Zootaxa 3221: 48–59 (2012)
www.mapress.com/zootaxa/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

Description of a new species of deepwater catshark, *Bythaelurus giddingsi* sp. nov., from the Galápagos Islands (Chondrichthyes: Carcharhiniformes: Scyliorhinidae)

JOHN E. McCOSKER[1,4], DOUGLAS J. LONG[1,2] & CAROLE C. BALDWIN[3]

[1]*Department of Aquatic Biology, California Academy of Sciences, 55 Music Concourse Drive, San Francisco, California, 94118-4503,United States. E-mail: jmccosker@calacademy.org*

[2]*Department of Natural Sciences, Oakland Museum of California, Oakland, California, 94607, United States. E-mail:dlong@museumca.org*

[3]*Divisiion of Fishes, National Museum of Natural History, Smithsonian Institution, Washington, D.C., 20560, United States. E-mail:baldwinc@si.edu*

[4]*Corresponding author*

Abstract

We describe *Bythaelurus giddingsi* **sp. nov.** based on 7 specimens collected using the submersible *Johnson Sea-Link* from deepwater (428–562 m depth) areas of the Galápagos Islands. It is presumed to be endemic to the archipelago. The new species differs from its congeners in its coloration, the length of its anal-fin base, and in other morphological characters. The disjunct distribution of species of the widely-distributed Indo-Pacific genus *Bythaelurus* is discussed.

Key words: Ichthyology, systematics, Scyliorhinidae, *Bythaelurus*, new species, endemism, Galápagos

Introduction

In recent years, two of us (JM and CB) had an opportunity to survey the Galápagos ichthyofauna using the one-atmosphere submersible *Johnson Sea-Link*. Numerous new species and new locality records were obtained between the surface and 1000 m (McCosker, 1997; McCosker *et al.*, 1997; McCosker & Rosenblatt, 2010), including a not uncommon catshark (Figures 1 & 2) that was observed and collected at several locations in the Galápagos Archipelago. The Galápagos catshark specimens described herein have been noted prior to this description as *Bythaelurus* sp. (Compagno 2005a, Compagno *et al.*, 2005, Kyne & Simpendorfer 2007, Hearn *et al.*, 2009, McCosker & Rosenblatt 2010, Ruiz *et al.*, 2011).

Bythaelurus Compagno 1988 was first described as a subgenus of *Halaelurus* Gill 1862, based on a number of shared morphological features, and contained *H. canescens* (Günther 1878), *H. dawsoni* Springer 1971, *H. hispidus* (Alcock 1891), *H. immaculatus* Chu & Meng 1982, *H. lutarius* Springer & D'Aubrey 1972, and *H. alcocki* Garman 1913 (Compagno, 1988). Compagno (1988) identified the following diagnostic characters of *Bythaelurus*: "Snout bluntly rounded, without a pointed, knoblike tip. Eyes not noticeably elevated on dorsal surface of head. Gill openings not elevated above horizontal head rim ... Skin thin, body soft. Precaudal pit shorter, 0.5-0.6 of snout-vent length. Clasper hooks absent (*H. canescens*) or few (*H. hispidus*); other species unknown. Postanal space 0.2–0.4 in anal base. Distance from anal origin to second dorsal origin 0.7–0.8 times second dorsal base. Anal posterior margin 0.7–0.8 times second dorsal base. Anal posterior margin 1.0–1.4 times anal anterior margin. Color uniform brownish, gray, or blackish, sometimes with a line of white spots but without a prominent color pattern of dark stripes or spots ... MP counts 28.2–33.9, DP counts 31.7–36.0, DP?MP ratios 0.9–1.2." Compagno (1999) later added *H. clevai* Séret 1987. Compagno & Didier (2002) elevated *Bythaelurus* to full generic rank in a species checklist that included *B. hispidus* and *B. immaculatus*, and Compagno (2005a, b) subsequently added *B. alcocki, B. canescens, B. dawsoni, B. lutarius,* and *B. clevai* in a more complete taxonomic checklist. *Bythaelurus alcocki*, a deepwater Arabian Sea species known only from the small type specimen, is considered a possible synonym of *B.*

 Accepted by M. R. de Carvalho: 12 Jan. 2012; published: 5 Mar. 2012

hispidus (Compagno, 1984, Compagno *et al.*, 2005), but since the holotype is apparently lost, formal assessment to clarify its identity and relationship to other *Bythaelurus* species is currently not possible. In summary, *Bythaelurus* is now treated as a valid genus (Compagno *et al.*, 2005; and by Last & Stevens, 2008 in their description of *Bythaelurus incanus*), and we follow that accepted practice in this paper.

Material and methods

Measurements are straight-line (point-to-point) and made with dial calipers and recorded to the nearest 0.1 mm or with a meter ruler and measured to the nearest 0.5 mm. Terminology for external structures, vertebrae and dentition follows Compagno (1988). For vertebrae, an additional abbreviation "PC" is introduced for precaudal (monospondylous + diplospondylous precaudal) vertebral counts. The abbreviations and methods of measuring follow the FAO system of Compagno (1984) except that the measurement MOL (mouth length) was incorrectly shown in the diagram (Compagno, 1984:12) as extending from the lower symphysis to the mouth corners; it should be from the *upper* symphysis to the mouth corners. Also, following general usage in ichthyology, TL is used for total length and PCL is used for precaudal length (instead of TOT and PRC). Other abbreviations are listed in Table 1. Institutional abbreviations are as listed at http://asih.org/codons.pdf. Type specimens of the new species are deposited in: the California Academy of Sciences (CAS), San Francisco; the Muséum National d'Histoire Naturelle, Paris; the National Museum of Natural History (USNM), Washington D. C.; the South African Museum (SAM), Cape Town; and the Scripps Institution of Oceanography (SIO), San Diego. Galápagos island names follow those of Woram (1989).

Results

***Bythaelurus giddingsi* sp. nov.**
(Figures 1–4, Plates 1–2, Tables 1–2)

Proposed common name. Galápagos Catshark.

Bythaelurus sp.: Compagno (2005b: 20), McCosker & Rosenblatt (2010: 172, 187), Ruiz *et al.*, (2011: 12).
Bythaelurus sp. B: Compagno *et al.* (2005: 215, pl. 35), Kyne & Simpendorfer (2007: 53), Hearn *et al.* (2009: 51).

Material examined. All specimens are from the Galápagos Islands, collected aboard the submersible *Johnson Sea-Link* during 1995 and 1998.

Holotype. CAS 210091, 402 mm TL, female, Darwin Island, 01º42.0' N, 92º00.0' W, (station number JSL 3103, field number JM 145), 428 m depth, collected by J.E. McCosker on 18 July 1998.

