




Galeus friedrichi (Carcharhiniformes: Pentanchidae), a new sawtail catshark from the Philippines

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Abstract

A new species of sawtail catshark, *Galeus friedrichi* n. sp., is described from the Philippines. The new species is separable from other western Pacific *Galeus* species by the absence of saddle or blotch markings, a large size >50 cm TL, 40 monospondylous vertebrae, and 83 precaudal vertebrae. All regional *Galeus*, other than *Galeus sauteri*, can be distinguished by having a marking pattern made up of a series of dark to light saddle or blotch patterns beneath the dorsal fins and on the caudal fin. *Galeus sauteri* can be separated from *G. friedrichi* n. sp. by its relatively small adult size, <50 cm TL, and fewer precaudal vertebrae (73–76 vs. 83). The two other large regional species, *G. longirostris* and *G. nipponensis* are presently known only from Japan and Taiwan. The new species is the third *Galeus* species, after *G. sauteri* and *G. schultzi*, documented from the Philippines.

Key words: taxonomy, ichthyology, Chondrichthyes, elasmobranch, western Pacific Ocean.

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Introduction

The genus *Galeus* Rafinesque, 1810 (Pentanchidae) comprises one of the more species-rich shark genera with 18 valid species (Ebert et al. 2021). The genus is distinguished from other members of the Pentanchidae by a combination of its color pattern of blotches and spots, relatively large pectoral fins, as well as the absence of enlarged denticles along the ventral surface of the caudal peduncle which characterizes sharks of the genus *Figaro* Whitley, 1928 (resurrected by Gledhill et al. (2008)), their closest relatives in the family. *Galeus* is wide ranging, occurring mostly on outer continental shelves and slopes, and insular slopes from about 100 to 2000 m deep (Ebert et al. 2021).

Many *Galeus* species have relatively restricted ranges, with 8 *Galeus* species known to occur in the western Pacific Ocean (Ebert et al. 2021). Five species are recognized in the western North Pacific: *Galeus eastmani* (Jordan & Snyder, 1904); *Galeus longirostris* Tachikawa & Taniuchi, 1987; *Galeus nipponensis* Nakaya, 1975; *Galeus sauteri* (Jordan & Richardson, 1909); *Galeus schultzi* Springer, 1979; and three species from the southwestern Pacific, *Galeus corriganae* White, Mana & Naylor, 2016; *Galeus gracilis* Compagno & Stevens, 1993; and *Galeus priapus* Séret & Last, 2008. Two of these species, *G. sauteri* and *G. schultzi*, are currently documented from Philippine waters (Compagno et al. 2005, Ebert et al. 2021). A third *Galeus* species, reported from the Philippines as an undescribed species by Compagno et al. (2005), is described here based on three preserved Philippine specimens. The live or fresh appearance has not been documented.

Materials and Methods

Morphometric measurements were taken in full on the holotype and two paratypes following the methodology and terminology of Nakaya et al. (2008) for the genus *Apristurus*, but modified following other recent new *Galeus* species descriptions (Séret & Last 2008, White et al. 2016). Morphometric values to the nearest millimeter (mm) are presented as ratios of the total length (TL). Meristics, including tooth and vertebral counts, were taken for the holotype and two paratypes.

The type series is deposited in the fish collection at the California Academy of Sciences Ichthyology (CAS-ICH), San Francisco, CA, USA. Comparative material was examined from the CAS-ICH, American Museum Natural History (AMNH), New York, NY, USA; Biodiversity Research Center, Academia Sinica (ASIZP), Taipei, Taiwan; Australian National Fish Collection of the Commonwealth Scientific and Industrial Research Organization, Division of Marine and Atmospheric Research (CSIRO), Hobart, Tasmania, Australia; Hokkaido University Museum, Fisheries Science Center (HUMZ), Sapporo, Hokkaido, Japan; Iziko South African Museum (SAM), Cape Town, South Africa; Moss Landing Marine Laboratories (MLML), Moss Landing, CA, USA; Muséum national d'Histoire naturelle (MNHN), Paris, France; National Museum of Marine Biology, Pingtung (NMMB-P), Checheng, Taiwan; and the South African Institute for Aquatic Biodiversity (SAIAB), Grahamstown, South Africa. Institutional abbreviations follow Sabaj (2020).

