

First records of golden trevally (*Gnathodon speciosus*, Carangidae), sharp-tail mola (*Masturus lanceolatus*, Molidae) and evidence for white shark (*Carcharodon carcharias*, Lamnidae) in the Galápagos Islands, Ecuador

V.L.G. TODD^{1,2} AND J.S. GROVE^{3,4}

¹Ocean Science Consulting Ltd, Ocean House, 4 Brewery Lane, Belhaven, Dunbar, East Lothian, EH42 1PD, Scotland, UK, ²Institute of Sound and Vibration Research, University of Southampton, University Road, Southampton, SO17 1BJ, UK, ³Section of Fishes, Natural History Museum of Los Angeles County, 900 Exposition Boulevard, Los Angeles, CA 90007, USA, ⁴Zegrahm Expeditions, 192 Nickerson St #200 Seattle, WA 98109, USA

*In 1995, a complete survey of the fish collection in the Charles Darwin Research Station (CDRS) Museum (Galápagos Islands, Ecuador) was undertaken. Five specimens represented possible new records to the archipelago, but insufficient material was available at CDRS to confirm identification. On 5 November 2007, the specimens were removed from the CDRS fish collection under licence from the Parque Nacional Galápagos (PNG) on loan to the Los Angeles County Museum of Natural History (LACM). Identification of all species was confirmed using comparative LACM voucher specimens, including X-rays, scientific keys and other resources, which were, at the time, unavailable to scientists at the CDRS. Four of the five specimens were incorrectly identified in 1995, the fifth, the golden trevally, *Gnathodon speciosus*, is the first confirmed record of this species for the Galápagos. One of the originally mis-identified specimens, the longnose anchovy (*Anchoa nasus*), proved to be *A. ischana* (sharpnose anchovy), and *A. nasus* can now be eliminated as a verified record from the islands. The first confirmed record of the sharp-tail mola, *Masturus lanceolatus*, for the archipelago is also presented based on photographic and video evidence. The first physical evidence of the white shark, *Carcharodon carcharias*, in the Galápagos Archipelago based on discovery of a tooth and C¹⁴ analysis, is presented.*

Keywords: golden trevally, sharp-tail mola, white shark, Galápagos Islands, Ecuador

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INTRODUCTION

The World Heritage listed the Galápagos Islands as an isolated archipelago within one of the four provinces distributed in the Eastern Tropical Pacific (ETP) biogeographic region described by Hastings (2000). In the Galápagos Islands, the indigenous shallower ichthyofauna was isolated from mainland tropical fauna by the thermal gradients to the north and south, the wide expanse East Pacific Barrier (EPB) to the west and by the central American landmass to the east. Thus, the Galápagos Archipelago is a conservation hotspot of fish biodiversity and one of the world's top-ranked areas based on the percentage of endemism (Allen, 2008). The ichthyofauna was found to be more diverse in the Galápagos Islands than in other ETP islands such as Cocos and Isla Malpelo (Grove & Lavenberg, 1997). In fact, if endemics are excluded,

the shallower ichthyofauna in the Galápagos Islands comprises a mosaic of elements from the Panamic, Chilean, western Pacific and Atlantic faunas (McCosker & Rosenblatt, 1984; Robertson & Cramer, 2009). McCosker (1998) updated the list of 444 species described by Grove & Lavenberg (1997), to include 526 species, 73 of which are endemic and 13 exclusively found at the Galápagos, Cocos and/or Malpelo Islands.

This paper confirmed two new fish records for the Galápagos Archipelago. In addition, physical evidence of a new shark record to the islands was also detailed.

MATERIALS AND METHODS

The existing fish collections made from 1962 to 1995 and held at the Charles Darwin Research Station (CDRS) Museum were examined by V.L.G.T. in 1995. The available material comprised 55 families, 150 species and 296 specimens. The taxonomy was standardized by reference to Eschmeyer (1998) and Nelson (1994). Results were compared with the available

Corresponding authors:

V.L.G. Todd and J.S. Grove

Emails: v.todd@oceanscienceconsulting.com; JSGImages@aol.com

literature (e.g. Grove *et al.*, 1984; Goodson, 1988; Humann, 1993; Allen & Robertson, 1994) and five specimens were thought to be new records for the Galápagos Islands. Thus, they were removed from the CDRS Museum and transported by J.S.G. under licence from the Parque Nacional Galápagos (PNG) to the Los Angeles County Museum of Natural History (LACM). Identification was carried out in the LACM by means of comparative voucher material, a digital linear X-ray scanner (EZ320 NTB GmbH, Germany), scientific keys and unpublished colour notes of the Instituto Nacional de Pesca (INP), Guayaquil, Ecuador. The specimens were then returned by J.S.G. to the CDRS collection.