Paratypes. MNHN 2010-0004 (originally CAS 210092), 324 mm TL, immature male, JM 146; SIO 99-99, 217 mm TL, immature male, JM 147; and CAS 210093, 300 mm TL (partially dissected), immature female, JM 148; Darwin Island, all collected with the holotype. CAS 86559, 261 mm, immature male, Darwin Island, 01º42.05' N, 92º00.02' W (JSL 3967), 511 m depth, collected by J.E. McCosker on 21 Nov. 1995. USNM 364283, 301 mm TL, immature female, Marchena Island, N. shore, 00º24.0' N, 90º26.5' W (JSL 3106, JM 175 & CB 98-49), 562 m depth, collected by C.C. Baldwin on 19 July 1998. SAM-35042, 453 mm TL, male, Marchena Island, N. shore, 00º24.0' N, 90º26.5' W (JSL 3109, JM 199), 454 m depth, collected by J.E. McCosker on 21 July 1998.

Diagnosis. A moderate-sized species of *Bythaelurus* with the following characteristics: snout bluntly rounded; preoral length 4.7–6.8% TL; head short, its length about equal to pectoral-pelvic space, 21–24% TL; precaudal length 73–80% TL; dorsal and anal fins subequal; length of anal-fin base about equal to length of interdorsal space; precaudal vertebrae 81–85 (mean = 82.6); color chocolate brown dorsally, paler on ventral surface from snout to anus; body, flanks, caudal and median fins overlain with pale spots about equal in size to eye, becoming smaller below lateral midline, and showing a bilaterally asymmetrical pattern.

Description. Measurements are in millimeters, parenthetically followed by their proportions as percentages of total length and precaudal length, respectively. Proportions and counts of the holotype and paratypes are listed in Tables 1–2.

TABLE 1. *Bythaelurus giddingsi* **sp. nov.** Proportional dimensions as thousandths of total length of holotype and six paratypes. 1 = CAS 210091, the holotype; 2 = MNHN 2010-0004; 3 = SIO 99-99; 4 = CAS 210093; 5= USNM 364283; 6 = SAM-35042; 7 = CAS 86559. Abbreviations for measurements are: ACS = anal-caudal space; ANA = anal anterior margin; ANB = anal base; ANF = anterior nasal-flap length; ANH = anal height; ANI = anal inner margin; ANL = anal length; ANP = anal posterior margin; CDM = dorsal caudal margin; CLB = clasper base width; CLI = clasper inner length; CLO = clasper outer length; CPH = caudal-peduncle height; CPL+U = combined lower and upper postventral caudal margin; CPV = preventral caudal margin; CPW = caudal-peduncle width; CST = subterminal caudal margin; CTL = terminal-caudal lobe; CTR = terminal-caudal margin; D1A = first dorsal anterior margin; D1B = first-dorsal base; D1H = first dorsal height; D1I = first dorsal inner margin; D1L = first dorsal length; D1P = first dorsal posterior margin; D2A = second dorsal anterior margin; D2B = second-dorsal base; D2H = second-dorsal height; D2I = second dorsal inner margin; D2L = second-dorsal length; D2P = second dorsal posterior margin; DAI = second dorsal-anal insertion; DAO = second dorsal-anal origin; DC = caudal centra; DCS = dorsocaudal space; DIS = interdorsal space; DP = diplospondylous precaudal centra; ESL = eye-spiracle length; EYH = eye height; EYL = eye length; GIR = girth; GS1 = first gill-opening height; HDH = head height; HDL = head length; HDW = head width; INO = interorbital width; INW = internarial width; LLA = lower labial-furrow length; MP = monospondylous precaudal centra; MOL = mouth length; MOW = mouth width; NOW = nostril width; P1A = pectoral anterior margin; P1B = pectoral base; P1H = pectoral height; P1I = pectoral inner margin; P1L = pectoral length; P1P = pectoral posterior margin; P2A = pelvic anterior margin; P2B = pelvic base; P2H = pelvic height; P2I = pelvic inner margin; P2L = pelvic length; P2P = pelvic posterior margin; PAL = preanal length; PAS = preanal space; PC = precaudal vertebrae; PCL = precaudal length; PD1 = pre-first dorsal length; PD2 = pre-second dorsal length; PGI = pregill (prebranchial) length; POB = preorbital length; POR = preoral length; PP1 = prepectoral length; PP2 = prepelvic length; PPS = pectoral-pelvic space; PRN = prenarial length; PSP = prespiracle length; SPL = spiracle length; SVL = snout-vent length; TL = total length; TRH = trunk height; TRW = trunk width; and ULA = upper labial-furrow length.

	1	2	3	4	5	6	7	Mean	RANGE
Sex	F	M	M	F	F	M	M	--	--
WT gm	355	146	43	132	98	291	62	--	62–355
TL mm	402	324	217	300	301	453	261	--	217–453
PRC	803	756	774	770	754	797	727	769	727–803
PRN	46	42	37	40	30	33	38	38	30–46
POR	53	52	58	47	53	57	68	55	47–68
POB	60	49	60	67	48	38	65	55	38–67
PSP	119	131	124	120	113	86	123	117	86–131
PGI	174	168	170	177	166	152	172	168	152–177
HDL	240	227	221	227	232	210	241	228	210–241
PP1	224	233	214	227	213	200	251	223	200–251
PP2	473	417	401	437	442	463	406	434	401–473
SVL	483	485	465	467	458	514	441	473	441–514
PAL	595	583	548	550	575	589	559	571	550–595
PD1	465	472	433	440	468	466	418	452	418–472
PD2	644	627	594	617	618	642	602	623	594–644
IDS	107	102	106	113	111	117	125	112	102–125
DCS	61	77	55	53	63	77	50	62	50–77
PPS	211	179	147	170	166	203	180	179	147–211
PAS	58	83	78	77	90	91	90	81	58–91
ACS	80	96	115	80	83	82	68	86	68–115
EYL	50	49	48	57	51	88	56	57	48–88
EYH	17	19	23	20	25	20	21	21	17–25
INO	86	74	92	92	85	75	96	86	75–96
NOW	30	21	35	40	38	45	34	35	21–45
INW	25	21	18	22	23	20	25	22	18–25
ANF	19	12	18	27	18	20	25	20	12–27
SPL	10	6	13	9	8	17	10	10	6–17
ESL	8	10	12	10	12	10	13	11	8–13
MOL	54	45	41	50	53	42	49	48	41–54
MOW	114	144	106	113	106	113	97	113	97–144
ULA	9	9	7	8	8	7	13	9	7–13
LLA	17	22	18	17	15	20	21	19	15–22
GS1	30	27	23	28	25	20	21	25	20–30

continued next page

TABLE 1. (continued)