Genus *Galeus* Rafinesque, 1810

Galeus Rafinesque, 1810: 13

Type species. *Galeus melastomus* Rafinesque, 1810
by subsequent designation of Fowler, 1908, Proc. Acad. Nat. Sci., Philadelphia, 60: 53.



Figure 1. *Galeus friedrichi* n. sp. holotype, CAS-ICH 247314, adult male, 534 mm TL, lateral view, after preservation.

Galeus friedrichi, n. sp.

Philippines Sawtail Catshark

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Figures 1–5, Table 1

Holotype. CAS-ICH 247314, mature male, 534 mm TL, Philippines, Mindanao, Zamboanga del Norte, Dapitan City, off Sikayab-Bukana (landed location), 550 m, 17 April 1999.

Paratypes. CAS-ICH 247315, juvenile male, 455 mm TL, 25 March 2000; CAS-ICH 247316, female, 413 mm TL, 14 April 1999 (landed at same location as holotype).

Diagnosis. A large slender *Galeus* species distinguished from all regional congeners by a combination of an absence of saddle or blotch patterns on body and caudal fin (except *G. sauteri*); large size, exceeding 50 cm TL (except *G. longirostris* and *G. nipponensis*); a higher count of monospondylous vertebrae (40) (except *G. longirostris* and *G. nipponensis*); and 83 precaudal vertebrae.

Description. (percentage of TL, holotype and range for two paratypes) Body elongate, slender, tapering slightly behind first dorsal fin (Figs. 1–3); head height 5.8% (5.8–5.9); abdomen long, pectoral-pelvic space 15.9% (14.1–16.5), 1.22 (1.21–1.42) in head length; pelvic-anal space long, 1.69 (1.38) times anal-fin base; caudal peduncle elongate, anal-caudal space 0.56 (0.58–0.63) times anal-fin base; peduncle moderately compressed. Snout moderately long, tip rounded; preoral length 6.0% (6.6–6.8), 0.78 (0.93–0.94) times mouth width; prenarial snout 1.13 (1.06–1.06) times eye length. Eyes dorsolateral on head, oval, with well developed subocular ridges and nictitating lower eyelids; eyes small, length 3.0% (3.7–3.9), 6.50 (5.13–5.35) in head length. Spiracles dorsolateral on head, subcircular, close to, but well separated from eyes; spiracle small, length 3.2 (4.0–5.7) in eye length. Gill slits straight to slightly concave, moderately long, gill filaments not visible externally, upper ends slightly above lower edges of eyes; gill slits descending in height, fifth gill slit shortest and above pectoral-fin origin.



Figure 2. *Galeus friedrichi* n. sp. paratype, CAS-ICH 247315, juvenile male, 455 mm TL, lateral view, after preservation.

