hsu et al. (2012)	366.9	348	-	0.13	0.16	-	0	58.3	51.9
Atlantic Ocean	Aasen (1966)	-	-	394	-	-	0.133	39.8	0	0
	Stevens (1975)	-	-	423	-	-	0.11	45.5	0	0
	Aires-de-Silva (1996)	-	-	340	-	-	0.138	46.9	0	0
	Henderson et al. (2001)	-	-	376.5	-	-	0.12	55.5	0	0
	Skomal et al. (2003)	282.3	310.8	285.4	0.18	0.13	0.17	60.8	60.9	63.9
	Lessa et al. (2004)	-	-	352	-	-	0.16	52.5	0	0
	Skomal (1990)	343	375	-	0.16	0.15	-	0	45.5	45.9
	Jolly et al. (2013)	294.6	334.7	311.6	0.14	0.11	0.12	56.3	49.0	71.7
	Megalofonou et al. (2009)	-	-	401.5	-	-	0.13	31.1	0	0
	Silva et al. (1996)	309	382	284	0.12	0.09	0.14	39.9	37.2	38.8
	Hsu et al. (2015)	-	-	352.1	-	-	0.13	55.1	0	0
WCPO	**This study**	**336.4**	**322.1**	**-**	**0.12**	**0.11**	**-**	**-**	**45**	**48**

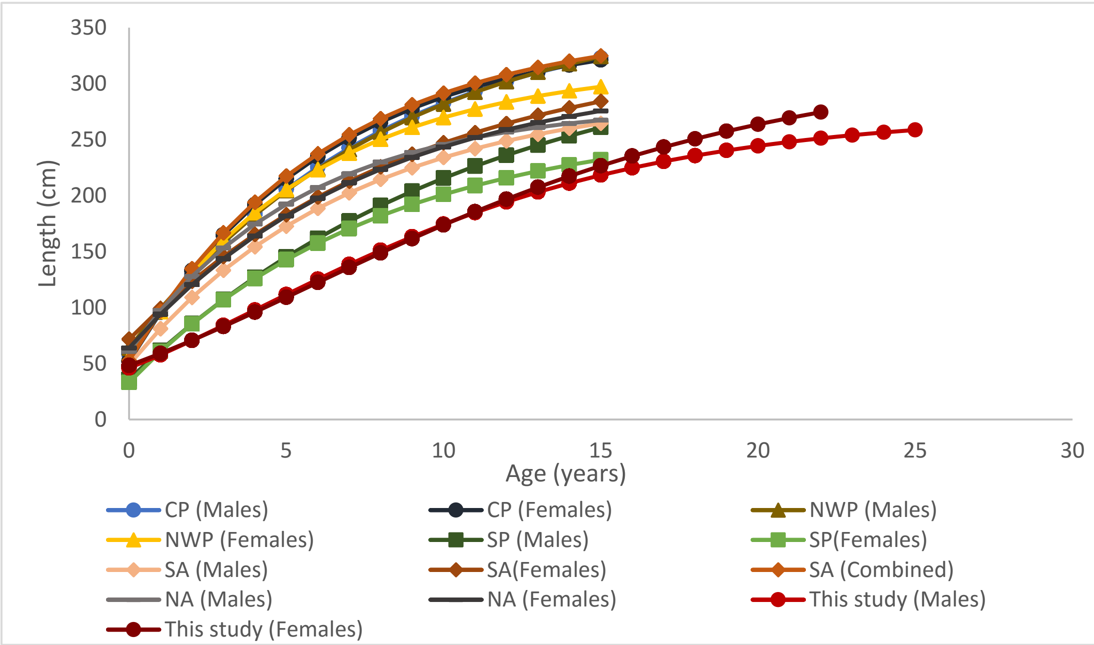


Fig.8: Comparison of the von Bertalanffy curves produced for *Prionace glauca* from the North Pacific Ocean (NWP; Hsu et al., 2011), Central Pacific (CP; Hsu et al. 2012), South Pacific (SP; Manning and Francis 2005), North Atlantic (NA; Skomal and Natanson 2003), South Atlantic (SA; Lessa et al. 2004, Jolly et al. 2013) to the Gompertz growth curves for sexes separate of *Prionace glauca* from the Western Central Pacific Ocean, Papua New Guinea (this study).

This study was the first to identify the required number of individuals to be back-calculated. Previous studies that have used back-calculation techniques have investigated the outcome of application of different back-calculation techniques like the Dahl Lea direct proportions method or Fraser Lee birth modified method, on length at age data (Cailliet and Goldman, 2004, Campana, 1990, Lessa et al., 2004). Unlike these other studies that have used all available samples, this study provided insight into the minimum number of individuals required to be back-calculated to produce robust model parameters. These results demonstrated that the minimum number of individuals varies for the different models and for parameters within models. For all three models, results showed that all individuals (81) would not be required to be back-calculated. Sample sizes from 10 (logistic) to 50 (VBGF) provided results that did not differ from the full data set depending on the growth function used. Growth parameters like asymptotic length (L_∞) and length at birth (L_0), are known to greatly vary between candidate models (Katsanevakis and Maravelias, 2008, Smart et al., 2016b). Therefore, it was expected that the minimum number of individuals required to be back-calculated to produce biologically realistic model parameters would vary between candidate models. As blue sharks from PNG were found to best fit the Gompertz model, the minimum number of individuals required to produce biologically realistic growth parameters can only be established for that model. Further studies on various species of elasmobranchs, with disparate life histories and growth, are required to conclude the minimum number of individuals to be back-calculated for different growth models. On conducting this meta-analysis, the minimum number of individuals required to be back-calculated that would produce biologically realistic growth parameters for all the growth models, can be established.

CONCLUSION

This study provided region specific life history parameters for *P. glauca* in the WCPO. Since the life history information available for blue sharks in the WCPO is limited to only one study from New Zealand, the life history information reported in this study provide essential biological information required to conduct accurate demographic analysis and stock assessment required to inform fisheries management in the region. This study also revealed that the blue sharks in the WCPO, grow differently in comparison to conspecific populations in other regions. Hence, it is important to perform regional life history studies, as the use of proxy data to inform fisheries would potentially bias the management of the local population. This study also revealed that all the individuals in a sample do not need to be back-calculated to produce biologically realistic growth parameters. This study has taken an important step towards optimising the back-calculation efforts for life history studies by demonstrating that all individuals in a sample are not required to be back-calculated to produce biologically realistic growth parameters for the population. This finding has important implications for the level of effort necessary to compensate for missing samples of yonger individuals.

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