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1 **A contribution to the anatomy of two rare cetacean species: the hourglass**  
2 **dolphin (*Lagenorhynchus cruciger*) and the spectacled porpoise**  
3 **(*Phocoena dioptrica*)**  
4

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## 49 **Ethical statement**

50 All sampling was undertaken under the research permits 39239-MAR, RNW/22/2003/182,  
51 and RNW/HO/2008/03 (Massey University), 39645-MAR and 48740-MAR (University of  
52 Otago) and 39400-MAR (Tūhura Otago Museum) issued by the Department of Conservation  
53 Te Papa Atawhai. All research was done with permission from local rūnanga and rūnaka  
54 (local indigenous tribal authorities) alongside Department of Conservation Te Papa Atawhai.  
55 As no live animals were sampled, we did not require animal ethics approval for this research.  
56 The datasets generated and/or analysed during the current study are available from the  
57 corresponding author on reasonable request.

## 58 **Data availability statement**

59 The data that support the findings of this study are available on request from the  
60 corresponding author. The data are not publicly available due to cultural and ethical  
61 restrictions.

## 62 **Conflict of interest disclosure**

63 The authors declare no potential conflict of interest.

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## 67 **Abstract**

68 The anatomical description of the hourglass dolphin (*Lagenorhynchus cruciger*) and the spectacled  
69 porpoise (*Phocoena dioptrica*) remains largely unexplored, due to limited specimen availability and  
70 preservation challenges. This study employed digital imaging techniques, conventional histology and  
71 computed tomography to provide visualisation of anatomical structures for a detailed analysis. We  
72 present a comprehensive analysis of the gross macroscopical and microscopical morphology of two  
73 hourglass dolphins and four spectacled porpoises. The hourglass dolphins were characterised by their  
74 distinctive black and white pigmentation and a hooked dorsal fin, while the spectacled porpoises were  
75 defined by their large dorsal fin, lack of a visible rostrum and unique eye markings. Morphometric  
76 measurements and skeletal characteristics aligned with the literature, while internal anatomy (organs  
77 and systems) were similar to other odontocetes. Although precise lung measurements were  
78 challenging, qualitative assessments indicated relatively large lungs for their body size, supporting the  
79 "short dive, big lung" hypothesis and suggesting that these species are not deep divers. The spectacled  
80 porpoise dorsal fin was uniquely large with a well-developed blood supply; this is hypothesised to act  
81 as a thermoregulatory window, helping to manage body heat. Overall, this study provides new data on  
82 the anatomy of the hourglass dolphin and spectacled porpoise, contributing insights that may  
83 influence future research on these rare species. The findings highlight the importance of anatomical  
84 studies in explaining evolutionary relationships within cetaceans and their ecological roles in the  
85 Southern Ocean ecosystems.

86

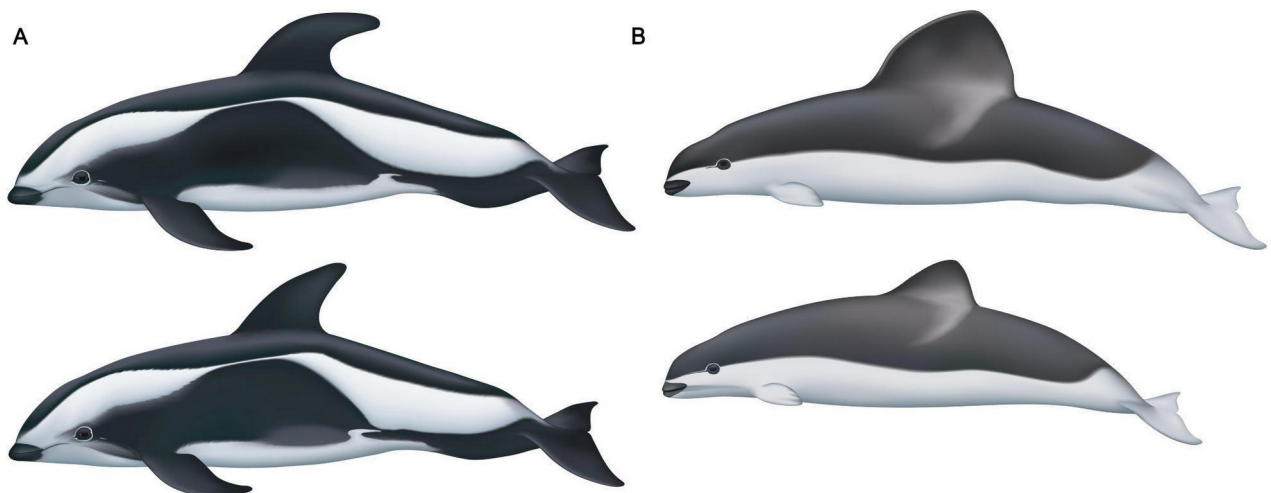
## 87 **Keywords**

88 Morphology; Computed-Tomography; Osteology; Histology; Polar.

## 89 Introduction

90 The hourglass dolphin (*Lagenorhynchus cruciger*, Quoy & Gaimard, 1824), and the spectacled  
91 porpoise (*Phocoena dioptrica*, Lahille, 1912) are two species of small (ca. 2 m) cetaceans that inhabit  
92 subantarctic and Antarctic waters (Fordyce et al., 1984; Brownell and Donahue, 1999; Hammond et  
93 al., 2008; Cipriano, 2018; Goodall and Brownell et al., 2018). While aspects of their external  
94 morphology have been reported (Cipriano, 2018; Goodall and Brownell et al., 2018; refer to Table 1),  
95 internal anatomy has seldom been considered, likely because of their southern, limited geographic  
96 range and correspondingly poor access to fresh, intact specimens. The hourglass dolphin belongs to  
97 the family *Delphinidae*, though its taxonomy is still under debate with a recent proposal to shift from  
98 *Lagenorhynchus* to *Sagimatus* genus (Vollmer et al., 2019; see Jefferson et al., 2015 for taxonomy  
99 and general description). Recent genomic analysis offers further insight to the hourglass dolphin and  
100 its placement within the *Delphininae* subfamily (McGrath et al., 2025). The most relevant external  
101 characteristics are the distinctive white and black pigmentation of the flanks and the markedly hooked  
102 dorsal fin (Figure 1A). The common name arises from the hourglass shaped white marking extending  
103 from the beak to the tail flukes (Jefferson et al., 2015; Cipriano, 2018).

104 The spectacled porpoise belongs to the family *Phocoenidae*, and also suffers taxonomic uncertainty as  
105 to whether it is best placed within genus *Phocoena* or elsewhere (Jefferson et al., 2015). The species  
106 is characterised by a very large dorsal fin with a convex posterior margin, this feature is pronounced  
107 in males (Figure 1B). The eye is set within a small oval of black, with a thin dorsal semicircle of  
108 white, hence the common name "spectacled" (Jefferson et al., 2015; Goodall and Brownell, 2018).



109

110 Figure 1: (A) Typical aspect of an adult male (top) and female (bottom) hourglass dolphin (*L.*  
111 *cruciger*) and (B) adult male (top) and female (bottom) spectacled porpoise (*P. dioptrica*).  
112 Illustrations kindly provided by Uko Gorter (<https://ukogorter.com/>).

113 While the literature describes the external morphology and skeleton of both species (Table 1),  
114 information on their visceral anatomy is scarce, possibly due to the limited number of specimens  
115 observed and to the decomposition status of the carcasses.

116 Our anatomical description of these little-known species yields new data that increase our  
117 understanding and may help in resolving their taxonomic status. Specifically, our study describes for  
118 the first time, the gross external morphology and the visceral macro- and micro-anatomy of six

119 specimens (2 hourglass dolphin, 4 spectacled porpoise) examined postmortem.

120 Table 1 - Selected data available on hourglass dolphin and spectacled porpoise specimens available in  
121 the published literature.

Parameters	Hourglass dolphin		Spectacled porpoise		Reference
	Value	n	Value	n	
Total length (cm)	♂ 162,6 - 187	6	♂ 109 - 224	8	Goodall et al., 1997; Brownell and Donahue, 1999; Gazitúa et al., 1999; Fernández et al., 2003; Brownell, 1999; Evans et al., 2001; Pinedo, 2002
	♀ 142 - 182,9	7	♀ 119 - 203,5	13	
			? 94 - 101	11	
Weight (kg)	♂ 93 - 100	3	mixed sex 1.6 (foetus) - 115	7	Goodall et al., 1997; Gazitúa et al., 1999; Fernández et al., 2003; Brownell, 1999; Evans et al., 2001; Pinedo, 2002
	♀ 73,5 - 88	2			
Condylbasal length (mm)	316 – 370	11	276 – 424	54	Goodall et al. 1997 Gazitúa et al., 1999 Cipriano, 2018 Perrin et al., 2000
Visible teeth (per side)	26 – 34 top 27 – 35 bottom	6	16 – 26 top 17 – 23 bottom		Perrin et al., 2000
Vertebral column	C= 7 Th= 13 – 14 L= 18 – 19 Ca= 27+	9	C= 7 Th= 14 L= 14 – 16 Ca= 32 – 33		Marchesi et al., 2016 Perrin et al., 2000
Ribs (per side)	12 – 13	9	13 – 14		Perrin et al., 2000
Phalangeal formula	I= 2 – 3 II= 8 – 11 III= 6 – 8 IV= 2 – 4 V= 0 – 2	6	I= 2 II= 7 III= 4 IV= 3 V= 4		Perrin et al., 2000
Intestine length	18 – 19.7 m	3			Cipriano, 2018
Number of reniculi	670 (left kidney)	1			Cipriano, 2018
Other particularities	Single vena cava, absence of hepatic sinus	1			Goodall, 1997; Brownell, 1999

122

## 123 **Materials and Methods**

124 Conventional anatomical methods were applied, including dissection, photography, conventional  
 125 histological staining, along with post-mortem computed tomography (PMCT). PMCT examination  
 126 enhanced three-dimensional visualisation of organs and systems prior to dissection, allowing for  
 127 volume calculations and providing comprehensive insights.

### 128 **Animal data**

129 This study examined six specimens (n = 2 hourglass dolphins; n = 4 spectacled porpoise). All  
 130 specimens originated from stranding events in New Zealand between 2010 and 2020 (Table 2). Each  
 131 specimen was weighed, when possible, and measured prior to PMCT scanning.

132

133 Table 2. Specimen and strandings data of examined hourglass dolphins and spectacled porpoise  
 134 examined in the study. Decomposition code according to the standards of Ijsseldijk et al., 2019.

Species	Animal ID	Age class	Sex	Stranding date	Location stranding	Dissection date	Decomposition Code
hourglass dolphin	KS10-28Lc	Adult	M	7 Sept 2010	Flea Bay (43°86' S, 173°0' E), Akaroa, NZ	10 Sept 2010	2-3
hourglass dolphin	KS20-20Lc	Subadult	M	5 Aug 2020	Orepuki Beach (46°16' S, 167°43' E), Te Waewae Bay, NZ	29 Sept 2020	1-2
spectacled porpoise	KS14-45Pd/ X2020.76	Adult	M	17 Sept 2014	Pipikaretu (45°80' S, 170°7' E), Otago Peninsula, NZ	19 Sept 2014	1
spectacled porpoise	KS14-37Pd/ X2020.77	Subadult	M	2 Oct 2014	Caroline Bay Beach (44°38' S, 171°24' E), Timaru, NZ	2 Oct 2014	1
spectacled porpoise	KS15-29Pd/ VT3347	Juvenile	F	9 Aug 2015	Bayleys Beach, (43°49' S, 172°36' E) Kaitorete Spit, Canterbury, NZ	19 Aug 2015	3
spectacled porpoise	KS20-07Pd	Adult	M	14 Jan 2020	Washdyke Lagoon, Canterbury, NZ	22 Jan 2020	2

135

### 136 **PMCT scan data**

137 PMCT scanning of the first hourglass dolphin (KS10-28Lc) was performed with a LightSpeed VCT  
 138 CT scanner (GE Healthcare, USA), using the exposure parameters: 120 kV, 100 mA, 0.63 mm slice  
 139 thickness, and sFOV of 45 cm. PMCT of the second hourglass (KS20-20Lc) was conducted using a  
 140 CT 5000 Ingenuity CT scanner (Philips, Netherlands), with exposure parameters: 120 kV, 20 mA,  
 141 0.90 mm slice thickness, and sFOV of 50 cm. Three of the spectacled porpoises underwent PMCT

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142 scanning: KS14-37Pd/X2020.77 and KS14-45Pd/X2020.76 were conducted using a LightSpeed Pro  
143 16 (GE Medical Systems); exposure parameters for KS14-45Pd/X2020.76 were 120 kV, 390 mA and  
144 1.25 mm slice thickness, while for KS14-37Pd/X2020.77 were: 120 kV, 270 mA and 1.25 mm slice  
145 thickness. Due to logistical difficulties, the dorsal fin of KS14-45Pd/X2020.76 was scanned separately  
146 in the LightSpeed Pro 16 with scan parameters of 120 kV, 270 mA and slice thickness of 1.25 mm,  
147 this allowed for specific imaging of the dorsal fin structure. PMCT scanning of KS20-07Pd was  
148 conducted using an Optima CT660 (GE Medical Systems), with exposure parameters: 120 kV, 480  
149 mA, and 0.63 mm slice thickness. Due to logistical difficulties the tail stock was removed and  
150 scanned separately in KS20-07Pd (exposure parameters remained the same), rendering it difficult to  
151 determine the precise number of lumbar vertebrae caudal to the dorsal fin. CT data from KS20-07Pd  
152 and KS20-20Lc cases was assessed using PMCT methodology (Kot et al., 2020; Granados-Zapata et  
153 al., 2022) and were used to guide the necropsy, thus improving findings of the conventional necropsy.  
154 Both scans were viewed using the TeraRecon iNtuition workstation (TeraRecon, San Mateo, CA,  
155 USA). Morphological and volumetric examinations were performed using Slicer 3D  
156 (<https://www.slicer.org/>).