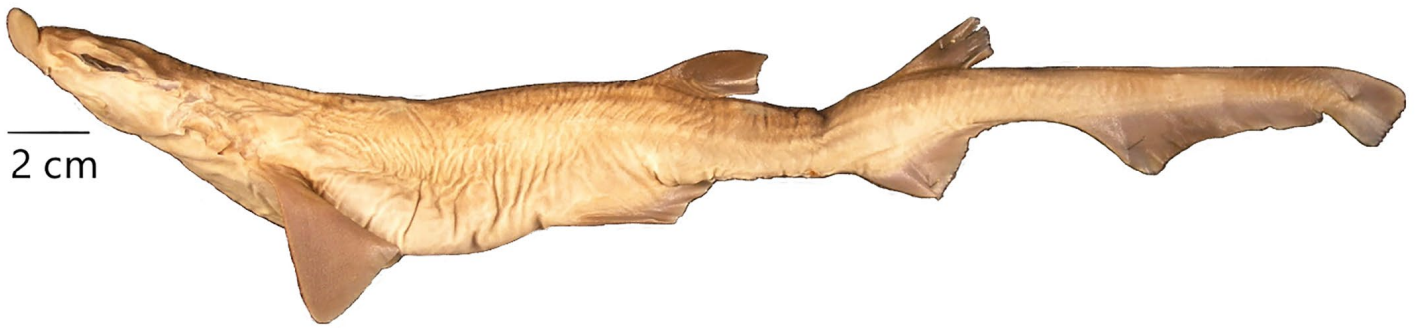


Figure 3. *Galeus friedrichi* n. sp. paratype, CAS-ICH 247314, female, 413 mm TL, lateral view, after preservation.

Mouth moderately large and long, arched, width 6.7% (7.0–7.3), 2.00 (2.13–2.31) times its length; labial furrows well developed, lower furrows much shorter than mouth length, uppers not extending forward to symphysis (Fig. 4). Teeth with mainly three cusps; strong central cusp flanked by well developed lateral cusp about one-half length of central cusp; in about 50 rows in upper and lower jaws.

Denticles on sides of trunk below first dorsal fin cuspidate, semi-erect, slightly overlapping. Supracaudal crest along dorsal caudal margin well developed, about 1.22 times length of interdorsal space; origin of crest posterior to second dorsal-fin free rear tip, denticles mostly in parallel rows of two prominent, erect, posteriorly directed denticles, bordering one or two smaller denticles in between; denticles progressively increasing in size from crest origin to about level of lower lobe origin, then decreasing in size posteriorly; subcaudal crest absent.



Figure 4. *Galeus friedrichi* n. sp. holotype, CAS-ICH 247314, adult male, 534 mm TL, ventral view of head.

TABLE 1

Proportional measurements of type specimens of *Galeus friedrichi* n. sp.
as percentages of total length

	holotype CAS-ICH 247255	paratype CAS-ICH 247315	paratype CAS-ICH 247316		holotype CAS-ICH 247255	paratype CAS-ICH 247315	paratype CAS-ICH 247316
Total Length (TL) mm	534	455	413	P1-P2 origins	19.1	18.9	18.6
Pre-D1 length	45.9	45.1	44.8	P1-P2 insertions	23.6	23.3	23.4
Snout to D1 insertion	52.5	50.3	49.6	P2-anal space	14.2	12.1	13.3
Pre-D2 length	66.5	64.0	63.7	P2-anal origins	22.6	22.5	23.6
Snout to D2 insertion	72.3	69.2	68.3	D1 length	7.5	7.3	7.7
Head length	19.5	20	19.9	D1 base length	5.8	5.3	4.8
Pre-branchial length	13.7	15.4	14.8	D1 height	3.2	4.2	3.6
Pre-spiracle length	10.3	10.8	11.1	D1 inner margin length	1.9	2.0	2.9
Pre-orbital length	6.2	6.6	9.0	D2 length	7.1	7.3	7.3
Pre-outer nostril length	3.4	4.0	4.1	D2 base length	4.7	5.3	4.6
Pre-inner nostril length	4.3	4.8	4.9	D2 height	3.2	3.3	3.6
Pre-oral length	6.0	6.6	6.8	D2 inner margin length	2.1	2.0	1.9
PreP1 length	18.5	19.6	19.1	P1 base length	6.2	5.5	6.5
PreP2 length	39.3	38.5	39.5	P1 anterior margin	9.2	10.5	12.3
Pre-vent length	44.6	41.8	41.2	P1 posterior margin	8.8	9.9	10.7
Pre-anal length	61.4	59.3	58.6	P1 inner margin	4.3	5.3	6.1
Pre-caudal length (dorsal)	74.5	72.5	70.5	P2 anterior margin	5.4	4.8	5.6
Head height	5.3	4.8	4.8	P2 length	14.2	13.8	12.3
Head width (mouth corners)	5.8	5.9	5.8	P2 base length	9.4	8.8	8.2
Mouth width	6.7	7.0	7.3	P2 posterior margin	10.9	11.0	9.0
Mouth length	3.4	3.3	3.1	P2 inner margin	5.1	5.3	3.1
Internarial width	2.2	2.4	2.4	Anal base length	8.4	8.8	9.7
Upper labial furrow length	1.5	1.8	1.5	Anal anterior margin	4.9	5.9	5.6
Lower labial furrow length	1.7	1.8	2.2	Anal posterior margin	3.4	3.1	3.4
Orbit length	3.0	3.7	3.9	Anal height (muscle)	3.4	3.1	3.4
Orbit height	1.1	1.3	1.0	Anal inner margin	1.5	1.8	1.5
Nostril length	2.2	2.4	2.2	Caudal peduncle height	3.0	3.1	3.9
Nostril-mouth space	1.7	1.7	1.6	Caudal length	26.0	27.9	27.8
Interorbital width	5.4	5.5	6.3	Caudal height	6.8	6.6	6.8
First gill height	1.9	1.5	1.7	Caudal preventral margin	8.1	8.1	7.5
Third gill height	1.1	1.3	1.5	Caudal postventral margin	12.4	13.2	13.6
Fifth gill height	0.7	1.3	1.0	Caudal terminal lobe height	3.2	4.0	4.1
Intergill	6.2	5.8	6.0	Caudal terminal lobe length	4.3	5.1	4.8
Interdorsal space	16.1	13.6	12.1	Caudal terminal lobe post. margin	4.9	5.7	5.8
D1-D2 origins	20.8	21.1	21.9	Clasper outer length	15.4	9.9	n.a.
D1-D2 insertions	20.4	20.3	20.1	Clasper inner length	18.7	13.0	n.a.
P1-P2 space	15.9	14.1	16.5	Clasper width	1.5	0.9	n.a.
P1 tip to P2 origin	8.7	8.8	8.6				