In addition, an unusual ocean sunfish specimen was photographed and filmed in 2008 in Gardner Bay in the waters off Española Island ($1^{\circ}20'51.94''S$ $89^{\circ}39'17.85''W$) at about 18 m depth during a tour carried out by the vessel MV 'National Geographic Polaris'. Thus, species identification of this specimen was based on photographs and video footage.

Finally, a shark tooth was found in 1996 in the supralittoral zone at Urvina Bay, on the west side of Isabela Island ($0^{\circ}17'50.51''S$ $91^{\circ}21'29.86''W$), lying amongst an assortment of seashells, sea urchin spines and bleached coral fragments. The tooth was brought to the LACM, photographed and identified by direct comparison with catalogued white shark specimens. In addition, the tooth was C^{14} dated at the Center for Accelerator Mass Spectrometry at Lawrence Livermore National Laboratory, University of California and returned to the PNG.

RESULTS

Detailed information regarding the specimens re-identified in 2008 was reported in Table 1. Four of the above-mentioned CDRS specimens were misidentified during the examination carried out in 1995. One further fish record was confirmed, and evidence for another was presented.

Order CLUPEIFORMES

Family ENGRAULIDAE

Anchoa ischana (Jordan & Gilbert, 1882)

The CDRS V-6 specimen (Table 1) identified in 1995 as *Anchoa nasus* (Kner & Steindachner, 1867) (the longnose anchovy), is actually *Anchoa ischana* (sharpnose anchovy). The CDRS specimen was compared with a LACM *A. ischana* voucher specimen. Meristics, morphometrics and collection data for the CDRS specimen: dorsal and anal spines absent; anal rays: 22; *Anchoa nasus* (LACM 32911-1) has 24 anal rays. The pseudobranch is normal (not elongate) in the CDRS specimen; body rather elongate, semi-cylindrical; snout moderate, about 3/4 eye diameter; maxilla moderate, tip narrowly pointed, reaching onto sub-operculum, but not to edge of gill cover; gill cover canals of panamensis-type. Anal fin short, its origin below posterior third of dorsal fin base. A narrow silver stripe along flank, deeper above anal fin (about 3/4 to 2/3 eye diameter) broadening at tail.

An X-ray of this specimen is presented in Figure 1 alongside a LACM 32911-1 voucher specimen of *A. nasus*.

Table 1. List of fish specimens identified in 1995 and 2008 with indication of CDRS and LACM code no., date, location and coordinates of finding.

Family	Genus and species		N	LT (cm)	CDRS No.	LACM No.	Location	Latitude/longitude	Date collected	Collector	FB	References
	1995 ID	2008 re-ID										
ENGRAULIDAE	<i>Anchoa nasus</i>	<i>Anchoa ischana</i>	1	11.8	V-6	32911-1	Santa Cruz/ Academy Bay	$0^{\circ}44'30''S$ $90^{\circ}18'15''W$	07/10/1972	Unknown	0.80–1.00	(Whitehead <i>et al.</i> , 1988; Allen & Robertson, 1994, p. 62; Grove & Lavenberg, 1997, p. 183)
CARANGIDAE	<i>Gnathodon speciosus</i>	<i>Gnathodon speciosus</i>	1	19.7	V-777	-	Santa Cruz/ Punta Estrada	$0^{\circ}45'30''S$ $90^{\circ}18'10''W$	03/06/1983	Pelo Fino	0.80–1.00	(Allen & Robertson, 1994, p. 127; Grove & Lavenberg, 1997, p. 360; Robertson <i>et al.</i> , 2004, table 6)
SERRANIDAE	<i>Diplectrum maximum</i>	<i>Paralabrax albonaculatus</i>	1	24.5	V-1205	-	Unknown/ Mangroves	Unknown	12/03/1983	J. Pesantes	E	(Bortone, 1977; Allen & Robertson, 1994, p. 108; Grove & Lavenberg, 1997, p. 326–328; Danulat & Edgar, 2002)
SYNODONTIDAE	<i>Synodus evermanni</i>	<i>Synodus scittuliceps</i>	1	15.5	V-22	-	Unknown	Unknown	26/06/1973	Unknown	0.80–1.00	(Allen & Robertson, 1994, p. 72; Grove & Lavenberg, 1997, p. 202)
ACHIRIDAE	<i>Achirus mazatlanus</i>	<i>Trinectes fonsecensis</i>	1	7.6	V-42	6777-6	Santa Cruz/ Academy Bay	$0^{\circ}44'30''S$ $90^{\circ}18'15''W$	Unknown	G. Houvenaghel	0.80–1.00	(Allen & Robertson, 1994, p. 292; Grove & Lavenberg, 1997, p. 623)