## 157 **Dissection**

158 Dissections occurred at the Cetacean Pathology Unit, Massey University Auckland (KS10-28Lc,  
159 KS20-20Lc, KS20-07Pd), AgResearch Invermay Campus, Dunedin (KS14-37Pd/X2020.77) and  
160 Tūhura Otago Museum, Dunedin (KS14-45Pd/X2020.76, KS15-29Pd/VT3347), New Zealand,  
161 following standardised sampling techniques (Geraci and Lounsbury 2007; IJisseldik et al., 2019). A  
162 more restricted examination was performed on the first hourglass dolphin (KS10-28Lc, no ingoa  
163 (cultural) name assigned) in order to preserve the integrity of the cadaver for cultural display.  
164 However, a full system dissection for KS20-20Lc (ingoa name, “Harua-tai-nui”) and all spectacled  
165 porpoises was permitted. Standardised histological tissue samples of key organs were fixed in 10%  
166 buffered formalin solution then trimmed, paraffin embedded and subsequently sectioned (8 µm) on a  
167 rotary microtome. Sections were stained with conventional hematoxylin-eosin stain, or with Masson’s  
168 trichrome.

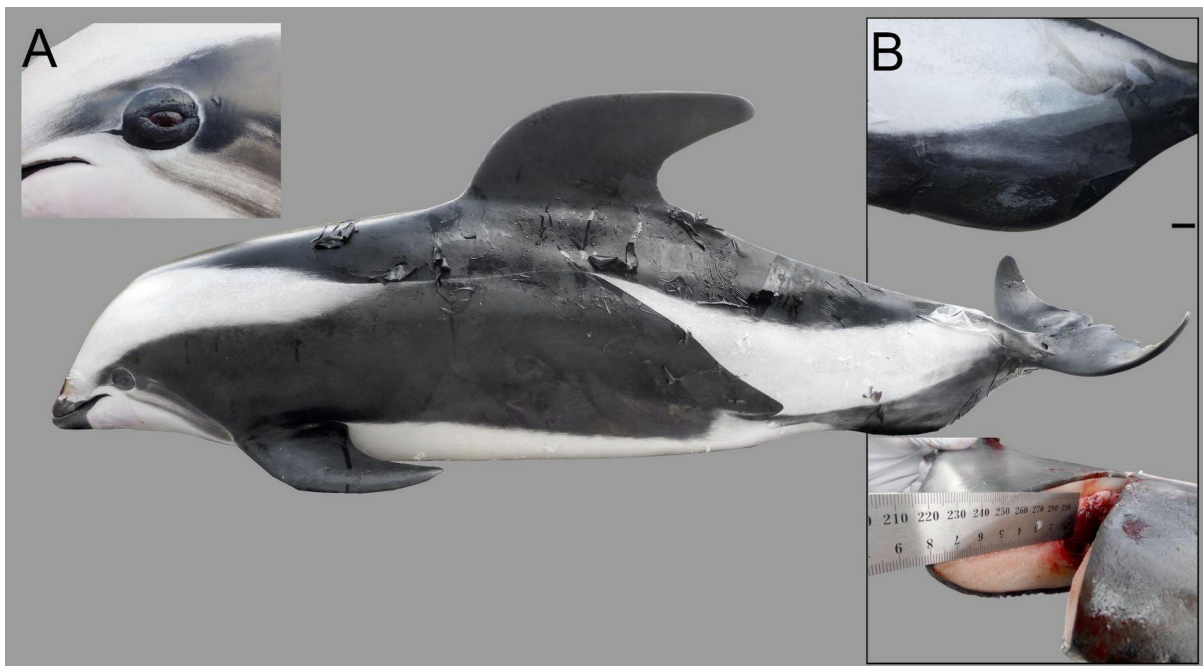
169 The pectoral fins were analysed morphometrically, following Benke (1993). The condylo-basal length  
170 was also measured following Mead and Potter (1995).

## 171 Results

### 172 External appearance

173 Weight and morphometric measurements of each specimen are reported below in Table 3.

174 The hourglass dolphins had a body shape broadly resembling a robust *Lagenorhynchus*, with a  
175 smoothly rounded head, and no protruding rostrum. The dorsal fin had a long base, was falcate, and  
176 notably tapered caudally, ending with a bluntly pointed tip. The pectoral fins displayed a narrower  
177 base and a notch on the caudal border adjoining the body. The caudal fin, or fluke, was relatively wide  
178 and thin. The caudal peduncle had an obvious ventral keel (Figure 2B), composed of dense connective  
179 tissue and blubber, with no additional musculature (Figure 2B). The characteristic colour pattern was  
180 similar to that described in the literature (see Figures 1 and 2). In common with the spectacled  
181 porpoise, the hourglass dolphins had an incomplete white line dividing the black eye spot with the  
182 black pattern of the head (Figure 2A).

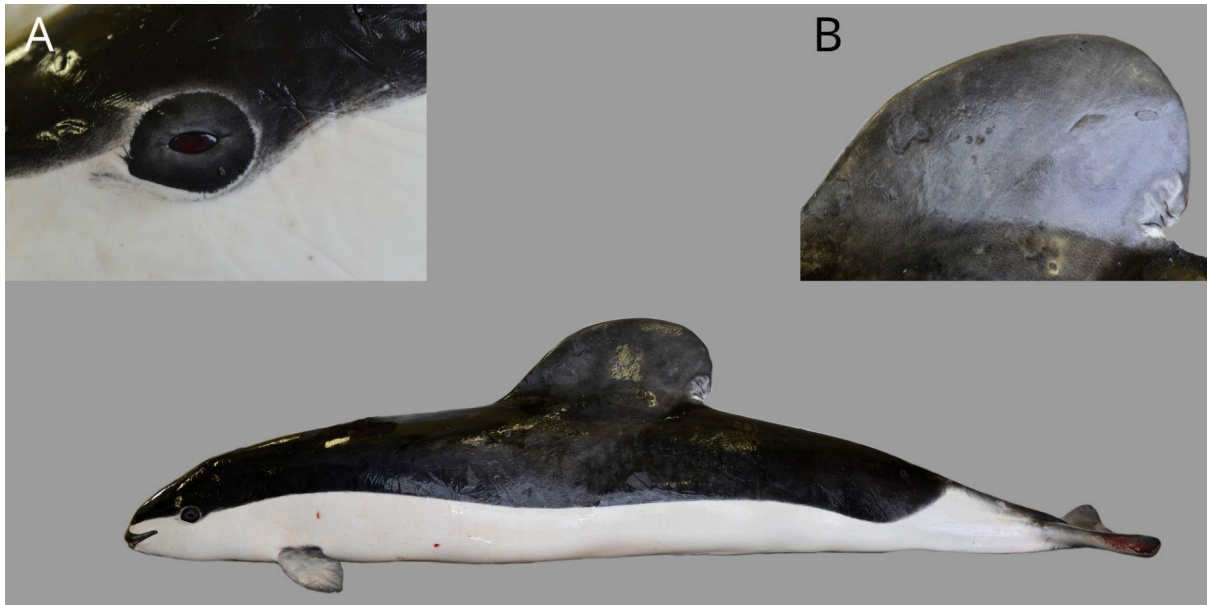


183

184 Figure 2: Adult male specimen of hourglass dolphin KS10-28Lc. Note: Pigmentation pattern with the  
185 characteristic shape of an hourglass. Note (A) white line around the eye spot and (B), caudal keel  
186 showing presence of connective tissue and absence of any musculature.

187 The spectacled porpoises showed a typical porpoise-like body form, having a squat and tapered body,  
188 a clear division between dorsal black and ventral white, rounded pectoral fins and a distinctively large  
189 dorsal fin with a convex trailing edge. The white line around the eye spot was incomplete (Figure 3).

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190

191 Figure 3: Adult male spectacled porpoise KS14-45Pd/X2020.76. Note (A), distinctive white rim  
192 around the black eye patch and (B), exaggerated, wide based dorsal fin.

193 In both hourglass dolphins, though not observed in spectacled porpoises, we detected four small pits  
194 in the skin of the rostrum, ca. 1 cm apart, likely representing remnants of the vibrissae.

195

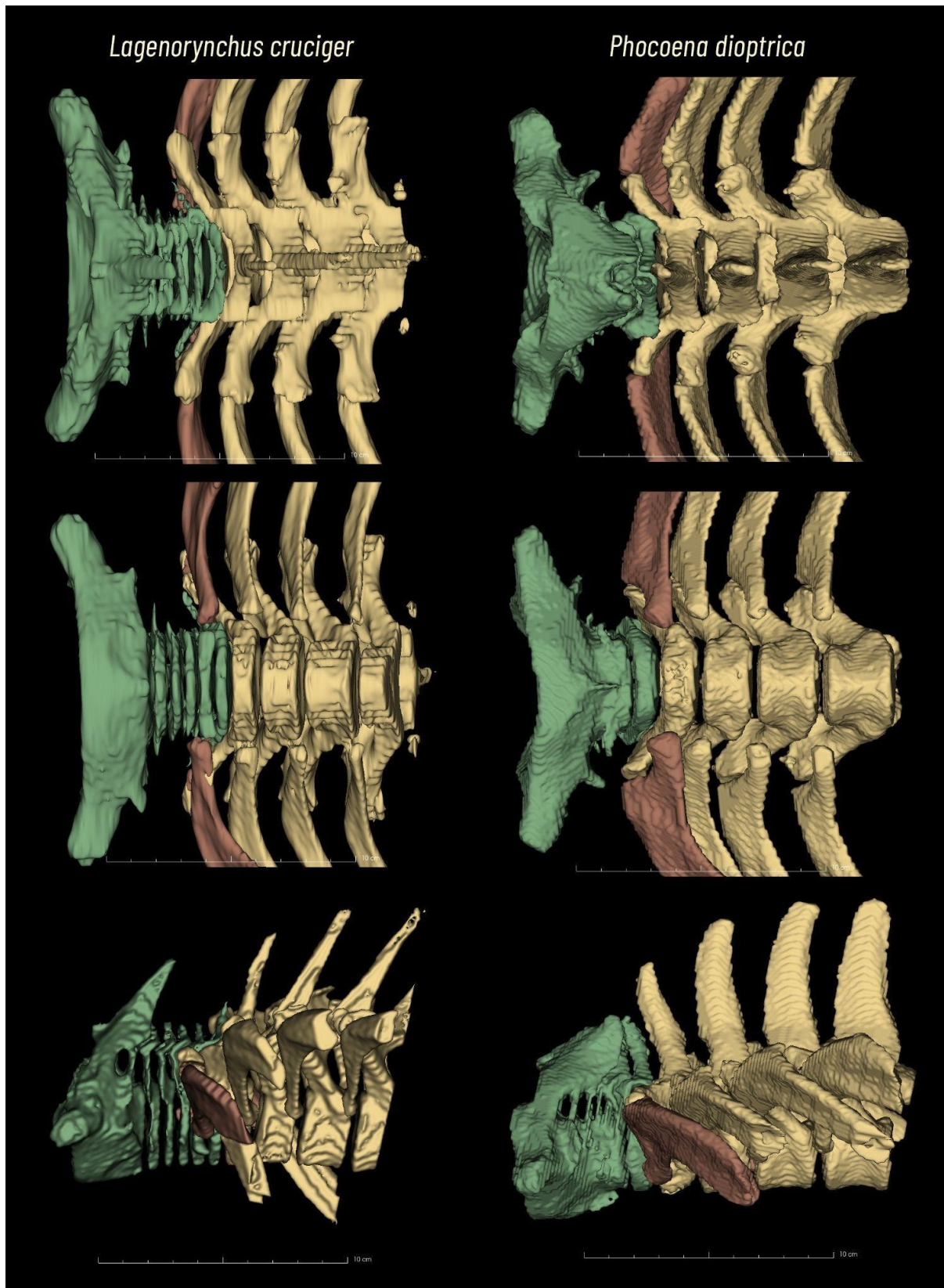
196 Table 3 - Weight (kg) and morphometrics (cm) of examined specimens.