Claspers of holotype stout, very long, tapering slightly towards distal tips (Fig. 5); length extending well behind pelvic fins, but distal tips not quite reaching anal-fin origin; tips slightly twisted; outer length 15.4%, inner length 18.7%, base width 1.6 times spiracle length. Pelvic-fin anterior inner margin not fused to clasper. Glans long, more than one-half length of clasper from apopyle to clasper tip; ventral and lateral surfaces densely covered with imbricated, erect to semi-erect hook-shaped denticles that are directed toward clasper base; exorhipidion and rhipidion covered with enlarged hooked denticles, forming sawlike rows. Cover rhipidion reduced, pseudosiphon small, narrow, slit-like; apopyle and hypopyle connected by a long clasper groove; rhipidion present, large, extending along hypopyle. Claspers of late adolescent paratype with outer length 9.9%, inner length 13.0%.

Dorsal fins similar in shape, anterior margins slightly convex, apex moderately rounded, posterior margin relatively straight, free rear tip angular; first dorsal fin slightly larger than second, height 1.00 (0.79–1.00) times second dorsal-fin height, origin over pelvic-fin base, slightly anterior to pelvic-fin insertion (axil); second dorsal-fin origin about mid-point of anal-fin base, insertion behind anal-fin insertion. Pectoral fins large, broadly rounded, anterior margin 9.2% (10.5–12.3). Pelvic fins moderately large, low, angular, length 14.2% (12.3–13.8). Anal fin relatively short, base 8.4% (8.8–9.7), 1.91 (1.25–1.55) in interdorsal space; origin slightly posterior to mid-interdorsal space; anal-fin height 2.50 (2.86–2.86) in length of base. Caudal fin slender, dorsal margin weakly concave to level with subterminal notch; ventral lobe high, apex angular; postventral margin concave; subterminal notch distinct; subterminal margin straight; terminal caudal margin relatively straight.

Vertebral counts: monospondylous centra 40; precaudal centra 83; caudal centra 56; total centra 139.