	1	2	3	4	5	6	7	Mean	Range
GS2	27	27	21	28	25	18	19	24	18–28
GS3	27	27	21	28	25	18	19	24	18–28
GS4	27	27	21	28	25	18	19	24	18–28
GS5	25	25	16	22	18	13	15	19	13–25
HDH	102	96	111	122	80	68	86	95	68–122
HDW	174	148	147	163	133	132	136	148	132–174
TRH	127	120	111	137	93	91	94	110	91–137
TRW	164	139	120	170	133	130	150	144	120–170
CPH	35	37	37	42	38	33	39	37	33–42
CPW	20	15	16	22	23	18	23	20	15–23
GIR	460	417	369	467	365	375	322	396	322–467
P1L	87	111	106	103	81	115	80	98	80–115
P1A	124	139	134	150	130	121	130	133	121–150
P1B	62	62	60	70	80	60	61	65	60–80
P1H	122	136	129	147	120	110	121	126	110–147
P1I	76	93	83	73	88	75	71	80	71–93
P1P	112	111	92	120	90	86	103	102	86–120
P2L	100	111	104	110	110	95	109	106	95–111
P2A	66	65	55	67	76	68	67	66	55–76
P2B	72	66	60	67	76	53	41	62	41–76
P2H	45	56	51	63	50	60	54	54	45–63
P2I	49	42	41	53	45	53	43	47	41–53
P2P	71	65	69	80	90	60	63	71	60–90
CLO	––	39	25	--	--	66	21	--	--
CLI	--	59	39	--	--	97	44	--	--
CLB	--	13	8	--	--	22	11	--	--
D1L	104	91	92	102	103	101	103	99	91–104
D1A	93	90	97	130	106	88	111	102	88–130
D1B	70	54	60	78	68	54	75	66	54–78
D1H	67	74	65	87	71	66	61	70	61–87
D1I	25	40	32	31	33	38	33	33	25–40
D1P	60	59	44	62	43	48	46	52	43–62
D2L	103	111	120	117	106	93	119	110	93–120
D2A	102	105	124	130	113	84	123	112	84–130
D2B	72	83	85	90	83	84	85	83	72–90
D2H	65	65	74	67	50	55	67	63	50–74
D2I	25	32	44	43	30	31	33	34	25–44
D2P	52	46	46	50	43	50	52	48	43–52
ANL	106	102	115	143	123	117	111	117	102–143
ANA	77	77	85	93	100	86	90	87	77–100
ANB	80	79	83	98	105	100	88	90	79–105
ANH	52	52	44	53	53	51	54	51	44–54
ANI	21	26	23	33	20	24	22	24	20–33
ANP	77	68	55	80	58	51	55	63	51–80
CDM	231	241	230	230	210	205	245	227	205–245
CPV	70	102	78	117	110	88	73	91	70–117
CPL+U	117	108	124	120	115	110	111	115	110–124
CST	46	51	78	53	53	35	54	53	35–78
CTR	57	46	51	60	50	46	61	53	46–61
CTL	65	68	76	73	61	55	73	67	55–76
DAO	55	34	37	53	56	51	48	48	34–56
DAI	31	43	28	48	32	31	40	36	31–48

TABLE 2. Vertebral counts for holotype and six paratypes of *Bythaelurus giddingsi*. 1 = CAS 210091; 2 = MNHN 2010-0004; 3 = SIO 99-99; 4 = CAS 210093; 5= USNM 364283; 6 = SAM-35042; 7 = CAS 86559.

	TL	MP	DP	DC	PC	DP/MP
1	402	41	41	~42	82	1
2	324	41	41	~41	82	1
3	217	41	44	~40	85	0.93
4	300	40	43	~41	83	0.93
5	301	42	40	~40	82	1.05
6	453	39	44	~51	83	0.89
7	261	41	40	~40	81	1.02
Mean	--	40.7	41.9	~42	82.6	0.97
Range	--	39–42	40–43	~40–~51	81–85	0.89–1.05

FIGURE 1. Underwater photograph of a living *Bythaelurus giddingsi* **sp. nov.** taken from the *Johnson Sea-Link* submersible at a seamount SE of San Cristobal Island, Galápagos, at 461 m depth on 5 November 1995 (the shark was not collected). The cynoglossid above the shark is *Symphurus diabolicus*.

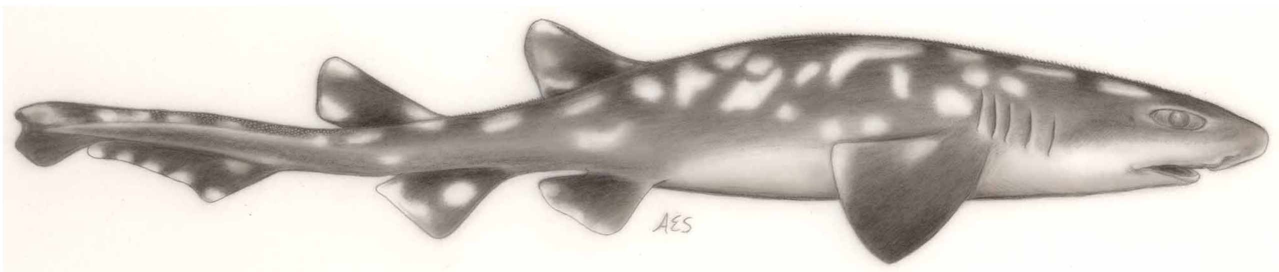

FIGURE 2. Holotype of *Bythaelurus giddingsi* **sp. nov.**, CAS 210091, 402 mm TL. Illustration by Alison E. Schroeer.