N, number of specimens; LT, length of specimen; FB, FishBase: likelihood of occurrence in Galápagos; E, endemic.



Fig. 1. LACM X-ray no. 1262. (A) LACM voucher of *Anchoa nasus*; (B) *Anchoa ischana* (CDRS V-6).

Order PERCIFORMES
Family CARANGIDAE

Gnathodon speciosus (Forsskål, 1775)

This CDRS V-777 specimen (Table 1) was confirmed *Gnathodon speciosus* (golden trevally). Meristics, morphometrics and collection data for the CDRS specimen: dorsal spines (total): VIII; dorsal soft rays (total): 19; anal spines: III; anal soft rays: 16; gill rakers on first arch (excluding rudiments) 21 + 29; no teeth; lateral line with moderate arch anteriorly; straight part of lateral line with 21 scales followed by 22 scutes; breast completely scaled; lips thick and fleshy; pectorals falcate; anal fin with two detached spines. Colour: faded in alcohol: silver; broad and narrow black bars alternating; fins yellow; few faint spots visible on sides; bars, faint. This specimen was captured in Puerto Ayora by means of a gill-net targeting mullet.

Order PERCIFORMES
Family SERRANIDAE

Paralabrax albomaculatus (Jenyns, 1840)

The CDRS V-1205 specimen (Table 1) identified in 1995 as *Diplectrum maximum* (Hildebrand, 1946) (greater sand perch), is actually *Paralabrax albomaculatus* (white-spotted sandbass). The CDRS specimen was compared with a LACM *D. maximum* voucher specimen. Meristics, morphometrics and collection data for the CDRS specimen: dorsal spines (total): IX; dorsal soft rays (total): 9; anal spines: III;

anal soft rays: 7. (LACM voucher specimen of *D. maximum* dorsal fin continuous; dorsal spines: X, dorsal soft rays 12). The CDRS specimen was further verified by the finely serrated pre-opercular margin and the third elongated spine on the dorsal fin. Colour: faded in alcohol, light brown on upper two-thirds, white below; seven large white spots on upper half of side, and smaller, irregular dark brown spots in surrounding areas, faint pale white line from upper corner of operculum to middle of base of tail fin; caudal fin white basally with dark brown bar across middle portion and broad yellowish rear margin.

Order AULOPIFORMES

Family SYNODONTIDAE

Synodus scituliceps Jordan & Gilbert, 1882

The CDRS V-22 specimen (Table 1) identified in 1995 as *Synodus evermanni* Jordan & Bollman, 1890 (spotted lizardfish), is actually *Synodus scituliceps* (lance lizardfish). Meristics, morphometrics and collection data for the CDRS specimen: dorsal soft rays: 11; anal soft rays: 13; lateral-line scales: 61. Protrusion at tip of lower jaw (as in *S. evermanni*). The CDRS specimen was also compared with a LACM *S. evermanni* voucher specimen. There are no blotches on the sides of the body and the lateral scale count is 57. Note position of the adipose fin where dorsal fin origin closer to adipose fin than snout tip.