Color. (Figs. 1–3) After more than 20 years of preservation, body brownish above becoming lighter below lower rim of orbit, below pectoral-pelvic fin space, and above pelvic-anal space; saddle patterns absent; dorsal fins whitish at apex; no markings on pectoral, pelvic, or anal fins; caudal fin with darker brown area along caudal pre-ventral margin near apex, midway along post-ventral margin, and at upper post-ventral margin at junction of caudal terminal lobe. Mouth roof, tongue, and floor beneath tongue and jaws all whitish.

Size. A large *Galeus* species, the male exceeds 50 cm TL.

Distribution. Known only from the type specimens caught off off Sikayab-Bukana, Dapitan City, Zamboanga del Norte, Philippines at a depth of 550 m.

Etymology. The new species is named in honor of Jürgen Friedrich, a European philanthropist and co-founder of the JAF Foundation (Switzerland), in recognition of his commitment to marine conservation, research, and advocacy.

Comparisons. *Galeus friedrichi*, n. sp. can be separated from all western Pacific *Galeus* species, except *G. sauteri*, by the absence of saddle or blotch patterns on its body trunk and caudal fin. Most western Pacific *Galeus* species have a series of dark to light saddle or blotch patterns beneath the dorsal fins and on the caudal fin. The new species also can be further distinguished from *G. corriganae*, *G. gracilis*, and *G. priapus* by having a whitish lining of the mouth (vs. dusky to black).

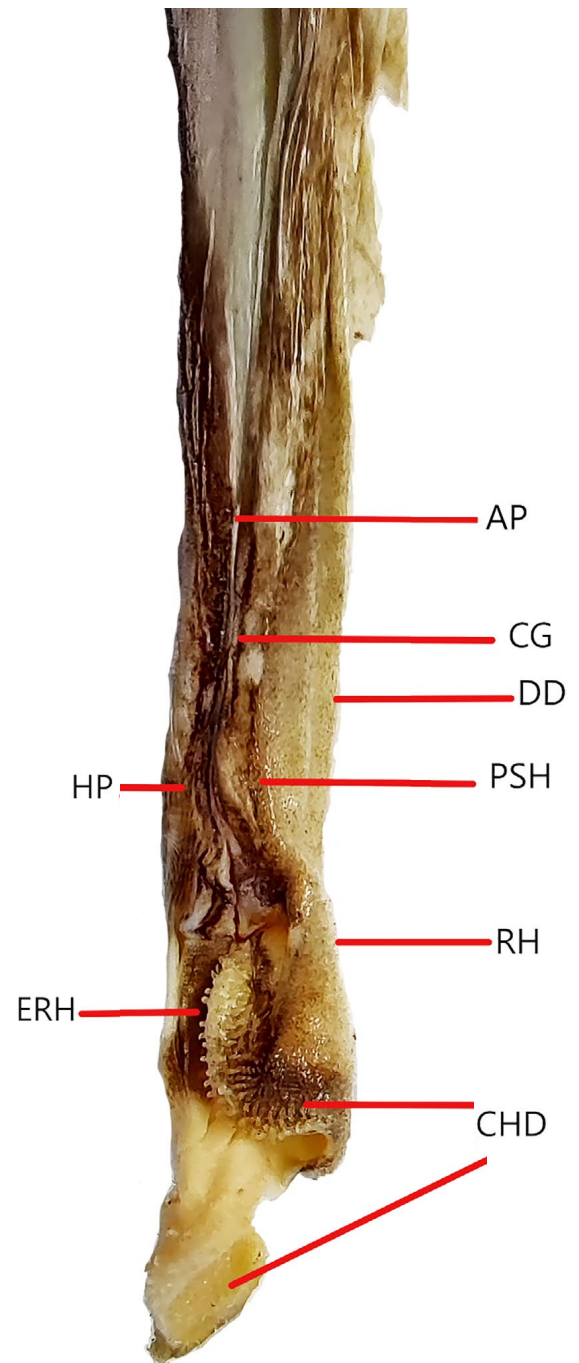


Figure 5. *Galeus friedrichi* n. sp. holotype, clasper: AP: apopyle; CG: clasper groove; CHD: clasper hooked denticles; DD: dermal denticles; ERH: exorhipidion; HP: hypopyle; PSH: pseudo-siphon; RH: rhipidion.