Total length 402 (100, 124); precaudal length 323 (80.3, 100). Tip of snout to: upper symphysis 41 (10.2, 12.7); nostrils 18.3 (4.6, 5.7); orbits 24 (6.0, 7.4); spiracles 48 (11.9, 14.9); 1st gill openings 70 (17.4, 21.7); 2nd gill openings 82 (20.3, 25.4); 3rd gill openings 89 (22.1, 27.6); 4th gill openings 92 (22.9, 28.5); 5th gill openings (= head length) 96.5 (24.0, 29.9); pectoral origins 90 (22.4, 27.9); pelvic origins 190 (47.3, 58.9); 1st dorsal origin 187 (46.5, 57.9); 2nd dorsal origin 259 (64.4, 80.2); anal origin 239 (59.5, 74.0); vent 194 (48.3, 60.1). Distance between: vent and caudal-fin tip 208 (51.7, 64.4); 1st and 2nd dorsal origins 72 (17.9, 22.3); 1st and 2nd dorsal bases 43 (10.7, 13.3); 2nd dorsal and upper caudal origins 53.5 (13.3, 16.7); 2nd dorsal base and upper caudal origin 24.5 (60.9, 75.9); pectoral and pelvic origins 100 (24.9, 31.0); pelvic and anal bases 23.5 (58.6, 72.8); anal and lower caudal origins 70 (17.4, 21.7); anal base and lower caudal origin 32 (80.0, 99.1). Eyes (palpebral apertures or fleshy orbits): length 20 (5.0, 6.2); height 7 (1.7, 2.2); width across anterior corners (interorbital) 34 (8.5, 10.5); eyeball diameter 8.5 (2.1, 2.6). Nostril width 12 (3.0, 3.7); internarial space 10 (2.5, 3.1). Spiracles: diameter 4 (1.0, 1.2); space between spiracles and eyes 3.3 (0.8, 1.0). Mouth (jaws in retracted position): length 21.5 (5.4, 6.6); width 46 (11.4, 14.2); width across outer edges of jaws 52 (12.9, 16.1). Gill-opening heights: 1st 12 (3.0, 3.7); 2nd 11(2.7, 3.4); 3rd 11 (2.7, 3.4); 4th 11 (2.7, 3.4); 5th 10 (2.5, 3.1). Head height: at spiracles 35 (8.7, 10.8); at 1st gill openings 43 (10.7, 13.3); at 5th gill openings 53 (13.2, 16.4). Trunk height: at 1st dorsal origin 51 (12.7, 15.8); at pelvic origins 41.5 (10.3, 12.8); at pelvic insertions 24 (6.0, 7.4). Girth: at 1st dorsal origin 125 (31.1, 38.7); at 2nd dorsal origin 57 (14.2, 17.6). Caudal peduncle height: at 2nd dorsal insertion 17 (4.2, 5.3); at upper caudal origin 13 (3.2, 4.0). Caudal peduncle width: at 2nd dorsal insertion 10.5 (2.6, 3.3); at upper caudal origin 7 (1.7, 2.2). Pectoral fin (right side - left is damaged), length of: anterior margin 50 (12.4, 15.5); posterior margin 45 (11.2, 13.9); origin to free rear tip 35 (8.5, 10.8); inner margin 30.5 (7.6, 9.4). Pelvic fins, length of: anterior margin 26.5 (6.6, 8.3); posterior margin 28.5 (7.1, 8.8); base 29 (7.2, 9.0); origin to free rear tip 40 (10.0, 12.4); inner margin 19.5 (4.9, 6.0); height 18 (4.5, 5.6). 1st dorsal fin, length of: anterior margin 37.5 (9.3, 11.6); posterior margin 24 (6.0, 7.4); base 28 (7.0, 8.7); inner margin 10 (2.5, 3.1); height 27 (6.7, 8.4). 2nd dorsal fin, length of: anterior margin 41 (10.2, 12.7); posterior margin 24 (6.0, 7.4); base 29 (7.2, 9.0); inner margin 10 (2.5, 3.1); height 26 (6.5, 8.0). Anal fin, length of: anterior margin 31 (7.7, 9.6); posterior margin 31 (7.7, 9.6); base 32 (8.8, 9.0); inner margin 8.5 (2.1, 2.6); height 21 (5.2, 6.5). Caudal fin, length of: dorsal margin 93 (23.1, 28.8); preventral margin 28 (7.0, 8.7); upper and lower postventral margins (combined) 47 (11.7, 14.6); subterminal margin 18.5 (4.6, 5.7); terminal margin 23 (5.7, 7.1); terminal lobe or sector 26 (6.5, 8.0); width of dorsal lobe at postventral notch 8 (2.0, 2.5); width of ventral lobe at postventral notch 2.5 (0.6, 0.8). Vertebral counts are given in Table 2.

Snout bluntly rounded, without a pointed knoblike tip (Figure 2, Plate 1). Head short, its length about equal to pectoral-pelvic space. Head depressed, roughly trapezoidal in cross-section. Outline of head in lateral view convex dorsally. Preoral snout short, nearly 1/2 mouth width, broadly rounded in dorsolateral view, minimally indented anterior to nostrils.

External eye openings with prominent anterior and posterior eye notches; eyes moderate and spindle-shaped; eye length 4.0–5.5 in head length and 3.0–4.8 times eye height. Eyes dorsolaterally on head, slightly above lateral midline. Subocular ledge broad and strong. Nictitating lower eyelids rudimentary, with shallow subocular pouches.

Spiracles minute, length 3.8–7.6 in eye length, 0.2–0.3 eye lengths behind and below the posterior eye notch. First four gill openings longer than the fifth. Upper edge of each gill opening below eye and spiracle. Gill openings nearly straight, gill filaments not visible from outside. A few minute gill-raker papillae present on gill arches.

Nostrils with broad, angular nasal flaps with rounded tips and moderate mesonarial flaps lateral on anterior nasal flaps, moderate excurrent apertures, no posterior nasal flaps. Nostrils nearly reaching level of mouth. Mouth broadly angular, short, its width 1.6–2.5 in head length. Mouth length 2.0–3.2 in mouth width. Lower symphysis nearly reaching upper symphysis. Maxillary teeth visible in ventral view (refer to Plate 1 for above characters). Tongue moderate, flat and rounded, filling most of floor of mouth. Many small buccal papillae on tongue and palate.

Teeth in 20–23/23–26 rows; 3–5/4–6 series functional, with more series functional in larger specimens and in posterior tooth rows than anterolaterals. Posterolateral teeth not arranged in diagonal files. No toothless spaces at symphysis. Teeth not strongly differentiated within jaws, but tooth-row groups along jaws demonstrating weakly defined monognathic heterodonty including symphyseals (S), anterior (A), anterolaterals (AL), and posteriors (P) in both jaws. No apparent difference in dentition between genders.

Anterolateral teeth (Figure 3) consist of single principal cusp with two pairs of lateral cusplets. Labial face of crown foot moderately concave, lingual face moderately convex. Principal cusp usually erect or showing slight distal inclination; this cusp mildly constricted at base at main crown, expanding slightly apically, tapering to an acute apex. Labial and lingual faces of cusp and cusplets mildly convex with short apicobasal ridges extending from crown foot to about 10% or less of height of principal cusp and cusplets. Primary cusplets, those proximal to principal cusp, erect or curving slightly toward central cusp, primary cusplets approximately 50% of height of central cusp; secondary cusplets, those distal to principal cusp, approximately 10–20% of height of primary cusp. A thin, unserrated cutting edge present on medial and distal edges of primary cusp and lateral cusplets, beginning at crown foot and terminating near crown apices. In posterior teeth, relative height of principal cusp reduced, cusp becoming comparatively wider, and relative height of cusplets increasing but never exceeding height of principal cusp. Symphyseal teeth with relatively narrow and usually containing only one pair of lateral cusplets. Lower teeth similar overall to anterolateral teeth except primary cusplets 60–90% length of principal cusp in anterolateral teeth.

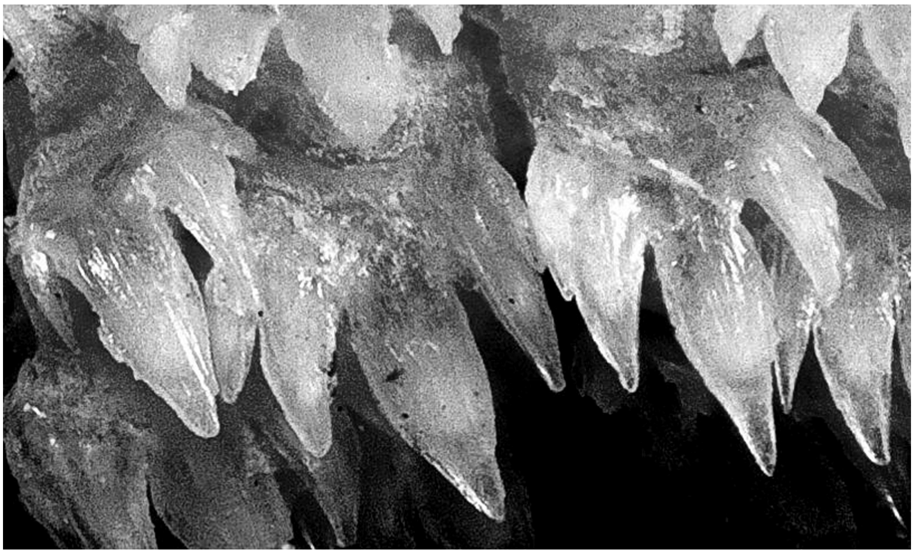

FIGURE 3. Photograph of teeth from upper left jaw of a paratype of *Bythaelurus giddingsi* **sp. nov.**, CAS 210093, showing an anterior tooth (left) and two larger anterolateral teeth (center and right).