Parameter	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )		Spectacled porpoise ( <i>Phocoena dioptrica</i> )			
	KS10-28Lc	KS20-20Lc	KS14-45Pd /X2020.76	KS14- 37Pd/ X2020.77	KS15- 29Pd/ VT3347	KS20-07Pd
Weight (kg)	78	n/a	120	96	26	n/a
Total length (cm)	170.5	183	215	200	125	210
Snout-anus	121.5	134	149	144	88	155
Snout-genital slit	102.5	113	126	117	81	137.5
Snout-navel	78	82.5	n/a	n/a	60	95.5
Snout-origin flipper	32	35.5	36	30	22	29.5
Snout-origin dorsal fin	67	83*	83 (anterior insertion of fin)	78	51	83
Snout-tip dorsal fin	104.5	119	128	n/a	70	119.5
Snout-blowhole	19	22		n/a	14	18
Snout-corner mouth	18.5	20.5	12	7.8	7	9
Genital slit	13	15	11	26	9	11.5
Rostrum length	2	n/a	n/a	n/a	15	n/a
Corner mouth-eye	5	5.5	20 (snout)	7.8	8.5	11
Eye-blowhole	20.5	18.5	n/a	12	8	17.5
Dorsal fin height	16	22	27	28.5	10	26
Dorsal fin lat base	30.5	42	49	50	25	49
Fluke width	47	53.5	53	46	32	49
Fluke length	17	20	17	18	14	17
Fluke notch	2	2.5	n/a	3	2.5	3
Flipper length internal	33.5	26	n/a	16	11	11
Flipper length external	18	35	23	21.6	17	24
Flipper length width	11	13	10.5	9.6	7	10
Girth eye	73	76	n/a	64	47	72
Girth flippers (back)	98	112.5	100 **	94	65	105
Girth navel	105.5	124	116	n/a***	73	n/a
Girth anus	59.5	69	81	70	43	83
Blubber (mid dorsal) Dorsal	0.9	1.8	2	2.1	1.4	1.8
Blubber (mid dorsal) lateral	1.4	1.4	2.36	2.14	1.4	1.57
Blubber (mid dorsal) ventral	1.4	1.8	2.36	2	1.5	1.9

197 \*anterior insertion of the fin \*\*with shark bite 108 based on measurements from right side; \*\*\*navel is mid dorsal fin,  
198 can't accurately measure this on mature adult male spectacled porpoise.

## 199 Osteology

200 In the hourglass dolphin, the two first cervical vertebrae (C1 and C2) were fused, while in the  
201 spectacled porpoise, C1 to C6 were fused (Figure 4). In both species, the atlas was large and relatively  
202 flat, while the remaining six vertebrae were tightly aligned with their body joined together. For  
203 vertebral formulae and details, see Table 4.



204

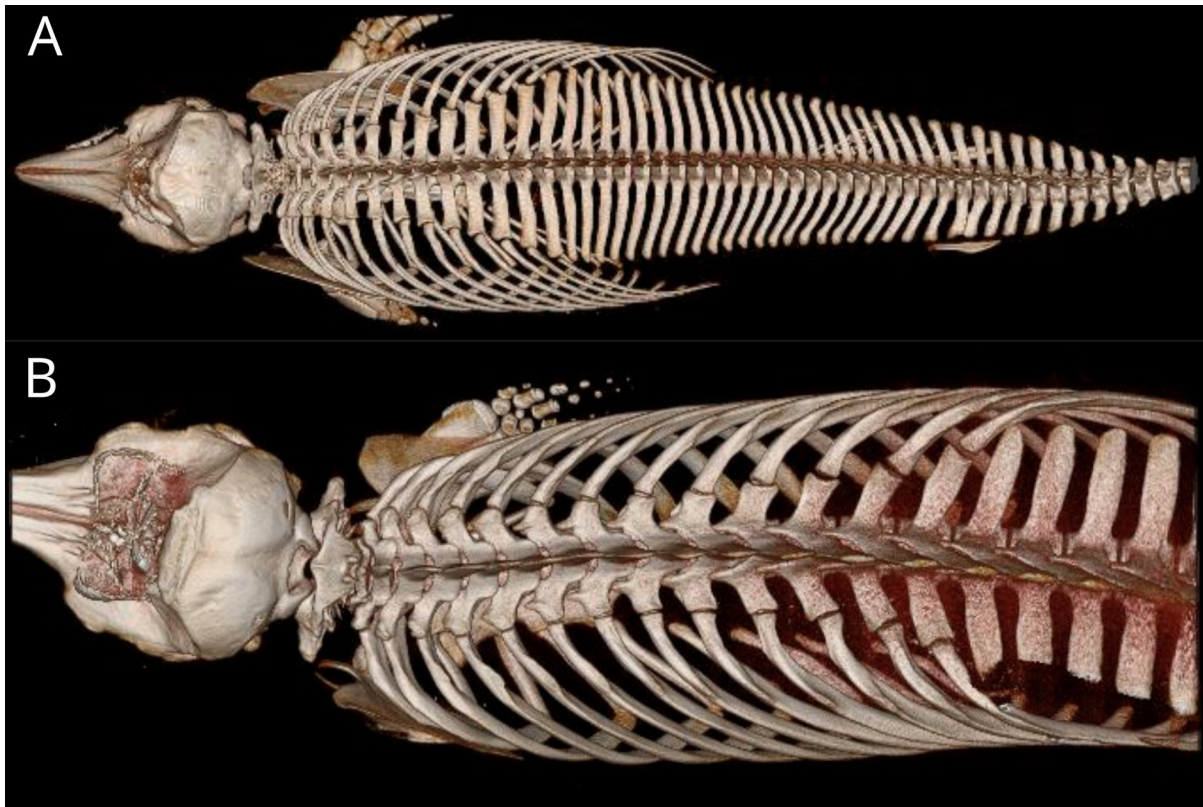
205 Figure 4. Adult hourglass dolphin KS20-20Lc and spectacled porpoise KS14-45Pd/X2020.76 cervical  
206 vertebrae segmented. In green C1-2, C3, C4, C5, C6 and C7; in yellow the first 4 thoracic vertebrae  
207 and ribs. In red, the first rib.

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208 Both hourglass dolphin specimens had 13 thoracic vertebrae (Th), and an analogous number of ribs.  
209 Ribs 1 to 5 articulated with the sternum. The distal extremities of ribs 6 to 8 joined the distal bony  
210 aspect of the ribs rostral to them, while ribs 9 to 13 did not connect to the sternum. Ribs 1 to 6  
211 articulated both with the transverse process of their vertebrae and the vertebral body or the vertebrae  
212 cranial to it (unlike in other mammals, in which it articulates between vertebrae), while ribs 7 to 13  
213 articulated only with the transverse process of their vertebrae. In the spectacled porpoises, ribs 1 to 4  
214 were connected to the sternum, ribs 5 to 8 were connected to the ribs rostral to them and the  
215 remaining ones were free of any relationship to the sternum (Figure 5).

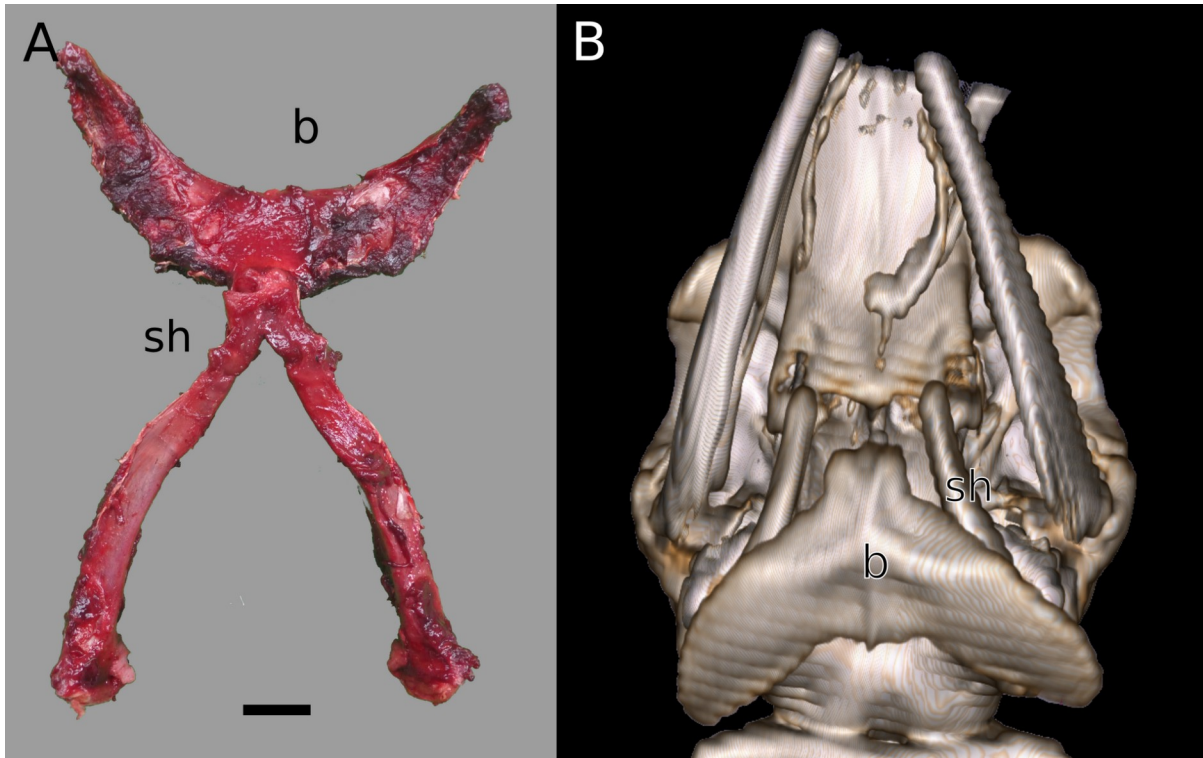
216 The hyoid complex in hourglass dolphin KS20-20Lc displayed a typical *Lagenorhynchus* basihyoid  
217 connected to the stylohyoids, as described by Yablokov et al. (1974). In the spectacled porpoises, the  
218 basihyoid and thyrohyoid were fused in a porpoise-like unique flat bone, articulated cranially with the  
219 two stylohyoids which in turn, run back caudally (Figure 6).

220 Pectoral morphometry was detailed in Figure 7 and Table 5.



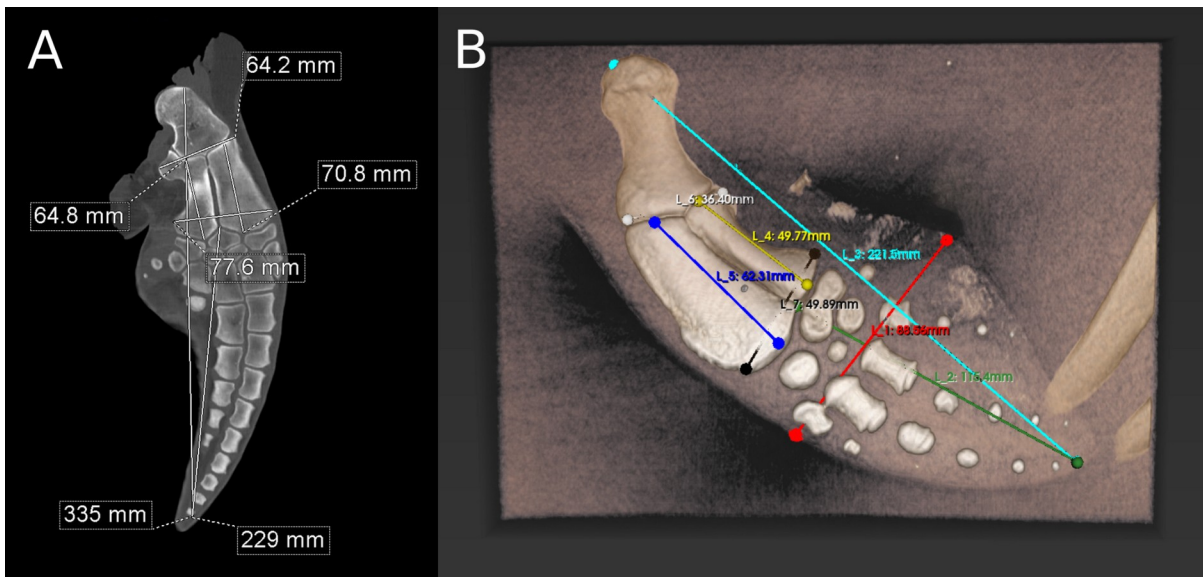
221

222 Figure 5: Representation of the skeleton up to the (A) caudal vertebrae of hourglass dolphin KS20-  
223 20Lc and (B) lumbar vertebrae of spectacled porpoise KS20-07Pd, as displayed by 3D rendering of  
224 the CT scans.



225

226 Figure 6: (A) Visualisation of the hyoid apparatus in a dorsal view of hourglass KS20-20Lc and (B)  
227 3D reconstruction of the skeleton in a ventral view including the hyoid bone of spectacled porpoise  
228 KS20-07Pd. Note: b, basihyoid; sh, stylohyoid. Scale bar = 5 cm.



229

230 Figure 7: Visualisation of the skeletal characteristics with measurements (A) CT of left pectoral  
231 flipper of hourglass dolphin KS20-20Lc and (B) 3D reconstruction of the left pectoral flipper of  
232 KS20-07Pd with principal measurements.