The new species has more monospondylous vertebrae (40) than *G. gracilis* (33–37), *G. priapus* (35–38), *G. schultzi* (32–35), *G. eastmani* (33–36), and *G. sauteri* (31–38). It also has more precaudal vertebrae (83) vs. a *G. gracilis* (74–79), *G. nipponensis* (80), *G. schultzi* (73–80), and *G. sauteri* (73–76); and a lower number of precaudal vertebrae (83) vs. *G. longirostris* (91–97). It also has more total vertebrae (139) than *G. gracilis* (128–134), *G. nipponensis* (123), *G. sauteri* (122–132), and *G. schultzi* (121–136).

In contrast to *G. friedrichi*, which exceeds 50 cm in TL, *G. eastmani*, *G. gracilis*, *G. priapus*, *G. sauteri*, and *G. schultzi*, all have a maximum TL of less than 50 cm. The only other *Galeus* species in the western Pacific known to exceed 50 cm TL are *G. longirostris* and *G. nipponensis*. The largest known specimen of *G. corriganae* is an adolescent male of 372 mm TL, and, although it may prove to be a larger species, the saddle pattern and black mouth lining distinguish it from the new species.

Morphological differences further distinguish the new species from the other large species: from *G. longirostris* by a shorter prenarial snout length 3.4–4.1%, about equal to the eye diameter (3.0–3.9%), vs. 5.0–5.5%, longer than eye diameter (3.4–4.0%); a shorter preoral length 6.0–6.8% (vs. 7.9–8.4%); a longer pelvic-anal distance 12.1–14.2% (vs. 8.5–11.3%); inside of mouth whitish (vs. grayish white); and males apparently maturing at a smaller size, 534 mm TL (vs. 660 mm TL); and from *G. nipponensis* by upper and lower labial furrows nearly equal in length (vs. lower slightly longer than upper); a shorter pregill length 13.6–15.4% (vs. 16.8%); a longer pectoral-pelvic space 14.1–16.5% (vs. 12.6%); a shorter inter-orbital space 5.3–6.3% (vs. 6.9%); a greater pectoral-fin height 9.4–10.4% (vs. 8.1%); a longer anterior pectoral margin 10.4–12.3% (vs. 9.2–10.8%); a longer pelvic-anal length 12.1–14.2% (vs. 9.8–11.8%); proportionally smaller dorsal and anal fins, i.e. first dorsal-fin length 7.3–7.7% (vs. 8.4%), base 4.8–5.3% (vs. 6.3%), and height 3.2–3.6% (vs. 4.7%); second dorsal-fin length 3.2–3.6% (vs. 4.7%), anal-fin length 9.7–10.9% (vs. 12.8%), anterior margin 4.9–5.9% (vs. 8.2%), base 8.5–9.7% (vs. 11.5%), and posterior margin 5.9–6.5% (vs. 10.7%); the second dorsal-fin origin located closer to the anal-fin origin 2.9–4.3% (vs. 6.8%) and the second dorsal-fin insertion about over the anal-fin insertion, i.e. distance behind insertion is 0.0–0.4% (vs. 1.6%). The claspers of the 534 mm TL holotype are proportionally longer (vs. a 619 mm TL *G. nipponensis*), with the outer length 15.4% (vs. 12.6%) and the inner length 18.7% (vs. 17.4%) and the claspers have numerous densely packed, enlarged, hooked denticles covering the exorhipidion and clasper tip (vs. relatively sparse denticle coverage).

Galeus friedrichi n. sp. is the third *Galeus* species found in the Philippines (Compagno et al. 2005, Ebert et al. 2021), with *G. schultzi* endemic to the Philippines and *G. sauteri* also occurring off Taiwan. *Galeus eastmani* is known from Japan to Taiwan, Vietnam, and possibly Malaysia, but has not been reported from the Philippines. *Galeus nipponensis* occurs from Japan to Taiwan (Ebert et al. 2013, 2021), *G. longirostris* appears to be endemic to Japan, while *G. corriganae*, *G. gracilis*, and *G. priapus* are only known from the southwestern Pacific (Ebert et al. 2021).