Order PLEURONECTIFORMES

Family ACHIRIDAE

Trinectes fonsecensis (Günther, 1862)

The CDRS V-42 specimen (Table 1) identified in 1995 as *Achirus mazatlanus* (Steindachner, 1869) (Pacific lined sole), is actually *Trinectes fonsecensis* (spottedfin sole). The specimen was compared with a LACM *A. mazatlanus* voucher specimen. Meristics, morphometrics and collection data for the CDRS specimen: dorsal rays: 60 commencing at tip of snout; anal rays: 45; pectoral rays: 2 (also a single small ray); blind side of head with fleshy long tentacles; lower lip of eyed side fringed; front nostril on eye-side without ring of cirri; border of operculum on blind side mostly scaled; pectoral fin present, but reduced to one ray; no hair-like filaments on scales; body oval, elongate. Colour: faded in alcohol, but ten dark brown bars visible; scattered rows of spots between bars faintly visible; median fins with dark brown spots visible. *Achirus mazatlanus* and *T. fonsecensis* have virtually identical vertebral and anal-fin ray counts, and there is also a broad overlap for dorsal-fin ray counts (H.J. Walker, personal communication). *Achirus mazatlanus*, however, has a lower dorsal count of ~52–54; the main distinguishing feature between the two species is the presence (*T. fonsecensis*) or absence (*A. mazatlanus*) of the septum between the branchial chambers (see Walker & Bollinger, 2001).

An X-ray of this specimen is presented in Figure 2 alongside a LACM 6777-6 voucher specimen of *T. fonsecensis*.

Order TETRAODONTIFORMES

Family MOLIDAE

Masturus lanceolatus (Liénard, 1840)

Figure 3 shows two photographs of the same specimen (both sides) of *Masturus lanceolatus*, the sharp-tail mola. Meristics, morphometrics based on Matsuura (2002): dorsal soft rays (total): 15–19; anal soft rays: 15–19. Dorsal and anal fins

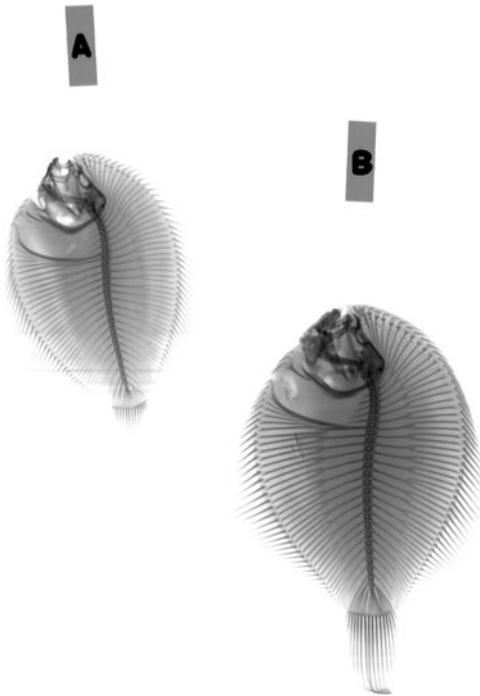


Fig. 2. LACM X-ray no. 1261. (A) *Trinectes fonsecensis* (CDRS V-42); (B) LACM voucher of *T. fonsecensis*.

similar in shape, positioned far back on body. Distinguished from the ocean sunfish (*Mola mola* Linnaeus, 1758) and the Southern sunfish (*Mola ramsayi* Giglioli, 1883) by the median projection from the clavus (extensions of the dorsal and anal fin rays). The species has been identified from the pointed medial aspect of the caudal fin. None of the other genera possess this feature. The *M. lanceolatus* in Figure 3 is accompanied by a number of juvenile pilot fish *Naucratus ductor* (Linnaeus, 1758). Footage of the sighting can be viewed and downloaded at <http://video.google.com/videoplay?docid=-8388366297406835949#>.

Order LAMNIFORMES

Family LAMNIDAE

Carcharodon carcharias (Linnaeus, 1758)

This specimen record of *Carcharodon carcharias* was based on the CDRS V-1249 large, triangular, saw-edged tooth (enamel height ~ 34 mm, crown width ~ 27.5 mm) (Figure 4). White shark tooth was compared to a dried *C. carcharias* jaw, LACM 38194-1. Results for the C^{14} dating of the shark tooth was 1010 age before present (BP) (Table 2).