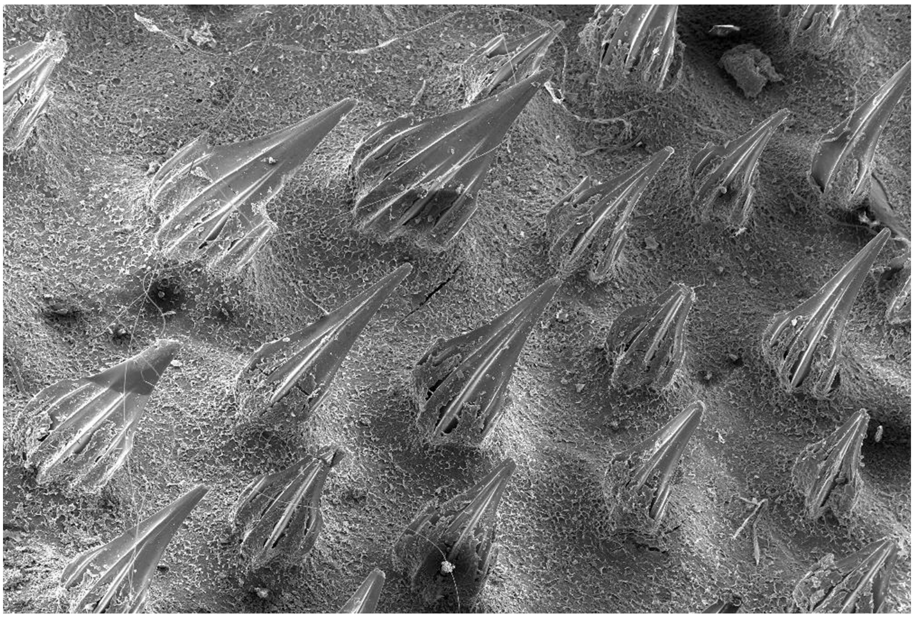

FIGURE 4. SEM of dermal denticles from a paratype of *Bythaelurus giddingsi* **sp. nov.**, CAS 210093 (300 mm TL); this skin section was removed from the upper left side of the body between the lateral line and dorsum anterior to the first dorsal fin, and shows the longer dorsal dermal denticles seen in smaller specimens. Compare this image to that of the larger 402 mm TL holotype (Plate 2).

Body robust in head and trunk region, nearly circular in cross section at mid-trunk, laterally compressed and tapering posterior to anus. No predorsal, interdorsal, or postdorsal ridges on midline of back; no postanal ridge between anal-fin base and lower caudal-fin origin. Lateral ridges absent from body. Caudal peduncle moderately elongate, laterally compressed, without lateral keels. Caudal-peduncle height 1.7–2.4 its width at posterior insertion of second dorsal fin, 1.3–2.3 in dorsocaudal space.

Dermal denticles, based on an examination of the holotype, vary widely in morphology depending on location on body (Plate 2). Dorsal dermal denticles, from dorsal surface of head and on trunk above lateral line, embedded in skin, spaced apart from (and not overlapping with) one another; these denticles blunt and single-cusped, widest at anterior base, often with two anterolateral lobes, and with 4–8 short, blunt longitudinal keels at base, often with keels extending posteriorly along most of length of denticles and becoming weaker near posterior apex. Lateral sides of the denticles usually weakly concave or occasionally straight; posterior apex acutely pointed, often rising well above skin giving a bristly appearance to dorsal surface of the head and body. Denticles longer than wide, those on dorsal trunk 2–3 times larger, more elongated, and with a more acute posterior apex than those on head. Dorsal dermal denticles, the only pigmented denticles on body, with pigment embedded in their anterior bases. Dermal denticles on lateral flanks colorless and semi-transparent, widely convex centrally and abruptly tapering to a thin, acute posterior apex; denticles longer than wide, with widest point at middle, usually smooth or showing a very weak central keel in middle, that keel absent at anterior base and posterior apex. Denticles are closely spaced and usually not overlapping, but sometimes barely so. Ventral dermal denticles colorless and semi-transparent, very thin without longitudinal keels; denticles wider than long, widest at base, quickly tapering to a blunt posterior apex; some denticles with a very short groove at medial base. Ventral dermal denticles closely-packed, usually with lateral edges barely overlapping neighboring denticles.

Dorsal edge of caudal fin, from caudal pit to posterior fin edge and from lateral line to the dorsal edge, with clumped comb-like dermal denticles that together exhibit the file-like "caudal crest" characteristic seen in several other *Bythaelurus* and *Parmaturus* catshark species (Springer 1979). These denticles transparent, elevated well above skin, and usually overlap 10–50% atop neighboring denticles. Each denticle consists of a single sharply-pointed primary cusp with two (rarely one) large lateral secondary cusplets only nominally shorter than primary cusp; each cusp with a single longitudinal keel extending from anterior base to posterior apex. Denticles somewhat longer than wide, with widely convex lateral margins, the widest point at middle of denticle where lateral cusplets diverge from main body. Denticles on caudal fin below lateral line transparent, lanceolate and basally widest, tapering posteriorly, with straight or weakly convex lateral edges and a bluntly pointed posterior apex. These denticles flat and thin, without lateral cusplets and longitudinal keels, but exhibiting a short central grove at anterior base. Denticles on caudal fin below lateral line slightly elevated above skin and are closely spaced, but not touching or overlapping. In comparing denticle morphology and arrangement between holotype and paratypes, denticles vary little between largest and smallest specimens and between males and females. Relative size of dorsal denticles on head and body of smaller specimens longer, giving them more of a bristly appearance (Plate 1, Figure 4), an ontogenetic trait noted by Shouthall & Sims (2003) in the catshark *Scyliorhinus canicula*.

Pectoral fins triangular, broad and rounded, not falcate, with broadly convex anterior margins, narrowly rounded apices, broadly rounded posterior margins, and free rear tips, inner margins and narrow bases. Pectoral-fin area subequal to area of first dorsal fin. Origins of pectoral fins beneath interspace between third and fourth gill openings. Apex of pectoral fin slightly anterior to its free rear tip when fin is elevated and appressed to body.