The conservation status for 7 of the 8 Western Pacific *Galeus* species have been assessed by the International Union for the Conservation of Nature (IUCN) as Least Concern due to their deepsea habitat and relatively stable populations. Three species (*G. corriganae*, *G. priapus*, and *G. schultzi*) occur in regions where deepsea fisheries either do not occur or are poorly documented (Dulvy et al. 2020, Séret 2018, Sherman & Cheok 2020), and they are also relatively small and of no market value. Four other species, *G. eastmani*, *G. longirostris*, *G. nipponensis*, and *G. sauteri*, are taken as bycatch in demersal trawl and longline fisheries, but are discarded, perhaps with high post-release survival (Rigby et al. 2020a, b, 2021a, b). This has been inferred because the populations of these species are either stable or have increased over time. The eighth species, *G. gracilis*, currently has insufficient information available to assess the species beyond Data Deficient (Kyne & Cavanagh 2016).

Since 2002, nearly one-quarter of all chondrichthyans have been described (White et al. 2022). This renaissance in chondrichthyan taxonomy over the past 20 years has led to the identification of many new species that otherwise could not have been assessed by the IUCN Red List. In fact, three of the 9 sawtail catsharks discussed here have only been named in the past 15 years. Many of these discoveries, including the new species, are deepsea species, highlighting how much remains to be discovered in this environment, especially as fisheries globally expand into the deep sea.

Other material examined:

Galeus eastmani (7 specimens): NMMB-P 12053, 3 females and 2 males, 192–340 mm TL, Nan-fang-ao, 11 March 2011; NMMB-P 12147, male 229 mm TL, Nan-fang-ao, 11 March 2011; NMMB-P 15372, female 340 mm TL, Nan-fang-ao, 26 July 2010.

Galeus gracilis (4 specimens): Holotype: CSIRO H1208-01. Paratypes: CSIRO CA 3304, CSIRO CA 4477, CSIRO CA 4478.

Galeus nipponensis (8 specimens): NMMB-P 12053, 2 males, 300 and 358 mm TL, Nan-fang-ao, 3 Mar 2011; NMMB-P 13704, female 530 mm TL, 2 males, 410 and 570 mm TL, NMMB-P 13791, male 565 mm TL, 19 May 2011; NMMB-P 13792, male 516 mm TL, NMMB-P 13793, female 756 mm TL, Dong-gang, 19 May 2011; HUMZ 213822, male 486 mm TL, Dong-gang, February 2012.

Galeus sauteri (15 specimens): AMNH 258160, adult male 369 mm TL, CSIRO H 7394-17, female 400 mm TL, CSIRO H 7394-18, female 412 mm TL, CSIRO H 7394-19, adult male 387 mm TL, CSIRO H 7394-22, adult male 390 mm TL, HUMZ 213823, female 228 mm TL, HUMZ 213824, female 241 mm TL, MNHN 2013-0498, adult male 377 mm TL, MNHN 2013-0441, female 288 mm TL, MNHN 2013-0442, female 230 mm TL, MNHN 2013-0443, female 237 mm TL, CAS 236061, juvenile male 250 mm TL, CAS 236061, female 246 mm TL, CAS 236061, juvenile male 212 mm TL, CAS 236061, juvenile male 156 mm TL, Da-xi, 13 March 2012.

Galeus schultzi (5 specimens): CAS-ICH 34852 (2), female 143 mm TL and male 155 mm TL, Balayan Bay, SE of Pagapas Bay, Batangas, Philippines, 4 August 1966, CAS-ICH 33783 (1), female 170 mm TL, Balayan Bay, south of Cape Santiago, Batangas, Philippines, 5 August 1966, CAS-ICH 34556 (2), males 165–182 mm TL, Balayan Bay, SE of Pagapas Bay, Batangas, Philippines, 28 July 1966.

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