Randall (1973) noted that approximate total length (TL) may be estimated based on the enamel height of the largest upper jaw tooth in white sharks. Based on Randall (1973), this tooth might come from a ~ 3.8 m TL white shark; however, there is no way to verify that this is the largest upper tooth.

DISCUSSION

These findings contribute to the ongoing effort to collect baseline data for the Galápagos Archipelago ichthyofauna (Edgar *et al.*, 2004). The variability inherent in all biological systems will cause new fish species to move into Galápagos

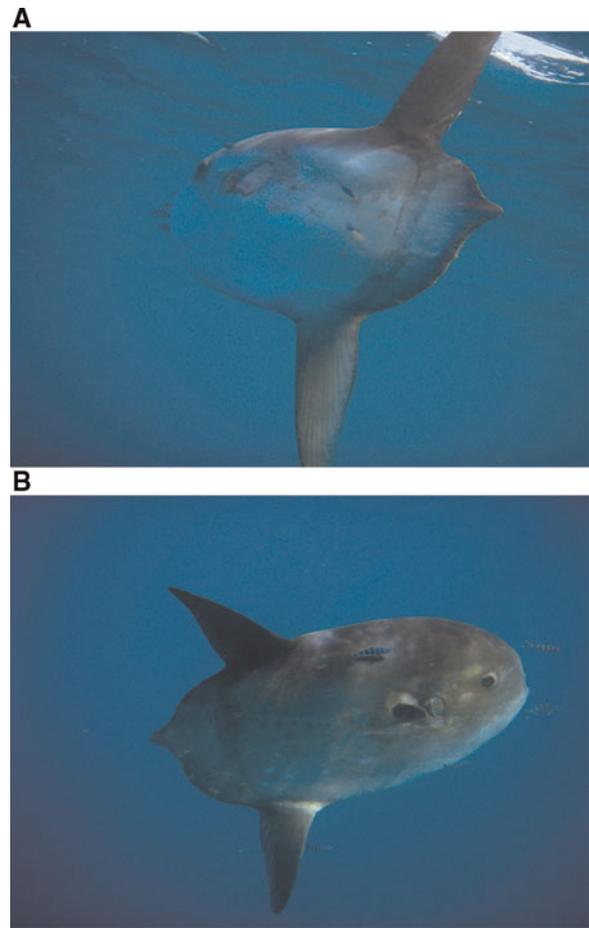


Fig. 3. *Masturus lanceolatus* observed off Española Island.

waters and other species decline or disappear. For example, since the 1982/1983 El Niño Southern Oscillation (ENSO) event, the Galápagos damselfish (*Azurina eupalama* Heller & Snodgrass, 1903) vanished from Galápagos waters and was presumed extinct (Grove & Lavenberg, 1997; Calvopiña & Edgar, 2009). During other ENSO events, a number of fish species were found to extend their distribution ranges (Victor *et al.*, 2001; Bearez & Prado, 2003). In addition to the emergence of new records from existing collections, new fish species are continually being discovered from sustained sampling within the archipelago (e.g. Cohen & McCosker, 1998; Anderson & Baldwin, 2000; Baldwin & McCosker, 2001). Moreover, the World Heritage Committee is developing a plan for a multi-national marine protected area between the islands of Cocos, Malpelo and Galápagos; therefore, ongoing re-appraisal of the existing collections and new acquisitions is essential to record accurately the fauna of this region.

In particular, *Anchoa ischana* is noted to occur in the Galápagos Islands (Whitehead & Rodríguez-Sánchez in Fischer *et al.*, 1995). The genus *Anchoa* is represented in the eastern Pacific by 17 species, most of which are very similar and difficult to distinguish (Allen & Robertson, 1994). *Anchoa ischana* is a schooling species occurring in coastal waters over sand, gravel and mud (Peterson, 1956). They feed primarily on planktonic organisms, particularly crustaceans, which are filtered by the gill rakers (Allen & Robertson, 1994). Listed as moderate vulnerability (38.31)