Pelvic fins broadly triangular. Pelvic anterior margins 1.2–2.4 in pectoral fin anterior margins. Pelvic area subequal to anal-fin area. Pelvic-fin anterior margins slightly curved, apices narrowly rounded, posterior margins nearly straight, free rear tips narrowly rounded, inner margins straight and not fused together over claspers of juvenile males.

First dorsal fin high, apically narrow and not falcate, with nearly straight anterior margin, narrowly rounded apex, slightly convex posterior margin, angular free rear tip, and straight inner margin. First dorsal-fin origin over middle of pelvic-fin base, insertion of fin just above a line behind insertion of pelvic fin. First dorsal-fin base 1.5–2.5 in interdorsal space, first dorsal-fin height 0.7–1.2 in first dorsal-fin base.

Second dorsal fin high, apically narrow and not falcate, subequal to first dorsal-fin in area and about subequal to first dorsal-fin height and base. Second dorsal fin with nearly straight anterior margin, narrowly rounded apex, slightly convex posterior margin, angular free rear tip, and straight inner margin. Second dorsal-fin origin in a line above anal-fin midbase, its insertion above anal-fin free rear tip, and free rear tip in front of upper caudal-fin origin by the length of its base. Second dorsal-fin base 0.6–0.9 in dorsocaudal space, second dorsal-fin height 1.1–1.5 in second dorsal-fin base, second dorsal fin inner margin 1.5–2.6 in second dorsal-fin height and 1.9–2.9 in second dorsal-fin base.

Anal fin low, apically broad, not falcate, about equal in size, height and base to that of second dorsal fin. Anterior margin slightly concave, apex broadly rounded, free rear tip bluntly pointed, and inner margin nearly straight. Anal-fin base without preanal ridges, anal-fin origin about 0.7–1.1 times anal-fin base length behind pelvic-fin insertions. Anal-fin posterior margin slanting posterodorsally, anal-fin insertion posterior to apex. Anal-fin base 0.8–1.4 in anal-caudal space, anal-fin height 1.5–2.0 in anal-fin base.

PLATE 1. Dorsal and ventral views of three specimens of *Bythaelurus giddingsi* **sp. nov.** showing relative variation in the shape of the nasal flaps, the mouth, upper dentition, and dermal denticles on dorsum of head. Left: Holotype CAS 210091, adult female, 402 mm TL. Center: Paratype USNM 364283, immature female, 301 mm TL. Right: Paratype CAS 86559, immature male, 261 mm TL.

Caudal fin narrow and asymmetrical, with large terminal lobe but ventral lobe not developed. Caudal fin short, dorsal margin 0.2–0.3 in precaudal length. Preventral caudal-fin margin 1.9–3.4 in dorsal caudal-fin margin, terminal lobe 3.0–3.7 in dorsal caudal-fin margin. Dorsal caudal-fin margin without lateral undulations but proximally and distally convex with a shallow concavity between the convexities. Preventral caudal-fin margin basally concave and apically straight, tip of ventral caudal-fin lobe bluntly rounded. Postventral margin not differentiated into upper and lower parts, its margin straight to concave. Subterminal notch a narrow slot, subterminal margin straight to concave and terminal margin straight and sometimes notched. Lobe formed by these margins slightly angular, tip of tail broadly rounded.

Vertebral counts and statistics are given in Table 2. The precise number of caudal centra difficult to identify due to their small size and abundance of large caudal denticles; therefore counts of both the number of caudal centra and total number of centra are approximate. Transition between MP and DP centra about 4–6 centra behind front of pelvic girdle. Last few MP centra before MP-DP transition hardly enlarged, not forming a "stutter zone" of alternating long and short centra. Dimensions (in mm) of selected centra of holotype: length of penultimate MP 4.02; width of penultimate MP 3.02; midcentral width of penultimate centrum 0.94; length of first PD 2.75; width of first PD 3.08; midcentral width of first PD 1.14. "A ratio" (Springer & Garrick, 1964) of holotype 146. "B ratio" (Springer & Garrick, 1964) of holotype 133. Ratio of DP/MP of holotype 1.0.

Color. In ethanol, chocolate brown dorsally, becoming pale brown on ventral surface from snout to anus. Body and flanks overlain with pale spots the largest of which about equal in size to eye, becoming smaller below lateral midline. A pale spot at anterior base of each dorsal fin. Pale spots extending onto caudal and median fins. Caudal region and all fins chocolate brown. The posterior margin of paired and dorsal fins pale. Tongue pale, anterior region of palate darker. Coloration in life can be seen in Figure 1.

Size. Relative to other species of *Bythaelurus*, adult *B. giddingsi* are moderate in size. Our capture technique, using a suction device, was biased toward smaller individuals, and from the submersible we observed but did not capture specimens that seemed to be slightly larger. Two of our specimens (the 40.2 cm female and the 45.3 cm male) appear to be approaching sexual maturity. Our largest specimen (45.3 cm) is about midway in length between the small species of *Bythaelurus*—*B. hispidus* (to 29 cm), *B. dawsoni* (to 35 cm, a subadult male), and *B. lutarius* (to 39 cm) — and the large species, *B. canescens* (to 70 cm), and *B. immaculatus* (to 70 cm) (comparative lengths from Compagno, 1984).