233

234 Table 4. Number of vertebrae per section, number of ribs and phalangeal formula (first number is left  
235 hand, second number is the right hand) by specimen. Note: CB = condylo-basal.

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	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )		Spectacled porpoise ( <i>Phocoena dioptrica</i> )			
	KS10-28Lc	KS20-20Lc	KS14-45Pd /X2020.76	KS14- 37Pd/ X2020.77	KS15- 29Pd/ VT3347	KS20-07Pd
CB length	319.6	362.8	307.2	293.4	239	289.6
Cervical	7	7	7	n/a	7	7
Thoracic	13	13	13	n/a	13	13
Lumbar	15	19	na	n/a	17	n.d.
Coccygeal	nd	16+20	32	n/a	37	27
Ribs	13	13	13	n/a		15?
Phalangeal formula	I= II= III= IV= V=	I= 3; 2 II= 10; 10 III= 7; 7 IV= 3; 3 V= 3; 3	I= 1; 1 II= 6 III= 5; 4 IV= 3; 3 V= 1; 1	n/a	Right only I=1 II= 6 III=5 IV=4 V=1	(only R) I= 2 II= 6 III= 5 IV= 4 V= 1

236

237 Table 5. Morphometry of the pectoral fins

Measurement (cm)	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )		Reference ( <i>Tursiops truncatus</i> ) (Benke, 1993)	Spectacled porpoise ( <i>Phocoena dioptrica</i> )	
	KS20-20Lc			KS20-07Pd	KS15-29Pd /VT3347
Side (Right and Left)	R	L	R	R	R
FLB (flipper width)	111	111	77	88.56	70.6
FLL (flipper length)	342	335	n/a	221.5	165
ML (manus length)	233	229	70	115.4	84.6
RL (radius length)	73.1	70.8	75	62.31	48.4
RUD (radius and ulna distal width)	80.3	77.6	70	49.89	42.8
RUP (radius and ulna proximal width)	63.4	64.2	64	36.4	38.6
UL (ulna length)	65.7	64.8	66	49.77	40.2

239

240

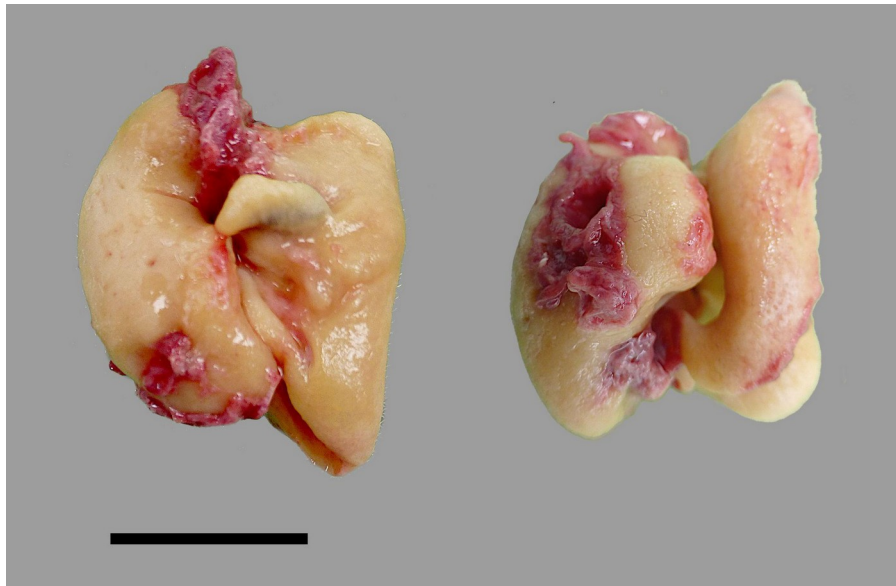
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241 *Tympano-periotic complex*

242 In hourglass dolphin KS20-20Lc, the right and left tympano-periotic complex weighed 18 and 17 g,  
 243 respectively (Figure 8). For a full reporting of measurements, refer to Table 6.



244 Figure 8: Tympano-periotic complex of hourglass dolphin KS20-20Lc. Scale bar = 1 cm.

245 Table 6. Morphometry of the tympanic-periotic complex. TPC, tympanic-periotic complex; T,  
 246 tympanic bone; P, periotic bone; L left; R, right. Measurements are shown as length x width x depth.

Parameter	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )		Spectacled porpoise ( <i>Phocoena dioptrica</i> )		
	KS10-28Lc	KS20-20Lc	KS14-45Pd/ X2020.76	KS14-37Pd/ X2020.77	KS20-07Pd
T R measurements (mm)	35 x 21	35 x 19	32 x 15	32 x 18	30 x 18
T L measurements (mm)	34 x 18	34 x 19	31 x 12	31 x 15	31 x 19
P R measurements (mm)	30 x 22	29 x 15 x 8	36 x 19	31 x 15	32 x 18
P L measurements (mm)	31 x 20	29 x 18 x 12	36 x 20	32 x 20	31 x 20

247

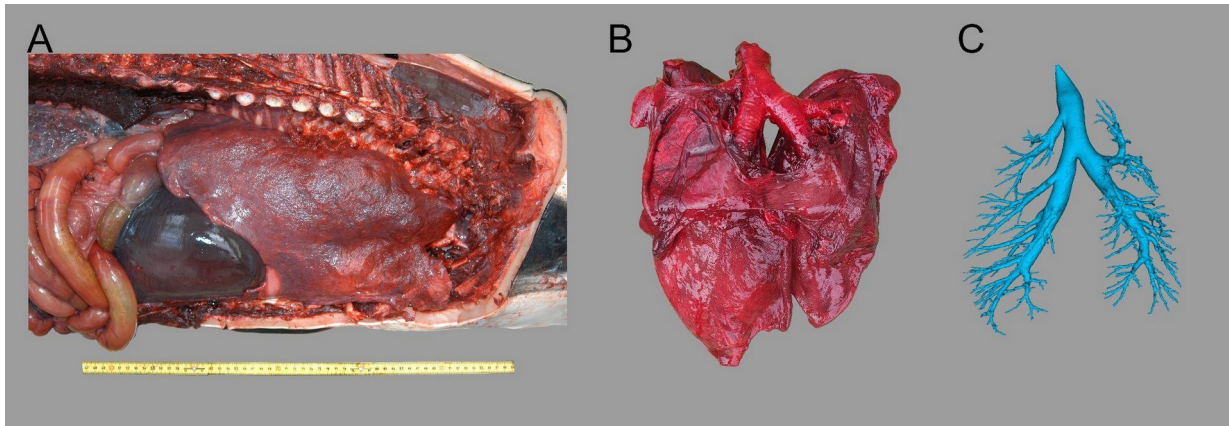
248 **Visceral anatomy**

249 *Respiratory system*

250 In both species we found robust tracheal cartilaginous rings, visible bronchial cartilages down to the  
 251 smallest distinguishable airway, a right tracheal bronchus slightly cranial to the primary bronchial  
 252 division and no apparent lobation of either the left or right lung. Some parameters can be found in  
 253 Table 7. In hourglass dolphins, both the lungs terminated in alignment with rib 12. In spectacled  
 254 porpoises, the left lung terminated approximately at rib 12, with the right lung aligned with rib 10  
 255 (Figures 9 and 10). Histologically, in both species it was possible to observe presumed myoelastic  
 256 sphincters surrounded by cartilage in the smaller bronchioles (Figure 11).

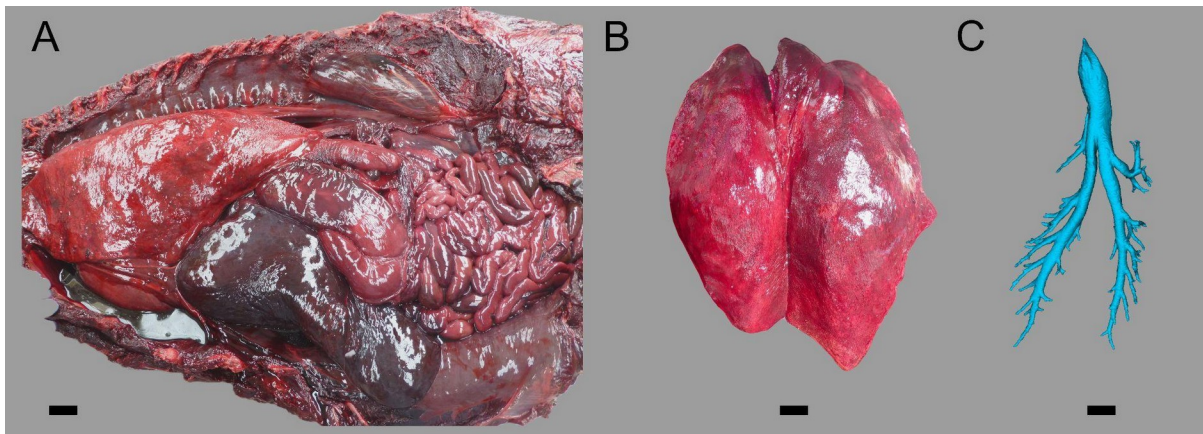
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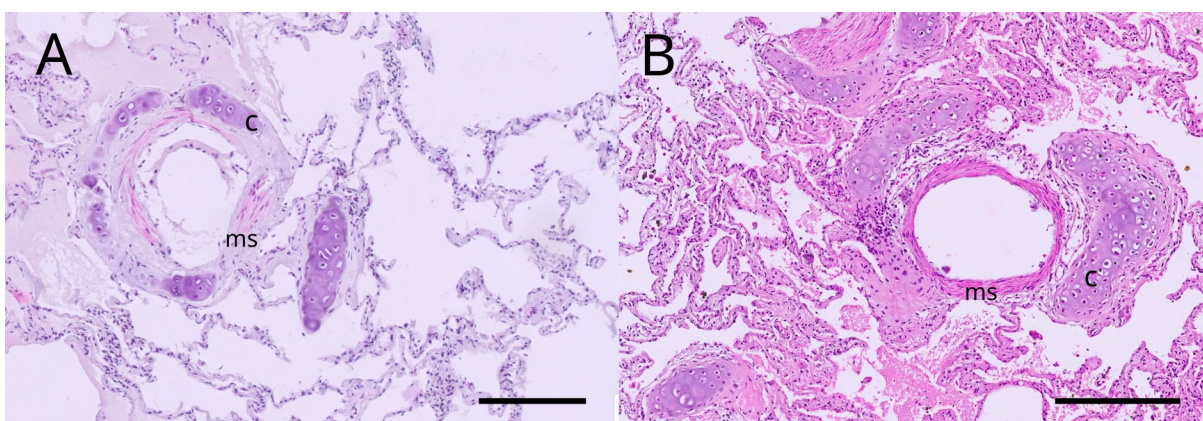
258

259 Figure 9: Thorax with lungs in their topographical location without ribs (A), isolated dorsal and  
260 ventral aspects (B), and as a 3D reconstruction, showing the trachea and bronchial tree of hourglass  
261 dolphin KS10-28Lc. Scale on the left is common to all images.



262

263 Figure 10. Representation of spectacled porpoise KS20-07Pd lungs (A) in their topographical location  
264 and (B) after removal. (C) 3D reconstruction of the trachea and bronchial tree of spectacled porpoise  
265 KS20-07Pd. Scale bar = 2 cm.



266

267 Figure 11. Photomicrograph of the (A) hourglass dolphin KS20-20Lc and (B) spectacled porpoise  
268 KS20-07Pd small bronchioles showing the presumed myoelastic sphincters (ms) surrounded by  
269 cartilage (c). Scale bar = 100  $\mu$ m. Hematoxylin-eosin stain.

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270 Table 7: Lung parameters. Measurements are shown as (craniocaudal) length x (dorsoventral) height x  
271 (lateromedial) width.

Parameter	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )	Spectacled porpoise ( <i>Phocoena dioptrica</i> )		
	KS20-20Lc	KS14-37Pd/ X2020.77	KS15-29Pd/ VT3347	KS14-45Pd/ X2020.76
Total weight (g)	3100	600,3 (L); 673 (R)	328,2 (L); 365.35 (R)	1456 (L); 1078 (R)
Total volume (L)	3.4	n/a	n/a	n/a
Right lung measurements (mm)	440x190x98	400x120	n/a	n/a
Left lung measurements (mm)	420x170x75	400x130	n/a	n/a

272

273 *Circulatory and lymphatic systems*

274 Heart and vessels

275 In both species, the heart was relatively flat dorsoventrally and triangular in shape, with wide and flat  
276 auricles. The left ventricle was larger, with a thicker wall compared to the right. Table 8 summarises  
277 the most important measurements in some specimens.

278 The heart of both hourglass dolphins was located between the intercostal spaces 1 to 5, lying on the  
279 sternum with its major axis oriented laterally, so that the right and left ventricles aligned to the right  
280 sides, respectively (Figure 12A, B). The paraconal groove was relatively deep with large arteries  
281 covered in fat. The diameter of the aorta was approximately 3 cm.