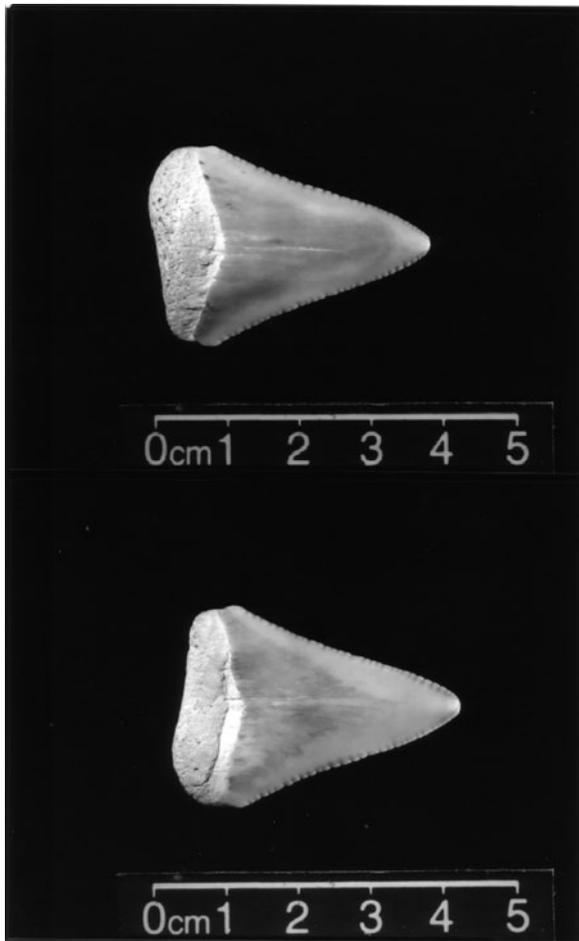


Fig. 4. *Carcharodon carcharias* tooth collected off Isabela Island, Galápagos. Upper photograph: lingual surface; lower photograph: labial surface.

on FishBase.org (Cheung *et al.*, 2005); not listed on the International Union for Conservation of Nature and Natural Resources Red List Status (IUCN, 2009).

The CDRS specimen identified in 1995 as *Gnathodon speciosus* was the first specimen recorded from the Galápagos Archipelago. Grove & Lavenberg (1997) noted that the species is likely to appear in Galápagos waters but interestingly, no other specimens or photographic records are known from the islands. This species is also found in Hawaii, Johnston Island, the Line and the Marquesas Islands, and is listed as a 'supposed eastward migrant' in Robertson *et al.* (2004). *Gnathodon speciosus* is a schooling fish found in deep lagoons and seaward reefs, where they use their protractile mouth to root for crustaceans, invertebrates and small fish in the sand (Allen & Robertson, 1994). Small juveniles live among the tentacles of jellyfish (Lieske & Myers, 1996) and the young display piloting behaviour with sharks and other large fish (Allen & Robertson,

1994). They are also known to follow divers (Jonklaas, 1975), presumably to gain protection from predators (Lieske & Myers, 1996). Listed as moderate to high vulnerability (45.85) on FishBase.org (Cheung *et al.*, 2005). The Red List status of *G. speciosus* has not been evaluated (IUCN, 2009).

Paralabrax albomaculatus is listed as endemic for the Galápagos Islands. *Paralabrax albomaculatus* is a reef-associated species found at depths of 10–75 m (Thresher & Colin, 1986) off rocky coasts and nearby sand patches (Allen & Robertson, 1994). They grow to a maximum size of ~50 cm (Merlen, 1988). Depth distribution varies according to temperature, with preference for cooler water (Reck, 1983). They feed on bony fish, mobile benthic crustaceans (shrimps/crabs), cephalopods including octopus, squid and cuttlefish (Robertson & Allen, 2008). *Paralabrax albomaculatus* is currently fished in the archipelago. There are currently no minimum catch-size restrictions for this species and anecdotal observations (J.S.G.) suggest that average size-at-landing for *P. albomaculatus* is decreasing annually. Listed as moderate to high vulnerability (52.66) on FishBase.org (Cheung *et al.*, 2005); not listed on the IUCN Red List status (IUCN, 2009).