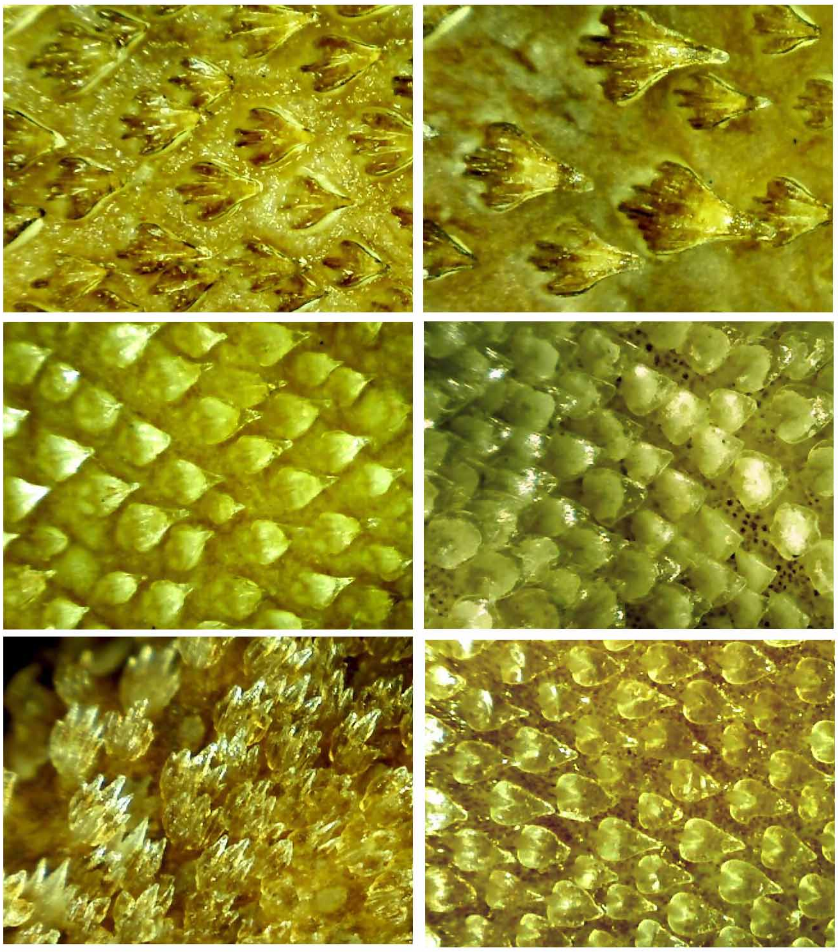

PLATE 2. Photos of dermal denticles from selected regions of the body of the Holotype of *Bythaelurus giddingsi* **sp. nov.**, CAS 210091, each at 100x magnification. Upper left: dorsal surface of head above eye; upper right: dorsum above gills between lateral line and dorsal midline; middle left: lateral flank above pectoral fin; middle right: abdomen between pectoral and pelvic fins; lower left: dorsal edge of caudal fin; lower right: lateral side of caudal fin.

Etymology. We are pleased to name this species in honor of Al Giddings, underwater filmmaker, naturalist, and friend.

Distribution. All known specimens are from the Galápagos Islands, and were observed and collected from Darwin and Marchena islands between 428–562 m depth, living on the bottom above sand or sand and mud substrates in the vicinity of lava boulders, either over flat bottoms or along slopes to 45º. Specimens were observed but not collected at Cabo Hammond, Fernandina Island, at 496 m, and were photographed at a seamount SE of San Cristobal Island at 461 m (Figure 1). Individuals were observed and photographed using an ROV off North Seymour Island during December, 2005, by Alex Hearn of the Estacion Cientifica Charles Darwin, Galapagos (*in litt*.). He reported "seeing a number of individuals" living at 500 m depth and photographed one "around 30 cm total length."

Remarks. *Bythaelurus giddingsi* is easily distinguished from its eight congeners on the basis of its coloration. All others are either pale, dusky, or possess a line of pale spots rather than the irregularly distributed spots of the new species. One interesting aspect of the markings is that the size, arrangement and distribution of the spots are unique to each specimen, and while this spotting pattern is unique to this species, the variable arrangement of spots does not show a consistent species-specific pattern. Moreover, the markings are not bilaterally symmetrical as in most sharks; an individual might have a spot on one side, and may have a smaller, larger, or differently-shaped spot on the other side, or lack it entirely.

There is no apparent difference in dentition between genders of *B. giddingsi*, however our specimens are limited to females and immature males. Sexually dimporphic heterodonty is present in sexually mature males of other species of scyliorhinids (Springer, 1966; Bass *et al*., 1975; Nakaya, 1975; Long, 1994).

It is notable that the clumped comb-like dermal denticles of the dorsal edge of caudal fin exhibit the file-like "caudal crest" characteristic seen in several other *Bythaelurus* and *Parmaturus* catshark species (Springer, 1979).

Bythaelurus giddingsi is a stouter species than the more elongate, uniformly drab *B. immaculatus* (Chu & Meng, 1982) and *B. incanus* Last & Stevens 2008. Its anal-fin base length (about subequal to the interdorsal space) further separates it from *B. canescens* (Günther, 1878), *B. hispidus* (Alcock, 1891), and *B. lutarius* (Springer & D'Aubrey, 1972), which have relatively short anal-fin bases (smaller than their interdorsal distances), and from *B. dawsoni* (Springer, 1971) which has a relatively longer anal-fin base. The poorly known *B. alcocki* (Garman, 1913) is said to have a small anal fin and black coloration.

The genus *Bythaelurus* is widely distributed in the Indian and Pacific oceans, however the distribution of most species of *Bythaelurus* is best characterized as disjunct (Compagno *et al*., 2005). *Bythaelurus dawsoni* is from southern New Zealand, *B. clevai* is from Madagascar, *B. lutarius* is from Mozambique and Somalia, *B. alcocki* is from the Arabian Sea, *B. hispidus* is from southernmost India, Sri Lanka, and the Andaman Islands, *B. immaculatus* is from Hainan Island, South China Sea, *B. incanus* is from northern Australia, *B. canescens* is from southwestern South America, and *B. giddingsi* is endemic to the Galápagos Islands. Future studies of the genetics, morphology, and biology of these species will allow a better knowledge of their phylogeny, and future explorations in remote deep waters will undoubtedly discover additional species.

Acknowledgments

We thank Eliecer Cruz, Arturo Izurieta Valery, Eduardo Amador, and Mario Piu of the Galápagos National Park for permission to perform research in the GNP; Alex Hearn of CDRS for sharing information and a photograph of a Galapagos specimen; Robert Bensted-Smith and the CDRS for general assistance in the Galápagos; Leonard Compagno for his help with an earlier draft of this manuscript; the staff of the Harbor Branch Oceanographic Institution and the crews of the R/V *Seward Johnson* and its submersible, the *Johnson Sea-Link*, and in particular its ace sub pilot Don Libertore; Alison E. Schroeer for preparing Figure 2; Christina Fidler and Lauren Scheinberg (CAS) for their assistance with shark teeth photographs; Al Giddings of Images Unlimited, David Clark, David Pawson, Julie Piraino, the Discovery Channel, IMAX, and the Smithsonian Institution Discovery Center Project for their support during the expeditions; and the David and Lucile Packard Foundation and the Griffith Family Foundation for financial assistance to JM in support of this and other Galápagos projects. We also thank the staffs of the following institutions for the assistance that they provided us: the California Academy of Sciences (CAS), San Francisco; the Muséum National d'Histoire Naturelle, Paris; the National Museum of Natural History (USNM), Washington D. C.; the Natural History Museum (BMNH), London; the South African Museum (SAM), Cape Town; and the Scripps Institution of Oceanography (SIO), San Diego.

References

Alcock, A.W. (1891) Class Pisces. *In* II—Natural history notes from H. M. Indian marine survey steamer 'Investigator,' Commander R. F. Hoskyn, R.N. commanding. — Series II., No. 1. On the results of deep-sea dredging during the season 1890–91. *Annals and Magazine Natural History,* (series 6), 16–34, 119–138.

Bass, A.J., D'Aubrey, J.D. & Kistnasamy, N. (1975) Sharks of the east coast of southern Africa. II. The families Scyliorhinidae and Pseudotriakidae. *Investigational Report of the Oceanographic Research Institute*, 37, 1–64.

Chu, Y.-T., C.-W. Meng, C.-W., Hu, A. & Li, S. (1982) Five new species of elasmobranchiate fishes from the deep waters of South China Sea. *Oceanologia et Limnologia Sinica*, 13, 301–311.