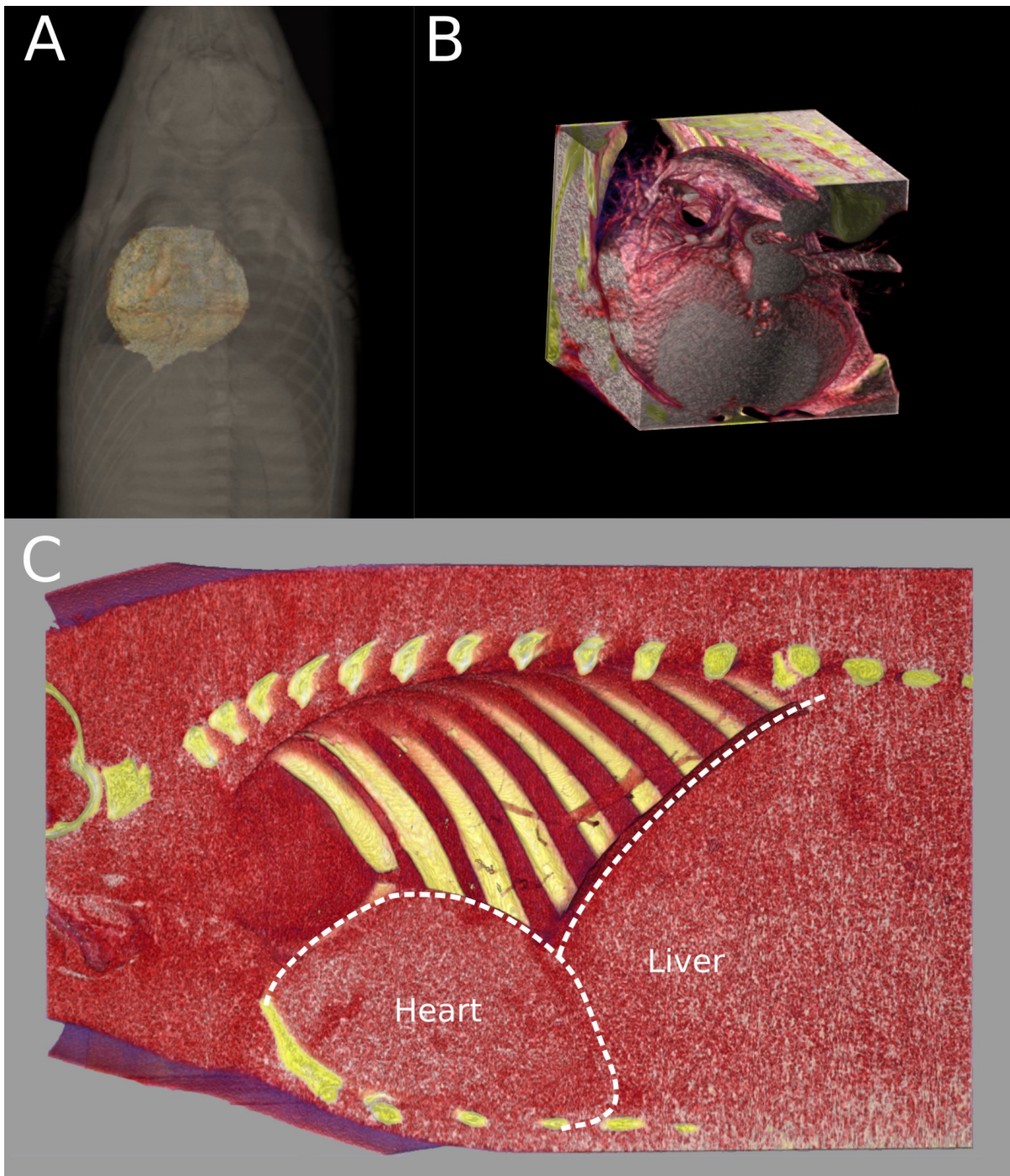
282 The hearts of spectacled porpoises KS20-07Pd and KS14-45Pd/X2020.76 were located on the  
283 sternum between intercostal space 1 and 4 (Figure 12C), and had an approximate volume of 1320 cm<sup>3</sup>.

284 The heart of KS20-07Pd weighed 813 g, with an aorta diameter of 3.9 cm recorded. Several vertebral  
285 arteries extended from the heart to the thoracic rete mirabile along its course in the thorax.

286 Table 8: Heart parameters. Measurements shown as width x length x diameter.

Parameter	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )	Spectacled porpoise ( <i>Phocoena dioptrica</i> )		
	KS20-20Lc	KS14-37Pd/ X2020.77	KS15-29Pd/ VT3347	KS14-45Pd/ X2020.76
Weight (g)	296.6	562.9	269.6	1037 (approx. vol. of 1857 cm <sup>3</sup> )
Measurements (mm)	n/a	180x220	n/a	192x210x45.6

287



288

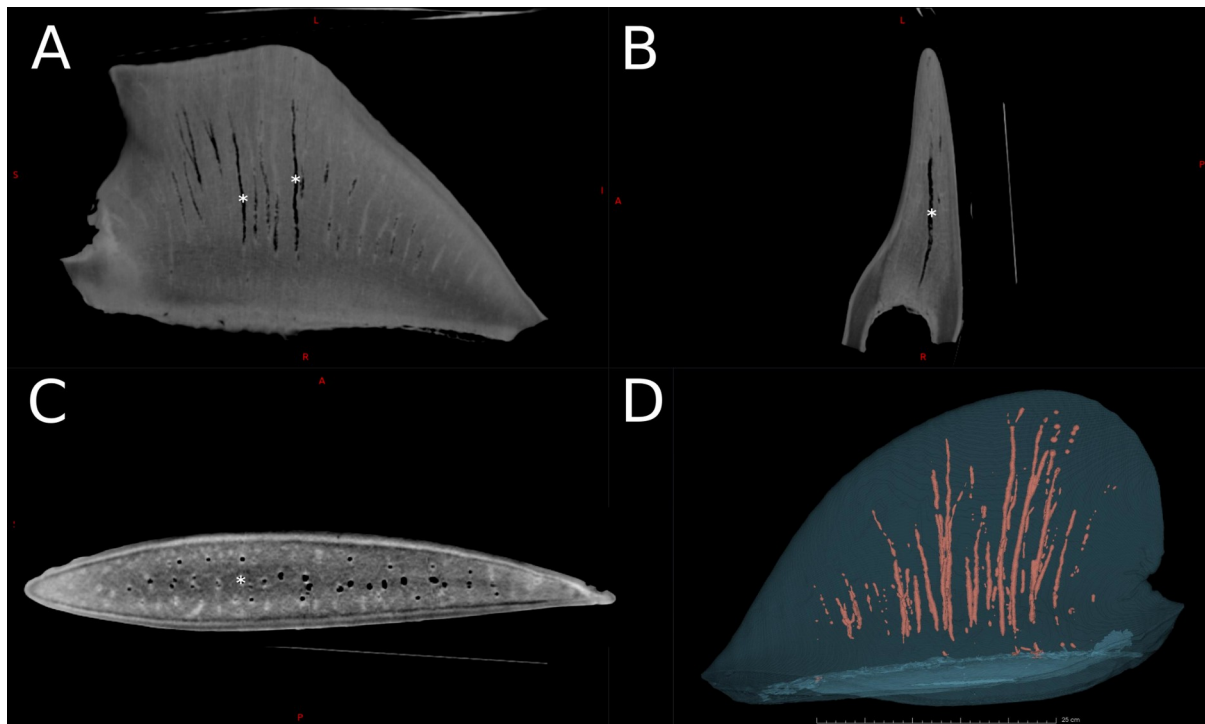
289 Figure 12. 3D reconstruction of the heart in (A, B) hourglass dolphin KS20-20Lc and (C) spectacled  
290 porpoise KS20-07Pd. (A) views the heart dorsally, showing its topography in the thoracic cavity, (B)  
291 illustrates the heart in isolation, with the aortic arch and onset of aorta shown and (C) presents a 3D  
292 model of the heart, sectioned along the sagittal plane, revealing detailed views of the right side of the  
293 heart and the liver.

294

295 In spectacled porpoise KS14-45Pd/X2020.76, it was also possible to remove the dorsal fin and scan it  
296 independently (Figure 13). The images displayed the characteristic pattern of the countercurrent  
297 exchange system in cetacean appendages, featuring central arteries located along the midline of the

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298 dorsal fin and branching dorsally, encircled by circumferential veins (Figure 13). We hypothesised  
299 that the central arteries originating from the body were represented by the hypodense areas in the CT  
300 scan, as these structures possessed rigid walls and may have lost their blood content, resulting in air-  
301 filled cavities while maintaining their structural integrity. However, instead of observing a singular  
302 line of arteries, we identified multiple lines, exhibiting an inhomogeneous distribution (Figure 13C).  
303 The 3D rendering revealed large vessels only in the central section of the dorsal fin, with scarcity in  
304 the rostral and caudal areas. Bifurcation varied, with some vessels bifurcating at the base while other  
305 vessels bifurcated more toward the tip, and others at mid-height (Figure 13D). Cranial and caudal  
306 arteries tended to curve cranially and caudally at the tip of the fin, respectively, while central arteries  
307 ran perpendicular to the fin.

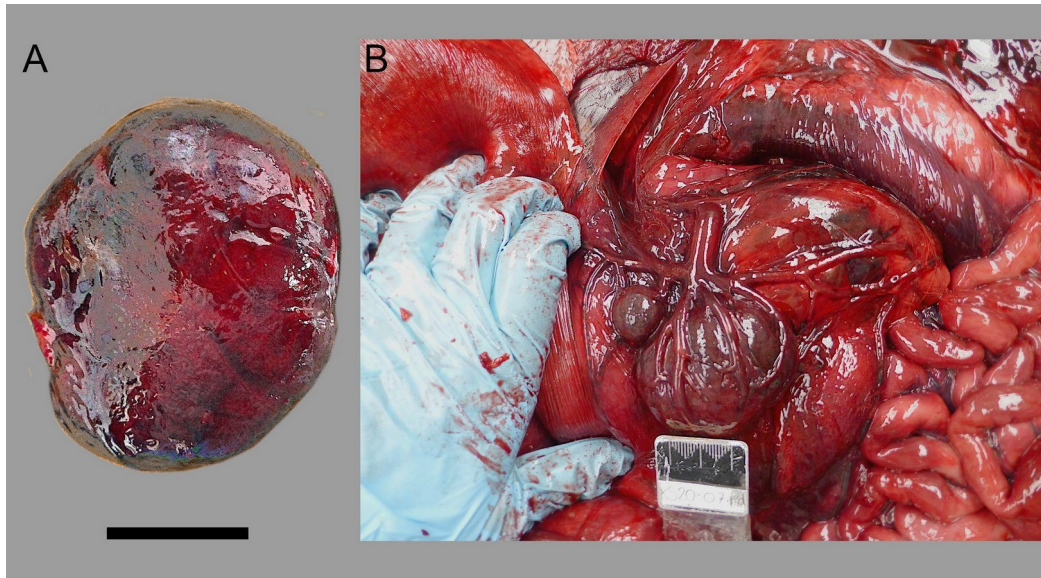


308

309 Fig 13. CT scan of the dorsal fin of spectacled porpoise KS14-45Pd/X2020.76. (A), (B) and (C) show  
310 the sagittal, transversal and axial planes at its base, respectively. (D) shows the 3D reconstruction with  
311 the render of the arteries. In (A), (B) and (C), the asterisks highlight the central arteries. These are  
312 shown as hypodense (dark) regions. The circumferential veins surrounding the arteries, due to their  
313 weaker wall and size, may have collapsed, thus appearing as small hyperdense areas. Conversely, the  
314 peripheral veins were visible as hyperdense areas.

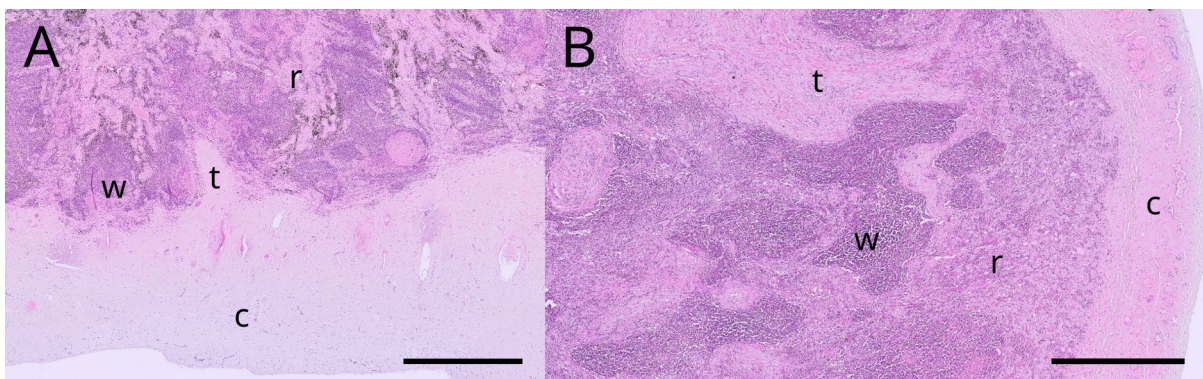
### 315 Spleen

316 In both specimens the spleen was found, with main parameters provided in Table 9. In spectacled  
317 porpoise KS20-07Pd, an accessory spleen was further recorded (Figure 14). In hourglass dolphin  
318 KS20-20Lc, prescapular lymph node weights and measurements were 15 g (L) and 20 g (R) in and 51  
319 x 40 x 11 mm (L) and 72 x 39 x 15 (R), respectively. Histologically, in both species the spleen was  
320 composed of an external capsule which also sent trabecule into the underlying parenchyma, a white  
321 pulp composed of immune cells distributed in the red pulp (Figure 15). Mesenteric lymph nodes were  
322 present at the root of the mesentery.