Synodus scituliceps is listed in Allen & Robertson (1994) but not treated in Grove & Lavenberg (1997). *Synodus scituliceps* is a tropical species (24°N–5°S) found in the ETP from the Gulf of California, to Peru, Cabo San Lucas, Mazatlán, Mexico down to Chile (Pequeño, 1989) including the Galápagos Islands (Allen & Robertson, 1994). *Synodus scituliceps* was first recorded in the Galápagos as *S. jenkinsi* by Jordan & Evermann (1896), later synonymized by Meek & Hildebrand (1923). A demersal, fairly common species, it is found in depths of 2–30 m on soft bottoms (Bussing & Lavenberg, 1995), particularly shallow muddy bottoms of bays (Allen & Robertson, 1994). It is listed as low vulnerability (52.66) on FishBase.org (Cheung *et al.*, 2005) and currently not on the IUCN Red List (IUCN, 2009).

Two genera and at least eight species of achirid, including one undescribed species of *Trinectes* occur in the ETP, but only *T. fonsecensis* was previously known from the Galápagos (Grove & Lavenberg, 1997). The species' distribution range extends in the ETP from the Gulf of California to Ecuador where it is found on shallow muddy and sandy bottoms, near estuaries and coastal lagoons (Krupp, 1995). *Trinectes fonsecensis* feeds on crustaceans, small fish and occasionally on detritus (Krupp, 1995). This species is listed as low to moderate vulnerability (30.01) on FishBase.org (Cheung *et al.*, 2005) and is not listed on the IUCN Red List of species (IUCN, 2009).

Masturus lanceolatus was neither listed in Allen & Robertson (1994) nor in Grove & Lavenberg (1997). *Masturus lanceolatus* is a circumglobal species (37°N–35°S) found in tropical to subtropical waters to depths of 6–700 m (Harbison & Janssen, 1987; Figueiredo & Menezes, 2000; Seitz *et al.*, 2002). This is the first verified sighting of *M. lanceolatus* for the Galápagos Archipelago, and one of a handful of sightings for the ETP. The species comprised a portion of the by-catch in the long-line, drift-net and gill-net fisheries that target sharks and rays off Peru. Listed as very high vulnerability (86.25) on FishBase.org (Cheung *et al.*, 2005); currently not on the IUCN Red List status (IUCN, 2009).

Carcharodon carcharias was never recorded verifiably in the Galapagos Archipelago. Allen & Robertson (1994) mentioned that it prefers cooler waters and ranges into the

Table 2. Radiocarbon age determination for *Carcharodon carcharias* tooth (CDRS V-1249). Radiocarbon age expressed as 'years before present'.

CDRS No.	UCR No.	CAM No.	Material	Submitter's ID	$\delta^{13}\text{C}$	C^{14} age (years BP)
V-1249	3636	46958	Dentin	None given	-16.0	1010 ± 40

northern and southernmost ETP. The species was listed as a 'questionable sighting' in Grove & Lavenberg (1997) and McCosker (1998).

The tooth found on Isabela Island may confirm the presence of white sharks in the archipelago, though it is possible that this tooth may have been dropped by a tourist, as shark teeth are routinely worn as necklaces. Nonetheless, this record may support the possibility that a white shark was present in the islands; certainly the geographical and oceanographic characteristics around the Galápagos Islands (Chavez & Brusca, 1991) provide extraordinary environmental conditions, sustaining large populations of potential white shark prey species such as resident and migratory cetaceans and pinnipeds. In particular, the western part of the Galápagos Islands (where the tooth was found) was characterized by a high primary productivity and upwelling systems (Merlen, 1995; Palacios, 2003) sustaining a high abundance of cetaceans.

Carcharodon carcharias is endangered and since 2003 has been listed on the CITES (the United Nations Convention on International Trade in Endangered Species of Wild Fauna and Flora) Appendix III and on CMS (Conservation of Migratory species) Appendices I and II. Considered as very high vulnerability (86.17) on FishBase.org (Cheung *et al.*, 2005) and as 'vulnerable' on the IUCN Red List status (IUCN, 2009).

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Correspondence should be addressed to:

V.L.G. Todd
 Ocean Science Consulting Ltd
 Ocean House, 4 Brewery Lane
 Belhaven, Dunbar, East Lothian
 EH42 1PD, Scotland, UK
 email: v.todd@oceanscienceconsulting.com

J.S. Grove
 Section of Fishes
 Natural History Museum of Los Angeles County
 900 Exposition Boulevard
 Los Angeles, CA 90007, USA
 email: JSGImages@aol.com