Compagno, L.J.V. (1984) *FAO Species Catalogue. Vol. 4, Sharks of the World. An annotated and illustrated catalogue of shark species known to date. FAO Fisheries Synopsis No. 125. vol. 4, pt. 2 (Carcharhinoformes)*. United Nations Development Programme/Food and Agriculture Organization of the United Nations, Rome, 251–655.

Compagno, L.J.V. (1988) *Sharks of the order Carcharhiniformes*. Princeton University Press, Princeton, New Jersey, 445 pp.

Compagno, L.J.V. (1999) Checklist of Living Elasmobranchs. *In* W.C. Hamlett (ed.) *Sharks, Skates, and Rays: The Biology of Elasmobranch Fishes*. The Johns Hopkins University Press, Baltimore, USA, 471–498.

Compagno, L.J.V. (2005a) Global Checklist of Living Chondrichthyan Fishes. *In* S.L. Fowler, R.D. Cavanagh, M. Camhi, G.H. Burgess, G.M. Cailliet, S.V. Fordham, C.A. Simpfendorfer & J.A. Musick (eds.) *Sharks, Rays and Chimaeras: The Status of the Chondrichthyan Fishes*. IUCN/SSC Shark Specialist Group, IUCN, Cambridge, UK, 401–423.

Compagno, L.J.V. (2005b) Checklist of Living Chondrichthyes. *In* W.C. Hamlett (ed.) *Reproductive Biology and Phylogeny of Chondrichthyes: Sharks, Batoids and Chimaeras. Reproductive Biology and Phylogeny, Vol. 3.* Science Publishers, Inc, Enfield, USA, 503–548.

Compagno, L.J.V., M. Dando, M. & Fowler, S. (2005) *Sharks of the World*. Princeton University Press, Princeton, USA, 368 pp.

Compagno, L.J.V, & Didier, D. (2002) Checklist of Living Chondrichthyes Cited in This Volume. *In* S.L. Fowler, T.M. Reed, & F.A. Dipper (eds.) *Elasmobranch Biodiveristy, Conservation and Management.* The IUCN Species Survival Commission Proceedings of the International Seminar and Workshop, Sabah, Malaysia, July 1997. Occasional Paper of the IUCN Species Survival Commission No. 25, 245–255.

Garman, S. (1913) *The Plagiostomia (sharks, skates, and rays).* Memoires of the Museum of Comparative Zoology of Harvard College, 515 pp.

Gill, T. (1862) Squalorum Generum Novorum Descriptiones Diagnosticae. *Annals of the Lyceum of Natural History of New York*, 7, 367–413.

Günther, A. (1878) Preliminary notices of deep-sea fishes collected during the voyage of H.M.S. 'Challenger.' *Annals and Magazine of Natural History* (series 5), 17–28, 179–187, 248–251.

Hearn, A., Klimley, A.P. & Ketchum, J. (2009) Vulnerability of top predators to climate change and adaptation options for their coastal and pelagic ecosystems: sharks case study. *In* J.R. Hoffman, A. Franseca, & C. Drews (eds.) *Cetaceans and Other Marine Biodiversity of the Eastern Tropical Pacific: Options for Adapting to Climate Change*. International Whaling Commission Full Document 61–18, Agenda Item 11.1.2, 50–54.

Kyne, P.M., & Simpfendorfer, C.A. (2007*) A collation and summarization of data on deepwater Chondrichthyans: biodiversity, life history, and fisheries. A report prepared by the IUCN SSC Shark Specialist Group for the Marine Conservation Biology Institute*, Gland, Switzerland, 137 pp.

Last, P.R., & Stevens, J.D. (2008) *Bythaelurus incanus* sp. nov., a new deepwater catshark (Carcharhiniformes: Scyliorhinidae) from northwestern Australia. *In* P.R. Last, W.T. White, & J.J. Pogonoski (eds.) *Descriptions of New Australian Chondrichthyans*. CSIRO Marine and Atmospheric Research Paper no. 022, Hobart, Australia, 123–128.

Long, D.J. (1994*) Historical Biogeography of Sharks from the Northeastern Pacific Ocean*. Ph.D. Diss., Department of Integrative Biology, University of California, Berkeley, 371 pp.

McCosker, J.E. (1997) A letter from the field: A half mile down. *Pacific Discovery*, 50, 42–45.

McCosker, J.E., Merlen, G., Long, D.J., Gilmore, R.G. & C. Villon (1997) Deepslope fishes collected during the 1995 eruption of Volcan Fernandina, Galápagos. *Noticias de Galápagos*, No. 58, 22–26

McCosker, J.E. & Rosenblatt, R.H. (2010) The fishes of the Galápagos Archipelago: an update. *Proceedings of the California Academy of Sciences*, Series 4, 61, Supplement II, No. 11, 167–195.

Nakaya, K. (1975) Taxonomy, comparative anatomy, and phylogeny of Japanese catsharks, Scyliorhinidae. *Memoirs of the Faculty of Fisheries, Hokkaido University*, 23, 1–94.

Ruiz, D., Chiriboga, A., & Banks, S. (2011) CDF Checklist of Galápagos Fish - FCD Lista de especies de Peces de Galápagos. *In*: F. Bungartz, H. Herrera, P. Jaramillo, N. Tirado, G. Jímenez-Uzcategui, D. Ruiz, A. Guézou, & F. Ziemmeck (eds.). *Charles Darwin Foundation Galapagos Species Checklist - Lista de Especies de Galápagos de la Fundación Charles Darwin*. Charles Darwin Foundation/Fundación Charles Darwin, Puerto Ayora, Galápagos, Ecuador.

Séret, B. (1987) *Halaelurus clevai*, sp. n., a new species of catshark (Scylliorhinidae) from off Madagascar, with remarks on the taxonomic status of the genera *Halaelurus* Gill & *Galeus* Rafinesque. *J.L.B. Smith Institute of Ichthyology Special Publication*, 44,1–27.

Southall, E.J. & Sims, D.W. (2003) Shark skin: a function in feeding. *Proceedings of the Royal Society of London, Supplemental Biology Letters*, 270, S47–S49.

Springer, S. (1966) A review of western Atlantic cat sharks, Sycliorhinidae, with descriptions of a new genus and five new species. *Fishery Bulletin*, 65,581–624.

Springer, S. (1971) A new cat shark (Scyliorhinidae) from New Zealand. *Records of the Dominion Museum (Wellington)*, 7, 235– 241.

Springer, S. (1979) A revision of the catsharks, family Scyliorhinidae. *NOAA Technical Report NMFS Circular* 422, 152 pp.

Springer, S. & D'Aubrey, J.D. (1972) Two new scyliorhinid sharks from the east coast of Africa with notes on related species. *South African Association for Marine Biological Research. Oceanographic Research Institute Investigational Report*, 29, 1–19.

Springer, V.G. & Garrick, J.A.F. (1964) A survey of vertebral numbers in sharks. *Proceedings of the United States National Museum*, 116,73–96.

Woram, J.M. (1989) Galápagos island names. *Noticias de Galápagos*, no. 48, 22–32.