323

324 Figure 14. Spleen of porpoise KS20-07Pd (A), with presence of accessory spleen (B) shown to the left  
325 of the primary spleen. Scale bar = 2 cm.



326

327 Figure 15. Photomicrograph of the (A) hourglass dolphin KS20-20Lc and (B) spectacled porpoise  
328 KS20-07Pd spleen. Note the capsule (c) sending trabecule (t) into the parenchyma, in turn divided  
329 into white pulp (w) and red pulp (r). Scale bar = 1000  $\mu$ m. Hematoxylin-eosin stain.

330 Table 9. Spleen parameters. Measurements shown as length x width x diameter (mm).

	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )	Spectacled porpoise ( <i>Phocoena dioptrica</i> )		
	KS20-20Lc	KS15- 29Pd/ VT3347	KS14- 45Pd/ X2020.76	KS20-07Pd
Weight (g)	20	19.93	16	27
Measurements (mm)	63x40x15	40x35	n/a	59x48x17

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331

332 *Digestive system*

333 Mouth and upper digestive tract

334 While most teeth were intact in the hourglass dolphin KS10-28Lc, most teeth in hourglass dolphin  
335 KS20-20Lc were worn to the gum (LR: 1-11; LL: 1-13; UR: 1; UL: 1-5 and 9-24). This indicates an  
336 older specimen, which was further supported in the mineralization of the pectoral limb (Figure 7) in  
337 KS20-20Lc. Teeth on KS15-29Pd were only partially erupted and teeth of KS14-37Pd/X2020.77 were  
338 not examined. The dental formula of examined specimens can be viewed in Table 10.

339 Table 10. Dental formula of selected specimens examined. Note: UL, upper left; UR, upper right; LL,  
340 lower left; LR, lower right.

Parameter	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )		Spectacled porpoise ( <i>Phocoena dioptrica</i> )		
	KS10-28Lc	KS20-20Lc	KS20-07Pd	KS14-45Pd/ X2020.76	KS15-29Pd/ VT3347
Teeth UR	24	19	18	21	18
Teeth LR	27	26	19	19	19
Teeth UL	25	24	19	23	18
Teeth LL	25	27	18	17	17*

341

342 The pointed tongue in KS20-20Lc measured 13.3 (L) x 6.3 cm (W), with no anterolateral papillae. Six  
343 vallate papillae were present at the root of the tongue, arranged in a V orientated towards the pharynx  
344 (arrowhead in Figure 16).



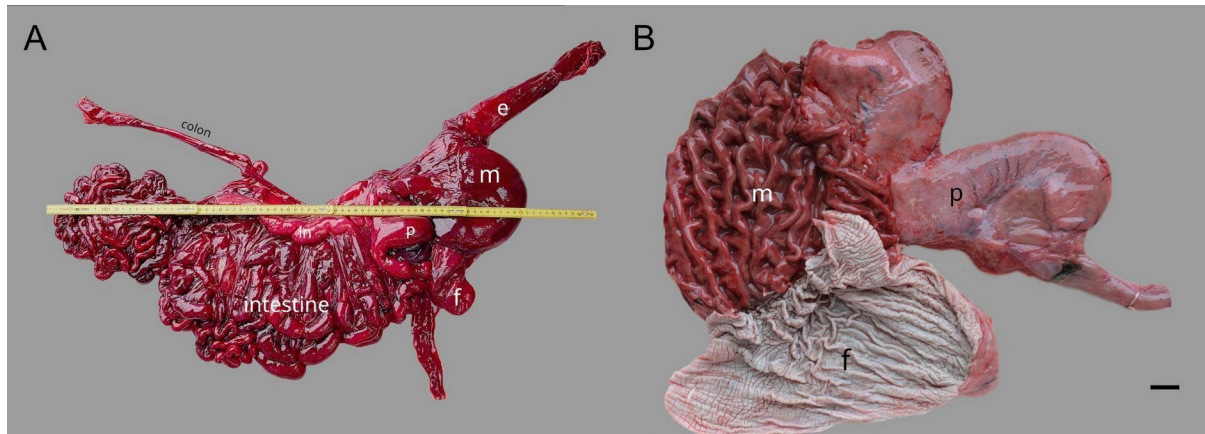
345

346 Figure 16. Tongue of the hourglass dolphin KS20-20Lc. Arrowhead denotes vallate papilla in a V  
347 orientated towards the pharynx. Scale bar = 2 cm.

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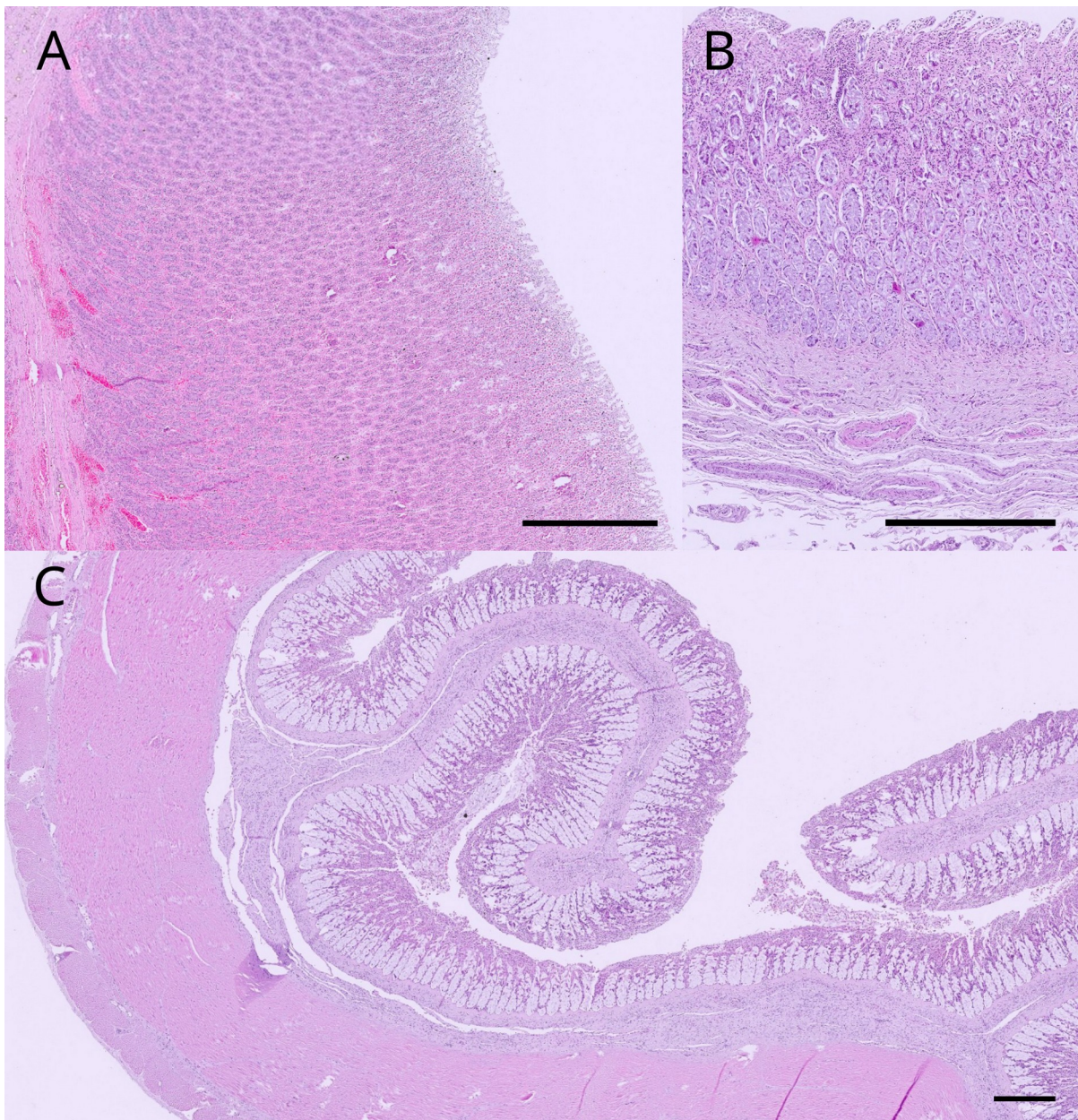
348 Stomach complex and intestine

349 The stomach chambers of all specimens resembled the typical delphinid pattern: one forestomach, one  
350 main stomach and one pyloric stomach. Similarly, in both species the intestine was a unique “tube”  
351 without macroscopical distinction between small and large parts, and lacking a caecum. The  
352 mesenteric lymph nodes were clearly identified (Figure 17). Microscopically, the main stomach  
353 (second chamber) mucosa was thick with the typical pattern of other mammals such as the presence of  
354 glandular cells secreting mucus and HCl (Figure 18A); the pyloric stomach (third chamber) mucosa  
355 was thinner with columnar epithelium and tubular glands (Figure 18B). Finally, the mucosa of the  
356 jejunum was characterized by the typical presence of villi (Figure 18C).



357

358 Figure 17. Gastrointestinal components of the digestive system. (A) whole gastrointestinal system of  
359 hourglass dolphin KS20-20Lc, starting from the oesophagus and terminating at the rectum. (B) gastric  
360 chambers of the spectacled porpoise (KS14-45Pd/X2020.76). e, oesophagus; f, forestomach; i,  
361 intestine; ln, mesenteric lymph nodes; m, main stomach; p, pyloric stomach. Scale bar = 1 cm.



362

363 Figure 18. Microphotograph of the different mucosae of (A) porpoise KS20-07Pd main stomach; (B)  
364 hourglass dolphin KS20-20Lc pyloric stomach and (C) porpoise KS20-07Pd jejunum. Scale bar = 200  
365  $\mu\text{m}$ . Hematoxylin-eosin stain.

### 366 Liver

367 In the two hourglass dolphins, liver position ran from the 10th thoracic to the 2nd lumbar vertebrae,  
368 on the ventral half of the abdominal cavity (Figure 19A). In KS10-28Lc, the right lobe extended  
369 considerably further than the left, which is consistent with its topography and the position (leftward)  
370 of the stomachs. The diaphragmatic surface of the right lobe was expanded cranially and contained  
371 most of the mass of the organ. The right lobe was separated from the left by a thin falciform ligament,  
372 which terminated in a sheet covering the cranial portion of the stomachs (Figure 19B). This was  
373 considerably less evident in the KS20-20Lc, where the liver appeared almost divided in even halves,  
374 although the right half was thicker than its left counterpart.

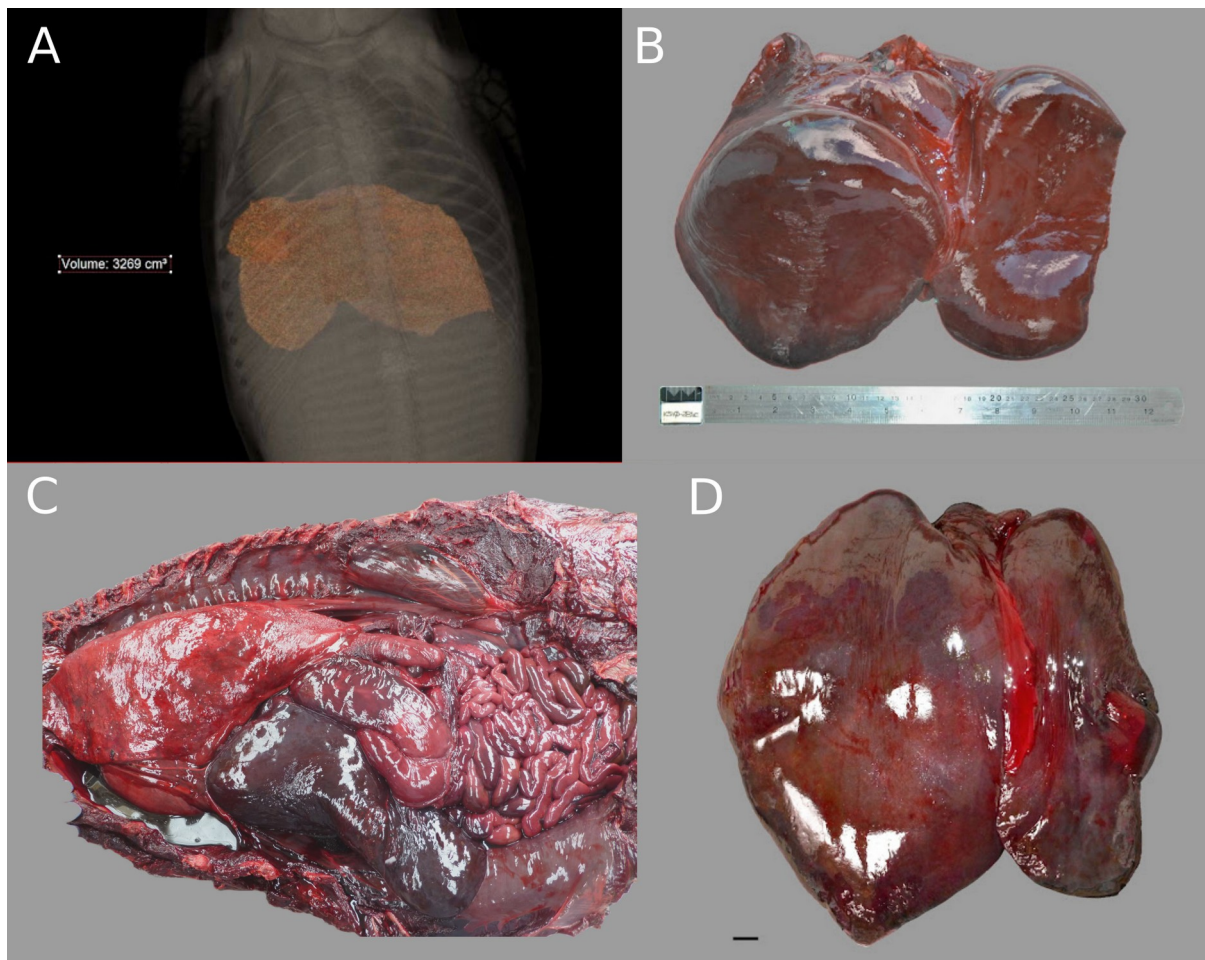
375 In the spectacled porpoises, the liver was positioned approximately between thoracic rib 8 to lumbar

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376 vertebra 4. A highly developed right compared to more inferior left lobe was noted, without the  
377 aforementioned diaphragmatic expansion for the two hourglass dolphin specimens. The falciform  
378 ligament still clearly divided the main left and right lobes of the liver (Figure 19C, D). In both species  
379 we also could not find any venous sinus, apparent lobulation nor gallbladder.

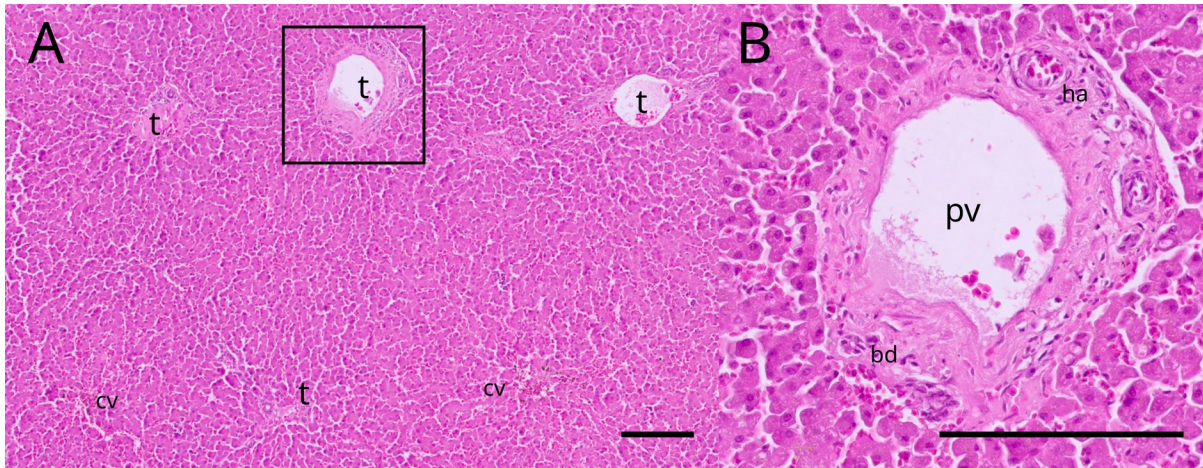
380 Histologically, in the hourglass dolphin the hepatic parenchyma was formed of lobules, not easily  
381 distinguishable due to the absence of connective septa and clear central veins. However, portal triads,  
382 in turn composed of a portal vein, hepatic artery and bile duct were identified (Figure 20). No definite  
383 muscular wall surrounding the portal vein was found.

384 Details on the dimensions and weight of the liver for three specimens (KS10-28Lc, KS20-20Lc and  
385 KS20-07Pd) are reported in Table 11.



386

387 Figure 19. Representation of the liver in the (A, B) hourglass dolphin KS20-20Lc and (C, D)  
388 spectacled porpoise KS20-07Pd. (A) and (C) showed the liver in its topographical location within the  
389 abdominal cavity while (B) and (D) the extracted and isolated organ. Note the difference between the  
390 large right compared to smaller left lobe. Scale bar of (D) = 1 cm.



391

392 Figure 20. Microphotograph of the KS28-10Lc liver. (A) low-magnification image showing the  
 393 overall hepatic organization in central veins (cv) surrounded by portal triads (t). (B) high-  
 394 magnification image of a portal triad of (A) showing the portal vein (pv), hepatic artery (ha) and  
 395 bile duct (bd). Scale bar = 200  $\mu$ m. Hematoxylin-eosin stain.

396 Table 11. Liver morphometry in hourglass dolphin and spectacled porpoise. Measurements shown as  
 397 width x length x height.

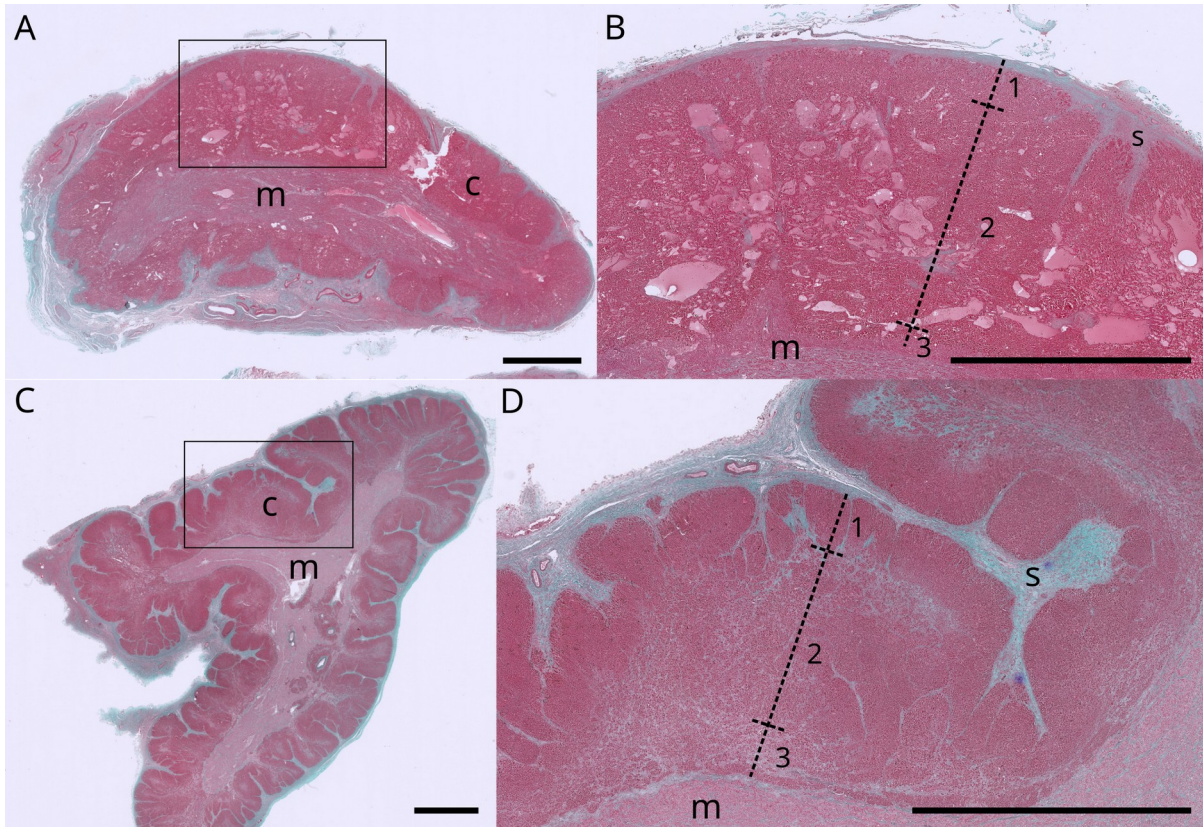
Parameter	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )		Spectacled porpoise ( <i>Phocoena dioptrica</i> )			
	KS10-28Lc	KS20-20Lc	KS20-07Pd	KS14-45Pd/ X2020.76	KS14-37Pd/ X2020.77	KS15-29Pd/ VT3347
Weight (g)	1865	1964	3855	4143	2368	861
Measurements (mm)	n/a	272 x 309 x 42	n/a	n/a	n/a	n/a

398

399 *Endocrine system*

400 Adrenal glands

401 In both species, the adrenal glands were composed of a thick cortex (divided into *zona glomerulosa*,  
 402 *fasciculata* and *reticularis*), and a thin medulla. The adrenal glands of hourglass dolphins  
 403 demonstrated a more ovoidal shape compared to the spectacled porpoises, which were more  
 404 pyramidal in shape. Microscopically, there were more septa in the spectacled porpoise compared to  
 405 the hourglass dolphin, with the *zona fasciculata* comprising the thickest component (Figure 21).  
 406 Details on size and weight of the adrenal glands are reported in Table 12.



407

408 Figure 21. Microphotograph of the adrenal glands of (A, B) hourglass dolphin KS20-20Lc and (C, D)  
 409 spectacled porpoise KS20-07Pd. (A) and (C) display the whole gland while (B) and (D) offer a  
 410 subdivision of the cortex into *zona glomerulosa* (1), *fasciculata* (2) and *reticularis* (3). c, cortex; m,  
 411 medulla; s, septa. Scale bar = 500  $\mu$ m. Masson's trichrome stain.

412 Table 12. Adrenal gland morphometry. Measurements shown as length x width x diameter. Note: L =  
 413 left; R = right.

Parameter	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )		Spectacled porpoise ( <i>Phocoena dioptrica</i> )		
	KS10-28Lc	KS20-20Lc	KS20-07Pd	KS14-37Pd /X2020.77	KS14-45Pd/ X2020.76
Adrenal R weight (g)	n/a	8	7	19.2	15
Adrenal measurements (mm) R	n/a	78 x 28 x 9	55 x 30 x 17	67 x 35 x n/a	n/a
Adrenal L weight (g)	n/a	7	8	18.4	11
Adrenal measurements (mm) L	n/a	52 x 23 x 7	51 x 34 x 10	55 x 26 x n/a	n/a

414

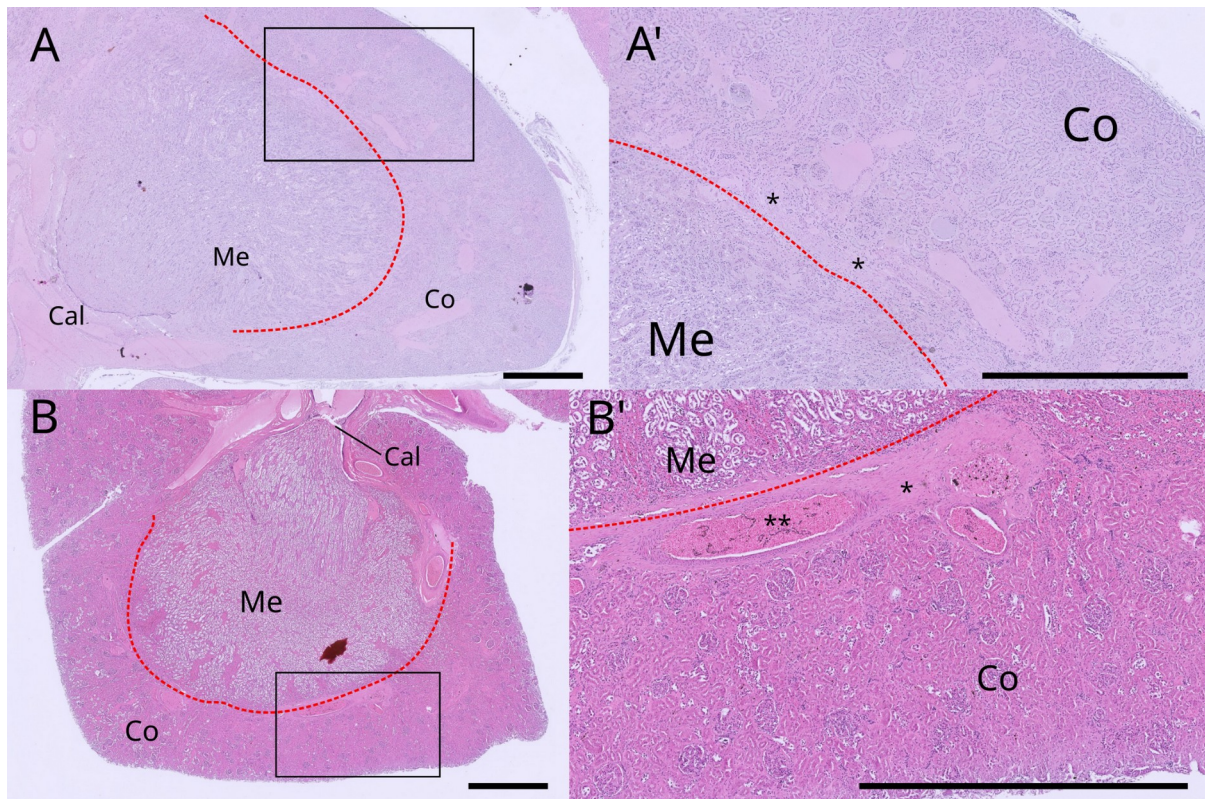
415 *Urogenital system*

416 Kidneys

417 Each kidney in the hourglass dolphins had ca. 300 reniculi, similar to that of bottlenose dolphin

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418 *Tursiops truncatus* (Cozzi et al., 2017). Renal structure was typical of cetaceans, with the muscular  
 419 basked (*sporta perimedullaris*) and renicular arterioles dividing the cortex and medulla (Figure 22).  
 420 Details on the morphometry of the kidneys are further summarised in Table 13.



421  
 422 Figure 22. Microphotograph of reniculus of (A, A') hourglass dolphin KS20-20Lc and (B, B')  
 423 spectacled porpoise KS20-07Pd. (A) and (B) show the whole structure with the red dotted line  
 424 dividing the cortex (Co) from the medulla (Me), which in turn collects the urine in the calyx (cal).  
 425 (A') and (B') show the muscular basket (\*) and renicular arterioles (\*\*). Scale bar = 1 cm.  
 426 Hematoxylin-eosin stain.

427 Table 13. Morphometry of the kidneys. K, kidney; L, left; R, right. Measurements: length x width x  
 428 diameter.

Parameter	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )		Spectacled porpoise ( <i>Phocoena dioptrica</i> )			
	KS10-28Lc	KS20-20Lc	KS20-07Pd	KS14-45Pd/ X2020.76	KS14-37Pd/ X2020.77	KS15-29Pd/ VT3347
R K weight (g)	300	455	378	414	324	112.26
R K measurements (mm)	200 x 90 x 25	251 x 104 x 27	238 x 99 x 25	250 x 90 x 30	198 x 79 x 41.6	n/a
L K weight (g)	335	458	372	431	260.6	105.5
L K measurements (mm)	220 x 90 x 30	243 x 123 x 21	233 x 98 x 25	240 x 90 x 33	210 x 80 x 31.4	n/a
Bladder weight (g)	n/a	47	n/a	n/a	n/a	n/a

Bladder measurements (mm)	na	103 x 34 x 20	na			na
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429

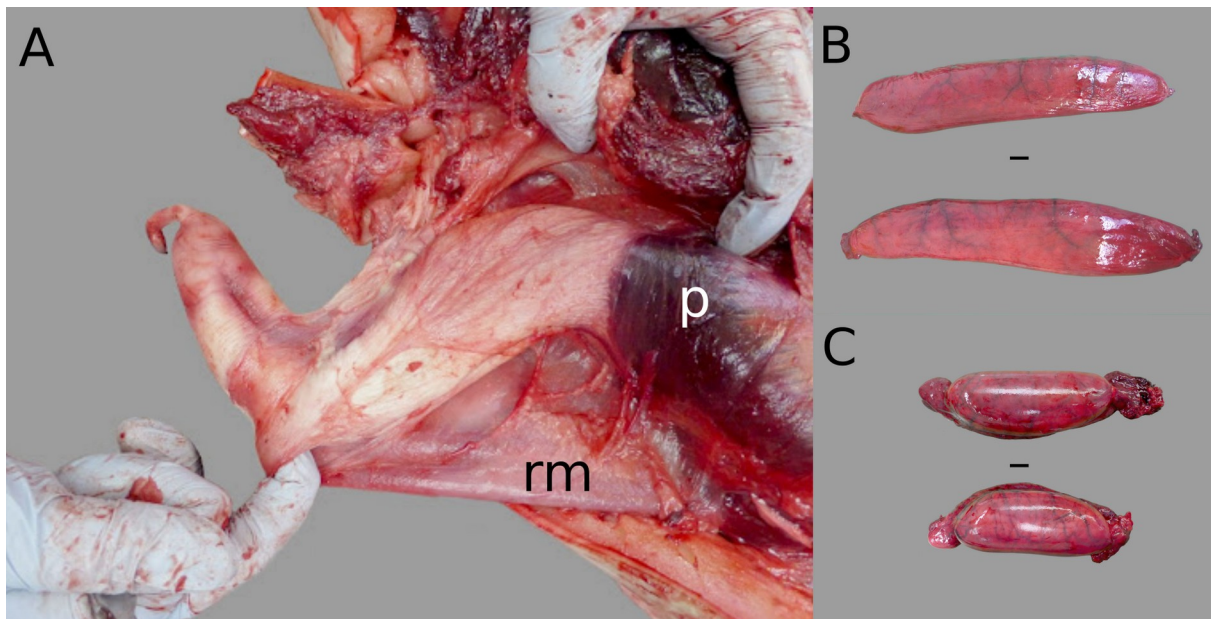
430 Gonads

431 In KS15-29Pd/VT3347, the left ovary weighed 1.9 g, was 15 mm in length, 10 mm in width and 5  
432 mm in diameter. The uterus was 30 mm in length and 15 mm in width, belonging to an immature  
433 female.

434 In males of both species, the penis was S-shaped and displayed the retractor muscles. The apex was  
435 thin and the prostate gland clear (Figure 23).

436 In the five males, testes were large, as usual in adult cetaceans, with a white-pearl colour, and an  
437 epididymis running on the dorsal border of the testicle for most of its length. However, the testes were  
438 more elongated in the hourglass dolphins compared to the spectacled porpoise. The size of the testes  
439 in both species indicated that all males were sexually mature. In the case of KS20-20Lc, sexual  
440 maturity was confirmed by the presence of spermatozoa on histological examination of testis.

441 Details on the morphometry of the genital apparatus are reported in Table 14.



442

443 Figure 23. Male reproductive system: (A) Penis of hourglass dolphin KS20-20Lc with retractor  
444 muscle (rm) and prostate (p) covered by the muscles ischiocavernosus and bulbo-urethralis; (B) testes  
445 of hourglass dolphin KS20-20Lc; (C) testes of spectacled porpoise KS20-07Pd. Scale bar = 1 cm.

446

447 Table 14. Morphometry of the male genital apparatus. Note: (T) testis, (E) epididymis; L, left; R,  
448 right. Note: Measurements are reported as length x width x diameter (mm).

Parameter	Hourglass dolphin ( <i>Lagenorhynchus cruciger</i> )		Spectacled porpoise ( <i>Phocoena dioptrica</i> )		
	KS10-28Lc	KS20-20Lc	KS20-07Pd	KS14-45Pd /X2020.76	KS14-37Pd /X2020.77

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R T + E weight (g)	315	434	323	n/a	119.9
R T - E weight (g)	267	369	276	n/a	n/a
R T measurements - length x width x depth (mm)	305 x 59	350 x 72 x 21	161 x 68 x 39	131 x 51 x n/a	150 x 50 x n/a
L T + E weight (g)	360	466	285	n/a	124.5
L T - E weight (g)	270	383	249	n/a	82.2
L T measurements - length x width x depth (mm)	285 x 55	375 x 74 x 19	152 x 61 x 39	138 x 50 x n/a	150 x 50 x n/a
Postanal hump measurements (cm)	4.3 x 28	6.5 x 5.2 x 28	n/a	n/a	n/a
Penis length (mm)	n/a	300	n/a	~190	n/a

449

## 450 Discussion

451 The anatomical description of little known or endemic species is rarely for the sole purpose of  
452 describing a new species, but rather to offer insight on where the species fits taxonomically. Here, we  
453 provided an anatomical overview and description of two seldom reported species, the hourglass  
454 dolphin and the spectacled porpoise, using not only photography and conventional histology but also  
455 computed tomography including three-dimensional reconstructions. This work was only possible  
456 thanks to the collaborative efforts of many individuals spanning multiple teams within and beyond  
457 Aotearoa, New Zealand.

458 In terms of size, both species were within similar ranges of total body length, although male hourglass  
459 dolphins weighed marginally less than what was reported for adult males (~90 kg). Skeletal features,  
460 including condylo-basal length and dental characteristics, aligned with previously reported ranges for  
461 these species (Goodall et al., 1997; Brownell, 1999; Brownell and Donahue, 1999; Gazitúa et al.,  
462 1999; Evans et al., 2001; Pinedo, 2002; Fernández et al., 2003). The anatomical features of other  
463 organs, such as the spleen, gastrointestinal tract, liver, adrenal glands, kidneys, and male reproductive  
464 systems, were similar to those of other odontocetes. This similarity reinforces the idea of a shared  
465 evolutionary lineage and common functional adaptations among marine mammals (Cozzi et al.,  
466 2017). This included the characteristic ‘keel’ of the hourglass dolphin, which, as in other delphinids,  
467 is composed of blubber and dense connective tissue.

468 The respiratory anatomy revealed a lack of lobation and the presence of a right tracheal bronchus,  
469 consistent with findings in other cetaceans (Fanning and Harrison, 1974; Cozzi et al., 2017). Although  
470 systematic measurement of lung weight and total lung capacity was challenging, qualitative  
471 evaluation indicated that both species possess relatively large lungs for their body size. This  
472 observation aligns with the "short dive, big lung" relationship observed by Piscitelli et al. (2010,  
473 2013), suggesting that their lung size is adapted for this diving behaviour. Meanwhile, observation of  
474 the cardiocirculatory system revealed that, in terms of topography and anatomy, the heart in both  
475 species aligns with that of other cetaceans (Cozzi et al., 2017).

476 The dorsal fin of the spectacled porpoise presented unique characteristics, including its size and blood  
477 supply. The dorsal fin of other cetaceans studied in captivity has been demonstrated to be a  
478 heterogeneous thermoregulatory window, together with the fluke and flippers (Meagher et al., 2002;  
479 Cozzi et al., 2017; Plön et al., 2018; Favilla et al., 2023), allowing these animals to conserve or  
480 dissipate body heat as required. In particular, vascularisation of the dorsal fin is hypothesised to cool  
481 down the male gonads (Plön et al., 2018). Our observations revealed large vessels branching  
482 extensively throughout the dorsal fin, reaching up to the tip. These findings were consistent with those  
483 reported by Plön and colleagues (2018) in their studies of the Indo-Pacific humpback dolphin (*Sousa*  
484 *plumbea*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*). However, we noted an  
485 inexplicable paucity of vessels in the cranial and caudal regions of the fin. This inconsistency may be  
486 due to technical limitations in detecting these vessels on CT or a true absence, which would require  
487 further investigation, including differences between sexes and potentially utilising MRI with contrast  
488 agents to enhance the quality of results. Interestingly, it is worth noting that the Dall's porpoise  
489 (*Phocoenoides dalli*), a relative of the spectacled porpoise that also inhabits cold waters, possesses  
490 both a small dorsal fin and fluke, in addition to having a relatively thin blubber layer (Jefferson,  
491 2018). This comparison highlights the variability in thermoregulatory strategies among cetaceans,  
492 indicating that thermoregulatory mechanisms need further investigation. The large size of the dorsal  
493 fin of the spectacled porpoise could therefore, serve multiple functions. A large dorsal fin could

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494 minimise lateral torsion during swimming, enhancing propulsive efficiency, while also maximising  
495 exposure to sunlight, which can aid in thermoregulation by warming the blood flowing through its  
496 extensive vascular network. To a lesser degree, the dorsal fin of the hourglass dolphin was also large  
497 with a wide surface area. However, no similar large vessels were observed in the available CT images,  
498 unlike the spectacled porpoise. An alternative hypothesis is that the enlarged dorsal fins of males  
499 would serve as a marker of sexual maturity. Collectively, these characteristics highlight the roles in  
500 which dorsal fins may affect the ecology and survival of the spectacled porpoise.

501 Regardless of insights provided, our study faced several limitations regarding the opportunistic  
502 methodologies employed. For example, not all specimens were dissected in the same manner or  
503 imaged uniformly. Variation in CT scan quality arose from access to different machines, and the  
504 advance of technology across the ten years of specimen acquisition. More recent scans showed  
505 improved resolution compared to the earlier scans. The unattached large dorsal fin of spectacled  
506 porpoise KS14-45Pd/X2020.76 hindered complete scans of the entire animal, making it difficult to  
507 count the lumbar vertebrae. Additionally, histological analyses were limited to only a selection of  
508 specimens, highlighting the need for greater consistency in future examinations of these rare and  
509 elusive species. Despite such challenges, the findings presented here support existing literature, while  
510 documenting for the first time the vascular pattern of the dorsal fin of the spectacled porpoise.

511 In conclusion, this anatomical study of the hourglass dolphin and spectacled porpoise underscores  
512 their adaptations to marine environments, reflecting evolutionary pressures that shaped their  
513 morphology and physiology. The ecology of these species is essentially a blank canvas. Further  
514 research is encouraged on their ecological roles and the potential impacts of environmental changes  
515 on their populations.

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